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Standard Making: A Critical Research Frontier for Information Systems

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December 12-14, 2003
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Guest Editors

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University of Michigan

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Case Western Reserve University

Contents

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AIMS AND SCOPE

From the Call for Papers

The workshop is aimed at gathering a group of scholars examining issues related to the development, adoption and diffusion, deployment and management of standards in ICT field. Standards have played an important role throughout the evolution of the field of information and communication technology (ICT). The importance of standards in managing and developing ICT has become increasingly critical, while the field has become more heterogeneous, networked, ubiquitous and complex. Firms that create successful standards can seize significant competitive advantage, while firms that are locked out of standardization process, or remain laggards in utilizing the standards face difficulties. Standard choice and the implementation of standards have also become a critical part of managing the IS function and developing software. At the same time traditional institutional forms of standardizing (standard developing organizations SDOs) have become rife with problems, and the scope, pace and success rate of standardization processes has changed drastically rendering uncertainty and new opportunities for different stakeholders.

As important as this topic is, there have been relatively few scholarly papers on standardization informing the scholarly discussion in the IS field. Slightly more than 2% of the published journal articles in the IS field have dealt with standards over the past 10 years, and most of this work has reported on newly established ICT standards rather than examining the processes and importance of standard setting processes. Notably absent are studies that analyze different standardization concepts, standardization processes, industrial coordination and strategy, and economics of standards. In addition, during this decade IS researchers will face new challenges and opportunities in investigating standards as the form and pace of standardization will continue to undergo significant changes.

The workshop will bring together IS researchers drawing on multiple disciplinary perspectives and adopting a variety of theoretical approaches to engage in a focused critique of prior research on standardization, share perspectives about future research, and encourage collaborations. The workshop will comprise presentations and discussions around peer-reviewed submissions as well as invited presentations by thought leaders. The workshop will provide authors the opportunity to further shape their work for submission to a special issue of the *MIS Quarterly* on Standardization (see http://www.si.umich.edu/misq-stds). The theme of the special issue will be aligned with the theme of the workshop.

John L. King
Kalle Lyytinen
May 2003

WORKSHOP ATTENDEES

Name	University	Presentation
Nitin Aggarwal	Texas Tech	Breakout 3
Conan C. Albrecht	Brigham Young	Breakout 1
Roman Beck	Goethe U.	Breakout 4
Waifong Boh	Carnegie-Mellon	Breakout 3
Beom-Jin Choi	Arizona State	
Ellen Christiaanse	University of Amsterdam	Panel
H. Michael Chung	CSU Long Beach	
Henk de Vries	Rotterdam	Breakout 2
Douglas L. Dean	Brigham Young	Breakout 1
Jason Dedrick	U.C. Irvine	Breakout 3
Samer Farag	U. Maryland	
Vladislav V. Fomin	U. Michigan	Breakout 2, Plenary 2
Sanjay Gosain	U. Maryland	Plenary 3
Ian Graham	U. Edinburgh	Breakout 1
James V. Hansen	Brigham Young	Breakout 1
Suzi Iacono	National Science Foundation	Panel
Edoardo Jacucci	U. Oslo	Plenary 1
Hemant Jain	U.W. Madison	Breakout 4, Plenary 3
Robert Kauffman	U. Minnesota	Panel
John Leslie King	U. Michigan	Keynote, Panel
Paavo Kotinurmi	Helsinki U. Tech.	Breakout 1
Stephen Kwan	San José State	
Hannu Laesvuori	Helsinki U. Tech.	Breakout 1
Thomas Lucy-Bouler	Auburn U. Montgomery	Breakout 4
Kalle Lyytinen	Case Western Reserve	Plenary 1, Breakout 2
M. Lynne Markus	Bentley	Plenary 1, Breakout 1
Francesc Miralles	U. Pompeu Fabra	
H. James Nelson	Ohio State	Breakout 2
Kay M. Nelson	Ohio State	Breakout 2
Matthew L. Nelson	U. Illinois	Plenary 1
Jeffrey V. Nickerson	Stevens Inst. Tech.	Plenary 2
Petter Nielsen	U. Oslo	Breakout 2
Rich Orwig	Wash. State U. Vancouver	
Nilesh Saraf	Florida Atlantic	Plenary 3
Michael J. Shaw	U. Illinois	Plenary 1, Breakout 3, Plenary 2
Robert A. Stegwee	U. Twente	Breakout 4
Charles W. Steinfield	Michigan State	Plenary 1
John Tillquist	U.C. Riverside	
Hal Varian	U.C. Berkeley	Keynote
Francesco Virili	U. Cassino	Plenary 3
Eric A. Walden	Texas Tech	Breakout 3
Tim Weitzel	Goethe U.	Breakout 4, Plenary 2
Joel West	San José State	Breakout 3, Panel
Rolf T. Wigand	U. Arkansas Little Rock	Plenary 1, Breakout 4
Mu Xia	U. Illinois	Plenary 2

PROGRAM

Friday, December 12

Reception (19:00-20:30)

An informal cocktail reception will be held in Meeting Suite 428 of the hotel from 7:00-8:30 p.m. You are welcome to bring a guest.

Saturday, December 13

1. Welcome and Plenary #1 (9:00-10:30)

Chair: Kalle Lyytinen, Case Western Reserve

The Evolution of Vertical IS Standards: Electronic Interchange Standards in the US Home Mortgage Industry

M. Lynne Markus, Bentley
Charles W. Steinfield, Michigan State
Rolf T. Wigand, U. Arkansas Little Rock

Reflexive standardization: Interpreting Side-effects and Escalation in Standard-Making

Edoardo Jacucci, U. Oslo
Miria Grisot, U. Oslo
Margunn Aanestad, U. Oslo
Ole Hanseth, U. Oslo

The Adoption and Diffusion of Interorganizational System Standards and Process Innovations

Matthew L. Nelson, U. Illinois
Michael J. Shaw, U. Illinois

2. Keynote (10:45-12:15)

Chair: John L. King, U. Michigan

Keynote address

Hal Varian, U.C. Berkeley

Discussion

Lunch (12:15-13:15)

3. Breakout Groups (13:30-15:00)

Group 1: Business Standards and Frameworks

Chair: M. Lynne Markus, Bentley

Institutionalisation of e-business Standards
Ian Graham, U. Edinburgh
Neil Pollock, U. Edinburgh
Alison Smart, Manchester
Robin Williams, U. Edinburgh

Standardization of XML-based E-business Frameworks
Paavo Kotinurmi, Helsinki U. Tech.
Juha-Miikka Nurmilaakso, Helsinki U. Tech.
Hannu Laesvuori, Helsinki U. Tech.

Market Place and Technology Standards for B2B Ecommerce: Progress and Challenges
Conan C. Albrecht, Brigham Young
Douglas L. Dean, Brigham Young
James V. Hansen, Brigham Young

Group 2: Standardization Practices and Coordination

Chair: Kalle Lyytinen, Case Western Reserve

Stakeholder identification in IT standardization processes
Henk de Vries, Rotterdam
Hugo Verheul, Technical U. Delft
Harmen Willemse, Rotterdam

The Role of Standards in the Information Infrastructure Development, Revisited
Vladislav V. Fomin, U. Michigan

Enabling an Operator-Independent Transaction Model for Mobile Phone Content Service Provision Through the Open CPA Standard
Petter Nielsen, U. Oslo
Ole Hanseth, U. Oslo

The Need for a Strategic Ontology
Kay M. Nelson, Ohio State
H. James Nelson, Ohio State

Group 3: Adopters and Adoption of Standards

Chair: Michael J. Shaw, U. Illinois

Monopoly Power in Standards is a Myth
Nitin Aggarwal, Texas Tech
Eric A. Walden, Texas Tech

Effectively Managing Information Systems Architecture Standards: An Intra-Organization Perspective
Waifong Boh, Carnegie-Mellon
Daniel Yellin, IBM
Bob Dill, IBM
James D. Herbsleb, Carnegie-Mellon

Why Firms Adopt Open Source Platforms: A Grounded Theory of Innovation and Standards Adoption
Jason Dedrick, UC Irvine
Joel West, San José State

Group 4: Industry-Specific Standards

Chair: Rolf T. Wigand, U. Arkansas Little Rock

The Network Effect Helix
Roman Beck, Goethe U.
Tim Weitzel, Goethe U.
Daniel Beimborn, Goethe U.
Wolfgang König, Goethe U.

Identification of Different Types of Standards for Domain-Specific Interoperability
Robert A. Stegwee, U. Twente
Boriana D. Rukanova, U. Twente

A Conceptual Model for Comparative Analysis of Standardization of Vertical Industry Languages
Hemant Jain, UW Madison
Huimin Zhao, UW Madison

Is Digital Medicine a Standards Nightmare?
Thomas Lucy-Bouler, Auburn U. Montgomery
Dan Morgenstern, Auburn U. Montgomery

4. Plenary #2 (15:30-16:45)

Chair: Vladislav V. Fomin, U. Michigan

A Network ROI
    Tim Weitzel, Goethe U.

Open e-Business Standard Development and Adoption: An Integrated Perspective
    Mu Xia, U. Illinois
    Kexin Zhao, U. Illinois
    Michael J. Shaw, U. Illinois

Defending the Spirit of the Web: Conflicts in the Internet Standards Process
    Michael zur Muehlen, Stevens Inst. Tech.
    Jeffrey V. Nickerson, Stevens Inst. Tech.

Sunday, December 14

5. Plenary #3 (9:00-10:30)

Chair: Helmant Jain, U. Wisconsin

Realizing the Vision for Web Services: Strategies for Dealing with Imperfect Standards
    Sanjay Gosain, U. Maryland

Product Interoperability in the Enterprise Systems Software Industry: A Social Network Approach
    Ramnath K. Chellappa, U. So. Calif.
    Nilesh Saraf, Florida Atlantic

Design, Sense-making and Negotiation activities in the “Web Services” standardization process
    Francesco Virili, U. Cassino

6. Panel Discussion (10:30-11:45)

Chair: John L. King, U. Michigan

The Role of Standards in the Creation and Use of Information Systems
    Joel West, San José State

Panel discussion: What Role Should Standards Play in I.S. Research?
    Ellen Christiaanse, University of Amsterdam
    Suzi Iacono, National Science Foundation
    Robert Kauffman, University of Minnesota

Conclusions (11:45-12:00)

Chairs: John L. King, U. Michigan and Kalle Lyytinen, Case Western Reserve

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INSTITUTIONALISATION OF E-BUSINESS STANDARDS

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ABSTRACT

This paper addresses the formation of standards in business-to-business (B2B) e-commerce. The contrast between the developing of generic standards and sector specific standards is considered and the argument that users will commit to developing sectoral standards while IT vendors will direct their resources to generic standards is restated. Specifically, the emergence of the OASIS committee developing a Universal Business Language is considered. The claim that the OASIS process is open and that all interested actors can contribute is described and considered critically in relation to the dominance of US based IT system suppliers in the process.

Keywords: B2B standards, e-commerce standards, UBL, institutionalisation of standards

INTRODUCTION

Forrester Research has projected that e-commerce will represent $6.8 trillion transactions annually by 2004, of which 90% will be business-to-business (B2B) inter-organisational transactions (Business Week, 2001). Castells (2001) claims that B2B e-Business, driven by global pressures for enterprises to adopt lean, decentralized structures and develop integrated co-operative relationships with trading partners, is leading to “a profound reorganization of the way in which business operates.”

The dominant form of B2B e-commerce is EDI (electronic data interchange). The model underpinning EDI is the translation of paper-based documents into electronic messages that may be exchanged between computer systems. However, the technological basis of e-business is currently undergoing a two-stage transition. First, orthodox EDI messages are being replaced by XML (eXtensible Markup Language) messages. XML includes the use of schemas which can be centrally held in a trading community and define as metadata the acceptable values of message elements so that XML messages can be validated. Second, there is an evolution away from a focus on the design of messages towards defining objects and methods which trading partners may access across the web. The greatest interest here is in the use of SOAP (Simple Object Access Protocol) to encapsulate XML. The model of defining object interfaces and methods accessible across organizational boundaries is leading to a convergence of inter-organisational systems with internal object-based architectures (Hagel & Brown, 2001).

These technologies are currently available but the institutional structures to co-ordinate their use in e-business are less well developed. The dot.com boom saw sectoral collaborations, for example Covisint in the automotive sector, or strategic initiatives, for example EnronOnline, setting up B2B exchanges linking wide communities of buyers and sellers. It was claimed that they would lower procurement costs and create more competitive markets, but they have struggled to gain business. As Wise and Morrison (2000) point out, their emphasis on increasing market competition runs counter to the dominant institutional paradigm of co-operative supply. The alternative is for e-business to develop by increasing inter-organisational integration between organisations in existing trading relationships, but this requires collaboration to develop the standards. The collaborative process of developing generic XML e-business standards is now dominated by the CEFACT process, which has evolved from the UN-ECE (United Nations Economic Commission for Europe) sponsored EDIFACT process for developing global EDI messages and OASIS (Organisation for the Advancement of Structured Information Standards). Below the global institutions are a plethora of sectoral initiatives to develop standards tailored to specific local needs (Frank, 2001), with users possibly being able to take advantage of the flexibility of XML to extend or translate standard messages.

It is claimed that the strength of XML in general is its flexibility, but for e-commerce systems to develop communities must form based around the same, or similar, business semantics and process models. As an inter-organisational technology B2B XML should exhibit strong network externalities. This creates the danger of lock-in to particular business models (Arthur, 1990) and may lead to the embedded business process models suiting some users over others. At the heart of the evolution of XML e-business is a tension between competition/collaboration which has temporal and spatial dimensions. In the development of EDI the earliest adopters were either single firms (e.g. Ford) or highly concentrated industry groups (e.g. Tradanet in UK retailing) (Graham et al, 1996). This model enabled them to gain the benefits quickly with low co-ordination costs, but as EDI matured a global process evolved under the aegis of the United Nations, CEFACT (United Nations Centre for Trade Facilitation and Electronic Business), allowing standards to be adapted between sectors but still allowing local or sectoral variation. The early history of XML-based B2B is showing a similar pattern (Kotok & Webber, 2002), with early proprietary initiatives being replaced by local sectoral initiatives and then the emergence of a global over-arching institutional structure. The earliest proponents of XML in e-business were Microsoft and IBM, who were instrumental in the development of SOAP, WSDL and UDDI[1]. All three of which have moved from being proprietary standards to ratification by W3C, the Internet standards body, as open standards. In 1999 RosettaNet, a collaboration of major electronics firms, released its definitions of key processes (Partner Interface Processes) in XML B2B trading. In 1999 CEFACT initiated ebXML (electronic business XML) as a joint exercise with OASIS to develop a generic framework for XML-based e-business, including registries and repositories for business models. In May 2001 the ebXML specification was issued and is now being adopted in sectoral e-business communities, for example RosettaNet in the electronics sector.

[1] WSDL (Web Service Description Language) and UDDI (Universal Description, Discovery and Integration) are specifications for descriptions of web service interfaces and web service directories respectively.

The organisational and institutional milieu in which XML e-business is being developed is complex and dynamic. Standards constitute rules about what those who adopt them should do (Brunsson and Jacobsson, 2000). This emerging institutional structure is a significant issue because, to an even greater extent than was the case with EDI standards, the outputs of the process are models of standard business processes that many users may have to accept. Who is involved in the process and who is excluded may be a significant influence on the development of e-business and, due to path dependency, once a business model is institutionalised in a standard it may become difficult to develop alternative standards.

SOCIAL SHAPING OF B2B STANDARDS

A standard for B2B represents a technology which is being shaped by the needs of potentially diverse constellations of actors. The social shaping approach to the analysis of technology (MacKenzie & Wacjman, 1999) tries to uncover the complex social interactions influencing the development of technologies, rejecting technological determinist positions that seek some underlying universal rationality. The social shaping approach has been applied to the analysis of XML information standards within hospitals (Hartswood et al, 2002). However, as has been noted by Söderström (2002), the analysis of e-business standards is problematic because the standards extend beyond the technologies for exchanging data to encompass the semantics of the information and the underlying business processes. Bowker and Star (1999), when discussing disease taxonomies, have shown that classification systems are shaped by complex political processes. A complication in applying a social shaping approach to the analysis of standardization is the lack of a tangible artifact. In an analysis of the development of telecommunications standards Schmidt and Werle (1998) overcame this obstacle by synthesizing a social shaping approach with New Institutional organization theory (Scharpf, 1997). Schmidt and Werle analysed the organizations co-ordinating standards development as emerging institutions. This follows DiMaggio and Powell's definition of an institution as "a system of rules that structure the courses of action a set of actors might choose". In their seminal article on New Institutionalism DiMaggio and Powell (1991) sought the institutional factors explaining isomorphism, the similarities in organizational form found in sectors. Following this institutional argument, the development of standards which include a standardized model of business processes will also be a force for isomorphism, leading enterprises to adopt similar practices. However it may be that the flexibility implicit in XML-based systems will facilitate organizational diversity. Organisations developing standards are an arena in which these issues are being resolved, making their structure, membership and procedures significant forces in the shaping of B2B.

Xml-Based B2b Standards

A diverse range of organisations are currently involved in the development of B2B standards using XML. There are three routes seen in the formation of B2B standards. The first route is for a major player to define the standards, embody them in software and market them to users. Second, individuals and enterprises may form a consortium to develop and maintain the standard. These consortia represent an institutionalization of standards development, and may be classified by their membership rules, range of activities, intellectual property policies, standards development procedures and organizational form, including number of staff employed. In creating a standards consortium the developers may draw upon existing institutions, for example by adopting recognized decision making procedures, which may be seen as representing best practice and aid acceptance of the consortium. This re-use of existing institutions is

described by Berners-Lee (1999) in his account of the formation of the World Wide Web Consortium (W3C) to develop standards for the Web. Berners-Lee describes the formation of W3C as a reaction to the failing of the Internet Engineering Task Force (IETF), notably its slowness in ratifying standards, but also describes how W3C drew on the membership and IPR procedures of IETF. Third, groups interested in developing standards may add their activities to an existing organization, effectively adopting this organisation's institutions. This was seen in the developers of EDI messages in Europe channeling their activities through UN/ECE because it was seen as having less bureaucratic and cumbersome processes than ISO, leading to an organization with a role in international trade standardization widening its remit to incorporate all EDI transactions.
Examples of all three routes have been seen in the development of standard XML schemas for B2B. The first route was taken by Veo Systems in developing xCBL (XML Common Business Library) as a generic platform for B2B. The second route was followed by a consortium including Ariba and Sterling Commerce, both systems suppliers, to develop CXML (commerce XML) for automated order receipt and fulfillment, and sectorally by Rosettanet in electronics and Hl7 in healthcare. The third route has been followed within the Open Applications Group which has evolved from a consortium of actors interested in system interoperability into the developers of OAGIS (Open Application Group Integration Specification), with open procedures allowing members to define the standards development agenda. The trends has been away from development by single firms towards collaborative consortia and away from closed consortia towards standards development processes more open to potential participants and more visible to external observers. The organization which most exemplifies this evolution is OASIS (Organization for the Advancement of Structured Information Standards).

In 1993 *SGML Open* was founded as an open consortium of vendors and users developing guidelines for interoperability among products using the Standard Generalized Markup Language (SGML), the precursor of both HTML and XML, developed for standardizing the layout of documents. In 1998 *SGML Open* changed its name to OASIS to reflect the broadening range of its standardization activities, including XML and related standards. The OASIS mission is described on the OASIS website: *"OASIS is a not-for-profit, global consortium that drives the development, convergence and adoption of e-business standards. Members themselves set the OASIS technical agenda, using a lightweight, open process expressly designed to promote industry consensus and unite disparate efforts. OASIS produces worldwide standards for security, Web services, XML conformance, business transactions, electronic publishing, topic maps and interoperability within and between marketplaces."*

Membership of OASIS has three levels: *sponsors* are corporate bodies paying $13,500 per year who are given prominence in OASIS communications, *contributors* are corporate bodies paying between $5750 for firms with over 10 employees to $1000 for not-for-profit organizations, and *individuals* are people paying $250 per year. *Individual* members can play a full part in the standards development process but do not have voting rights. *Individual* memberships were *"intended primarily for those involved in academia--individuals whose technical contributions bring substantial value and merit subsidy by OASIS organizational members".* Individual members cannot use their membership to promote their employers so the affiliations of individual members within the OASIS process is opaque. OASIS has more than 600 corporate and individual members in 100 countries around the world. Any three members may set up a Technical Committee to develop standards in an area of interest. There are currently 60 active

OASIS technical committees, which split between committees developing generic standards and those developing sector specific standards.

The United Nations body for Trade Facilitation and Electronic Business (UN/CEFACT) joined with OASIS in 1999 to initiate an 18 month project to standardize XML business specifications. UN/CEFACT and OASIS established the Electronic Business XML Working Group to develop a framework to allow XML to be used in a consistent manner for exchanging all electronic business data, but not the standardizing of business documents. Responsibilities for ebXML were defined in a Memorandum of Understanding between CEFACT and OASIS, with UN/CEFACT responsible for Business Processes and Core Components and OASIS being responsible for Transport, Routing and Packaging, Registry and Repository, Collaboration - Protocol Profile and Agreement, Security and Conformance. ebXML comprises three components of XML-based electronic commerce infrastructure: a specification for XML messaging, a specification for trading partner agreements, and a specification for registries and repositories. UBL is intended to provide the standard documents to be exchanged over standard messaging.

The ebXML standards provide an architecture for web service based e-commerce and provide the building blocks from which messages may be developed but do not cover the specification of messages using these standards. The ebXML standards can therefore be adopted by sectoral groups, for example Rosettanet in the electronics sector, to develop ebXML compliant e-commerce. In addition an OASIS technical committee was established to develop a Universal Business Language (UBL): generic standards for e-commerce.

UNIVERSAL BUSINESS LANGUAGE

The UBL standards have their roots in CBL (Common Business Library), developed by Veo Systems in 1997. CBL was developed within a project funded by the United States Department of Commerce's Advanced Technology Program. Its initial development in a government funded project was important for its appropriation within UBL because it ensured that it was an open published standard, unlike CXML (Common XML) developed by Ariba and Sterling Commmerce. In January of 1999, Commerce One acquired Veo Systems and the CBL technology. The Veo CBL was tailored to support the Commerce One products and customers, which entailed making it interoperable with EDI. xCBL 2.0 (XML Common Business Library) was explicitly XML based and provided companies using EDI a way to transform those applications to XML. In 1999 Commerce One launched Common Business Library (CBL) 2.0, an open XML specification for the cross-industry exchange of business documents such as purchase orders, invoices, product descriptions, and shipping schedules. A proposal was put forward by an ad hoc Universal Business Group of actors interested in developing CBL to form an OSIS CBL Technical Committee in 2001, but his proposal was blocked, ostensibly because of duplication with the CEFACT Core Components project that was developing standard generic components for use in ebXML compliant e-commerce.

The OASIS UBL Technical Committee has its roots in a Universal Business Group that proposed a OASIS CBL TC in 2001, but this was held up due to concerns that it duplicated efforts with the CEFACT Core Components project. A proposal was made to set up an XML Syntax group within the UN/CEFACT process, but this approach was vetoed in June 2001. Following this rejection a Universal Business Language TC was set up within OASIS in September 2001, with a plan to produce *“a coordinated set of*

XML grammatical components that will allow trading partners to unambiguously identify the business documents to be exchanged in a particular business context."

It is recognized by participants in the UBL process that developing generic global standards in e-commerce is a complex task. Gertner (2002), a participant in the UBL process, sees the main challenges for initiatives like UBL as being technical and political:

> "It's not impossible to imagine someone coming up with standard definitions of catalogs, orders, advance shipment notices, bills of lading, invoices, and payment requests. But any survivor from the various Electronic Data Interchange (EDI) standards efforts will tell you that it's a daunting technical task to define data formats that come even close to meeting the requirements of a broad range of diverse enterprises, and perhaps an even more daunting political task to get companies to adopt them." (Gertner, 2002)

The open OASIS process is designed to allow the breadth of participation to ensure the needs of "a broad range of diverse enterprises" are satisfied", but the composition of the UBL Technical Committee suggests that participation is narrower than expected.

The UBL Technical Committee has sixty-three members. Of these, 30 are individual members of OASIS, so it is not apparent where they are resident and who they represent. Of the thirty-three members associated with corporate OASIS members, the resident countries of their employers are:

United States	27
United Kingdom	2
Germany	2
France	1
Singapore	1

Although it is not necessarily the case that all the staff of a corporation headquartered in one state are resident there, the breakdown suggest a strong United States centred influence over a process which has a claim to be developing global standards.

The organizations represented in the UBL TC cover a range of types:

System vendors	26
Public sector	3
Collaborative standards body	2
Academic unit	1
User	1

The process participants are therefore predominantly system and technology vendors. On the one hand this is unsurprising as they have both the expertise and the business incentive to be involved in the definition of generic standards; user organizations have a stronger incentive to participate in sector specific standards development. However this lack of user participation in the UBL committee leaves the potential users under-represented in the process.

DISCUSSION OF THE UBL PROCESS

OASIS by being free from the national representative processes, as seen in ISO and CEFACT, allows members to define their own standards' agenda, and has created a standards process able to respond quickly in a technology that is developing rapidly. The freedom for any group of three enterprises to join OASIS and set up their committee has been seen as behind moves by IBM and Microsoft to pursue standardisation through OASIS rather than W3C (Koch, 2003). The widespread use of internet interaction within Technical Committees and the open membership policies have led to the creation of a *public sphere* (Habermas, 1989), freer from state involvement than earlier standards institutions in e-commerce and based around an open discourse between any interested parties.

OASIS is a non-governmental standards institution that has evolved rapidly from a collaboration in the use of SGML to take on a central role in e-commerce standardization. In expanding its activities in this area it has overlapped with other standards bodies, particularly IEC, ISO, ITU, and UN/ECE, leading to a co-operation with UN/ECE in ebXML and participation in February 2002 in the Memorandum of Understanding on e-Business Standards. The Memorandum of Understanding was agreed between IEC, ISO and UN/ECE in 1995 to define the roles of each organization and avoid duplication of efforts. While the Memorandum of Understanding acts an institution coordinating B2B standards development, there remains a possible conflict between OAIS processes allowing members to define their own agenda and an agreement aiming to avoid these activities transgressing on another organisation's activities.

The UN/ECE's early involvement in e-commerce, specifically EDIFACT EDI standards, may be seen as due to it being less encumbered by bureaucracy than ISO, the procedures of OASIS, based on open access to standards development and majority voting rather than consensus represent a further stage in the evolution of flexible and open e-commerce standards development.

The ISO process has been described as encompassing four principles of organization (Tamm Hallstrom, 2000): *expertise*, *representation*, *user orientation* and *participation*. The openness of the OASIS process severs the connection between participants and their national affiliation, with the corporate and national affiliations of *individual* members being hidden from inspection of OASIS documents. The openness of the process also reduces the institutionalised legitimation of expertise: rather than being selected as an expert, participants must demonstrate their expertise in interactions with other process participants. Tamm Hallstrom (2000) identifies the problem in ISO committees of the process being dominated by intermediaries, for example consultants who can see the experience gained through participation becoming marketable, rather than users, who participate to develop standards that meet their needs based on their expertise. Rather than leading to heterogeneity, the openness of the OASIS UBL process appears to have led to a process that, compared to equivalent ISO or CEFACT committees, is narrower in its geographical distribution and more homogenous in its membership.

The development of global standards for inter-organisational integration implies a convergence in business processes across networks of organisations. Over the past ten years there has been an emphasis in the IT literature on the identification of generic processes unrelated to sector (Davenport, 1993). Following this argument, we would expect to see in the global processes evidence of convergence between sectors driven by the needs of system suppliers, as evidenced by their participation in UBL.

Alternatively, if the major locus of development is in sectoral constituencies, we would expect to see divergence between sectors driven by the needs and embedded practices of user communities.

The participants in developing B2B e-commerce standards, their organisational affiliations, and their objectives in developing linkages, are all critical determinants of how the systems take shape. Who controls the development of standards, who is excluded and what mechanisms exist to build a broad constituency? Is there evidence of divergence in the development of standards to accommodate regional differences in business processes or is their global convergence within sectors.

The domination of the UBL process by IT vendors suggests that the conflict between sectoral standards and global generic standards will only be resolved in their use. Sectoral standards tailored to meet the needs of localised communities whose development is supported by major sectoral players will compete with generic standards whose development is supported by the suppliers of IT systems, that while tailored to satisfy the needs of all compromise on accommodating sectoral or local contingency.

ACKNOWLEDGEMENTS

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REALIZING THE VISION FOR WEB SERVICES: STRATEGIES FOR DEALING WITH IMPERFECT STANDARDS

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ABSTRACT

Organizations considering the adoption of the web services framework for their Information Technology (IT) applications are confronted with a period of technological ferment, as standards for supporting non-trivial business process functionality are not yet in place. Evolving standardization poses challenges in the form of inter-temporal dependencies, as organizations' conformance to the standards that emerge in the future is contingent on their current design choices that need to be made ex-ante without complete information. At the same time, there are significant early-mover benefits to be gained by executing an IT strategy using web services as a cornerstone. This paper draws upon coordination theory to develop a conceptual framework outlining three approaches for organizations to deal with changing standardization regimes: (a) The dependencies across components, conforming to different standardization regimes, are continually bridged through intermediary services (e.g. using a protocol adapter that translates to an emergent standard), (b) The dependencies across components are minimized through loose coupling so that standardization regime changes for any component have a minimal impact on other components (e.g. encapsulating the functionality susceptible to design change into a module with abstract interfaces), and (c) The impacted components are rapidly reconfigurable as and when standardization regime changes (e.g., by building in "extension" features into applications). The risk for organizations investing in web services can be further managed by mechanisms such as organization's attention to signals from the periphery, undertaking low-risk experiments to learn in different areas, and bricolage-like improvisations of their legacy components at hand.

Keywords: Imperfect standards, web services, coordination theory.

INTRODUCTION

A Web Service (WS) is a software system identified by a Universal Resource Identifier (URI), whose public interfaces and bindings are defined and described using the eXtended Markup Language (XML). Its definition can be discovered by other software systems. These systems may then interact with the Web service in a manner prescribed by its definition, using XML based messages conveyed by Internet protocols (W3C 2002). Web services depend upon a number of standards governing web-based interactions that essentially enable applications to find and connect with other applications that provide a desired functionality. The vision for web services is for scaleable "snap-together" system-to-system communication. While there is great potential for web services, the standards that they represent are still imperfect and will be likely to mature over time. Although many vendors have agreed on a core foundation for HTTP and

XML-based Web services protocols and interfaces (e.g., SOAP, UDDI and WSDL[1]), this core set is only sufficient in trivial situations (Gartner 2002).

This paper presents a conceptual framework to suggest how enterprises may deal with the lack of a complete set of standards for building business applications that use web-services protocols. This paper is organized as follows. It starts by providing a brief introduction to the web services framework and its core standards. It then discusses some of the critical characteristics of technological standards such as path dependence, network effects, and tipping which provide insights into managing in an era of technological ferment. We then review the current state of standardization and conclude that the standards are still not complete and there is a potential threat of fragmentation for some high level standards. Next, a framework is developed to provide a typology of approaches to manage in a world of imperfect standards. This is followed up with details of approaches using this typology. Finally, we point to directions to further work.

UNDERSTANDING TECHNOLOGICAL STANDARDS

Technological standards are codified specifications that prescribe rules of engagement among components of a system (Garud & Kumaraswamy 1995). Technological standards have distinct characteristics that need to be understood in order to manage in their absence:

The structuration paradox – standards enable and constrain at the same time: Giddens' structuration theory has been widely applied to suggest a duality for information technology (IT) --it enables and constrains organizational practices at the same time and structure emerges as a result of repeated enactment (Orlikowski 1992). Technological standards have similar characteristics --they *constrain* the practices of organizations by inscribing rules that force adopters into specific trajectories of technology use. On the other hand, they also *enable* enterprises by equipping them with functional capabilities that arise from interoperability. Standards can be enabling, as they create an orderly framework within which economies of scale can be realized and technological progress can materialize, but they also create rigidities as they amplify the costs of any change that would require modification of the standard.
Adoption of technological standards generates network effects: Network effects refer to the utility that a user derives from consumption of the good increasing with the number of other agents consuming the good (Katz and Shapiro 1985). Standards create synchronization value for their adopters because of the additional value derived from being able to interact with other adopting organizations. A key characteristic of such product markets is that often only one technical standard is likely to prevail and the markets are prone to tipping --as one product gets ahead, it becomes progressively more attractive to the other adopters.

Interdependencies occur among standardization decisions across different layers/components: A natural progression in the layered development of information technology means that new standards come into place enabled by an underlying layer that gains maturity. For instance, the Web Services Choreography Working Group is chartered under the auspices of W3C to design a language to compose and describe the relationships between Web services. This standard is predicated on the existence of lower-level standards. Due to this hierarchical layering, the vertical industry standards have been the slowest to arrive. This also implies the existence of interdependencies in standardization decisions across layers as adherence to a specification in one layer may force the organization into a constrained choice for a different layer.

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[1] The appendix provides a brief introduction to these protocols

Path dependence affects emergence of dominant designs: Path dependence refers to a process of economic allocation such that the outcome of the process does not depend only on a-priori determinants such as technology and factor endowments but on the specific history of the process. In essence, chance historical events shape future outcomes. Processes of technological change are known to be path dependent under three conditions (a) Technological interrelatedness of system components (b) Quasi-irreversability of investments, and (c) Positive externalities of increasing returns to scale (David 1985). Path dependence has been shown to arise when increasing returns to adoption are realized dynamically on the supply side through learning effects or on the demand side due to positive externalities (Arthur 1994). Given that technological standards for application connectivity meet these criteria, the emergence of dominant designs due to path dependence is likely. Thus, organizations may be locked into technological trajectories based on small accidental events that are magnified due to complex interactions among different organizations. However, Leibowitz & Margolis (1995) suggest that allocation processes may not be path dependent if organizations have foresight into the implications of their choices, or are able to coordinate individual organization choices through market interventions or communications, or internalize the network externalities.

Lastly, changing or evolving standardization implies inter-temporal dependencies: An organization embedded in a technological domain characterized by evolving standardization faces inter-temporal dependencies that need to be managed. Their current technical choices could be at variance with the dominant designs that emerge in the future and restrict the level of compatibility with new standards.

This discussion suggests that technological standards have important implications for how organizations make their technology choices. Next we look at the specific complexity of standardization in the web services space.

WHY IMPERFECT STANDARDS?

Markets for information goods may fail to coordinate on standards as few firms have the market power to set de-facto standards and most must accommodate the choices made by firms across the world. Standard setting is also prone to failure as interested stakeholders may be part of rapid changing and highly decentralized networks (Bailetti & Callahan 1995). Markets forces thus often fail to achieve standardization under oligopolistic competition in industries with network effects (Farrell and Saloner 1986a), and may even settle on a standard that is inferior in terms of overall social welfare.

Mobilizing a collective around common standards is inherently difficult as standards constitute a duality – they simultaneously constrain and enable organizational practices. New technologies will need to overcome the inertia in supplanting standards that enable existing technologies to work, while the new standard will also constrain their practices in the future (Garud, Jain & Kotha 2001). Vendors with their own versions of technical designs and associated investments may not acquiesce to giving up their market control in the interests of creating essentially a public good. IBM and Microsoft, for example, have been at odds with each other over the standards for web services choreography, leading to the threat of fragmentation (LaMonica 2003).

A rapid rate of technical progress leaves formal standardization efforts slow to catch up, if the standards are formulated by relatively slow moving and deliberate standard-setting bodies. In the case of web services, the underlying technologies are relatively new and still evolving –-with some apprehension that the technology evolution is still trying to catch up to the marketing hype (Thompson 2000). There is also a need to create consensus across multiple stakeholders among different organizations that are impacted by the standards. Industry analysts, for example, consider public UDDI registries a lost cause because they are “complicated and only generally defined” (Chappell 2002). Also, a number of different standard-setting bodies (W3C, IETF, OASIS, WS-I etc.) are involved with developing standards for different areas that impact the design, development and deployment of web services. This variety has been due to the different functional scopes, different time frames, and different approaches to protection of intellectual capital, among others. While standard-setting organizations help to mediate between different interests and technologies to impose a standard (Chiesa 2002), they are often slow to react to change and, in the absence of concrete implementations, may lack specification clarity. It may also be that the process of conceiving and delineating standards is inherently easier than the process of equipping current software to interpret them.

An alternate standard-setting approach is to let the marketplace decide in favor of a dominant design such as when there is no explicit technical basis for a choice. In this case as well, there is likely to be an interim time frame when competing and incompatible designs complicate the emergence of one dominant design. Technological change is not only driven by technical logic but dominant designs result from complex processes influenced by economic, social, political and organizational factors – “from a negotiated logic enlivened by actors with interests in competing regimes” (Tushman and Rosenkopf 1992). Given that web services have been extensively deployed by only a small number of early-adopter companies, a complete and dominant design is yet to emerge.

Lastly, there is significant heterogeneity across organizational contexts so that issues of semantic differences and contextual specificity may be very difficult to overcome, even over time, though XML namespaces and XML schemas provide some basis for structured extensibility.

The problem with imperfect standards is particularly an issue with web services because of a distributed deployment environment with no central authority, limited possibility of “out-of-band” communication, and increasing complexity in transaction-heavy environments. Next, we examine the current state of standards for web services applications.

THE CURRENT STATE OF WEB SERVICES STANDARDIZATION

Figure 1 illustrates the different layers in the web services application stack needed for enterprise applications (Figure 1).

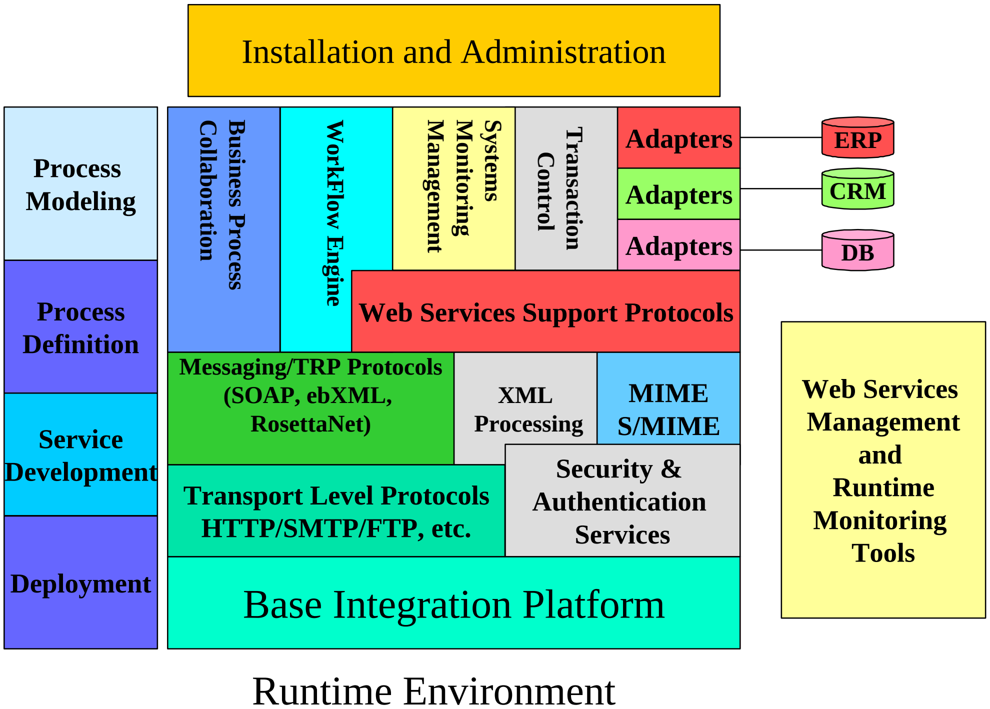

Figure 1. The Web Services Application Stack

Table 1 outlines some of the emerging standards in these different areas. It is apparent that there is a lack of consensus on a dominant standard for these different areas.

Technology	Description	Standard
1. Reliable Messaging	The process of building guaranteed data delivery into applications.	WS-R, WS-RM. Rosetta-Net and ebXML specifications.
2.Identity Authentication	The process of determining if someone or something is what it is declared to be.	WS-Security, PKI, Kerberos, Passport.
3. Authorization	The process of granting someone or something permission to do or have something.	SAML, XACML, LDAP, Active Directory.
4. Transport Encryption	The process of obscuring the connection between two end-points by applying specific security protocols at the transport layer e.g. HTTP/S.	SSL, S/MIME, TLS, VPN.
5. Message Encryption	The process of applying a cryptographic algorithm to obscure all or part of a message, e.g. a header or body element, an attached document, or the entire message.	XML-SIG, X.509, Symmetric keys.
6. Web Services Choreography or Orchestration	The process of specifying how Web services interact to form business transactions.	WSCL, WSCI, W3C BPML, ebXML BPSS, WSFL, Rosetta Net PIP, XAML, XLANG, BPEL4WS.
7. Provisioning	The process of defining communication between provisioning systems, users and resources.	SPML.

Table 1. Web Services Standards

Next, we propose a framework to guide organizational decision making in such a context, where the complete set of standards is not yet in place.

A FRAMEWORK TO DEAL WITH IMPERFECT STANDARDS

Domain with Imperfect Standards

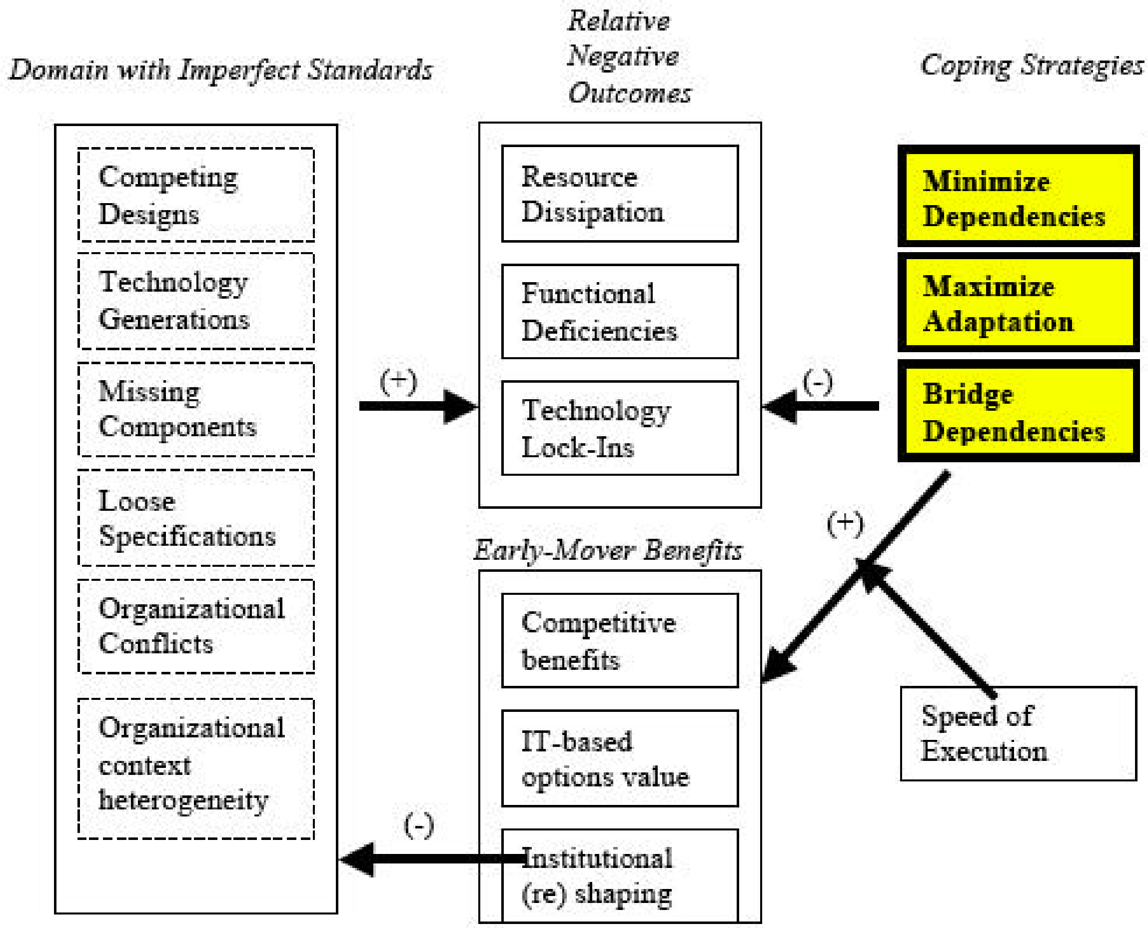

Figure 2. The Framework

The framework (Figure 2) illustrates why a technological domain can have imperfect standards and how that leads to negative outcomes for an organization. In essence, the web services applications stack can be seen as reflecting an organization's adoption of different high-technology products. The level of compatibility or the availability of complementary products (e.g., network externality considerations) form critical barriers for high-technology adoption (McCade et al. 2002). The lack of such compatibility can cause the organization to suffer from resource dissipation, functional deficiencies and lock-in effects. In case of web services there are a number of areas where clear standards are yet to emerge such as reliable messaging, security, identity authentication, distributed transactions, business process workflow, billing, payment, provisioning, monitoring and reporting. These contribute to the *relative* negative outcomes, compared to a base case where such standards exist.

The coping strategies allow these negative outcomes to be ameliorated to some extent. They also provide valuable benefits to the early movers, in terms of IT-based capabilities that have competitive implications, the generation of real options that have strategic value and increase an organization's flexibility, and, perhaps most importantly, allow the organization to influence the shaping of the standards.

IMPERFECT STANDARDS AND TECHNOLOGICAL FERMENT

Technological discontinuities trigger periods of technological ferment –a period in which there is experimentation and competition in a product class until a dominant design emerges as a synthesis of proven concepts (Tushman & Anderson 1986). During the era of ferment there is relatively little agreement on rules of engagement and criteria on which performance should be measured, and several technological trajectories may exist, each with its own distinct institutional environment. These institutional environments may further legitimize certain norms and operational concerns and can cause enterprises to be tied to specific boundaries of competences. Ultimately, rivals compete on architectural standards, which eventually congeal into a dominant design (Anderson & Tushman 1990). The figure illustrates such a period of ferment showing how rival technological trajectories and institutional environments may cause lack of convergence on technical standards.

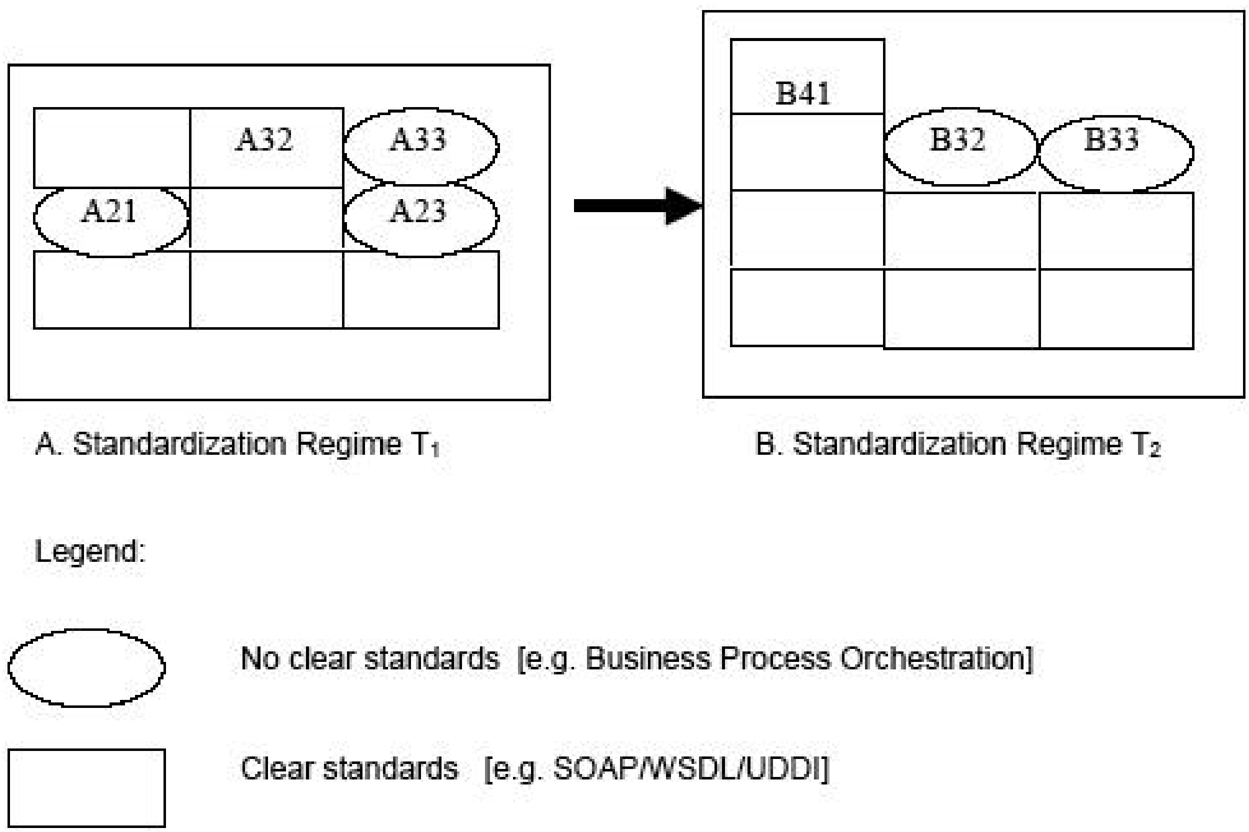

Figure 3. Evolution of Standardization

The figure illustrates how imperfect standardization regimes evolve through stages where a complete set of standards is not available for building web-service application components. At T_1, A21, A33 and A23 are layers in the architecture where there are no clear standards. By T_2, a clear consensus has emerged for the A21 and A23 so that they can now be built to standard specifications. However, a standard is still not available for B33, while a conflicting set of specifications has emerged for B32. Also, a new layer of standardization is enabled at T_2 and B41 becomes a new specification where there was no capability available earlier.

This stylistic representation illustrates the situation that organizations are confronted with. There is a greater possibility of fragmented standards at the higher layers while core specifications have emerged at the lower levels (Gartner 2002).

Organizations need to be able to upgrade design for layers where there are no current standards but where standards may emerge (A21), be cognizant of the layers where standards are unlikely to emerge (A33), be aware of the possibility of altogether new layers (A41) and also attend to potential mismatches that could result when competing designs emerge for an earlier standard (A32).

COORDINATION THEORY AND IMPERFECT STANDARDS

A standard may be conceptualized as a coordination mechanism around non-proprietary sknowledge that organizes and directs technological change (Reddy 1987). In the information technology arena standards enable coordination between technical systems. In an imperfect standardization regime, this mechanism breaks down. Coordination theory provides us with three main ways of achieving coordination (Table 1). In the absence of standards, these will provide us with alternate mechanisms to seek coordination across different technical systems.

We adopt a coordination theory perspective to understand how interoperability may be achieved among possibly mismatched application components. Coordination is the process of managing dependencies between activities (Malone & Crowston 1994). For web services applications there are dependencies between application components that need to interoperate and these may be designed to conform to different standardization regimes. Based on coordination theory (Table 2), we propose that the overall application can better deal with imperfect and *evolving* standards if:

(a) The dependencies across these components are continually bridged through intermediary layers as and when standardization regime changes.
(b) The dependencies across these components are minimized through loose coupling so that standardization regime changes in any layer have a minimal impact on other layers.
(c) The impacted components are rapidly reconfigured when standardization regime changes.

The residual risk from standardization regime changes not handled strategically through these approaches may be minimized through other organizational risk management approaches.

	Bridge Dependencies	**Minimize/Uncouple Dependencies**	**Maximize Adaptation**
March & Simon (1958)		Coordination by plan	Coordination by feedback
Lawrence & Lorsch (1967)	Integrative Subsystems, Specialists in integration, Integrating teams		
Van de Ven et al. (1976)		*Impersonal mode* - preestablished plans, schedules, formalized rules, policies and procedures, and standardized information and communication systems	*Personal mode* and *group mode* (mutual task adjustments through vertical or horizontal channels of communication)
Galbraith (1973)		Rules, programs & procedures, common understanding of targets & goals	Creation of slack resources, self-contained task groups, information systems, lateral linkages
Daft & Lengel (1986)	Integrators	Plans, formal information systems, rules & regulations	Direct contact, group meetings
Nadler & Tushman (1989)	Liaison role, integrator role, matrix structure		
Mintzberg (1989)	Direct supervision	Standardization of work processes, outputs, skills & knowledge, norms	Mutual Adjustment
Crowston (1991)		Interdependencies between tasks, interdependencies between task and object, interdependencies between objects	
Gittell (2002)	Boundary spanners	Routines	Relational Coordination

Table 2. Coordination typologies mapped to three pathways

STRATEGIES TO BRIDGE DEPENDENCIES

Use of Protocol Converters (Gateways/Bridges/Proxies)

This strategy relies on the existence of gateways that take information available via one protocol and make it available via another. The availability of converters, translators, emulators, and other ‘gateway technologies’ that achieve compatibility ex post, serve to reduce the social costs of failure to standardize *ex ante* (David and Greenstein 1990). The cost of providing converters would be influenced by the variety of distinct technical systems that need to be made interoperable, as well as by the number of dimensions in which alternative technological designs diverge. In Electronic Data Interchange (EDI) applications, such protocol converters are often used to translate incoming messages to the formats of internal business applications. In case of Internet applications, proxy services may be used to tunnel through firewalls or to provide conventional HTTP interfaces on unconventional transports. Intelligent adapters may also encapsulate business rules and error handling routines to enable them to provide robust protocol conversion.

Glue Services

This strategy relies on services that provide the resources to convert to components that adhere to different protocols. For example, namespaces and resource registries that provide interface characteristics may make it easier to adjust to different protocols, or context translation intermediaries may help to overcome semantic heterogeneity issues.

As an example, web services lack standards for semantics and thereby the information exchanged among services may have inconsistent meanings. A context mediation framework that provides a domain model to define rich types, and context definitions to define different interpretations of types in each web service (e.g. MIT COIN project - Madnick 1999; Bressan et al. 2001) would help to avoid potential semantic conflicts. The W3C is also pursuing the “semantic web” initiatives on similar lines.

Wrappers

This approach involves creating a layer of code that provides a web-service interface that meets the needs of a specific standardization regime. As an example, a major retail chain manages its gift card usage and balance on an IBM 390 mainframe in a DB2 database. An application server platform on a Unix server is used to build Enterprise Java Bean (EJB) wrappers for several services such as gift card balance, redemption and authorization. The EJBs talk through an adapter to the mainframe application and are exposed as web services.

STRATEGIES FOR MINIMIZING DEPENDENCIES

Modular Design

Modularity refers to the extent to which system components may be produced separately and used interchangeably in different configurations without compromising system integrity (Garud & Kotha 1994). The power of modular design arises because they allow flexible responses to change --evolution favors systems consisting of stable sub-assemblies that may be discarded or modified in response to environmental change (Simon 1962). Modularity allows for environmental disturbance to be confined to specific modules and for component innovations to be easily integrated with the overall system (Orton & Weick 1990).

In contrast to integrated architectures, modular architectures provide many entry points for firms to design complementary and compatible components. Firms benefit from the economies of substitution in modular systems as the cost of designing a higher performance system through a partial retention of existing components is lower than a complete redesign (Garud & Kumaraswamy 1996).

The modularity principle suggests that proprietary extensions to fill in the gaps in the features of web services should be implemented in a modular manner with clearly defined interfaces. Organizations should be wary of developing hybrids of applications with interdependent pieces that are standards-compliant and proprietary. Another implication of the modularity principle is to design web services without “chatty” protocols. As an example, services should not expose interfaces that make small updates to data elements, but should update a transformed element in a single service call (Burner 2003). The modularity principle also suggests that higher layers in the application stack (e.g. those focused on business processes) be also expressed in modular terms so that they can be easily recombined and reused, and limit the locus of changes that may be needed as standards evolve.

Abstracting from the implementation level

Interfaces refer to linkages shared among components of a given product architecture. Interface specifications provide the protocol for fundamental interactions across components. As the figure shows, an abstract interface can be specified for minimizing dependencies with external components, and different concrete implementations can be used to vary the actual implementation details.

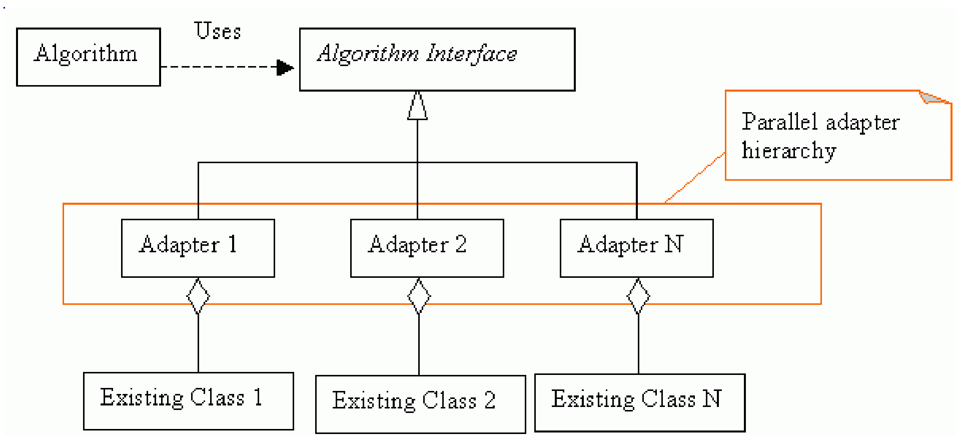

Figure 4. Abstracting Implementation Details.

[Source: http://www.shindich.com/sources/patterns/implied.html]

In the case of web services, through the abstraction idea, many different network endpoints can be specified to implement the same service contract and a client can select the best endpoint at run-time. Another important design implication is that organizations should "separate out" functions devoted to different areas – thus the business logic should be specified in abstract terms that are independent of the specific technology platforms.

Buffering through products

Commercial software products may provide products that wrap around a standard that may be susceptible to change or difficult to use. For instance, the XML DOM (Document Object Model) provides application programming interfaces (APIs) that developers use to manipulate XML documents. However, these are cumbersome and difficult to use. Software vendors provide Java toolkits that are simpler and more comprehensive. The task of dealing with XML and DOM specifications then falls to the toolkit vendor, thus buffering the organization from change. Vendors are then expected to provide clear migration paths as the level of standardization evolves.

Most major web services platforms provide services such as software developer kits that wrap soap functionality in a class library as well as toolkits that generate WSDL interfaces, web service containers and client proxies from existing applications. In addition these platforms may also support the ability to manage, deploy, maintain, monitor and test web service end-points.

As standards evolve, it is expected that these would get encapsulated into specific services offered by such platforms. As an example, following on the release of the BPEL4WS Web services orchestration standard to describe business processes, toolsets have been developed to enable the modeling and documentation of business processes using a rich graphical modeling environment.

Despite the clear advantages of using such products, there may remain interoperability issues that need to be addressed. For instance, there are a number of commercial tools that provide SOAP toolkits in the form of libraries to prepare XML-based SOAP envelopes, send the envelopes over a transport protocol such as HTTP or SMTP, and process incoming SOAP envelopes (Hong 2001). There have been found to be interoperability issues among these toolkits because they may implement only part of the SOAP or XML specification or implement ambiguous parts of the specification differently or not send optional information that is expected by the other toolkit (e.g., type information for encoded parameters).

STRATEGIES TO MAXIMIZE ADAPTATION

Intelligent controllers

This strategy relies on a hierarchical nature of control whereby layers at a higher level in the hierarchy are able to coordinate across differing protocols at the lower level. Thus changes in standards can be more easily responded to by augmenting the capability of this super-layer.

Web-services based applications adapt themselves to changing interfaces, by downloading the latest WSDL interfaces and adapting its interface appropriately. But this is not always possible. In case of more drastic changes, they may employ a Service Broker architecture that scans incoming requests and informs the older interface invocations of incompatibility, by giving an appropriate response. Third-party services can also dynamically scan WSDL schemas looking for changes in their structures. (Irani 2001).

Another approach would be to build in management points (figure) that use rules to provide protocol translation and migration to cope with a change in standardization regime.

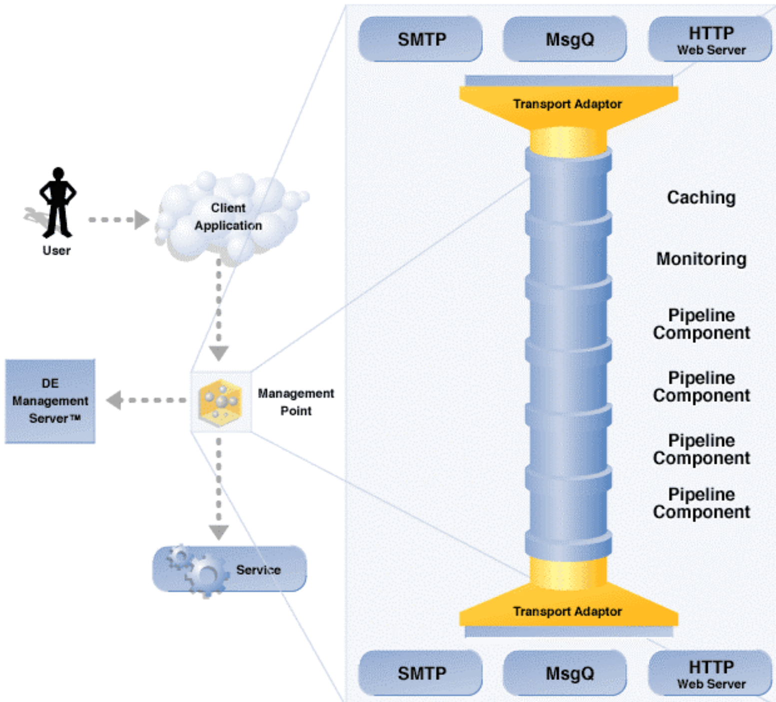

Figure 5. Intelligent Control Example. Source: Digital Evolution.

Architectural conformance

Product architecture refers to the arrangement of the elements of a product into its physical building blocks, including the mapping from functional to physical elements and the specification of interfaces among interacting physical components (Ulrich 1995). Through conformance to the underlying architecture of a system, firms can guarantee enough compatibility for customers and suppliers to upgrade from one product generation to the next. Innovations and improvements may then be embodied in the components.

One of the ways of instituting architectural conformance is through the use of design patterns. Patterns provide structure by specifying the high-level logical components and their interactions needed to implement business functions. As an example, before standards such as WSDL, UDDI and SOAP came along, companies like Google had been exposing their site information through XML-over-HTTP. This prepared the organization to then move on using the standards when they became available, since there was a fundamental conformance to the overall loosely-coupled architecture.

Specific design patterns can also be used to deal with versioning issues that arise when standardization domains change. Burner (2003) suggests a "web service façade" pattern where version numbers are encoded into a URI and when new versions of a service are published they do so in a namespace created by incrementing the version number. This protects clients written to an old contract trying to call a new service.

Upgradability of components

Organizations need to consider the upgradability and extensibility of components designed using existing standards that may be subject to change. As an example, web services applications that operate with the remote procedure call (RPC) style tend to be fragile as development tools simply wrap application objects that may not have been meant to be exposed as public APIs. On the other hand, XML-document-type web services are more robust and allow for evolution. An application may only work with a portion of the document and ignore others allowing the document and the system to evolve independently (Rourke 2003).

Given that XML schemas are core to the deployment of web services, it is important to ensure that general-purpose schemas be developed, anticipating the need for extensibility. A useful approach can be based on the use of “extensions” that modify a base data type in an XML schema definition. This will allow applications to extend data with custom properties.

Organizational Capabilities

In order to respond quickly to technology standards once they are instituted, organizations need to understand the current state of technology, the gaps in standards, and architectural break-points where standards are likely to emerge across time. They need to prepare their own organization as well as partners to quickly take advantage of standards as they gain maturity and, if possible, even shape them. XML schema definitions are particularly key to web services and an important step is to research and keep track of the work on schema definitions for the organization’s industry. Consumer expectations are also critical in shaping the adoption of products with network effects (Gandal 2002) –hence the organization should also carefully monitor shifts in consumer perceptions on web-services design.

An important caveat needs to be highlighted as organizations monitor the technological changes. An obvious strategy for technology providers in network markets that are experiencing intense supply-side competition is to pre-announce their products. This is based on the expectations of self-fulfilling prophecies –that the illusions held out for consumers will be rationally acted upon resulting in their concretization. Incumbents may also make strategic announcements about forthcoming releases to cloud the prevailing incentives that favor switching (Farrel & Saloner 1986b). Thus organizations should be careful of “vaporware” claims in making their web-services decisions.

Organizations should be mindful of the layered nature of web services applications. Conformance at lower layers may particularly help to clarify the scope of incompatibilities at the higher layers. For instance, XML as a standard eliminates incompatibilities in the parsing of data that is exchanged across applications –-a developer does not have to rewrite a parser for each application that accepts data from other applications. At the same time, it does not overcome the problem of semantic heterogeneity. However, it does make the problems of semantic differences much clearer at a higher level as they are no longer obfuscated by syntactic issues.

Organizations also need to be actively engaged with the progress made by standard-setting bodies. Non-market relationships, such as those embodied in industry standard-setting bodies influence the process of technology commercialization (Aram et al. 1992) and organizations need to be sensitive about the direction and shaping of such inter-institutional efforts. In the adoption space, organizations need to be aware of the extent of adoption for competing designs in different technology layers and be alert to likely “tipping points” that would be followed by bandwagon adoption.

Organizations need to be particularly engaged in schema definitions and business process specification activities in their industry and be able to incorporate common specifications in their web-services applications.

Organizations need to conceive their IT architecture as a service-oriented architecture (SOA) --a method of designing and building loosely coupled software solutions that expose business functions as programmatically accessible software services for use by other applications through published and discoverable interfaces (Adams et al. 2002). An SOA also separates application functionality into specialized tiers dealing with presentation, business logic and persistent storage. A business can use an SOA to compose and organize applications from a collection of distributed services; thus they can use it to construct new applications and alter existing ones by reusing their own assets as well as the business functions of their partners. Web services represent one implementation of a service-oriented architecture, but not all SOA applications can be considered Web services. Organizations that have already prepared for the SOA would be able to leverage web services standards as they are unveiled.

POINTERS TO FURTHER WORK

The framework presented in this paper has important implications for managers designing their IT applications as well as researchers interested in IT infrastructure issues. Due to the word limit specified for the workshop, this paper does not present the implications that follow from the framework presented earlier. The insets provide a brief outline of the direction of theorizing that builds upon the ideas presented in the paper. This will be more fully developed in the complete paper.

Inset 1. Legacy Components & Change: Strategy as *Bricolage*

Bricolage (origin: French, 'doing odd jobs') refers to the process of using the materials on hand to create a response to a task (Levi-Strauss 1966). The bricoleur engages in continual reconstruction from the same materials. By being open to and trying out new uses of an object, a bricoleur develops a rich understanding of the object and is able to improvise in its use (Weick 1993). The bricoleur conducts practical experimentation followed by thoughtful modifications, is mindful of when to change or when to persist with existing configurations, and is cognizant of the fact that she is placing bets that have probabilistic outcomes (Garud & Karnoe 2001). The bricolage process links the observations that result from probing the real world to the cognition that conceptualizes how changes will affect the emergent order.

In a world of technological ferment, the bricolage strategy suggests:

(a) Conceptualize technology artifacts in multiple ways and be open to their use in different ways as technology and standards evolve.

(b) Loosely couple experiments/actions and emerging outcomes in the real world.

(c) Be “mindful” of resources, embedded in earlier institutional regimes, that can be reused

Inset 2. Attending to Signals from the Periphery

The lack of well-defined standards in the web services space may be conceptualized as due to emerging technology (high level of uncertainty and embryonic industry structure). Day & Schoemaker (2000) suggest that emerging technologies signal their arrival long before they grow into full-fledged commercial successes. However, managers often are unable to filter out the noise that obfuscates the signals that inform about the future potential and direction of these technologies. An important reason for this lies in the mental models employed by managers. These mental models that result from a history with current technologies may be situated in past experience and reinforced by ongoing commitments. On the other hand the signals from new technology are only going to be sensed if the managerial mindset is attuned to looking past the disappointing results, limited functionality, and modest initial applications to anticipate the future possibilities. The weak signals to be captured usually come from the periphery, where new competitors are making inroads, unfamiliar customers are participating in early applications, and unfamiliar technology or business paradigms are used. However, the periphery is very noisy, with many possible emerging technologies that might be relevant. In order to cultivate a mindset that will be attuned to capturing these weak signals at the periphery, an organization requires:

- Openness to a diversity of viewpoints within and across organizational units,
- Willingness to challenge deep-seated assumptions of entrenched mental models while facilitating the forgetting of outmoded approaches, and
- Continuous experimentation in an organizational climate that encourages and rewards "well-intentioned' failure.

APPENDIX
The Building Blocks of Web Services

Essentially, web services provide programmatic access to business functionality using the following Internet protocols:

XML (eXtensible Markup language): ***The lingua franca of Web services***
A universal standard for identifying content and specifying the structure of data in documents. Makes it easier to exchange data among applications and to validate data elements. XML Schema is a format for describing XML data types and allows applications exchanging XML documents to parse and validate data elements. XML standards are widely accepted support by vendors in terms of tools that allow XML documents to be manipulated.

SOAP (Simple Object Access Protocol): ***Cleaning up the exchange***
A set of rules that facilitate XML exchange between applications. Along with WSDL, SOAP performs message transport functions. SOAP describes envelope and message formats, and has a basic request/response handshake protocol.

WSDL (Web services Description Language): ***Accessing the service***
Provides a common framework for describing tasks performed by a web service and a way for service providers to describe the basic format for requests made to their systems regardless of the underlying protocol (such as Simple Object Access Protocol or XML) or encoding (such as Multipurpose Internet Messaging Extensions). With WSDL, it is possible to automate the generation of proxies for Web services in a truly language- and platform-independent way.

UDDI (Universal Description, Discovery, and Integration): ***The Yellow Pages***
A set of specifications for creating XML based directories of web services offerings. Users and applications may discover and locate web services through UDDI repositories. UDDI is an independent consortium of vendors, founded by Microsoft, IBM, and Ariba, for the purpose of developing an Internet standard for Web service description, registration and discovery.

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PRODUCT INTEROPERABILITY IN THE ENTERPRISE SOFTWARE SYSTEMS INDUSTRY: A SOCIAL NETWORK APPROACH

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Abstract

An important criterion for organizations when they purchase application software products from different vendors is that these components should adhere to a consistent set of interfaces. These interfaces are typically a part of the organization's IT standards. However, the enterprise software systems (ESS) industry consisting of application software vendors, has established neither open high-level compatibility standards nor a single set of leading standards of a dominant vendor.

While prior research identifies access to user bases as the primary *technical* benefits of these alliances we argue that these alliances also yield other benefits along the *social* dimension such as knowledge spillovers of current technology, reputation transfer and third party investments in integration tools (or expertise). We also argue that benefits from such compatibility are transmitted through both, direct and indirect partners in the alliance network. We use the social network approach to conceptually aggregate alliance benefits into the construct of *Sociotechnical capital*.

Our key proposition is that rather than merely maintaining a higher number of alliances, those vendors that have higher socio-technical capital by virtue of these alliances, perform better. Data on 97 ESS vendors is used to test this proposition where relative *prominence* is used as a proxy measure for socio-technical capital and *outdegrees* indicates the number of alliances in vendor's network. To address the limitations of extant social network measures we develop an alternative theoretically grounded metric for prominence and then use it in our empirical testing. Results indicate that socio-technical capital is indeed strongly related to software licensing revenue. These results suggest that in systems industries, rather than a dyadic level focus, a greater focus on the network mechanism is necessary to understand factors leading to better vendor performance.

Keywords: Technology standards, software industry, enterprise resource planning (ERP), software architecture, partnerships, social network theory, standards competition.

INTRODUCTION

It is well understood that the core of most organizational IT portfolios includes software components provided by *enterprise software systems* (ESS) vendors such as SAP, i2, PeopleSoft, among others (Davenport 1998). Despite the need for these components to interoperate, the ESS industry lacks uniform interoperability standards among vendor products[1]. For the purpose of maintaining interoperability vendors commonly adopt (or interface with) a complementary vendor's *proprietary* standards. We observe that in the ESS industry this interoperability is achieved through alliance formation among vendors. Thus, each vendor makes strategic choices in selection of specific vendors with whom to maintain an alliance with.

This study tests the proposition whether high prominence of an ESS vendor in its alliance network leads to higher performance. Though, this research objective is typical of many industry level studies, our objective poses challenges that are unique to hi-tech *systems industries*[2] with under-developed standards, of which the ESS industry is a prime example. The research questions are: how is interoperability maintained between products of different vendors who are alliance partners? What are the types of resource flows associated with such alliance formation? Access to what type of resources constitutes high prominence of an ESS vendor in its alliance network? What is the impact of these alliances on market performance? We suggest that the above research questions will remain relevant in the long-term because industry-wide standards emergence in the ESS industry is likely to be retarded. This is because IT applications execute business processes, which being *firm-specific*, are of strategic importance. Such specificity is likely to make it difficult to standardize IT applications at the vendor level therefore highlighting the importance of our research questions.

We utilize the insights offered by three streams of literature including the strategy literature, to understand the strategic process through which interoperability across vendor products is maintained. In the IS literature, the term corporate *IT standards* (Kayworth and Sambamurthy 2000) refers to enterprise-wide software rules for integrating the IT portfolio. This literature has primarily focused on the benefits of adopting uniform IT standards within an organization (Goodhue, Wybo et al. 1992; Wybo and Goodhue 1995; Streeter, Kraut et al. 1996; Chatfield and Yetton 2000; Hasselbring 2000; Truman 2000; Yang and Papazoglou 2000). While the economics literature has analyzed standards competition extensively using analytical methods (Katz and Shapiro 1985; Matutes and Regibeau 1988) our empirical approach has certain strengths as we describe in the next section. In the strategy literature performance impacts of alliance networks on firms has been examined extensively and therefore provides a theoretical base on which to build our understanding.

We proceed towards addressing our research questions by describing the ESS industry and the role of alliances. Specifically, we present a qualitative understanding of the *content* of the alliance ties between vendors in terms of, for example, how resource flows occur between vendors and how cross-vendor interoperability is maintained. We then identify the social network perspective, commonly used in organizational studies, as an empirical framework to test our proposition that higher prominence in its alliance network should be related an ESS vendor's performance. However, prior to applying the social network perspective, we also develop a measure of prominence of an ESS vendor. Data on 100 ESS vendors is used and analyzed for testing our proposition.

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[1] In contrast to the ESS industry, other sectors in the high technology electronics and computing industry have well-established and uniform industry-wide standards. Examples are the video tape, operating system and telecommunications industries.

[2] In *systems industries* vendors offer multiple components performing different functionality that are then integrated by users into a composite system. A vendor may offer one or more component while competing in a systems industry (Katz and Shapiro 1994).

THE ESS INDUSTRY AND EXISTING QUANTITATIVE FRAMEWORKS

An organization's enterprise system is almost always a collection of software components manufactured by a multitude of vendors (Davenport 1998). For example, a simple payroll system that was programmed in COBOL and housed in a mainframe may now consist of components ranging from an Oracle database, a Web server by Apache, browsers from Netscape and an application component from an Enterprise Resource Planning application (ERP) vendor like SAP. However, in the ESS industry, while there are standards for low level communication (e.g., at the transport level and object stages), there exist no uniform set of high level compatibility standards at the business level (Altman 1998; Yang and Papazoglou 2000). For this reason, two ESS vendors typically adopt a consistent set of interface specifications, to ensure interoperability. This typically requires explicit alliances between ESS vendors that may involve licensing, product development and release agreements, etc. In addition, there are also adapters or consultants in this industry who train themselves to offer integration services to organizational users. These third parties are also influential in social interaction processes such as joint conferences, trade shows, and training sessions.

Behavior of software firms that engage in strategic compatibility decisions has primarily been studied by economists using analytical models (Matutes and Regibeau 1988; Saloner 1990; Axelrod, Mitchell et al. 1995). These contexts include the early VCR industry, where VHS emerged as the winning standard and the operating systems markets where, multiple separate standards such as Unix, Windows, MacOS, etc., still exist(Grindley 1995). The underlying theory for much of this literature is the accumulation of network externality advantages and product complementarities, either by adopting a common standard, or by constructing adapters to enable compatibility. Along these lines, Katz and Shapiro (1985) have argued that firms with small user bases have strong incentives to make their products compatible with products of players will larger user bases. This study is based on a single component market. Others have considered multi-component markets and have argued that in a duopoly (Matutes and Regibeau 1988), or even in a competition between multiple firms of equal size (Economides 1989), compatibility enables competitors to keep prices high and capture a larger market. These economic models provide prescriptions for industries with competing standards and evaluate the benefits of adopting the leading standard in terms of the potentially accessible user bases. However, as against the above analytical studies, an empirical approach becomes useful because extending the above analytical models to a multi-firm context where each firm has linkages with multiple others, becomes an intractable problem. The second feature of the ESS industry that makes it analytically intractable is that there are no clear leaders or leading standards to choose from. Third, these models assume that externality advantages (measured as user bases or market share) due to standards are the only benefits transferred in an alliance network and that these benefits to software vendors are limited to *direct* partnerships. This is a narrow understanding of the benefits accruing from alliance linkages. We note that these drawbacks of an analytical approach are consistent with the observation that using economic models such as conventional game-theoretic analysis to study complex alliance compositions is "especially difficult because payoffs for each firm depend upon the choices made by all other firms" (Axelrod, Mitchell et al. 1995, p. 1497).

We propose that a social network perspective can be useful in analyzing the performance consequences of alliances among ESS vendors. The social network method is used typically in the strategy literature to aggregate the benefits from alliances and their impact on market performance (Nohria and Eccles 1992). In the following section 3.1, we develop a contextual understanding of the *content* of these alliances, i.e., the resource flows across alliance partners. Using this conceptual understanding we state our assumptions that form the basis of our key proposition in section 3.2 and of the prominence measure in section 4. This measures allows us to test our key proposition in section 4.2.

SOCIAL NETWORK VIEW OF ESS INDUSTRY

Research from the social perspective of markets observes that "industrial structures can be represented as a set of positions that are arranged hierarchically according to the prominence of their occupants (Stuart, Hoang et al. 1999, p.318)." In the status-based models of market competition, prominence plays an important role in influencing organizational performance of a firm as well as that of its affiliates (Podolny, Stuart et al. 1996; Benjamin and Podolny 1999; Ahuja 2000; Burt 2000; Stuart 2000). According to this literature, the status of an actor is influenced by its firm specific attributes such as past demonstrations of quality, technological pioneering or higher market share. In addition, in many technological domains, status can also increase through linkages with prominent firms that provide access to knowledge, technological capabilities, newer markets, production know-how and R&D know-how. (Walker, Kogut et al. 1997). Higher prominence of a firm can also serve to further augment its own position, through benefits such as lower transaction costs and risks (Podolny 1993), preferential treatment from suppliers and higher returns from quality (and therefore price) compared to their less prominent counterparts (Benjamin and Podolny 1999), etc. It has also been observed, for example, that firms with low status benefit in their market capitalization and time to IPO due to their partnerships with high status firms (Stuart, Hoang et al. 1999).

The process through which resources flow and therefore prominence accrues to an organizational actor in a network varies across industry contexts. In the following section we describe the nature of benefits that flow from one firm to another in an alliance network of ESS vendors as well as from indirectly connected firms. We term the aggregate resources as *Socio-technical capital*. Thus, firms not only have intrinsic resources and capabilities that are exogenous to the network, but they also acquire network resources due to their structural position in the alliance network. Since social capital is regarded as an umbrella concept we operationalize it as a function of the structural position, relative prominence. That is, we term this structural position as the *relative prominence* of a firm and propose that it is positively related to firm performance.

Social and technical resources transferred between ESS firms

We propose that in the ESS industry, there are two dimensions to the benefits derived from alliances, technical and social. In the *technical dimension*, benefits to each partner result from technical compatibility between two components. Access to user bases of each other is the most significant outcome of technical compatibility as is considered in the analytical models of network externalities. In the telecommunications industry, for example, technical compatibility yields the most immediate impact on the market performance by providing access to larger user bases of another network. In this context, compatibility pertains significantly to the artifact, i.e., the telecom switching equipment. Access to another telecom network (and thus its user base) is instantaneous when the computer controlled telecom switch is manipulated. As another example, Netscape would have had higher access to users of Microsoft Windows if Microsoft makes Netscape browser completely compatible and as tightly integrated with Windows as Internet Explorer[3].

[3] However, Netscape's access to Microsoft user bases is not certain in the longer term due to changing technology. Thus, in a certain respect technical benefits arise largely due to compatibility at the lower levels as per the OSI architectural framework.

In the ESS industry integration between products of different vendors is most often *not* one-shot as in the above examples. For example, even if SAP made its products compatible with the supply chain components of i2, there is no plug and play capability – but instead weeks and months of effort is needed to ensure smooth functioning when these products are implemented in user organizations. A primary requirement is of diverse knowledge domains to configure the firm-specific business rules in these applications. This integration effort can be significantly reduced by alliances and therefore buyers often prefer their ESS vendors to have mutual alliances (Chellappa and Saraf 2002). We term the benefits that accrue through alliances as the *social dimension* of the resource flow. The first type of benefit is the transfer of reputation of the alliance partner. This results in each vendor becoming more preferable than before to buyer organizations because of its alliance with another reputable ESS vendor. The second type of benefit is the accumulation of third-party investments such as those by integrators and consultants. This leads to more resources being devoted to speed up the integration of products offered by the two vendors when, for example, integration vendors begin to offer off-the-shelf integration tools. The third type of social benefit is the spillover of technology-related knowledge and business domain knowledge. Thus, for example striking an alliance with an ESS who is incorporating Web services architecture into its product design benefits its alliance partner in terms of faster adoption of this new technological breakthrough. Similar knowledge flows can also be about the business domain if both vendors are serving the same vertical industry buyers.

The benefits described above can be seen as accruing *directly* by virtue of the alliance. However, *indirect* benefits also accrue because alliance links act as a conveyor of benefits (see Table 1). This indirect effect of alliances is extensively supported in management literature (Nohria and Eccles 1992), where indirect benefits are transferred from partners of directly connected partners. Based on our above description of the content alliances amongst ESS vendors, we next articulate our assumptions. These assumptions form the basis of our rational choice model underlying the measure, relative prominence of an ESS vendor. Due to lack of prior analysis of this industry, we also substantiate our assumptions. This discussion also provides theoretical support for our main proposition.

Assumptions

In the alliance network context, to begin with, every firm by virtue of its own technology and past demonstrations of quality, brings with it a certain amount of resources (including user bases, reputation, access pool of consultants, etc.) to the network, that are now available as potential benefits to its partners. Unlike a private good, these resources are shared, but not to every body, as public goods are. Instead, these resources are available only to those partners who have invested in relationships with the firm. More generally, an alliance increases partner-specific absorptive capacity (Cohen and Levinthal 1990; Dyer and Singh 1998) of each partner because of which know-how and expertise can be exchanged more efficiently (Conner and Prahalad 1996). Furthermore, access to these resources such as knowledge and reputation spillovers is higher if the alliance partners are heavily endowed with these resources.

The above description of how resources flow between firms also applies to industries characterized by network externalities. Here small firms may have significant incentives to make their products compatible with those of larger firms because of the potential *technical* benefits (Katz and Shapiro 1985; Kauffman, McAndrews et al. 2000) such as access to user bases. Similarly, in the ESS industry, access to resources such as knowledge about latest computing technology and standards or about the industry specific business processes, is higher if the alliance partner is a prominent vendor. Thus, we make the first assumption as follows:

<u>Assumption 1</u>: The greater the exogenous (non-network based) resources of the alliance partners, greater are the social and technical benefits derived by the focal software firm."

Alliances that enable flow of network resources not only need initial investment, but like all types of relationships they also incur a maintenance cost (Adler and Kwon 2000). We argue that these costs are increasing with the status of the partner firm in its network because prominent firms are considered to be selective in their partnerships (Benjamin and Podolny 1999). As an alliance partner, a firm has to invest in upgrading its product quality and developing additional capabilities that are complementary and useful to its affiliate. From a technical perspective, firms that wish to make their components compatible with another firm's, incur a cost either in the form of licensing fees or developing (and regularly updating) self-constructed adapters. For example, many ESS vendors offer certification programs and certified Application Programming Interfaces (APIs) to its alliance partners, which are useful for accessing a larger market.

<u>Assumption 2</u>: Higher the relative prominence of the focal ESS firm, higher is the technological and social investment required by its alliance partners to maintain a relation with the focal firm.

A firm’s status is damaged if the affiliate has a low quality product. Therefore, firms strive to maintain their reputation and signal quality when forming alliances (Stuart, Hoang et al. 1999). This may involve social signaling through hiring of a high profile CIO, engaging a known and expensive advertisement firm, partnering with specific adapters (integrators), etc. Often these costs are directed at the type of firm they wish to partner with. In order to exploit and sustain the opportunities afforded by relationships with partner firms, organizations also have to invest in continuous learning mechanisms (Metcalfe and Miles 1994) where learning is then dependent on the status of partners in a network. Not only may a prominent ESS firm charge higher licensing fees but it may also require its partner firms to invest in jointly sponsoring user conventions, trade shows, etc. We broadly term these costs incurred to maintain relationships at a non-technical level as investments required to enhance the compatibility between vendors’ products.

A unique element of multi component markets is that while firms have to cooperate in some complementary component markets to leverage externality benefits, they may compete with the same firm in other markets. Firms that have more of the same components and less of complementary requirements would choose to form a weak relationship. Thus, we conceptualize the *aggregate tie strength* as the extent to which firms are related net of their competitive posture with respect to each other. The aggregate tie strength represents as the level to which learning mechanisms of one ESS vendor is partner-specific or information-processing structures (Galbraith 1973) are aligned. Thus if a firm chooses to have a very close relationship which may go beyond the licensing of technology to co-development of products as well, then it would naturally have to invest heavily. Consequently, a strong relationship can better facilitate the flow of benefits.

<u>Assumption 3</u>: A software firm’s required investment and corresponding benefits from an alliance is related to the strength of the relationship it chooses to maintain with the alliance partner.

The choice of alliance partners is a conscious act by the firms and they incur costs to maintain compatibility with their partners’ products. However, if a third firm is indirectly connected to a focal firm through a common partner, then the third firm's components are likely to be more compatible as compared to a completely unconnected firm. For example, if two vendors of niche software components are partners of SAP, then their products are likely to be compatible because SAP may adopt a common platform and API technology. Sometimes vendors also bundle products of their partners and offer these as a complete package. In these cases, consistent interfaces are developed by vendors to achieve better integration. Thus product bundling across different component makers can further enhance benefits derived by an indirect alliance partners. More generally, similar to direct ties, indirect ties also provide access to knowledge and technical breakthroughs, etc. (Ahuja 2000). However, effects from indirect ties are mediated by the intermediate relationships (Holm, Eriksson et al. 1999, p.475). That is, we assume that indirect social and technical benefits are also not fully transitive - rather they are moderated by the strength of the relationship between the firms.

Assumption 4: A software firm derives social and technical benefits from indirectly connected firms at no direct cost to itself. And these indirect benefits are mediated by the intermediate firms."

	Technical dimension	Social dimension
Indirect ties	**Benefits** • Access to user bases from compatibility (Katz and Shapiro 1985; Matutes and Regibeau 1988; Economides 1989)	**Benefits** • Knowledge spillovers and information transfer (Holm, Eriksson et al. 1999; Ahuja 2000)
Direct ties	**Benefits** • Access to user bases due to compatability (Katz and Shapiro 1985; Matutes and Regibeau 1988; Economides 1989) **Costs** • Licensing fees (Kotabe, Sahay et al. 1996) • Constructing and maintaining adapters (Farrell and Saloner 1992)	**Benefits** • Transfer of reputation (Podolny 1993) • Knowledge spillovers and information transfer (Ahuja 2000; Argote and Ingram 2000), e.g., product architectures and new software technology such as web services or encryption. • Stimulating third party investments (Metcalfe and Miles 1994), e.g., by consultants and integration vendors **Costs** • Installing learning mechanisms such as product teams and alliance managers (Metcalfe and Miles 1994) e.g., joint product development teams, alliance manager and technology liaisons.

Table 1: Sociotechnical Resource Transfer Matrix

Sociotechnical Capital as an aggregate resource construct

We term a firm's access to net social and technical benefits (Table 1) from a network of ties as the Sociotechnical capital of a firm. This term is derived from an umbrella concept called "social capital," broadly defined as "the sum of resources accruing to an individual or group by virtue of their location in the network of their more or less durable social relations (Adler and Kwon 2000)." Bourdieu and Wacquant's (1992) define social capital as “the aggregate of the actual or potential resources which are linked to the possession of a durable network of more or less institutionalized relationship of mutual acquaintance or recognition." While many definitions for social capital exist in literature (see Adler and Kwon (2000) for a review), we primarily adopt the view that Sociotechnical capital is a network resource that is created in the alliance network of ESS firms, which can be converted to gain performance advantage. This resource is not a substitute for intrinsic or exogenous capability of a firm or its technology. Rather, as suggested by Portes (1998), it is a complement to these exogenous abilities of the firm. Also, given that sociotechnical capital is not "free" and requires a maintenance cost, the choice of alliance partners has to be strategic decision.

As discussed in section 3.1, in our context, the relative prominence of a firm in its alliance network is an important factor in determining a firm's strategic performance, i.e., how it is able to utilize other vendors' social and technological resources to enhance its performance. The following proposition tests the performance implications of high socio-technical capital.

<u>Proposition 1:</u> *The relative prominence of an ESS firm arising from its access to social and technical resources from both, directly and indirectly connected partners, is positively related to its performance.*

Social capital has been operationalized using network measures of centrality, betweeness, brokerage and prominence (Burt 2000). To test our proposition we proceed along the following steps. First, we discuss how extant measures of firm prominence are limited in their ability to capture the moderated flow of benefits discussed in assumption 4. Thus, in the following section, after a review of existing network metrics, we present a modified prominence measure that satisfies assumptions 1 through 4. This measure allows us to test proposition 1 in section 4.2

PROMINENCE MEASURES IN NETWORK ANALYSIS

Modified prominence measure for Sociotechnical capital (see appendix A)

A literature search reveals that none of the existing measures of prominence incorporate all our assumptions. Specifically, assumption 4 was not built into any of these measures (see Chellappa and Saraf(2002) for a detailed discussion). Therefore, we extend the rational choice model of status (Braun 1997) as follows. Based on other firms' exogenous resources, the focal firm decides to maintain alliances to enhance its Socio-technical capital. For every alliance, the firm incurs a cost that is proportional to the strength of relationship it chooses to maintain. As discussed in assumption 2, this cost is also a function of the partner firm's relative prominence in the network, as given by eq. A1. The benefits as described in assumptions 1&4, are sum total of benefits from both the direct and indirect alliances, giving us the benefits equation given by eq. A3. Under equilibrium, when all network resources have been distributed, such that the costs incurred equal the network benefits, we obtain the measure of prominence as below:

$$s_i = \frac{\sum_{p=0}^{n-1} \sum_k z_{ik}{}^p}{1+n} + \frac{\sum_{p=0}^{n-1} \sum_k z_{ik}{}^p \sum_j r_{kj} s_j}{1+n}$$

From this equation, we see that the relative prominence of the focal firm is a function of the relative prominence of the firms that it partners with s_j, and the relationship strength, r_{ij}, it maintains with each of the partnering firm. This metric is then obtained by solving simultaneously for the prominence of all firms.

Data – Alliance network of enterprise systems software firms

To test proposition 1, we consider the context of ESS firms manufacturing core enterprise resource planning (ERP) components and the allied complementary software providers (CSPs) as shown in Table 2. We collected data from several sources. Data on the type of components the sample of ESS firms offer and their software licensing revenue (SOFTREV) for the year 1999 was collected using questionnaires to vendors. The questionnaire was administered by a consulting organization that was hired by a vendor-neutral industry group. It was confirmed that the questionnaire was administered to all the firms operating in the industry. The response rate was near 100% for the top ranked firms, and we considered this pool of the top 97 firms and a representative sample is shown in Table 2[4].

Example set of enterprise system vendors *	Software component markets **
SAP America, Oracle Corp., J.D. Edwards, Baan Company, JBA International, System Software Associates, i2 Technologies, PeopleSoft Inc., Trilogy Software, Kronos Inc., EXE Technologies, HK Systems, Intellution, Wonderware Corp., Aspect Development	Advanced Planning and Scheduling (25)
	Customer Response Management (9)
	E-Business (20)
	Enterprise Resource Planning (50)
	Product Data Management (15)
	Component Management (15)
	Groupware (15)
	Supply Chain Planning (31)
	Forecasting & Demand Management (10)
	Supply Chain Execution (24)
	Transportation & Logistics (12)
	Warehouse Management (22)
	Enterprise Asset Management (12)
	Supervisory Control (22)
	Business Intelligence (2)
* This is a list of 15 ESS vendors from the sample of 97. ** The component categories are based on component classification assumed by the data sources. Parentheses in the second column state the number of vendors in the sample offering the particular component.	

Table 2: Enterprise system firms and component markets they compete in

Data was on alliances among the sample of 97 vendors constituted our network data which was collected from various sources, including corporate data-sheets, websites, telephone interviews, etc. An alliance linkage was noted if a firm indicated that it had a partnership with any of the other 97 firms. This yielded a matrix of alliances of the top 97 firms (Figure 1). From this matrix, 29 vendors had no links with other vendors within the pool. By definition, the measure of socio-

[4] Data collection about ESS vendors can pose a significant problem as there is no specific SIC code for enterprise software. For example, the SIC code category 7372 (pre-packaged software) includes not only ESS vendors but also vendors that sell off-the-shelf desktop software. Hence we identified an industry group that specifically collects information on ESS vendors. We compared our sample of 97 vendors with information on ESS vendors from OneSource database and confirmed that no known ESS vendors were excluded.

technical capital of these vendors is zero. A large percentage (60%) of these isolates are small vendors. Further, on running the distance matrix procedure in the network software UCINET IV (Borgatti, Everett et al. 1992), it was found that five vendors had links among themselves but not with the rest of 65 firms. The remaining 65 vendors had a total of 196 alliance links amongst themselves of which 96 were reciprocated links. The 97 vendors offered components from a list of 15 products ranging from Advanced planning and Scheduling to Business Intelligence software (see Table 2). To compute Sociotechnical capital (STC) for each vendor, a software program was created in Matlab using the expression in section 4.1. Employee strength (SIZE) and *outdegree* (OUTDG) (number of alliances struck by a vendor) were included as a control variables. Whereas employee size is commonly used in studies to control for organizational slack, *outdegree* controls for the variation in degree to which ESS vendors form alliances. Since data on employee count for the year 1999 was available for only 92 of the 97 firms, our sample size shrunk to 92.

Variables	Data source
ESS firm's software licensing revenue	MSI index and newsletter
Alliances formed by ESS firms	• Websites • Corporate press releases • Phone
Employee size	• Mergent Online • Securities and exchange commission • OneSource Business Browser

Table 3: Variables and Data Sources

Data Analysis and Results

Table 4 reports the descriptive information on the variables. Typically, since the functional form is not completely specified, performance variables are often log transformed. Similarly, SOFTREV and SIZE are log transformed. Graphical plots of the log transformed variables reveal a normal distribution. The correlation between STC and OUTDG is high at 0.72 but after socio-technical capital is log-transformed (rather Log (STC+1) since the transformation is not valid for those vendors with zero socio-technical capital), the correlation drops to 0.62. When the models are tested, variance information factor (VIF) (Hair, Anderson et al. 1992) for all variables is below 2 which indicates that multi-collinearity is under control. All pair-wise correlations are significant at 0.05 level.

Table 5 presents the results from a multiple regression (OLS) with software licensing revenue as the dependent variable. Models 1 and 2 are the baseline models which validate the use of SIZE as the control variable but OUTDG is not significant. However, including LSTC increases the explained variance (R-square) and parameter estimate for LSTC is also significant at 0.05 level. The F-test also indicates that the increase in R-square is significant for LSTC. Thus, overall the results strongly support our argument that rather than a strategy of increasing the number of alliances, the consideration of whom to align with is more important. This is borne out by the fact that the estimate for OUTDG is not significant at the 0.05 level.

Variable name	Means	Standard Deviations	Log(SIZE)	Log(STC+1)	OUTDG
LREV = Log (SOFTREV)	4.08	1.15	0.822	0.499	0.328
LSIZE = Log(SIZE)[5]	6.2	1.36	-	0.424	0.292
LSTC = [Log(STC+ 1)]	1.13	0.85		-	0.628
OUTDG	2.03	2.88			-

Table 4. Means, standard deviations and Pearson correlations

MODEL	1	2	3
LSIZE	0.696*	0.672*	0.63*
OUTDG		0.038	0.003
LSTC			0.257*
R^2	0.676	0.684	0.704
Adjusted- R^2	0.672	0.677	0.694
Number of observations	92	92	92

Table 5. Regressing Firm Performance of ESS Vendors on Socio-technical Capital

IMPLICATIONS

This paper contributes in several ways. This is one of the first works to study the context of standards and compatibility in the IS area. Specifically, we link the traditional understanding of corporate IT standards to the alliance and compatibility decisions of the software firms themselves. Based on an in-depth understanding of the context we conceptualized the resource flows through alliance linkages as consisting of not only knowledge spillovers, traditionally discussed in strategy literature, but also demand-side mechanisms such as, perceptions of higher compatibility and access to user bases, as characteristics of the ESS industry.

A further contribution of this study is the introduction of social network theory to understand strategic behavior of ESS vendors due to under-developed standards. The social network framework allows empirical tests of the intuitions generated in prior research and thus helps to overcome the limitations of analytical methods in this rich domain. The social network

[5] Data on employee count for only 92 firms was available

framework also enriches the understanding of how alliances may result in the convergence between the technological trajectories of high-technology companies.

This paper also makes a significant contribution to research in social network theory. Burt (2000) says, “Research will better accumulate if we focus on network mechanisms responsible for social capital effects rather than trying to integrate across metaphors of social capital loosely tied to distant empirical indicators”. In our research we identify some of these mechanisms by a contextual study of the software industry alliances.

The understanding developed in this work is also rich enough to help examine a variety of issues in an industry that is dependent on standards but does not enjoy uniform, industry-wide product interoperability. For example, a longitudinal study of a software industry using our model can provide insights into the standards formation process itself. This research can also be extended to understand alliance formation even in the presence of industry-wide standards, as the social dimension becomes the only differentiating basis for competition in the face of rapid technological obsolescence. Particularly, the role of user organizations in shaping standards emergence in the ESS industry is an important contribution that has yet to be made by IS scholars.

Our model can also be applied to structure IS problems in intra-organizational situations. For example, identifying the right amount to invest in systems resources is of great importance in IS (Keen 1991), and our network model can help guide this decision. For example, one can construct an intra-organizational network of workflow and resource inter-dependence (Wybo and Goodhue 1995). Similar to the operationalization of Sociotechnical capital, network measures can be used to explore the fit between prominence in the workflow networks and the system compatibility networks. A high mismatch may be an indication of the need to refocus integration efforts.

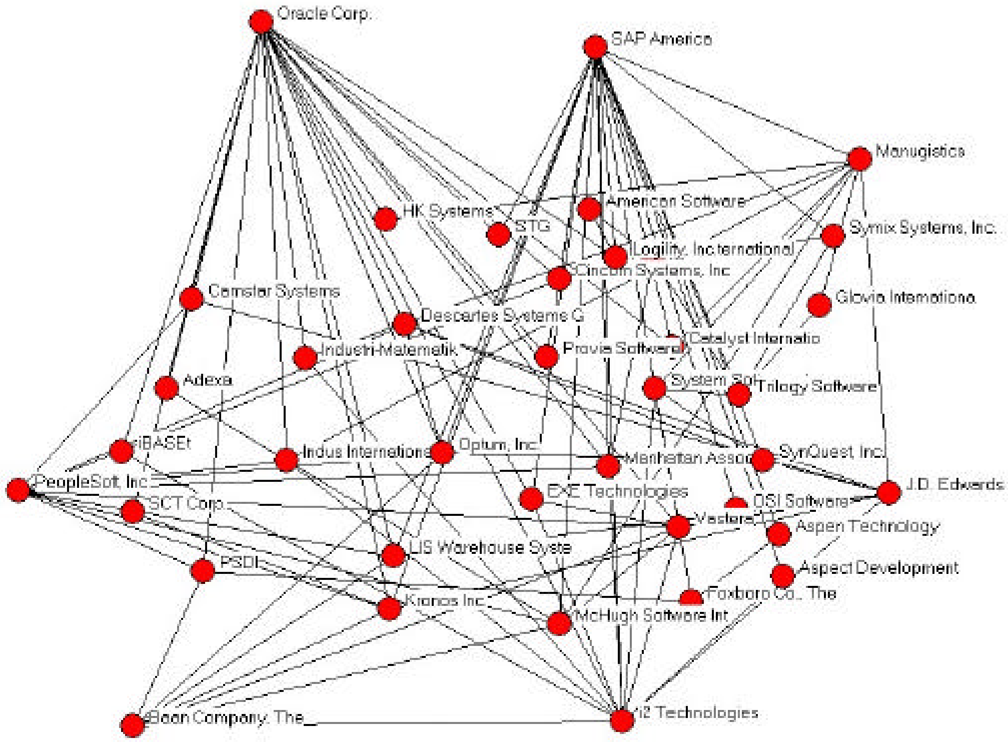

Figure 1: Example Alliance Network of Enterprise System Firms

APPENDIX

In section 3.2, assumption 3, we define the construct of aggregate relationship as representing the extent to which firm j is dependent on i. We can therefore define r_{ij} as "the extent of vendor j's dependence on vendor i as a fraction of vendor j's dependence on all other vendors directly connected to it." The adjacency matrix R is therefore a nXn column stochastic matrix with elements r_{ij}, such that for each j, $\sum_i r_{ij} = 1$. Similarly we also now formally define $s_j \geq 0$ as the relative prominence of vendor j such that $\sum_j s_j = 1$, i.e., s_j is standardized over all vendors in the network. Thus cost c_i can be formalized as $c_i = \sum_j r_{ij} s_j$ for each i

(1)

Every firm brings with it a certain exogenous value the network. Let this expected value be e_j, such that $e_j > 0$ and $\sum_j e_j = 1$. This value e_j is intrinsic to each firm j, and is representative of resources such as potential users, army of consultants, integrators, implementers, etc. that vendor j may bring to the network. This conceptualization is in line with the observation made by Portes[6]. In the absence of any network or relationship with other firms, a firm j would depend only on its own resources. Thus we can represent $b_j = f(e_j)$

(2)

However from assumptions 1,3,&4 in our network context, benefits for a firm i at any time is constructed as:

$$b_i = \sum_j r_{ij} e_j + \sum_k r_{ij} r_{jk} e_k + \sum_l r_{ij} r_{jk} r_{kl} e_l + \ldots \qquad (3)$$

To simplify equation-3, we use power matrices of R. Let us consider an array of power matrices where $z_{ij}{}^0 = 1_{i=j}(=0)_{i \neq j}, z^1{}_{ij} = r_{ij}, z^2{}_{ik} = \sum_j r_{ij} r_{jk}, \ldots . z^n_{in}$ and in matrix notation $z^2{}_{ik}$ can be represented as $z^2 = R.R$. Similarly, $z^p = R^p$ where power p represents the number path lengths between two firms. Using the power matrix notation we can now represent

$$b_i = \sum_j r_{ij} e_j + \sum_j z^2{}_{ij} e_j + \sum_j z^3{}_{ij} e_j + --- \sum_j z^P{}_{ij} e_j \qquad (4)$$

This can be further reduced to equation

$b_i = \sum_{p=1}^{P} \sum_k z_{ik}{}^p e_k$ for all i and In matrix notation we have, $b = \sum_{p=1}^{n} (Z^p.e)$ (5)

First Order Conditions for Equilibrium: At equilibrium every vendor's resource investments are such that the marginal cost is equal to the marginal benefit. Differentiating equations 1 and 3 with respect to r_{ij} and equating the derivatives we get:

$$s_j = \sum_{p=0}^{n-1} \sum_k z_{jk}{}^p e_k \qquad (6)$$

The above can be represented in matrix notation as $S = \sum_{p=0}^{n-1} (Z^p.e)$ (7)

where S is the column vector of statuses of the vendors.

From equation 5 we have a functional relationship between benefits and intrinsic value of a firm $b_j = f(e_j)$, representing the utility of the firm in the absence of any network investments and resources. At equilibrium the network has stabilized with the actors maintaining a concrete relationship as represented by the adjacency matrix R. Hence we may assume, that benefits are once again functionally related to intrinsic values. However the functional form itself may vary.

If we assume a linear utility function similar to Braun (1997) such as:
$b_i = (1+n)e_i - 1$ (this implies even if $e_i > 0$ we can still have $b_i = 0$)

[6] He clearly distinguishes between resources themselves from the ability to obtain them by virtue of membership in different social structures. Portes, A., "Social capital: Its origins and applications in modern sociology," *Annual Review of Sociology*, 24, (1998), 1-24.

and if we substitute cost for benefit, we have $e_i = \frac{1+c_i}{1+n} = \frac{1}{1+n} + \frac{1}{1+n}.\sum_j r_{ij} s_j$

alternatively for any k we have $e_k = \frac{1}{1+n} + \frac{1}{1+n}.\sum_j r_{kj} s_j$. Multiplying both sides by $\sum_{p=0}^{n-1}\sum_k z_{ik}{}^p$,

we have from equation 6 $s_i = \frac{\sum_{p=0}^{n-1}\sum_k z_{ik}{}^p}{1+n} + \frac{\sum_{p=0}^{n-1}\sum_k z_{ik}{}^p \sum_j r_{kj} s_j}{1+n}$

and in matrix notation we have

$$S = \frac{\left(\sum_{p=0}^{n-1} Z^p\right).J + \left(\sum_{p=1}^{n} Z^p\right).S}{1+n} \tag{8}$$

Equation 8 implies that the prominence of a firm is dependent on s_j , the status measure of other firms and r_{ij} , the corresponding strength of relationship.

Solving equation 8 for S , we have $S = (I - X)^{-1} YJ$ where $Y = \frac{\sum_{p=0}^{n-1} Z^p}{n+1}$, $X = \frac{\sum_{p=1}^{n} Z^p}{n+1}$

The power series form of $S = (I - X)^{-1} YJ$ would be as follows:

$$S = \frac{1}{1+n}\left(I - \frac{\sum_{p=0}^{n} Z^p}{1+n} \right)^{-1} \left(\sum_{p=1}^{n-1} Z^p\right).J = \frac{1}{1+n}\sum_{l=0}^{l=\infty}\left(\frac{\sum_{p=1}^{n} Z^p}{1+n} \right)^{l} \left(\sum_{p=0}^{n-1} Z^p\right).J \tag{9}$$

The above power series is valid since $\left\| \frac{\sum_{p=1}^{n} Z^p}{1+n} \right\| < 1$

From Kincaid and Cheney (1996), we can confirm the existence of the inverse if the norm $\left\| \frac{\sum_{p=0}^{n} Z^p}{1+n} \right\| \le 1 \Rightarrow \left\| \sum_{p=0}^{n} Z^p \right\| \le n+1$, where $\sum_{p=0}^{n} Z^p$ is also a stochastic matrix with column sums equal to n . Therefore, taking $\frac{1}{n}\sum_{p=0}^{n} Z^p = G$, the inverse is always said to exist if and only if $\|G\| \le (n+1)/n$. Matrix G , being a column stochastic, its norm is $\|G\| = \frac{\max}{1 \le j \le n} \sum_{i=1}^{n} |a_{ij}| = 1$. Since $(n+1)$ is always greater than n , the existence of the inverse is confirmed.

For further empirical studies, e and c can be expressed as:

$$c = Rs = R.\frac{1}{1+n}\sum_{l=0}^{l=\infty}\left(\frac{\sum_{p=1}^{n} Z^p}{1+n}\right)^l\left(\sum_{p=0}^{n-1} Z^p\right).J = \frac{1}{1+n}\sum_{l=0}^{l=\infty}\left(\frac{\sum_{p=1}^{n} Z^p}{1+n}\right)^l\left(\sum_{p=1}^{n} Z^p\right).J \qquad (10)$$

Equation 7 gives $e = \left(\sum_{p=0}^{n-1}(Z^p)\right)^{-1}.S$, and therefore from equation 9 we have

$$e = \frac{1}{1+n}\sum_{l=0}^{l=\infty}\left(\frac{\sum_{p=1}^{n} Z^p}{1+n}\right)^l.J$$

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MONOPOLY POWER IN STANDARDS IS A MYTH

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ABSTRACT

This paper explores the optimal organization of an industry of manufacturers who require standards to make their products function. We apply concepts found in neo-classical economics and concepts from increasing returns in order to show that IT standards, in particular, are natural monopolies. We further illustrate that once the manufacturers of IT intensive products realize that a monopolistically supplied standard will be more costly than a competitive standard, they will organize to mitigate the monopolistic supply problem. Specifically, we propose that they engage in a strategy of *coopetition*, wherein manufacturers that compete in the final goods market, cooperate in developing standards as a provision of inputs. This means that, as an industry, manufacturers can gain the advantages of a single supplier, while mitigating the costs of monopolistic supply, by jointly owning the standard authority. We illustrate this idea with the market dynamics of the DVD standard.

Keywords: Standards, network effects, network externalities, increasing returns, coopetition, industrial organizations.

INTRODUCTION

The importance of standards for information systems (IS) is undeniable. In his letter to Business week, Michael Dell admits that there is a “shift in customers’ preference to standard based technology and away from expensive proprietary systems” (Dell 2003, p.18). Standards not only help reduce uncertainty in the minds of customers but also help industry move forward. Bill Gates notes that businesses can put together software pieces more rapidly and flawlessly now than before (Orenstein 2000). One of the central functional roles of a chief information officer in an organization is to set standards and manage interoperability (Libicki 1995). It’s because of standardization, that customers across the country can connect to the internet through their wireless devices in any Starbucks coffee outlet (Maier 2002).

Information technology (IT) standards are no longer solely an engineering issue. Control of IT standards can be very lucrative and guarantee businesses super normal profits for extended periods (David et al. 1990; Shapiro et al. 1999b). They have become a strategic tool in the hands of businesses to gain competitive advantage and control the market. Incompatibility exists not because of lack of technical expertise but because of the self-seeking nature of businesses (Shirky 2000). There is often an implacable standards war before a dominant standard emerges (Shapiro et al. 1999a). It does not make good business sense to be part of these battles. Not only are there far more losers than winners, but the uncertainty that multiple standards bring to the marketplace retards adoption of all standards, so there may be no winners at all.

Prior strategy literature on standards has focused mainly on how the owner of a standard can maximize its value from the control of a standard (Dranove et al.; Shapiro et al. 1999b). In doing so, the literature has largely ignored the viewpoint of the customer of those standards—the manufacturers of products. End consumers do not usually buy standards, but rather purchase a product in which the standards are embedded. It is the manufacturer of those products that pay the licensing fees for the standards. Thus, the customers of standard owner are usually large, powerful commercial entities who have the clout, the resources, and the knowledge to shape industries. This means that traditional analysis of standards with passive customers is problematic, and new forms of industrial organization are needed to address the problems inherent in standards.

We posit that, because IT standards are generally associated with network externalities and economies of scale, they are natural monopolies. A single standard generates greater network effects and cost less than multiple standards. However, having a standard controlled by a single firm leads to monopolistic pricing. We put forward that IT industries can obtain the benefits of network externalities and scale while ameliorating the negative consequences of monopolistic supply by reorganizing the provision of standards as coopetition[1] (Bradenburger et al. 1996; Dagnino et al.; Garraffo).

THEORY DEVELOPMENT

We would like to briefly outline the theory and then define the terms before proceeding with the detailed analysis.

IT standards are natural monopolies. In general, an industry will only support one standard in the long run. The primary reason for this is, that as a means of communication, standards are possessed of network externalities (Economides 1996; Gallaugher et al. 2002; Kauffman et al. 2000). In addition, developing IT standards requires a huge upfront cost. It is preferable for an industry to only pay this cost once.

With monopolistically supplied IT standards, the customer's welfare is dependant on the monopolist's pricing strategies. A single entity with control over dominant standards can behave opportunistically and charge monopolistic premiums to users. Thus, all benefits of falling average costs and network externalities accrue to the supplier of standards and customers may end up paying monopolistic premiums for the use of the standard.

The above represents two conflicting scenarios for organizations wanting to adopt standards. Scale benefits tend to arise naturally for standards, which suggest that standards should be provided for externally, benefiting from vendors economies of scale. However, adopting IT standards from external supplier puts manufacturer at risk of being charged monopolistic premium, which would suggest that IT standards should be provided for internally.

Defining roles

Before proceeding with theory development, it is useful to define some terms and concepts. First, we assert that standards do not posses intrinsic worth, but rather generate value only when embedded in some usable product that is then sold to end consumers. This implies three distinct entities in the value chain—the standard authority, the manufacturer of the product, and

[1] We define coopetition in detail later in the paper. However, for the reader's convenience coopetition is cooperation among competitors.

the end consumer—as illustrated in Figure 1. We are concerned with the economic, legal and strategic relationship between the manufacturers and the standard authority, and thus do not further discuss the end consumer.

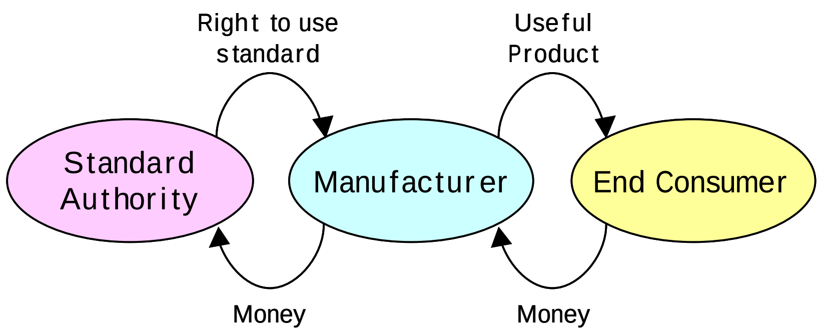

Figure 1: Conceptualization of Market

The standard authority is the organization that controls and administers the standard. The defining characteristic of the standard authority is the ability to decide which other entities may use the standard. This is generally decided based on a cash transfer. The manufacturer is the organization that creates the useful product for the end consumer. Throughout this paper, manufacturer refers to an organization that uses a standard to create a product, and a standard authority refers to an organization that controls a standard. We also note that the manufacture of an end product and the control of a standard may not always be independent functions. However, for conceptual clarity, this paper assumes independence of these two activities, so that there are no particular gains (or losses) from combining or separating the two activities.

We define IT standards as a set of technical specifications that allow communication between IT entities. We conceptualize standards into 2 broad categories—product standards and process standards. Product standards are a set of technical specifications that define how IT products interact with each other (e.g. TCP/IP, Wireless 802.11b and 802.11g). Process standards are a set of technical specifications that define how people developing systems interact with each other (e.g. RUP, extreme programming and systems development life cycle).

We limit the scope of our paper to discussing IT product standards only. We do this to maintain conceptual clarity and ease of understanding. Monopolistic problems usually arise more often in IT product standards than IT process standards. IT product standards are more thoroughly codified and hence can be legally protected. Whereas, IT process standards are more flexible and less codified. IT product standards are frequently developed by a single entity with the express purpose of allowing communication between different products. IT process standards usually emerge from the best practices of groups across different organizations. IT product standards are generally software and, hence, can be replicated at virtually no cost. However, replicating IT process standards involves user training and expensive coaching, and thus, marginal costs can be substantial. We will discuss the implications of privately owned IT process standards in our discussion section.

We also assume no difference in the quality of competing standards. Again, we do this to maintain conceptual clarity and ease of understanding. This assumption can be relaxed without losing generalizability of our analysis. Markets are as likely to lock in to inferior standard as they are to lock into one which is superior (David 1985).

While prior work has focused on how a standard authority could maximize their welfare, we focus on how manufacturers (users of standards) should go about maximizing their own welfare. Prior work recognizes that manufacturers are significant decision makers and that their cooperation is necessary for a standard authority to achieve success (Cargill 1989; Jacobs 2000; Shapiro et al. 1998). However, the manufacturers were treated as relatively passive organizations whose only real choice was to decide which standard to use. Although this is a helpful abstraction, it misses a significant part of the story, particularly when the manufacturers are themselves organizations such as General Electric, IBM, and Sony, which possess both power and intelligence.

We take the opposite perspective in this work, focusing on the manufacturers' motivations, and treating the standard authority as a relatively passive organization. Again, it is a useful abstraction that allows us to concentrate solely on one aspect of the problem. Nevertheless, it is an abstraction, and thus does not relay the entire story. We do, however, hope that this gives the reader a new viewpoint on standards issues and encourages future research that considers both perspectives.

From the manufacturer's point of view, IT standards can be viewed as inputs into the production of IT intensive products. As is illustrated in Figure **2**, standards form one of many inputs to a production process. For example, an end consumer may buy music as a final product. However, for a manufacturer to prerecord music, it requires the intellectual property of the song, the materials for the recording medium, and a variety of other inputs including encoding standards that allow the recording medium to be read by a player.

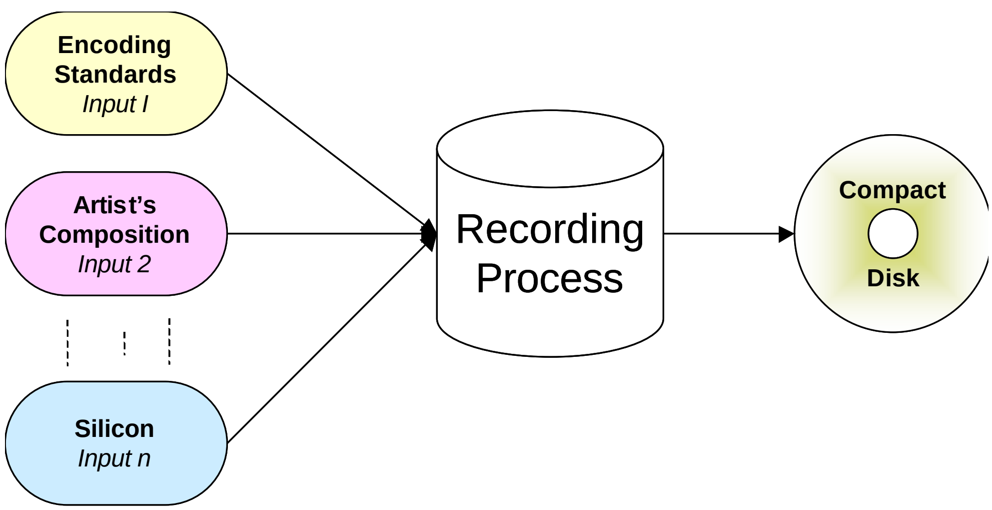

Figure 2: **Standards as one of the inputs of organizational process**

A manufacturer in need of IT standards can develop them internally or provide for them externally by adopting a third party standard. The main issue faced by the manufacturer, with respect to IT standards, is to minimize the total cost of those standards. That may be done by developing proprietary standards or adopting the standards of an external standards authority that has reached economies of scale.

The manufacturer is assumed to have no goal to profit from the sale of standards. This is where we depart from traditional economic thought about standards. We recognize that in reality, there is probably interest in the sale of standards, but that particular issue is well studied

(Dranove et al.; Shapiro et al. 1999b). This work is specifically interested in the examination of other goals, besides the sale of standards. Thus, we remove this goal to more clearly examine the impact of other goals. We repeat, again, that this does not tell the whole story, but it does offer a useful viewpoint that can be combined with the existent literature in order to more fully understand standards and their impact on industrial organization.

Standards as Natural Monopolies

IT standards are natural monopolies. Monopoly refers to a market structure where there is only one provider of a product—an IT standard in this case. The term natural means that industry-wide welfare can only be exploited with a single provider. This does not mean that industry-wide welfare will be maximized, but that the potential benefits are greatest with a single supplier. For IT standards, this naturalness arises from both demand side and supply side effects. On the supply side, avoiding paying high up-front costs multiple time, and the corresponding drop in average costs as a larger portion of the industry uses a single standard, results in a market that tends toward monopoly. On the demand side, network externalities, which arise from communication benefits of IT standards, and the up-front cost of deploying an IT standard, drive the market toward monopoly. We now examine each of these effects.

Falling Average cost

IT standards, being a knowledge product, require huge upfront investment and resource commitment from the organization (Arthur 1996; David et al. 1990; Shapiro et al. 1998). They require a great deal of intellectual effort by highly skilled and compensated teams and, thus, result in considerable upfront cost. Thereafter, the cost to replicate or distribute these standards is almost negligible. As production volume increases, the large up-front costs are amortized across a larger number of products, while marginal costs stay consistently low. Thus, average production costs tend to fall, as output increases.

However, these investments also represent sunk costs for the firm and the market as a whole. Since these are costs and they are substantial, multiple instances of their occurrence represent a sub optimal solution of allocation of economic resources. For example, Circuit City took a $ 200 million write off for the development and marketing of DIVX and earmarked another $114 million for exit costs (Newswire 1999). Thus, converging on one standard is a ‘natural justice’, and investing in only one standard is socio-economic rationality.

Network Externalities

Network effects arise when the value of membership in a network is an increasing function of the number of members on the network (Economides 1996; Kauffman et al. 2000). The causal process basically posits that, as more people adopt a particular standard, the value of that standard increases, encouraging additional adoption. This starts the process for demand side economies of scale. The virtuous circle continues, causing rapid growth in adoption and leading to economies wherein a single organization promptly emerges as the dominant player (Mantena et al. 1999). From a returns perspective, this means that there is tremendous opportunity cost for not adopting a dominant standard. As the adoption of dominant standard increases, the opportunity cost of alternative standard decreases because the network size increases, conversely the opportunity cost of not adopting the dominant standard increases. For example, while the production cost of a telephone is relatively small, the opportunity cost of not having equipment compatible with other phones would be enormous.

This provides an incentive for the new users to adopt the same standard as others. It is intuitive that more products developed on common standards will hold more value in the eyes of users than those developed in isolation. Products developed on common standards will be compatible, resulting in greater user satisfaction. The initial gains and positive feedback soon translate into standards becoming the industry norm. The competition in the market continues to decline, gradually leaving a lone player in the market. With increasing returns, it is possible for just one standard to serve the needs of the entire market, thus forming a natural monopoly. As the competition dies out in the market, so does the capability of the adopters to negotiate better prices for licensing or using standards. In the long run, it is highly unlikely that more than one standard will survive, which means that the only remaining player in the market will have the capability of charging huge royalties.

Lock ins and SWITCHING costs

IT Standards are technology intensive products, and adoption involves a great amount of learning effort on the part of the adopter. Repeated use of standards makes the adopter comfortable and expert in the use of specific applications of standards. Moreover, a manufacturer will spend considerable time and effort in tooling-up its manufacturing line to assemble products based on a certain standard. This tooling-up includes not only actually configuring machines, but also putting into place the organizational structures, like help lines, marketing and branding, to optimize production based on a specific standard. As a consequence, it becomes hard for organizations to switch to a different standard in the short run. Like the large up-front costs in development, it is undesirable for manufacturers to pay learning costs repetitively.

In summary, IT product standards are natural monopolies. The intellectual contribution to their design requires huge up-front costs that an industry should only pay once. Similarly, the tooling-up costs for manufacturers is substantial It is preferable for manufacturers to only have to pay these costs once. Lastly, IT standards are communication technologies, and as such, are characterized by network externalities. With a single supplier of the IT standard, all relevant products can talk to each other, which increase the value for everyone.

Monopolistically supplied Standards

The characteristics of IT standards discussed above suggest that a single standard is desirable in an industry. However, from the perspective of the manufacturer that must pay the licensing fee for a single IT standard, there is one significant problem. If the single industry standard is owned or controlled by a single organization, then that organization has great incentive to charge a premium for the use of the standard. Whichever organization eventually wins a standards war tends to then hold-up all of the other organizations in an industry, by charging them much more than they otherwise would.

For the purpose of this paper, we differentiate between monopolistically supplied IT standards and monopoly. Whereas, monopoly refers to a single standard authority, monopolistically supplied means, the standard authority exercises its monopoly control on the standard to charge a greater licensing fee than what it would have charged otherwise. The term, monopolistically supplied, captures the specific behavior of an organization where it acts opportunistically and takes advantage of its position in the industry.

The premium that must be paid for a monopolistically supplied standard depends on the number of competing standards. We assume one to one mapping between the number of suppliers and the number of standards. The problem is greatest with one supplier-one standard, but exists, to a smaller degree, for a small number of suppliers as well. Below, in Figure 3, we illustrate the price premium using a simple model of Cournot oligopoly. As the figure shows, the standard assumptions of competition hold until the number of suppliers of standards becomes very small, at which point the price premium increases dramatically. Standards exhibit high levels of increasing returns and thus tend to have few suppliers. Hence, the monopolistic supply problem must be seriously considered.

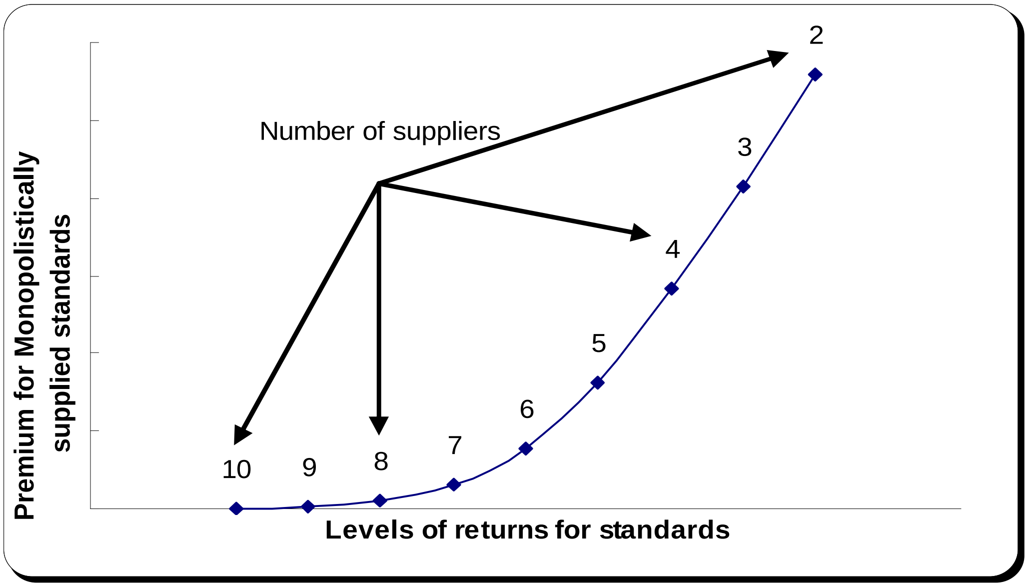

Figure 3**: Price premium due to monopolistic supply of standards**

About coopetition

While a single standard supplier benefits the industry (and the owner of the single standard), manufacturers are concerned with their individual benefits, which will be reduced by a monopolistically supplied standard. Manufacturers are largely stuck with the accidents of the past, but have learned from those accidents. For example, many buyers of Netscape server software purchased the software purely based on the fact that it was not controlled by Microsoft (Cusumano et al. 1998).

New technologies are being developed on an almost daily basis and thus new IT standards are needed on a similar basis. Manufacturers want to avoid a monopolistically supplied standard, yet want to gain the cost and network benefits of having a single agreed upon IT standard for a new product. To satisfy these opposing goals, manufacturers have developed an alternative strategy for the provision of IT standards, called coopetition.

Coopetition is the simultaneous cooperation and competition between organizations (Bradenburger et al. 1996; Dagnino et al.; Garraffo). In this case, manufacturers compete in the final goods market but cooperate in the input market. In our model, this means that all the major organizations of the industry come together and jointly develop the IT standard. This way, each organization stakes a claim in the ownership of the standard but no one controls it. This can be thought of as joint multiple vertical integration.

The term joint multiple vertical integration is a logical extension to the term vertical integration, which means an organization integrates or acquires its customers or suppliers in order to avoid transaction costs associated with their opportunistic behavior. In our case, multiple organizations in the industry jointly own the IT standards or the standard setting body in order to avoid the monopoly premium. Hence, the distinction between monopoly and monopolistic supply. In coopetition, the standards authority is the only supplier and hence a monopolist, however, as it is controlled by its customers—the manufacturers—, it cannot supply the standards monopolistically. If the standard authority did charge a monopolistic premium, it would go back to the manufacturers as royalty payments, they being the owners. Coopetition in a standards setting usually leads to an increase in the market pie (Bradenburger et al. 1996). Therefore, organizations in the industry cooperate to build the pie and compete to divide the pie.

The differences between internal provision in a competitive market, external provision in a monopolistic market, and coopetition are illustrated in Table 1.

	External Provision (Monopoly)	Internal Provision (Competition)	Coopetition
Number of Standards	1	Many	1
Number of Owners	1	Many	Many
Scale Benefits	High	Low	High
Price Premium	High	Low	Low

Table 1: **Benefits of Different Provision for IT Standards**

As the table shows, coopetition creates an industry structure with a single IT standard, but that standard is owned by all market participants (i.e. manufacturers). This alternative form of industrial organization is possible simply because their legal structures allow the number of owners of a standard to be different than one. This is a subtle but important fact that has not been widely considered in prior IT standards research. We illustrate this in Figure 4.

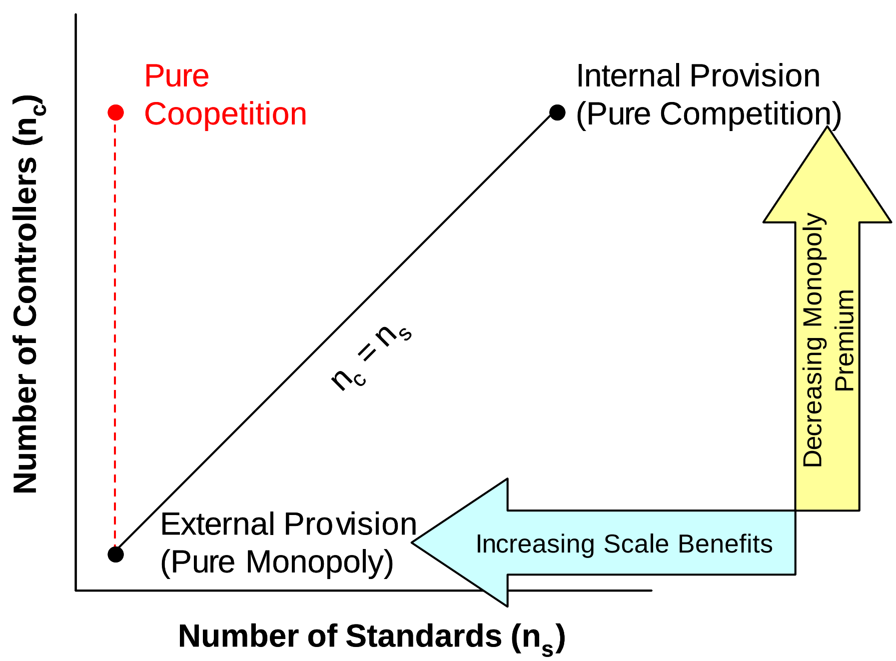

Figure 4: **Coopetition as a strategy with one supplier and many owners**

In Figure 4 we represent pure coopetition, pure competition and pure monopoly as archetypes. Any industrial organization in the graph is possible. However, in reality, we would talk about an industry being more monopolistic or more competitive or more coopetitive, rather than the pure states. However, for theoretical understanding, a discussion of the pure states is simpler.

The actual ability of the industry to take advantage of the legal institutions that allow for joint ownership is facilitated by the fact that manufacturers of a particular set of IT intensive products are usually a concentrated group, numbering in the dozens, or hundreds, at most. That is why it is important to consider the manufacturers as the customers of the IT standard, rather than the end consumers who may number in the millions or even in the billions. The organizations that actually write the check to pay the monopolistic premium have the resources, knowledge and incentive to take advantage of these legal structures.

ILLUSTRATIVE EXAMPLE

We now provide an illustrative example in support of our theory. This is not to suggest that this is the only example, as there exists a wide variety of illustrative examples of coopetition for standards, such as the object management group's common object request broker architecture (CORBA)2, The IEEE's P802.11 standards for wireless networking3, and the Open Mobile Alliance cell phone data transfer standards4. We build on prior literature (Dranove et al. 2003) and briefly describe the standards issues surrounding digital versatile disks (DVD). While Dranove and Gandal offer an excellent and detailed examination of standards issues from the viewpoint of the supplier of the standard, we look at the same standard from the viewpoint of the user of the standards. Thus, our work offers a comparison and contrast to their work in the same domain. We note that, in some instances, the user and the supplier are the same firm.

One early DVD standard was the super density (SD) format jointly developed by seven firms, including Toshiba, Hitachi Ltd., Matsushita Electric Industrial Co. Ltd., its subsidiary MCA Inc., Electronic Corp., Thomson Consumer Electronics SA, and Time- Warner Inc. This jointly developed and owned standard was aimed at avoiding the costs of a monopolistically supplied standard. As Toshiba puts it:

> *The aim of setting up the joint company is to help avoid doubling of royalty charges or unnecessary increases in license fees for users of the technologies… (Newswire December 04, 1995)*

This early coopetition standard was challenged by a more monopolistically supplied standard, the Multimedia Compact Disk (MMCD), which was owned by Sony and Phillips, and based on Sony's proprietary audio CD standard. Compatibility with already accepted CD technology suggested the MMCD standard, but fear among the coopetition group, of monopolistic supply of that standard, suggested the SD standard. One industry observer describes the coopetition group's unwillingness to use the Sony standard, in this way:

> *Toshiba, Matsushita and their allies shunned Sony's initiative because they were still smarting from their bitter experience with CDs. They have been forced to pay huge sums in royalties for CD technology to Sony, which has an array of key patents shared with Philips. Sony presents its DVD format as an extension of the CD technology, raising the specter of vast royalties being demanded from licensees… (Newswire June 27, 1995)*

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[2] see http://www.omg.org/gettingstarted/corbafaq.htm

[3] see http://grouper.ieee.org/groups/802/11/abt80211.html

[4] see http://www.openmobilealliance.org/

Sony recognized that the increasing returns meant that only one DVD standard should exist. In his statement as the chairman of the Electronic Association of Japan, Sony Chairman Norio Ohga stated that the "existence of two standards was undesirable" (Newsbytes December 8, 1995). Eventually, Sony recognized the manufacturer's resistance to a monopolistically supplied standard and joined the coopetition group along with Phillips and one other electronics manufacturers, bringing the number of members to ten and paving the way for the DVD standard.

History repeated itself not long after the DVD issue was resolved. Circuit City, lured by the prospect of being the monopolistic supplier of a high density optical storage device developed the Digital Video Express (DIVX) standard. DIVX was more technologically advanced than DVD. Not only could it play DVD movies, but it could also allow for single play disks. Single play disks can be used for a period of 48 hours and then become locked. This could effectively revolutionize the rental industry as the locked disks could only be unlocked with a purchasable code that can be downloaded from home, essentially turning a rental into a purchase or repeat rental. As a matter of fact, the concept of disposable disks has reemerged recently, only this time in jointly owned DVD format.

However, the intention of Circuit City was clear—to charge a monopolistic premium to manufacturers of DIVX products. Richard L. Sharp, Chairman and CEO of Circuit City Stores, Inc. relay the intentions of Circuit city in saying, "We believe the tremendous market potential Divx represents an opportunity for outstanding shareholder returns" (Newswire September 8, 1997). As Dranove and Gandal put it, "If DIVX became the dominant standard, Circuit City could extract a licensing fee from every unit of hardware and software. Circuit City could extract profits from all phases of the industry…" (Dranove et al. 2003).

As in the SD-MMCD case, manufacturers were wary of paying for a monopolistically supplied standard, and chose to go the coopetition route instead. After two years, Circuit City abandoned its attempt at DIVX, stating:

> *"We have always said that we had to have adequate studio support and additional retail outlets for software and hardware. We could not be the lone distributor or financier, those three components were not coming into play as we had envisioned. Despite strong consumer interest the risk and rewards turned in the other direction." (Kane June 15, 1999)*

While both of the monopolistically supplied standards have been rejected, the coopetition-based standard remains. In fact, there are more than 200 members of the DVD standards body today. The interesting thing is that while these 200 cooperate to define and distribute the standard at a low royalty rate, the same firms are largely fierce competitors in the market for the sale of DVD technologies.

DISCUSSION

There are a number of IT standards in existence today and many of those are monopolistically supplied. Because IT standards form natural monopolies, manufacturers are stuck with them for the foreseeable future. However, there are also a number of new technologies on the horizon, for which IT standards will be required. Manufacturers have learned previous hard lessons from fighting standards wars and from paying monopolistic suppliers. In the future, when new technologies are developed, where IT standards are needed, we hope and expect that manufacturers will reject monopolistic suppliers and instead work together to create jointly owned industry standards through the strategy of coopetition.

If we have done our job, the reader is convinced that coopetition is a viable and valuable strategy. Given this, and the particular circumstances of IT standards—high up-front cost, high learning costs, and network externalities—it is essential that IS research investigate this strategy further. While this work offers a starting point, there is plenty of room for additional research.

We limit our discussion to IT product standards, which can generally be thought of as software. However, IT process standards are a significant and fertile field for additional consideration. As educators, it is imperative that we know which processes to teach. For industry, it is important to know which IT process standards to use. Process standards are likely to be different in several ways. Because they are rules for people, they will tend to be less precise and more flexible. Moreover, the marginal cost of training people in processes is not, by any means, zero. Finally, the lack of precision leads to much more difficulty establishing ownership of an IT process standard. Without a credible ability to establish ownership, there is no credible threat of monopolistic supply. In fact, it is difficult to believe that an IT process standard can be charged for—although the training can be changed, there is no licensing fee for the actual use of the process.

Another area that we have left for future research is the possibility of competition among two or more coopetitions e.g. (Garraffo 2002). That is to say that, some set of manufacturers may coopete for one standard and some others for a different standard. How would this effect the industry structure? It would seem that the chance of winning such a standard war would go up for all participants, though the benefits of being one of many winners would be less. Under some circumstances, this would seem to be a rational strategy.

We have assumed, throughout, that IT standards are characterized by network externalities. However, not all IT standards are. For example, DVD write technology does not possess the same level of network externalities as DVD read technology. The read technology allows all DVD products (players and disks) in a region to communicate. However, given the encoding standards, the method of actually writing the DVDs does not possess great network externalities. Similar arguments can be made for the level of externalities for operating systems and other system software, as compared to application software. This is a particularly fertile area for future empirical work.

This work has focused on the economic motivations, but the sociological issues in coopetition are equally important. Organizations often prefer to work with certain other organizations. Coopetitions may be organized as temporary or permanent concerns. Academia could play an important third party role. Board interlocks and personal relations may be necessary (or detrimental) to the formation of a coopetition. The end consumers and government surely play vital roles. These are important issues beyond the scope of the work presented here.

CONCLUSION

This theory and example illustrates that the manufacturers who use IT standards as inputs to the production process have become cognizant of the fact that IT standards are natural monopolies. In order to garner the production efficiencies of a single supplier, without having to pay the price of a monopolistic supplier, these organizations are increasingly turning to coopetition. Many competitors, all of whom have need of the standard, cooperate with one another to jointly own and administer the standard. This leads to a whole new form of industrial organization that blurs the traditional boundaries of the firm and the traditional roles of firms within an industry.

Frequently, academic research assumes the customers of technology standards are millions of powerless, ignorant individuals. This is often incorrect, because the entities that actually write the checks to the standard authority are not individuals, but rather manufacturing firms. These customers are a handful of powerful corporations who are aware of the subtleties of business and have both the power and the incentive to avoid a single monopolistic supplier. We would suggest to those organizations who are fighting to be the monopolistic suppliers of an advanced technology standard, much like wolves fighting over a particularly fat sheep, to look again at the sheep and make sure it is not actually a rhinoceros, with no intention of being eaten.

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A NETWORK ROI

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ABSTRACT

In this paper, a method for determining the equilibrium under which firms will cooperate concerning their standardization decisions is developed.

From a theoretical perspective, the network ROI concept is aimed at synchronizing local and global efficiency disturbed by network effects by explicitly determining the value impact of standardization and using it for optimizing enterprise internal decisions concerning standards (i.e. internalizing network effects). From a managerial perspective, ROI based methods are reasonably simple and especially widely accepted. Since the costs of solution determination are considered (by a "virtual instance"), the concept might be applied by a cost center unit responsible for standardization. Methodologically, the solution is developed using basic game theory to understand the discrepancy between local and global efficiency in standardization decisions and later applied to a network of six enterprises as part of an extensive case study.

Keywords: standardization, return on investment, ROI, X.500, network, coordination problem, infrastructure, fair allocation

STANDARDS IN INFORMATION SYSTEMS

Standards play a prominent role in many systems that are characterized by interaction or interrelatedness. In information systems such as software environments or Intranets standards provide for compatibility and are a prerequisite for collaboration benefits. More generally speaking, standards can constitute networks. Examples include supply chains, the "network" of users of certain software products, and corporate intra- and extranets. Inherent in standards, the commonality property deriving from the need for compatibility implies coordination problems. As a consequence, corporate information management is increasingly occupied with coordinating standardization decisions as a basis for information and communication infrastructures. These decisions have to deal with numerous problems. First, of course, the existence of network effects makes decisions by otherwise possibly autonomous agents interdependent. The ultimate decision quality is thereby not only the result of individual decisions but is strongly determined by the decisions of others. Hence a major uncertainty to be dealt with concerns the standardization behavior of communication partners. Second, there might be additional uncertainty about the costs and benefits associated with the implementation of standards or future application flexibility. From a practical perspective, a virulent lack of theoretically sound and yet applicable methods for controlling standards and networks leaves substantial efficiency potentials unused. The challenge for corporate standardizers thus results from the reciprocity of local and global phenomena: local efficiency cannot sufficiently be analyzed independent of macro-effects like especially network effects. Hence, decision support models have to incorporate not only the local determinants of standardization processes but also their global diffusion and efficiency effects. A famous example in corporate reality for the resulting diffusion start-up problem is *aggressive awaiting*, an often-witnessed strategy of agents trying to avoid the risk of being the first - and possibly only - adopter of a new technology that then does not offer enough benefits to compensate for the costs. In network effect theory, this excess inertia phenomenon is known as penguin effect (Farrell, Saloner 1986, 943). In practise, this problem is often further aggravated by the asymmetry between the costs and benefits resulting from standardization when independent business units perceive no incentive to invest into compatibility (from their autonomous IT budget) when the benefits from standardization are accredited to the "entire" firm or any other entity different from the investing unit. Thus, the benefits of standardization need to be explicated and incorporated into a decision model in order to make them managerial.

In this paper, a method for standard controlling synchronizing local and global efficiency is developed. The concept is based on a *network return on investment* (ROI) to make standardization benefits tradable. The method can help firms to establish competitive IS infrastructures by actively controlling their standardization processes. Thereby, this paper aims at contributing to the workshop's goals by providing a managerial economic model to control standard diffusion and implementation processes. Goal of this paper is to

- develop a simple model to determine network equilibria under which firms will cooperate on standardization
- and thereby derive a solution strategy for corporate standard implementation

in order to develop a method for overcoming the renowned start-up problem and contribute to making the use of standards controllable. One important finding of modelling the strategic situation of network agents using basic game theory is that firms may collaboratively implement standards given a set of conditions that is explicated in the model. The mutually advantageous solution that can be achieved using the network ROI is a Nash equilibrium since no firm will be better off deviating from it.

Based on a brief overview of standardization problems, the conceptual standardization framework underlying this work is introduced in section 2. In section 3, the concept of a network ROI is developed, starting from a simple two-player standardization solution that is then generalized to an n-player standardization game with a virtual principal. In section 4, the approach is applied to a real network of six enterprises deciding on the introduction of an X.500 standard based directory service. The experience from that project demonstrates the value of the network ROI approach but also highlights other practical obstacles which are discussed as further research in section 4.

CONCEPTUAL FRAMEWORK

Network effect theory

Standardization problems or more generally economic network analysis are often based upon the theory of positive network effects (Besen, Farrell 1994, 118). Network effects describe a positive correlation between the number of users of a standard and its utility (demand side economies of scale (Farrell, Saloner 1985) (Katz, Shapiro 1985)). They imply multiple equilibria (Arthur 1989) and hence possibly unfavorable outcomes. The pattern of argument in network effect theory is always the same: the discrepancy between private and collective gains in networks under increasing returns leads to possibly Pareto-inferior results (market failure, unexploited network gains) (David, Greenstein 1990). With incomplete information about other actors' preferences, excess inertia ("start-up problem") can occur as no actor is willing to bear the disproportionate risk of being the first adopter of a standard or technology and then becoming stranded in a small network if all others eventually decide in favor of another technology (Farrell, Saloner 1986). This renowned start-up problem prevents any standardization at all even if it is preferred by everyone. From an economic perspective, this is not surprising: in traditional neoclassical economics there is no difference between local and global efficiency (private and collective gains) if the validity of the fundamental theorems of welfare economics (Hildenbrandt, Kirmann 1976) can be proven. This is the case when certain premises are fulfilled as especially the absence of externalities. Unfortunately, network effects as a constituting particularity in networks are a form of externality, thus disturbing the automatic transmission from local to global efficiency (Weitzel et al. 2000). Accordingly, standardization problems, that are characterized by the existence of strong network effects, transcend large parts of traditional economics. Additionally, since the network metaphor, and therefore most practical standardization problems, are strongly influenced by factors outside the premises mentioned above, it has proven difficult to find empirical evidence for e.g. start-up problems that is not too ambiguous (Liebowitz, Margolis 1995). The reason is that many of the traditional findings owe their particularities in large parts to implicit premises like infinitely increasing network effects or homogeneous network agents. Thus, while the traditional models contributed greatly to the understanding of a wide variety of general problems associated with the diffusion of standards, much research is still needed to make the results applicable to real world problems (Liebowitz, Margolis 1994). Additionally, the specific interaction of standards adopters within their personal socio-economical environment and the potential decentralized coordination of network efficiency (as has long been demanded by sociologists and institution theorists) are neglected. As a result, important phenomena of modern network effect markets such as the coexistence of different products despite strong network effects or the fact that strong players in communication networks force other participants to use a certain solution cannot be sufficiently explained by the existing approaches (Liebowitz, Margolis 1994) (Weitzel et al. 2000). For an extensive overview see (David, Greenstein 1990) (Economides 2000) (Weitzel 2003).

Controlling standards and infrastructures

Due to interdependency (or commonality) properties associated with standards, interoperability problems are often infrastructural problems (Perine 1995). Typically, in standardization problems there are significant uncertainties concerning factual costs and benefits as well as adequate planning and controlling strategies. Also, network agents can collaboratively implement a standard to channel their mutual network effects or they can decentrally decide on standardization. While centrally deciding (top down by a centralized authority) might in principal internalize more network effects, decentrally deciding firms (bottom up, e.g. by business units with autonomous IT budgets) are more likely to refuse centralized control especially if there is no transparent model explicating the local and global benefits of mutually standardizing. Due to the asymmetry of costs and benefits between the mostly heterogeneous participants (or affected agents) these phenomena often result in considerable underestimations of network potential, leading to observable behaviors like "aggressive awaiting". There are many structurally similar examples, among them EDI networks (Weitzel 2003, 165-183) and most corporate intra- and extranet decisions (e.g. document, knowledge, and security management systems or office software (Westarp 2003)).

Apart from the network effect and also diffusion theory literature, there are approaches trying to support decisions concerning the coordination of decentralized investments in corporate infrastructure, e.g. in the controlling literature (Kargl 2000) (Krcmar 2000), TCO models (total cost of ownership) as proposed by Gartner Group in 1986 (Berg et al. 1998) (Emigh 2001) (Herges, Wild 2000) (Riepl 1998), scoring models or qualitative models such as Balanced Score Cards (Wiese 2000). Many contributions to network effect theory suffer especially from neglecting decentralized solution mechanisms which makes them largely inapplicable to corporate standardization problems (Weitzel et al. 2000). At the same time, most approaches from the controlling literature are incapable of incorporating interdependencies given rise to by network effects.

A basic model: Network costs and benefits

The *benefits of standardization* derive from improved interaction between partners. These improvements are associated with decreased information costs due to cheaper and faster communication (Kleinemeyer 1998, p. 63) and less converting and friction costs (media discontinuities) (Braunstein, White 1985) (Thum 1995, pp. 14-15) as well as more strategic benefits enabling a further savings potential like for instance just in time production (Picot et al. 1993).

The *costs of standardizing* include technical and organizational integration associated with costs of hardware, software, switching, and introduction or training, often referred to as standardization costs. Furthermore, the interdependence between individual decisions occasioned by network externalities can yield coordination costs of agreeing with market partners (Kleinemeyer 1998, p. 130). More generally, coordination costs embody the costs of developing and implementing a network-wide communications base comprised of a specific constellation of standards which considers the individual, heterogeneous interests of all actors. Concretely, these include costs for time, personnel, data gathering and processing, and control and incentive systems. Depending upon the context, these costs can vary widely (Barua, Lee 1997, pp. 402-403).

Let K_i denote the standardization costs of agent i and c_{ij} the standardization benefits to agent i from j also standardizing (i.e. direct network effects to i) (Weitzel et al. 2003b). Equation 1 then describes the (decentralized) standardization condition for agent i.

$$\sum_{\substack{j=1 \\ j\neq i}}^{n} c_{ij} - K_i > 0$$

Equation 1: Standardization condition of agent i (ex post)

In contrast, a network owner would prefer a centralized solution with $\sum_{i=1}^{n} c_i - \sum_{i=1}^{n} K_i \rightarrow \max!$. The challenge is finding a mechanism that allows to close the gap between these two coordination regimes (Weitzel et al. 2003b). This is exactly the aim of the network ROI developed in the next section.

A NETWORK ROI

The concept of ROI

Standardization is a decision problem implying the common trade-off between standardization costs (K_i) and associated benefits from network participation (c_{ij}). From the perspective of a central entity (such as the management of a huge firm where the "agents" are autonomous business units), the coordination problem arises of how to synchronize individual and aggregate objective functions. One classic solution is profit sharing guaranteeing each participating agent “fair” returns on their participation costs (Varian 1994). Incentive compatibility then results from the virtual identity of the individual and collective objective functions. But this rests upon the assumption that overall there are sufficient network gains to be redistributed and that a redistribution design can be developed in the sense that all those agents suffering from the change can at least be compensated so that everyone is at least not worse off afterwards. In economic equilibrium analysis the first proposition implies that the eventual allocation is Kaldor-Hicks-superior to the former and the second proposition that it is even Pareto-superior (Weitzel et al. 2003).

An often used measure for decision quality is the return on investment (ROI) describing the profitability of invested capital (of firms, units, products etc.). The ROI serves as a strategic yield return rate that is usually supposed to cover the costs of capital and that should be above the industry's average (Franke, Hax 1995, pp. 177-179). The concept became famous as early as 1910 when DuPont company used it for finance allocation (Kaplan 1984). A basic presupposition is a clear definition of input and output (Horvath 1988) so that a ROI can be determined as $\frac{output}{input}-1$. Break-even analysis analogously determines the period of ROI=1 (or a similar minimum success) and was called the "dead point" in 1923 by J. F. Schär (Schär 1923).
In the next sections, the concept is extended towards a network ROI to show under what conditions preferable equilibria are reached and how agents deciding on standardization can achieve preferable outcomes from standardization games.

A two player solution

We first analyze the situation that in a 2-player standardization scenario with complete information agent 2 favors standardization, but not agent 1 ($c_{12}<K_1$ und $c_{21}>K_2$) while from a central perspective standardization is advantageous ($c_{12}+c_{21}>K_1+K_2$) (see Table 1). Strategically, this is a conflict equilibrium that needs some redistribution scheme (see Weitzel et al. (2003) for an explicit network equilibrium analysis). Without redistribution, bilaterally no standardization is an equilibrium. The question now is how to overcome this dilemma. Let A_{21} be the compensation paid by agent 2 in case of bilateral standardization, then according to Equation 2 the standardization equilibrium (s_{12},s_{22}) is realized when the standardization costs of 1 reduced by the side payment are smaller than information costs.

$$K_1-A_{21}<c_{12}$$

Equation 2: Condition for side payment from the perspective of agent 1

	agent 2	
agent 1	s_{21}	s_{22}
$\mathbf{s_{11}}$	(c_{12},c_{21})	$(c_{12},c_{21}+K_2)$
$\mathbf{s_{12}}$	$(c_{12}+K_1-\mathbf{A_{21}},c_{21}+\mathbf{A_{21}})$	$(K_1-\mathbf{A_{21}},K_2+\mathbf{A_{21}})$

Table 1: Infrastructure decision with side payments

Agent 2 agrees to the side payment design if his benefits exceed his standardization costs including the compensation (Equation 3). The lower and upper bounds for the side payment can now be determined as in Equation 4.

$$K_2+A_{21}<c_{21}$$

Equation 3: Condition for side payment from the perspective of agent 2

$$K_1-c_{12} < A_{21} < c_{21}-K_2$$

Equation 4: Lower and upper bounds of side payment

Still, standardization is not a unique equilibrium and the eventual amount of the side payment remains open. It will be determined by factors like the negotiation skills of the partners. Especially in the context of decisions like the X.500 case described later, developing mechanisms for determining side payments that are considered to be *fair* by all affected agents is crucial for finding solutions to standardization problems. In the following, we will propose a possible method of determining "fair" compensation payments that is based on the idea of redistributing a network ROI such that all participants in the solution reap similar network benefits. Ultimately, a higher degree of standardization will be achieved at the cost of the biggest profiteers, compared to the case of overall standardization without redistribution. It is important to remember that an investment's return in this definition is not necessarily associated with a direct cash flow, making all calculations somewhat soft, of course.

In a two player network the ROI can be determined according to Equation 5 (see Equation 19 for an application to empirical data):

$$ROI = \frac{c_{12} + c_{21}}{K_1 + K_2} - 1$$

Equation 5: Network ROI for a two player network

If the ROI is negative, standardization will not pay off. In cases where it is positive, standardization can possibly be advantageous for all agents. The side payment for overcoming a possible coordination problem can be determined according to Equation 6.

$$ROI_i = \frac{c_{ij} + A}{K_i} - 1 \overset{!}{=} \frac{c_{12} + c_{21}}{K_1 + K_2} - 1 = ROI_{(network)}$$

Equation 6: Individual ROI$_i$

A positive side payment A implies transfers from j to i and vice versa. For two player networks, possible side payments are alike and can be determined according to Equation 7. Although fairness is a concept that is often disputed, the proposition of guaranteeing positive payoffs for all participants could meet a basic understanding.

$$A^* = \frac{c_{12} + c_{21}}{K_1 + K_2} K_i - c$$

Equation 7: Side payment in a two player network

Using side payments, the strategic situation of the players changes as shown in Table 2.

	agent 2	
agent 1	s_{21}	s_{22}
s_{11}	(c_{12},c_{21})	$(c_{12},c_{21}+K_2)$
s_{12}	$(c_{12} + K_1 - \mathbf{A^*}, c_{21} + \mathbf{A^*})$	$(K_1 - \mathbf{A^*}, \mathbf{K_2 + A^*})$

Table 2: Infrastructure decision with side payments

Algebraic signs of equilibrium side payments A* are determined according to Table 1.

$$A^* = \left| \frac{c_{12} + c_{21}}{K_1 + K_2} K_1 - c_{12} \right|$$

Equation 8: Side payment in two player network

The ROI-based compensation is within the interval $(K_1 - c_{12}) < A < (c_{21} - K_2)$:

$$K_1 - c_{12} < \left| \underbrace{\frac{c_{12}+c_{21}}{K_1+K_2}}_{>1} K_1 - c_{12} \right| = A^* \qquad c_{21} - K_2 > \underbrace{\left| c_{21} - \underbrace{\frac{c_{12}+c_{21}}{K_1+K_2}}_{>1} K_2 \right|}_{\text{difference exchangable since only algebraic sign is relevant}} = A^*$$

$$\text{s.t.: } c_{12} < K_1; c_{21} > K_2; c_{12} + c_{21} > K_1 + K_2$$

Equation 9.1-5: Side payments within the bounds described in Equation 4

In summary, ROI-based compensations can establish a unique (Nash) standardization equilibrium that is Pareto-efficient as well as Kaldor-Hicks-efficient. It is not strictly trembling hand perfect, though: The error probability of agent 1 concerning the standardization strategy (s_{12},s_{22}) is determined by Equation 10.

$$E(s_{11}) = e_2 c_{12} + (1-e_2)c_{12} < e_2(c_{12} + K_1 - A^*) + (1-e_2)(K_1 - A^*) = E(s_{12})$$
$$\Rightarrow e_2 > 1 - \frac{K_1 - A^*}{c_{12}}$$

Equation 10: Critical error probability of agent 1

If agent 1 estimates error probability ε_2 of agent 2 erroneously choosing strategy 1 (no standardization) to be greater than expressed in Equation 10 he will choose strategy 1, too. Accordingly, agent 2 chooses s_1 if he considers the tremble of 2's hand to be greater than expressed in Equation 11.

$$E(s_{21}) = e_1 c_{21} + (1-e_1)(c_{21} + A^*) < e_1(c_{21} + K_2) + (1-e_1)(K_2 + A^*) = E(s_{22}) \Rightarrow e_1 > 1 - \frac{K_2}{c_{21}}$$

Equation 11: Critical error probability of agent 2

An n-player solution

The network wide ROI for n-player networks can be determined using Equation 12.

$$ROI_{network} = \frac{\sum_{i=1}^{n} \sum_{\substack{j=1 \\ i \neq j}}^{n} c_{ij}}{\sum_{i=1}^{n} K_i} - 1$$

Equation 12: Network ROI for n agents

The numerator sums all c_{ij} since it is assumed that no optimal solution with regard to the optimum set of participating players in a network has been determined yet. If a network ROI for a particular constellation of agents is to be determined the c_{ij} of course only denote the relevant edges. This proposed mechanism requires that the set of agents participating in the standardization solution is already determined as for instance in the X.500 case described later. Thus, due to the interdependencies associated with network effects, the network ROI can not be used to determine the optimal set of standardizing agents but rather solve the start-up problem amongst a well known set of actors. See section *Problems associated with the ROI* for deficiencies of the ROI concept when applied to decide between alternative network constellations.

The individual decision functions have to consider the proposed side payments A_{ij} (given or received by i) as in Equation 13 (it is possible that payments can be received as well as paid).

$$ROI_i = \frac{\sum_{\substack{j=1 \\ i \neq j}}^{n} c_{ij} + \sum_{\substack{j=1 \\ i \neq j}}^{n} A_{ij}}{K_i} - 1$$

Equation 13: Individual ROI of agent i

$$ROI = \frac{\sum_{i=1}^{n} \sum_{\substack{j=1 \\ i \neq j}}^{n} c_{ij}}{\sum_{i=1}^{n} K_i} - 1 \overset{!}{=} \frac{\sum_{\substack{j=1 \\ i \neq j}}^{n} c_{ij} + \sum_{\substack{j=1 \\ i \neq j}}^{n} A_{ij}}{K_i} - 1 = ROI_i \Rightarrow \sum_{\substack{j=1 \\ i \neq j}}^{n} A_{ij} = \frac{\sum_{i=1}^{n} \sum_{\substack{j=1 \\ i \neq j}}^{n} c_{ij}}{\sum_{i=1}^{n} K_i} K_i - \sum_{\substack{j=1 \\ i \neq j}}^{n} c_{ij}$$

Equation 14: Determination of side payment for agent i

A network ROI for a virtual principal

By using a virtual principal, agents in a decentrally coordinated network could try to internalize some of their network effects. Among others, the principal can reduce the number of communication acts between the agents for coming up with a solution or provide a trusted service of using reported local information for controlling mutual network infrastructures but keeping them secret so as to protect individual information from being seen by others. Electronic marketplaces might serve as an example as well.

In controlling theory centralized (administrative) services are described by subadditive cost functions (due to economies of scale) which has the question arise what part of the associated costs should be covered by the business units receiving the services. Here the concept of fairness is discussed with regard to the different allocation schemes. See Ewert, Wagenhofer (1993, pp. 540-552) for an overview.

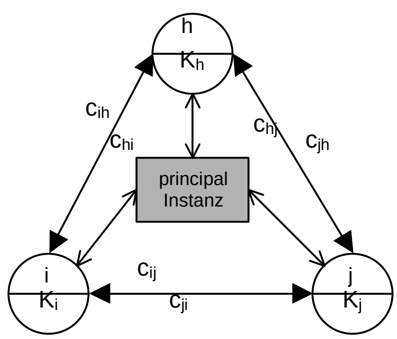

Figure 1: Network with three agents and a principal

Abstractly speaking and given that all agents report truthfully, the (virtual) principal described can transform a decentralized standardization problem under uncertainty to a centralized scenario. These services will require some compensation that can in this context be interpreted as agency costs (Schmidt, Terberger 1997, p. 405) that reduce the network wide ROI but might still yield better results than a decentralized scenario without any multilateral coordination. These principal's costs (K_P) increase aggregate standardization costs (Equation 15 and Equation 16).

$$ROI_{network} = \frac{\sum_{i=1}^{n} \sum_{\substack{j=1 \\ i \neq j}}^{n} c_{ij}}{\sum_{i=1}^{n} K_i + \underbrace{K_P}_{\substack{coordination \\ \cos ts}}} - 1$$

Equation 15: Network ROI in n-player network with principal

$$ROI_i = \frac{\sum_{\substack{j=1 \\ i \neq j}}^{n} c_{ij} + \sum_{\substack{j=1 \\ i \neq j}}^{n} A_{ij}}{K_i + \frac{1}{n} K_P} - 1$$

Equation 16: Individual ROI of agent i in n-player network with a principal

Side payments can be determined by equaling ROI_i and $ROI_{network}$ according to Equation 17.

$$ROI_{network} = \frac{\sum_{i=1}^{n} \sum_{\substack{j=1 \\ i \neq j}}^{n} c_{ij}}{\sum_{i=1}^{n} K_i + K_P} - 1 \overset{!}{=} \frac{\sum_{\substack{j=1 \\ i \neq j}}^{n} c_{ij} + \sum_{\substack{j=1 \\ i \neq j}}^{n} A_{ij}}{K_i + \frac{1}{n} K_P} - 1 = ROI_i \;\Rightarrow\; \sum_{\substack{j=1 \\ i \neq j}}^{n} A_{ij} = \frac{\sum_{i=1}^{n} \sum_{\substack{j=1 \\ i \neq j}}^{n} c_{ij}}{\sum_{i=1}^{n} K_i + K_P} (K_i + \tfrac{1}{n} K_P) - \sum_{\substack{j=1 \\ i \neq j}}^{n} c_{ij}$$

Equation 17: Side payments for agent i considering principal's costs

The concept of the network ROI has been developed to propose a general way of solving the implementation problem. Still, for a particular problem a determination of individual side payments deemed fair by everyone involved remains a difficult task and is, among others, depending on individual negotiating skills and probably additional goals. The simple proposition to use a homogeneous ROI as a *fair* redistribution concept is certainly nothing more but a practical and supposedly controllable approximation. See Güth et al. (2001) for an experimental analysis of fairness within firms (one principal, many agents).

Problems associated with the ROI

The determination of target costs, earnings, or revenues is a prominent problem in corporate accounting and planning (Ewert, Wagenhofer 1993, p. 289) (Sakurai 1989, p. 43). The ROI is a measure frequently used to describe the cost effectiveness of investments. In contrast to the more frequently used ROS (return on sales) the ROI requires the difficult assignment of invested capital to products. What is often surprising, is that the biggest problem is the interpretation of the ROI in dynamic problems. As emphasized above, the network ROI is not suitable for determining the optimal set of network participants. The reason is that an ROI measures average capital efficiency. As a result, maximizing the ROI regularly yields results very different from the (centrally) optimal strategy. Under-investing is an especially frequent result when mistaking the ROI for determining the optimum investment policy because any additional investment besides the single most profitable - in this case new agents - has *average* profitability decrease. Thus using an ROI to configure an investment program would result in the investment manager choosing only one project which is the one with the highest profitability. See Ewert, Wagenhofer (1993, pp. 460-465) for an example. In the context of the standardization problem this implies that for any given constellation of network participants an ROI needs to be positive to make it possible for the solution at choice to be centrally advantageous. But since the ROI measures average profitability it is not adequate for choosing between different solutions. The problem becomes obvious in the network of Figure 2. Evidently, all three agents should standardize. But the highest ROI is achievable if only agents 1 and 2 standardize (33% versus 20% if all standardize). This is, of course, only a very rudimentary consideration (or a 'capital productivity') since the capital stock is quasi endogenized: what happens to the remaining capital not invested? For a more subtle analysis capital costs need to be considered in order to discuss an ROI in the context of investment problems in managerial accounting.

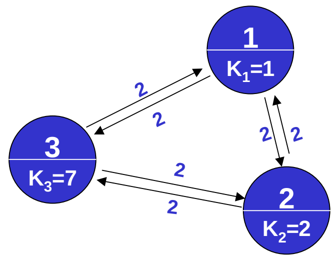

Figure 2: Example of discrepancy between maximum ROI and centralized solution (edges show c_{ij}, i.e. efficiency potential if both adjacent nodes standardize)

It must be stressed again that the proposed concept so far only addresses the implementation problem between agents that are basically willing to cooperate, sometimes referred to as a start-up problem. It does not account for situations like in some supply chains where e.g. size per se establishes asymmetric negotiating power and can determine the outcome of standardization games, i.e. when a network agent has to standardize "out of strategic necessity" (Barua, Lee 1997, p. 399). Despite these problems, for traditional investment and internal controlling decisions an empirical survey among 620 of the biggest U.S. enterprises revealed that 65% of all managers use the ROI as their only profitability measure, another 28% used the ROI and residual earnings (which avoids most of the problems) (Reece, Cool 1978). This is a major reason why ROI based solutions stand a fair chance to be adopted by managers.

APPLYING THE NETWORK ROI - A CASE OF X.500 DIRECTORY SERVICES

The case study described below deals with the decision to use a common X.500-based directory service as an electronic phone directory among six German bank and insurance companies in cooperation with Siemens AG. As part of a profitability analysis, costs and benefits are qualified. To guarantee anonymity, the six enterprises are called E1 to E6 in order of decreasing size (number of employees). We discriminate between a centralized decision (cooperative solution that allows reaping 'central' coordination benefits) and decentralized (individual) decision. Empirical data was collected using a questionnaire that was presented to the respective IT managers in personal interviews. In particular, additional cost data information was provided by Siemens managers due to their experience with DirX. Necessary assumptions were based on the experience of Siemens employees and the six enterprises and are, compared to similar studies, largely conservative. For the full study see Weitzel (2003, pp. 192-205).

Directory Services

A Ferris study from November 1998 shows the importance of a common standard-based infrastructure for sharing data from different sources: 50 Fortune 1,000 IT managers are responsible for 9,000 directories which makes an average of 180 directories per enterprise (Ferris 1998b, pp. 45ff.). Since 1988, the OSI standard X.500 has been the foundation for distributed directory services aiming at integrating computer systems of different vendors and platforms (ISO 1988). An X.500-Directory (meta directory) can be considered a virtual data pool residing on top of (and synchronizing) all underlying directories („all directories in one"). The benefits of using X.500 directory services and associated interface standards like LDAP in particular (making data easily available using TCP/IP) are the following:

- enhanced data availability
- more reliable and real time data (*Single Point of Administration & Access)*
- security and single sign on/single log on (SSO/SLO; X.509)
- efficient administration (data maintenance, user management, software updates etc.)

The *benefits* consist of short term and long term benefits (Lewis et al. 1999, pp. 13ff.). Short term benefits describe improved communication between network participants and are composed of reduced communication costs. Long term benefits describe strategic effects that are very difficult to estimate.

The *costs* associated with directory services are:

- product costs: hardware, software, licenses, typically amounting to 50% of total costs.
- professional services: especially during systems integration, these costs derive from namespace design, development of a directory schema, integration with legacy data and testing. There can also be (administrator and user) skilling costs.

Empirical data

Standardization costs

Product costs ($C_P^{X.500}$) contain start-up costs and operational ongoing costs (support etc.) (Lewis et al. 1999, p. 25) for the directory. Each enterprise must buy a server (DEM 25,000), client licenses (DEM 100 per user, rebates are described later) and support (2.8% of total costs for three years). In cases of centralized coordination, rebates of up to 30% are possible for user licenses but a seventh server would also be required (Siemens 1999, pp. 6ff.).

Professional services ($C_{PS}^{X.500}$) include personnel (especially status quo analysis, directory design, and implementation). Burton Group estimates that the costs of a directory for a Global 1,000 enterprise average $1-2 Mio. (Lewis et al. 1999, p. 5). The average personnel service costs of the analyzed enterprises (decentralized coordination) were DEM 350,000 (gross costs of 1 person, 1 year) per enterprise. This number was weighted to consider the relative complexity of the respective tasks, measured by administration overhead as time per data change operation using a multiplier from the interval [0.6; 1.3] with 0.6 describing low complexity. The complexity key is used to assign professional service costs according to their origin:

$$\text{complexity key for } C_{PS}^{X.500} = \frac{\text{administration (hour/month)}}{\text{fluctuation} * \text{employees}}$$

Equation 18: Complexity key

With centralized coordination, professional services ($C_{PS}^{central}$) amount to two person years (DEM 700,000) because collectively implementing the standard offers great savings potential especially when planning the directory. Again, these costs are assigned using the complexity key.

Standardization benefits

Short-term benefits ($C_i^{X.500}$) of the meta directory comprise communication cost savings consisting of user costs ($C_{User}^{X.500}$), administration costs ($C_{Admin}^{X.500}$), printing costs ($C_{Print}^{X.500}$).

Long-term benefits are not quantified because of their vague nature. Yet these benefits are probably the most important, especially considering tendencies towards growing system complexity due to mergers, acquisitions and generally the increasing significance of integrating partners into common networks. Examples of strategic aspects are security management (PKI), knowledge management, customer care (CRM), directory-enabled computing (applications are provided by a directory or use a centralized information pool) or new collaboration forms like virtual teams. The short-term benefits are based upon these premises:

End user cost savings ($C_{User}^{X.500}$) quantify accelerated searches and improvements qua single sign on (Radicati 1997, pp. 5ff.). These improvements are estimated to be 5 minutes per user and day with a user productivity of 80% and tariff wages of DEM 80,000 p.a. (210 working days, 38.5 hours per week). Social costs etc. to determine gross employee costs are considered by multiplying the annual gross wage by 1.8. Variations of the 5 minute assumption are discussed in the sensitivity analysis in Weitzel et al. (2001).

Administration cost savings ($C_{Admin}^{X.500}$) come about due to easier data management (bi-directional synchronization, single point of access & administration, consistent data, integrated HR systems with globally working set-up, change and delete operations etc.). Time savings are estimated to be 25% (average wage DEM 100,000; 40 hours per week)

Print cost savings ($C_{Print}^{X.500}$) consist of hard costs (materials) and distribution costs. The Canadian government was able to save $ 1.5 million within two years using a directory because the number of phone books printed twice a year could be reduced from 250,000 to 7,000 (Ferris 1998a, pp. 16ff.). Print costs are estimated to amount to DEM 10-20 per employee and are assigned based upon the number of employees and their dispersion (number of locations).

Profitability analysis

E1 is the largest of the participating enterprises, accounting for more than half of network size (58.1%) and therefore being responsible for the majority of costs and benefits. Table 3 summarizes the initial situation of the six firms.

	E 1	E 2	E 3	E 4	E 5	E 6
employees/locations	11500 / 88	4580 / 22	1200 / 5	1000 / 9	800 / 73	700 / 3
fluctuation (in %)	1.5%	8.6%	30%	$>$ 100%	18.75%	30%
administration (h/month)	88	24	24	1,5	16	16
phone books used (p)aper, (e)lectronic	p e	p e	p e	p	p e	p e
issued	biannually	bi.ann.	bi.ann.	bi.ann.	bi.ann.	bi.ann.
synchronization	manually	man.	man.	man.	man.	man.
complexity key professional services	$\frac{88}{0.015 \text{ x } 11500} \approx 0.51$	0.061	0.067	0.0015	0.107	0.076

Table 3: Basic data of the six firms

After determining the complexity keys according to Equation 18, the multipliers are determined for all enterprises with E1 having the highest complexity grade (0.51) and therefore the largest multiplier (1.3) as shown in Table 4. The figures show a professional service savings potential when centrally implementing the directory of DEM 948,500. In addition, there are decentralized product costs according to Table 5.

	E 1	E 2	E 3	E 4	E 5	E 6	S
C_{PS}-multiplier	1.3	0.68	0.69	0.6	0.74	0.7	
C_{PS} (decentral)	455,000	238,000	241,500	210,000	259,000	245,000	1,648,500
C_{PS} (central)	193,206	101,062	102,547	89,172	109,979	104,034	700,000

Table 4: C_{PS}-multiplier and professional service costs

server DEM	25,000	
user licenses (700 x 100.- DEM)	70,000	
support (2,8% of total costs for 3 years) DEM	(0.028 x 95,000)/3= 887	***= 95,887 DEM***

Table 5: Calculation for product costs of E6

Since multi-user rebates going together with centralized coordination allow for license rebates of 30%, centralized standardization costs DEM 2,273,924. In contrast, decentralized coordination amounts to DEM 3,796,362 (+ DEM 1,522,438) (Table 6).

	E 1	E 2	E 3	E 4	E 5	E 6	S
			DECENTRAL				
server	25,000	25,000	25,000	25,000	25,000	25,000	150,000
client licenses	1,150,000	458,000	120,000	100,000	80,000	70,000	1,978,000
support	10967	4508	1353	1167	980	887	19,862
total costs	1,185,967	**487,508**	**146,353**	**126,167**	**105,980**	**95,887**	**2,147,862**
			CENTRAL				
server	25,000	25,000	25,000	25,000	25,000	25,000	150,000
client licenses	805,000	320,600	84,000	70,000	56,000	49,000	1,384,600
support	7,747	3,226	1,017	887	756	691	14,324
total costs	**837,747**	**348,826**	**110,017**	**95,887**	**81,756**	**74,691**	**1,548,924** + 25,000 **1,573,924**
			DIFFERENCE				
$C_p^{dec} - C_P^{cen}$	**348,220**	**138,682**	**36,336**	**30,280**	**24,224**	**21,196**	D **573,938**

Table 6: Product costs (DEM)

Increased user productivity is achieved by accelerated information search and single sign on. Based on an estimated 5 minutes per user and day, benefits ($C_{User}^{X.500}$) of ((80,000.- DEM · 1.8)/(210 · 7.7 · 60 min)) · 5 min = 7.40 DEM/day or DEM 1,554.- p.a. can be achieved. At 80% productivity, this results in DEM 1,243.20 per user and year. Institutional savings are summarized in Table 7.

	E 1	E 2	E 3	E 4	E 5	E 6	Σ
users	11,500	4,580	1,200	1,000	800	700	19,780
$C_{User}^{X.500}$ (DEM/year)	14,296,800	5,693,856	1,491,840	1,243,200	994,560	870,240	24,590,496

Table 7: User cost savings

Besides reducing user costs, a directory can improve upon administration costs as described in Table 8. Print cost savings (Table 9) are easily and definitely measurable. shows the results for administration cost savings while Table 10 determines overall standardization benefits.

	E 1	**E 2**	**E 3**	**E 4**	**E 5**	**E 6**	S
administration (min/year) data mgmt.	5,280	1,440	1,440	90	960	960	10,170
$C_{Admin}^{X.500}$ (DEM/year)	28,195	7,690	7,690	481	5,126	5,126	54,308

Table 8: Administration cost savings

	E 1	**E 2**	**E 3**	**E 4**	**E 5**	**E 6**	S
employees/phone users	11,500	4,580	1,200	1,000	800	700	19,780
total costs phonebooks (DEM)	20	16	14	14	12	10	∅
print cost savings p.a. $C_{Print}^{X.500}$)	460,000	146,560	33,600	28,000	19,200	14,000	701,360

Table 9: Print cost savings

	E 1	**E 2**	**E 3**	**E 4**	**E 5**	**E 6**	S
$C_{User}^{X.500}\ {}^{DEM}\!/_{year}$	14,296,800	5,693,856	1,491,840	1,243,200	994,560	870,240	24,590,496
$C_{Admin}^{X.500}\ {}^{DEM}\!/_{year}$	28,195	7,690	7,690	481	5,126	5,126	54,308
$C_{Print}^{X.500}\ {}^{DEM}\!/_{year}$	460,000	146,560	33,600	28,000	19,200	14,000	701,360
$\sum C_i^{X.500}\ {}^{DEM}\!/_{year}$	**14,784,995**	**5,848,106**	**1,533,130**	**1,271,681**	**1,018,886**	**889,366**	**25,346,164**

Table 10: Determinants of standardization benefits

Deriving a network ROI for directory services

The empirical data can now be aggregated as a profitability measure. We can determine a return on investment for directory services (ROI_{DS}) (Radicati 1997, 5) according to Equation 19.

$$ROI_{DS}^{central} = \frac{C_{User}^{X.500} + C_{Admin}^{X.500} + C_{Print}^{X.500}}{C_{P}^{X.500} + C_{PS}^{X.500}} = \left[\left(\frac{24{,}590{,}496 + 54{,}308 + 701{,}360}{1{,}573{,}924 + 700{,}000}\right) = \left(\frac{25{,}346{,}164}{2{,}273{,}924}\right)\right] \approx 11.15$$

Equation 19: Return on investment (directory services)

Ultimately, implementing the directory enables to help realize savings amounting to DEM 25 million. The benefits exceed the costs by 11 in the centralized scenario, by 6.7 in the decentralized case. The break-even point is reached within 8 months. Figure 3 summarizes the findings and shows the relations between enterprise size and costs and benefits. See section *Problems associated with the ROI* for warnings of misapplying the concept.

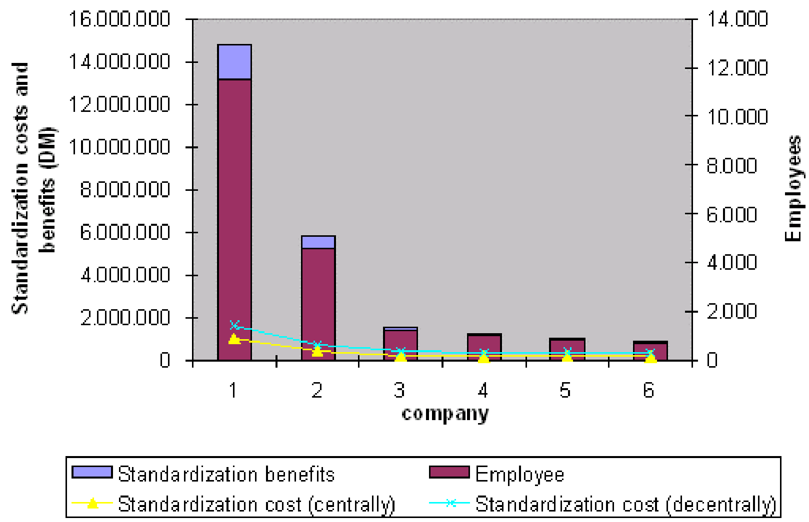

Figure 3: Costs and benefits of X.500 standard implementation

A virtual principal as solution

The enterprises participating in the study had searched for ways of building a common IT infrastructure. Like business units in one large enterprise, E1-E6 have been working together closely for years and plan doing so in the future. Thus, the partners already knew each other and building a common infrastructure was basically already agreed upon. The situation is therefore similar to the early stages of airline alliances such as the Star Alliance with huge enterprises and voluminous internal data traffic with an increasing fraction of cross enterprise communication.

For planning and maintaining their common infrastructure they founded in common a firm (which we will call P subsequently, as in section *A network ROI for a virtual principal*) that was intended to take care of planning, development and operations of telecommunications technology standards and applications. Other duties include controlling quality and security standards and the integration of new partners. Since E1-E6 autonomously decide on how to spend their individual IT budgets, a major responsibility of P is offering cooperation designs to the six enterprises that promise greater utility than individual, decentralized activities. From the interviews it was obvious that the enterprises considered substantial long-term collaboration to be essential. Thus reflecting the fact that especially investments in infrastructure yield some "hard" benefits but mostly serve as an enabler for a variety of other applications the benefit of which are only very tough to anticipate, participants expressed a satisfactory rather than maximization decision behavior during an early planning stage: investments in a common infrastructure are made as long as there is a substantial expectation that costs will at least be covered. Thus, P generally has to come up with a cost and compensation plan, making sure that no participant suffers from net losses. Thereby, the responding managers supported the network ROI concept.

But despite this verbal confirmation, the project yielded different practical experiences. On the one hand, modeling the standardization situation as above turned out to be a very valuable approach to all participating firms since it demonstrated the extent of interrelatedness no one was aware of before. Also, quantifying the dependencies made them negotiable which was a substantial step forward. But on the other hand, determining a theoretically advantageous or fair solution turned out to be not sufficient. Until now, despite the extraordinarily large ROI potential, the firms did not implement the common directory for two reasons. The first and surprisingly insurmountable reason is rooted in the firms' organization. Most of those responsible for the standardization decisions were "cost centers" and thus did not have any incentive to invest anything since a cost center is only responsible for local costs but not local or global benefits. The other reason was that despite an exogenously enforceable promise to compensate for all costs exceeding the benefits and especially notwithstanding the announcement to happily accept a guaranteed positive ROI, the managers were reluctant to participate since they all felt their share of the costs might be larger than that of the others. As a result, mutually no benefit was individually preferred to a definite benefit to all. All these phenomena, from organizational restrictions over the discrepancy between announced and actual objective functions of the managers to not taking sure bets, show the limitations of the proposed approach and establish strong challenges for future work.

FURTHER RESEARCH

While the network ROI can only be one of many ideas for addressing corporate standardization problems, it is undisputed that better solution strategies that are relevant for management controlling decisions are bitterly needed. These could be developed and tested using and adapting the findings from larger parts of the literature on game theory, controlling and organization theory, option price theories, to name but a few. One approach could be extending the model to analyze the influence of local coalitions in networks: similar to the network principal proposed, agents could make binding agreements with their most important (e.g. biggest c_{ij}) one, two, or more partners imitating centralized decision behavior within their individual clusters. If coordination costs increase with the number of partners forming the coalition, we can expect to find an optimum number of internalization partners. Empirical data concerning the cost development of the coordination costs compared to K_i, for example, could provide especially valuable assistance in evaluating coalitions as such. Standardization domains suitable for retrieving empirical data and for testing the results are, among others, EDI networks. In the X.500 case, interestingly the sum of all K_i also decreased due to the rebates. Thus, as part of the collaboration, in some cases side payments A could be implicitly provided by a large partner opening his superior prices to the smaller firms, too. In this context, "fair" mechanisms should be discussed again. No distribution or cost allocation is fair per se. Rather they should meet certain requirements like those, for example, proposed by Shapley values. See Güth et al. (2001, p. 100) for an experiment suggesting "that fairness concerns should be built into behavioral models of economic organizations". It appears a very promising area of further research to integrate and adapt findings from controlling theory to enhance network behavior. Among others, budgeting programs based upon residual earnings concepts to address agency problems under incomplete information as proposed by Ewert, Wagenhofer (1993, esp. pp. 397-559) might offer particularly good starting points for designing mechanisms for networks.

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THE EVOLUTION OF VERTICAL IS STANDARDS: ELECTRONIC INTERCHANGE STANDARDS IN THE US HOME MORTGAGE INDUSTRY

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ABSTRACT

In contrast to horizontal IT standards, which concern the characteristics of IT products and apply to users in many industries, vertical IS standards focus on data structures and definitions, document formats, and business processes and address business problems unique to particular industries. This paper contributes to the small but important literature on vertical IS standards by presenting the case study of the evolution of electronic interchange standards, with a particular focus on Internet-era standards, in the US home mortgage industry. This industry is particularly interesting for a study of vertical IS standards because of the relatively low level of technology adoption for interorganizational interchange until very recent years, which makes the standards-setting process highly accessible for study.

Keywords: vertical IS standards, Internet standards, electronic commerce, standards-setting process, standards adoption, standards impacts, mortgage industry.

INTRODUCTION

Interorganizational commerce has always required standards—standards of weights and measures, standards of product description and quality, standards regarding payment and logistics, etc. The rise of electronic commerce led to the development of IT-related standards—telecommunications protocols, electronic data interchange (EDI) document standards, and increasingly business process standards such as those contained in the RosettaNet protocols. The effect of these standards on the dynamics of competition among the participants in an industry sector is an important research question.

In the Information Systems (IS) field, the importance of standards has long been recognized. Although there is much research on the technical details of IT-related standards, surprisingly little empirical research addresses the development, the adoption, and the outcomes of IT-related standards. (Notable exceptions include Damsgaard and Lyytinen 2001 and van Baalen, van Oosterhout, Tan and van Heck 2000.) Outside the IS field, much of the standards literature has examined *product* standards and taken the perspective of technology producers; by contrast, the concern in the IS field has largely been with the *use* of technology products by non-producer firms.

Technology product standards such as telecommunication protocols, Windows, and XML, have the characteristic that they are applicable in many industries; we call them *horizontal* standards. The key movers in the development of horizontal standards are technology providers and governmental agencies. The competitive marketing tactics of technology firms are likely to play a pivotal role in the adoption and use of technology product standards.

Not all standards are applicable to many industries, however. A second kind of standard—*vertical* standards—is needed to address business problems unique to particular industries. For example, when the chemical industry began to expand its EDI document standards for Internet-enabled commerce, standards developers took as a starting point the RosettaNet standards under development in the electronics industry, then customized them to unique chemical industry processes, such as the shipment of hazardous materials.

Vertical standards such as RosettaNet and CIDX (the chemical industry standards) differ from horizontal standards, not only in their narrower applicability, but also in their technical content. IT product standards focus on elemental levels of interconnection, such as telecommunications protocols; by contrast, vertical standards focus on data and business processes. Because vertical standards concern not so much IT but how IT is used, we refer to them as vertical *information systems* (IS) standards, in contrast to horizontal *information technology* (IT) standards. (Information systems are often defined as the applications of IT to business problems.)

The development, adoption dynamics, and outcomes of vertical IS standards, such as RosettaNet and CIDX, are likely to exhibit very different characteristics than those of horizontal IT standards. Whereas technology firms and governments are generally the leaders in horizontal standards efforts, their role in vertical IS standardization efforts is likely to depend on such things as the maturity of the industry-specific IT sector (which may in turn be a function of vertical industry size and structure) and the extent of regulation in the industry. Since those who stand to gain (or lose) most from vertical IS standards are industry players, those most likely to champion vertical IS standards development processes are industry players, key suppliers and customers, and industry associations. Adoption and diffusion of horizontal standards are more likely to reflect competition among industry players than competition among technology providers. And although all standards involve network externalities, collective action to adopt a new standard en masse is more likely to occur within a single vertical industry than it is across industries.

This paper contributes to the small but important literature on vertical IS standards by presenting the case study of the evolution of electronic interchange standards, with a particular focus on Internet-era standards, in the US home mortgage industry. This industry is particularly interesting for a study of vertical IS standards because of the relatively low level of technology adoption for interorganizational interchange until very recent years, which makes the standards-setting process highly accessible for study.

BACKGROUND

The US home mortgage industry today is highly fragmented, with thousands of mortgage bankers and brokers, although it is consolidating rapidly. (It is estimated that the top five lenders originate over 50% of residential mortgage loans today, and that the top ten firms service over 50% of such loans.) It is also highly vertically disintegrated (Jacobides 2001a), although some analysts claim that it appears to be reintegrating, at least at the top end of the size spectrum (Van Order 2000). Automation and IT-enabled standards appear to be playing an important role in both structural evolutions (Jacobides 2001b; Van Order 2000).

Because of vertical disintegration, most business processes in the mortgage industry require the efforts of more than one organization—a situation that appears to be natural for electronic interchange. But the industry has been slow to adopt technology, and interorganizational standards-setting initiatives have only made progress in the last fifteen years. Since the widespread adoption of Internet standards in the last five or so years, the pace of standards-setting initiatives and the level of standards adoption in the industry have noticeably increased.

Brief Industry Overview

There are two mortgage industry markets: the primary market, where borrowers obtain loans from originators, and the secondary market, where mortgages are sold by originators and bought by investors (Cummings and DiPasquale 1997). The key primary market processes are *origination* (including application and underwriting—which considers the borrowers' credit and property characteristics), *closing and recording* (legal transfer of the property), and *servicing* (receiving payments, managing tax and insurance escrows, monitoring delinquencies, managing foreclosures, and making payments to investors) (Cummings and DiPasquale 1997).

Today, more than half of all mortgages are sold in the secondary market (Van Order 2000). The secondary market has three major threads: 1) mortgage originators who hold loans in portfolio, 2) originators who sell loans directly to investors who hold loans in portfolio, and 3) originators who sell loans to a conduit who packages and securitize the loans and sells interests in the securities to investors (Cummings and DiPasquale 1997). Most frequently, the conduits to the secondary market for residential mortgages are government sponsored agencies (GSEs), especially FannieMae and FreddieMac. GSEs are private corporations that were chartered by federal government mandate to create and grow the secondary mortgage market (Cummings and DiPasquale 1997) through securitization. The GSEs have grown rapidly into major players: roughly 50% of the $6.3 trillion (2003 figure) in outstanding US mortgage debt for single family residences is either held in portfolio by the GSEs or is held by investors in the form of mortgage backed securities guaranteed by the GSEs (Cummings and DiPasquale 1997). The perceived and real power and privileges of these companies (for example, they are exempt from SEC reporting requirements) generates considerable controversy (McKinnon and Kopecki 2003).

Standardization and Automation in Underwriting

Mortgage lending was historically viewed as less readily automated than other types of credit decisions. Until the mid-1990s, the mortgage process was largely manual and decentralized: tens of thousands of underwriters employed by thousands of mortgage lenders subjectively reviewed credit reports and voluminous paper files against their own underwriting guidelines as well as those of conduits and investors (Straka 2000). Many industry analysts view the GSEs as the agents of change who spurred the adoption of IT and IT-based standards in the industry, triggering widespread economic consequences (Kersnar 2001; Raiter and Gillis 1997).

Prior to the mid-1990s, most lenders made their underwriting decisions on the basis of simple heuristics, such as "loan to value". Credit scoring was not a major part of the lending decision because, in the early 1990s, "virtually no institution was storing credit records on mortgage loans in an easily accessible medium" (in large part because the GSEs did not require credit information) (Straka 2000 p. 213). Impetus for change came from an empirical study completed by Freddie Mac in 1992, showing the value of credit scores for predicting mortgage default (Straka 2000). In 1994, Freddie Mac deployed a pilot version of its automated underwriting (AU) system, called Loan Prospector, which used statistical mortgage scoring (Straka 2000). Shortly thereafter, Fannie Mae introduced a similar system called Desktop Originator.

Since about 1998, AU adoption has been rapid: By 2001, AU adoption by mortgage bankers was reported at 98% (Punishill 2001); 58% of mortgage bankers used one of the GSE's AU systems as opposed to an in-house system or one from an independent vendor (Kersnar 2001). The GSEs have continued to expand their technology offerings. Today, they offer IT-based support for secondary marketing, servicing, and integration with business partners, in addition to their core AU technology. In addition, they have continued to expand the scope of the AU technology (historically confined to conforming loans) to all residential mortgage loans, and they have gradually extended access to AU technology (historically confined to mortgage bankers) to other industry players such as mortgage brokers and real estate agencies.

The impacts of AU in the industry have been major and continue to unfold (Jacobides 2001b). Before AU, borrowers could wait weeks for an approval decision from lenders, because the lenders often had to wait weeks to get an "accept" decision from one of the GSEs (in essence, a guarantee that the GSE would purchase the closed loan, an important consideration to many mortgage bankers who did not plan to keep the loan in portfolio). Today, lenders and borrowers can get these approval decisions within minutes. The Mortgage Bankers Association of America estimates that the cost of originating a loan has decreased by 50% in the ten years since AU came online (MBA, personal communication 1/28/2003)—probably because the need for human underwriters in mortgage banks decreased sharply. (In addition, the skill level of the remaining underwriters is reported to have declined, Punishill 2001.) AU-enabled credit scoring is said to have markedly improved the accuracy of underwriting decisions, reducing mortgage default rates despite a declining economy. (Critics worry, however, about the potential for discrimination from standardized underwriting rules.) The concentration of enormous volumes of data in the hands of the GSEs (FannieMae's database holds data about one-third of all US homes and one-fourth of all US home buyers, Posner and Courtian 2000) is expected to provide AU users with new sources of potential revenue and competitive advantage, such as the ability to "personalize pricing" (Punishill 2001), i.e., to price loans on the basis of prepayment risk, not just credit risk (Van Order 2000). As a result of these developments, experts expect sizable *additional* reductions in the cost of loan origination over the next few years (Posner and Courtian 2000), thereby further increasing industry competitiveness and consolidation.

The competitive fallout from these first-order effects has yet to be assessed. According to some, "it quickly became clear that … [the GSE's AU systems] would tend to 'level the playing field' between larger, more technologically sophisticated lenders and midsize to smaller lenders" (Straka 2000, p. 215). On the other hand, the possibility of risk-based mortgage loan pricing afforded by AU has yet to be widely adopted even by the larger, more tech-savvy lenders (Punishill 2001), suggesting that superior knowledge about IT use may yet become a key differentiator in the industry. Mortgage bankers are said to fear AU-enabled competition from mortgage brokers—the source of about 70% of mortgage bankers' loan volume (Jacobides 2001a). Another second-order impact is the declining power of mortgage bankers relative to the GSEs (Jacobides 2001b; Van Order 2000): AU lowers the value added by mortgage bankers and opens the door to their possible disintermediation. The recent extremely rapid consolidation (and apparent reintegration, Van Order 2000) in the industry could be a direct effect of underwriting automation and IT-based standards.

Although AU has had a tremendous impact on the industry in a very short time, the potential for even more change is clearly evident. Internal inefficiencies owing to the lack of systems integration can be found throughout the industry, and closing and recording processes are still lengthy, costly, and error-prone. Given the informational nature of the mortgage loan, it is theoretically possible to originate, fund, and record a mortgage loan nearly instantaneously. Additional standards-setting efforts in the industry aim to address these problems.

INTERNET-BASED MORTGAGE INDUSTRY IS STANDARDS

In addition to the GSEs, the Mortgage Bankers Association of America (MBA http://www.mbaa.org/) has been a major force for standardization in the mortgage lending industry. Founded in 1914, MBA is the leading industry association for companies in the real estate finance business, the largest segment of the US capital market. Its approximately 2,800 members cover all industry segments, including mortgage lenders, mortgage brokers, thrifts, insurance companies, etc. MBA represents the industry's legislative and regulatory interests and conducts educational activities and research for its members.

In the late 1980's MBA launched its "electronic data initiative", designed to support the automation of "interagency" mortgage lending processes (Opelka 1994). Working with FannieMae and FreddieMac, the MBA's first targets were paper forms such as mortgage applications and appraisal forms (Braitman 1990; "MBA Makes "Extraordinary Progress" in Effort To Streamline Lending 1988). In the early days of these efforts, EDI was the approach taken to facilitate data interchange (Slesinger 1994), but the emergence of Internet standards inaugurated a change in approach.

MISMO

In January 2000, the MBA, in partnership with FannieMae and FreddieMac, launched the Mortgage Industry Standards Maintenance Organization (MISMO http://www.mismo.org). MISMO was established to coordinate the development and maintenance of vendor-neutral Extensible Markup Language (XML)-based transaction specifications to support data sharing both inside companies in the industry and externally among the many participants in mortgage lending processes. Internal integration is as necessary as external integration, according to industry experts, since a typical mortgage lender may re-key data about a borrower's loan application as many as seven times prior to closing (and several times thereafter).

Today, MISMO has over 100 members, including both leading players from all industry segments and IT vendors that specialize in the industry. MISMO's scope is the entire real estate financing process including origination from application through closing and recording (including ancillary real estate services such as appraisal, insurance, and title), secondary marketing, and servicing. The organization promises three deliverables: the XML specifications architecture, a data dictionary of over 3,600 elements with business definitions and the corresponding XML data element tag names, and a reference data model to illustrate the relationships among data elements in the dictionary. At the same time, MISMO carefully restricted its focus to *inter*organizational processes, thereby hoping to avoid the conflicts and stalemates that arise when standards-setting efforts start dictating intraorganizational processes and data formats (MBA, personal communication 5/28/03). MISMO standards are publicly available online.

A key milestone in MISMO's history occurred in July 2001, when MBA announced that FannieMae and FreddieMac had agreed on a common format for their automated underwriting systems. This specification allows companies "to send the same 'base' XML data file to both FannieMae and FreddieMac for an underwriting decision, thereby saving users money when they are implementing their interfaces" ("News Release: Common Format Adopted for Automated Underwriting" 2001). Industry observers consider this event significant, because the GSEs had previously pursued proprietary technology initiatives, imposing a burden on companies that wanted to do business with both.

In March 2002, MISMO released its first full set of standards covering the entire process from mortgage application through to servicing ("News Release: Release of Version 2.1 Triples Data

Coverage in Residential Mortgage Industry" 2002). In the meantime, MISMO began tackling the problem of fully electronic mortgage financing, which requires electronic signatures.

eMortgage Standards

The passage of the Uniform Electronic Transactions Act (UETA) in 1999 and the Federal Electronic Signatures Act (E-SIGN) in 2000 made it possible to envision a mortgage lending process that produces legally binding mortgages entirely without paper. These laws provide that electronic signatures can be used wherever existing law requires a "wet" signature.

In January 2001, MISMO launched its eMortgage Workgroup. To accomplish fully electronic mortgages, the eMortgage Workgroup developed "SMART docs": Secure, Manageable, Archivable, Retrievable, and Transferable documents that lock data and document presentation into a single computerized file using the underlying data formats of XML (for data transfer) and XHTML (a combination of HTML and XML, for document presentation). SMART doc standards ensure that information is transferred in a form that is readable both by computers and by humans, thereby enabling the requirements for filing with county recorders' offices to be met along with those of the GSEs and investors.

End-to-end technology support would automate numerous steps now done manually, among them: electronic exchange of data instead of mail, fax, and courier transmission, data reentry into multiple systems, data validation, and data storage. eMortgage experts claim that a fully electronic mortgage process will streamline processes, prevent lost documents, and improve document accuracy, saving about $150 per loan, cutting processing time at least 20% (the cycletime for the close to record process is estimated to be eight weeks), and eliminating unpleasant surprises for borrowers at closing time.

In June 2001, eMortages got a big boost when FannieMae and FreddieMac agreed to support MISMO's XML standards: The GSEs had been independently developing guidelines and standards for Internet-based electronic interchange. Today, the GSEs claim to be strong supporters of all-electronic mortgages. In January 2003, MISMO released the first version of its eMortgage Guidelines and Recommendations to the industry ("News Release: MISMO Announces eMortgage Release 1.0" 2003).

Although the first electronic mortgages were purchased by the GSEs in the year 2000, to date only about 100 eMortgages have been closed. Industry experts expect that it may a number of years before fully electronic mortgage are common (Michels and Morelli 2001a). Despite the progress represented by the MISMO eMortgage standards, numerous barriers to adoption remain:

- Because identical digital copies of an electronic mortgage are likely to exist, who holds the authoritative copy? To address this problem, MBA recently released requirements for an eNote registry that would track the location and the owner or controller of electronically originated and closed mortgage notes ("News Release: MBA Announces Release of Industry eNote Registry Requirements" 2003).

- Even though XML is inexpensive and easy to implement, "having the system and programming expertise to convert paper documents to SMART docs requires more than simple XML skills" (Story 2003, p.74). Many small and medium sized lenders lack those skills. Today, few lenders are using SMART docs in all lending processes (Story 2003). At least one vendor alliance (e-Mortgage Alliance) has been formed to link applications throughout the value chain, but the eventual appearance of outsourcers and ASPs may do more to mitigate this problem (Michels and Morelli 2001b).

- Fewer than 20 of the US's 3,600 county recorders can receive and record mortgages electronically, although 25 are in the process of converting and only some 250 major urban counties handle the majority of filings, somewhat reducing the scope of the adoption problem (Barta 2003).

- Many lenders are not convinced about the benefits of electronic mortgages (Barta 2003). The GSEs do not yet require electronic documentation (Michels and Morelli 2001a), and many in the industry appear to be looking to the GSEs to take leadership in this area (Michels and Morelli 2001b). The GSEs respond that electronic mortgages will stress the industry as much as automated underwriting did a decade earlier, and therefore they are reluctant to mandate adoption (Kersnar 2002). But observers point out that electronic mortgages do less to advance the interests of the GSEs than automated underwriting did, and therefore they expect the GSEs not to take such an active role in facilitating adoption of eMortgages (Kersnar 2002).

The MISMO Standards Development Process

The process MISMO set in place to guide the standards-setting process was apparently designed to maximize participation from all segments of the industry and to avoid domination by a few large players.

Membership and Governance

According to the MISMO Web site, more than 100 companies and more than 600 people are involved in standards activities. Membership in MISMO is voluntary and open to all, regardless of company size or the specific segment of the mortgage industry value chain within which a company operates. MISMO is subdivided into a number of Workgroups reflecting every aspect of the mortgage industry value chain, as well as groups focusing on foundational data definition standards. Subscribers to MISMO can join the Workgroups of their choice and participate in all activities except the leadership positions, which are filled in annual elections.

To ensure a fair and efficient process, Workgroups are required to follow published agendas. A code of conduct published on MISMO's website defines conflicts of interest and acceptable behavior, particularly with regard to potential violations of antitrust regulations. Members are reminded at each meeting that industry associations like MISMO are perfectly legal, but that discussions of such things as rates, terms, prices, and conditions of service are not legal. Members are encouraged to raise any concerns they might have about the direction of discussion in MISMO meetings.

A Governance Committee oversees the organization and gives final authorization for changes in the standards architecture after reviewing the recommendations of the relevant Workgroup. The MISMO Governance Committee reflects a balance between large and small players, as well as the breadth of the mortgage industry value chain. Seats on the governing committee, which is elected by the full membership, are provided to lenders, servicers, GSEs, insurers, credit reporters, and technology vendors representing different industry segments. In addition, the MBA has two non-voting seats on the committee, reflecting the Association's role as neutral facilitator.

Costs of participation are minimized by holding few in-person meetings, supplemented by the use of listservs, teleconferences, and electronic balloting. Hence, smaller firms are not kept out of the process by steep participation costs. MISMO holds three in-person meetings per year and periodic interim meetings. Email notifications of upcoming votes are sent out, and electronic balloting ensures that each company can influence election outcomes. MISMO operates on a "one company, one vote" process, both for elections to committee governance positions as well as for actual standards submissions and change requests. Moreover, the costs of using MISMO standards are minimized by making specifications freely available through downloadable documents. The MISMO web site offers free access to all MISMO participants.

Intellectual Property

MISMO gave considerable attention to the problems of opportunistic behavior around intellectual property rights (IPR). MISMO considered and rejected several IPR approaches used by other collaborative ventures (such as the "copyleft" license of the Open Source movement). Instead, MISMO opted for a royalty-free license approach to IPR. All participating companies must sign an IPR agreement that requires the company to pays for its own peoples' time on the project, to license any contributions to MISMO free of charge, and to allow MISMO to derive products from their contributions and make these products available to others (i.e., to sublicense them) via the Web or other means.

These provisions were expressly designed to prevent companies from pursuing a "submarine patent" approach, whereby participants file for their own business process patents while waiting for the technologies to reach a point where they can be implemented.[1] Then, once companies attempt to implement the standard, the opportunistic patent filer can claim royalties on what was supposed to have been an open and freely available standard. MISMO proactively implemented its IPR approach to prevent submarine patents from ever surfacing.

DISCUSSION

The MISMO standards effort suggests several important conclusions that need to be brought into congruence with the theoretical and empirical literature on standards-setting processes. Among our observations from this case are the following:

The Difference of Vertical IS Standards

Our analysis of the MISMO standards development process argues for the need to differentiate between horizontal *IT* standards (IT products and general standards) and vertical *IS* standards (industry-specific data and process standards). The former include protocols such as TCP/IP and representational formats such as HTML or XML that apply to many industry sectors, while the latter are relevant to a single industry, such as CIDX in the chemical industry or the MISMO standards in the mortgage sector. The former are likely to be driven by vendors in the IT and/or telecommunications industries and are unlikely to be tied to industry-specific products, business processes, or regulatory requirements. The latter are driven more by industry participants than technology vendors and integrate technical features with legal and business elements. It seems unlikely that much progress in vertical IS standards efforts can be achieved without significant development and penetration of horizontal standards. In the case of MISMO, vertical IS standards might not have emerged without the widespread take-up of TCP/IP and XML.

[1] Stix, G. (2002). Deep-sixing the submarine patent. Scientific American.com, September 13. http://www.sciam.com/article.cfm?articleID=000C4F59-8093-1D2B-97CA809EC588EEDF.

The Role of Major Organizational Players

The standards literature focuses heavily on the importance of network externalities and what they portend for the likelihood of collective action. In the case of automated underwriting, the GSEs played the role of resource-rich players who could provide a public good for all to use. In the case of MISMO standards, the MBA could not provide the public good, but it did facilitate the voluntary participation of many players, including small ones, and the MBA brokered the acceptance of MISMO standards by the powerful GSEs. By creating a governance framework emphasizing openness and equality, MISMO ensured than no one organization is in a position to dominate the standards development process, regardless of its market power. It remains to be seen, however, whether the market power of the GSEs or of mega-lenders with proprietary solutions will make a difference in MISMO standards adoption.

The Role of Individuals and Personal Relationships

MISMO's open and inclusive governance structure may reduce concerns by other industry players that MISMO standards are biased in favor of a company or industry segment. But this inclusive process does not imply that a large proportion of the industry is actively involved in standards-setting efforts. Rather, interviews with MISMO participants reveal that much of the work was done by a rather small group of regular members who come to all meetings, providing the continuity necessary to keep the process moving forward. Indeed, interviewees referred to this factor as the "same ten people phenomenon", pointing out that the effort depends critically on a small group of highly devoted people.

The "same ten people phenomenon" suggests to us that social relationships are key to the success of this standards-setting process. The formation of social bonds across company boundaries not only eased the process of information transfer, but also made it possible to achieve the compromises necessary to resolve impasses. Although the importance of personal relationships as a lubricant and governance mechanism in support of electronic transactions has been pointed out in prior literature (Kraut, Steinfield, Chan, Butler and Hoag 1999), the role of such relations in the standards-setting process has not yet received much attention.

The Role of IT Sector Maturity

Another observation concerns the relatively minor role played by large technology vendors in the MISMO standards efforts. The mortgage industry currently has no ERP analog—except for the suite of technologies offered by the GSEs. (The GSEs cannot be understood as technology vendors apart from their role as major industry players—as customers of some players and competitors of others.) Mortgage industry observers have speculated that one reason for the historically slow adoption of IT in the mortgage industry was the low level of maturity of the IT sector (Lebowitz 2001). This hypothesis deserves attention: The relationship between industry structure and IT sector maturity on the one hand and the emergence and adoption of IS standards on the other has been seriously underexplored.

In the case of the home mortgage industry, the low level of maturity of sector's IT industry is likely related to the historically extreme fragmentation of a now rapidly consolidating industry. However, given the time lag between industry structure changes and responses by the corresponding business services sector, we believe it is important to consider the effects of the sector's IT industry independently of industry structure.

The Scope of the Standards-Setting Efforts and Intraorganizational Conflict

Finally, the scope of vertical IS standards-setting processes appears to be important in the success of these efforts. MISMO deliberately avoided trying to develop standards for “everything including the kitchen sink”, because the attempt to standardize members’ internal processes and data structures would likely entail *intra*organizational conflict.

Vertical IS standards often affect multiple stakeholder groups *within* the organizations that participate in standards-setting efforts—in the case of the mortgage industry, for example, originating units, servicing units, and legal departments may each view a proposed standard from different points of view. Managing the scope of standards-setting processes is a useful tactic for keeping intraorganizational conflict from affecting the successful completion of an interorganizational standard. A potential downside of this approach is that some participants may lack the level of internal systems integration needed to adopt or capture benefits from interoganizational standards (Markus 2000).

CONCLUSION

Much work remains to integrate the findings of this case with the theoretical and empirical literature on standards-setting processes. Nevertheless, our case has revealed numerous promising avenues of theoretical development and empirical research. We look forward to the opportunity to explore these directions in the future.

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STAKEHOLDER IDENTIFICATION IN IT STANDARDIZATION PROCESSES

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ABSTRACT

Adequate stakeholder participation is essential to standardization processes in information technology. The stakeholder structure in information technology is complex and dynamic, while IT standards can have pervasive effects on many industrial sectors and even wider segments of society. However, there are strong indications of unbalanced stakeholder representation in IT standardization processes.

This paper presents a method for stakeholder identification and classification, which can by applied in IT standardization processes. Systematic stakeholder identification is an important first step in improving stakeholder participation. The method can be applied by standardization officers, committee members and other relevant parties in their identification of potential participants of standardization committees, working groups or other organizational forms where standards are developed. The method consists of two parts: a set of search heuristics to identify all relevant stakeholders, and a typology that can be used to differentiate between essential and less important stakeholders. A first application of the method was promising: the method provided a significant improvement over existing practices of stakeholder identification.

Keywords: Standards, standardization, stakeholder, stakeholder analysis, participation, methodology.

INTRODUCTION

The composition of standard committees is an essential element of standardization processes. A committee made up of many different stakeholders justifies the principle of openness for representation of all interested parties, which is a fundamental characteristic of formal standardization. In practice, however, many standardization processes are characterized by unbalances in stakeholder representation. Some stakeholder groups appear to be dominant, while others experience barriers for participation. This is not only a problem because of the 'democratic' principles of openness and consensus of formal standardization processes; it can also have a negative impact on the quality and the use of the resulting standard. On the other hand, increasing stakeholder participation will make the standardization process likely to become more complex and time-consuming. Also, not all stakeholders are willing to participate in the standardization process. The involvement of stakeholders in standardization processes should therefore be the result of a conscious deliberation. In many cases however, it is not apparent beforehand which stakeholders are affected by a certain standard, or should otherwise play a role in the standardization process. A systematic analysis will in many cases be needed to provide an overview of the relevant stakeholders.

This paper presents a method for stakeholder identification and classification, which can by applied in IT standardization processes. The method is based on standardization literature and stakeholder theory, and has been tested in four ex post analyses of standardization processes. The objective of this method is to support standardization officers, committee members and other relevant parties in their identification of potential participants of standardization committees, working groups or other organizational forms where standards are developed. The scope of the research is limited to formal standardization processes, although the method may be applied wider to include consortia and other non-formal standardization bodies.

The structure of the paper is as follows. The next section demonstrates the relevance of improving stakeholder participation in standardization processes in the information technology sector. Next, the theoretical background of the method is introduced. The method itself consists of two parts. First, search directions for the identification of stakeholders are presented: categories of firms and organizations that may have a stake in the standardization process. The next step is a stakeholder classification structure, which can be used to differentiate between stakeholders whose participation is essential, and stakeholders that can be given a less central role in the standardization process. The results of the first application of the method are presented next. The paper concludes with a discussion of the possible applications of the method and its potential to increase stakeholder participation in IT standardization processes.

THE IMPORTANCE OF STAKEHOLDER PARTICIPATION IN IT STANDARDIZATION PROCESSES

Specifications of many of Microsoft's products can be regarded as standards because of their intended and expected massive use. One company prepared them, without involvement of other stakeholders. However, most standards result from standardization processes in which more stakeholders are involved. Sometimes there is limited access: only a few stakeholders or just one or some categories of stakeholders are allowed to participate. This applies especially for certain industrial consortia. The standardization activities are open only for those who have been invited by the consortium and the rules for being invited differ from consortium to consortium (Cargill, 1997, p. 40). In many consortia, however, and in most governmental and sectoral standardization organizations many or all stakeholders are welcome to participate and in formal standardization all stakeholders are explicitly welcome. The scope of this paper is limited to formal standardization and therefore we use the official definition of 'standard': document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context (ISO/IEC, 1996, Clause 3.2).

This openness to all stakeholders is one of the main principles of formal standardization processes in general (ISO, 2001, paragraph 2.3; ITU, 1992, Article 2; Olshefsky & Hugo, 2003; NSSF, 2003, p. 4). In the IT sector, the role of users is particularly relevant. In some cases users have played a major role in standards setting. MAP[1] standardization, for example, was initiated by a big user: General Motors. GM involved other users. In the course of the process a shift from user-orientation to vendor domination could be witnessed (Dankbaar & Van Tulder, 1991, p. 29). In general, *coalitions* of users can be better vehicles for user participation in standardization than individual users (Forey, 1994; Jakobs, Procter & Williams, 1998).

Users may be regarded as organizations buying products affected by standards or using (external) standards for their production processes. In their book about user needs in IT standards, Evans, Meek, and Walker (1993, pp. 3-4) make a distinction between: *end users/terminal operators* using the computer as a tool in their job, *system administrators* who maintain the integrity of the IT environment, *users who establish and maintain the IT environment*, and *developers* who develop a solution to a problem, for instance, by making software or by integrating systems. *Non-human users* form a final category: information processing systems. All use IT standards, but will, in general, have different requirements. Evans, Meek and Walker seem to ignore final consumers as another user category. Their needs with regard to IT standardization are addressed by ANEC (2003). Naemura (1995, p. 96-97) stresses the need for standards providers to try to identify the various implementers in different environments. He draws a layered model of user types analogous to the Open System Interconnection Model.

Despite their important role, it seems that representation of users in IT standardization is often inadequate. Jakobs, Procter and Williams (2001) investigated IT standardization working groups of the International Organization for Standardization (ISO), the International Telecommunication Union (ITU) and the Internet Engineering Task Force (IETF) and found that other parties that participate include consultants, academia, research institutes, and governmental agencies. However, more than 60% of the participants come from providers or vendors. Especially users are underrepresented. Spring et al. (1995) found that in CCITT X3 committees for data communications standards, 75% of the participants described their job function as either R&D or product development. Only ten percent identified themselves as users. The remaining categories included marketing/sales, operations, system integration, consultant, and government representative –an unbalanced representation again. Rankine (1995, p. 567) concludes that users are not sufficiently involved in IT standards setting. The standards organizations concerned are open for participation of all stakeholders, but apparently there are barriers for participation. In our research project we found 27 different barriers, for example, lack of knowledge, time and money of potential participants, lack of transparency in committee structures and standards development procedures, standardization officers' and conveners' behavior, and committee culture (Verheul & De Vries, 2003). A major barrier appeared to be the lack of conscious and systematic stakeholder identification and selection prior to the standardization process. In many cases, a stable network of participants is involved in the development of related standards. No external search is carried out in order to identify additional potential stakeholders.It can be questioned whether or not the one-sided representation is a problem. Jakobs, Procter and Williams (2001, p. 6) state that users are the only ones in a position to contribute meaningful real-world requirements to the process, and their voice needs to be heard and strengthened, though their participation might cause problems because of the diversity of users. The fact that many of the thousands of standards that have been developed by ISO/IEC/JTC1 (the Joint Technical Committee on Information Technology of the International Organization for Standardization and the International Electrotechnical Commission) are hardly used in practice may be

[1]MAP = *Manufacturing Automation Protocol* – a set of standards defining rules for electronic communication in a manufacturing environment.

related to unbalanced representation of the stakeholders in the committees.

More in general, involvement of users and other stakeholder groups may contribute to the quality of the resulting standards and may enhance stakeholder preparedness to use these standards. Leiss (1995, p. 61), for instance, concludes that the tasks of setting and enforcing (environmental) standards are best conceived as a process of continuous micro-management, which requires the participation of a broad range of stakeholders. The European employers organization UNICE (1991, p. 3) states that co-operation at an early stage with all interested circles is indispensable in order to take the various requirements into account.

In the special case of governments that refer to standards in their legislation the openness for involvement of all parties concerned may be a prerequisite for their willingness to refer to the standards. The European public procurement directive (Council of the European Communities, 1993), for instance, explicitly list categories of standards of decreasing preference: (1) European standards, European technical approvals or common technical specifications, (2) national standards implementing international standards accepted by the country of the contracting authority, (3) other national standards and national technical approvals of the country of the contracting authority, and (4) any other standard. The European 'New Approach Directives' that apply to more than 50% of all products on the European market refer to formal (European) standards only. This preference is based on the legitimacy related to the principles of formal standardization, especially the principles of openness and consensus. Openness is the possibility for all interested parties to be represented in standardization. Within committees, decision-making is consensus-based, which should enable less power-full stakeholders to play a full role. This 'democratic' character should distinguish formal standardization organizations from others, in particular, consortia. However, Egyedi (2001) concludes that formal standardization organizations may be democratic in theory but seem to fail to be this in praxis, whereas most consortia are more 'democratic' than they are said to be. So the governmental preference for formal bodies may be disputed. This may challenge formal standardization organization to improve their practice. Our research project aimed to contribute to this in the case of the national standards body of The Netherlands. However, this body's primary concern is not to be 'acceptable' for the government but to serve the market better, especially the 'weak' stakeholders.

IT is just one of the sectors in which this issue is relevant, though it might be a sector in which stakeholder representation is extremely unbalanced. Given the deep impact of IT on many stakeholders (for instance, big, medium-sized and small companies, consumers, workers and their representatives), the issue of stakeholder involvement may be particularly important in this sector. Moreover, IT is more novel and innovative; networks are more dynamic and have not become as institutionalized as in other sectors. This makes a regular check on the balanced representation of stakeholders in standardization all the more necessary.

A METHOD FOR STAKEHOLDER IDENTIFICATION

Achieving a balanced stakeholder representation in standardization processes depends on many factors. Stakeholders need to be contacted and they have to be prepared to participate in the standardization activities. After that, the standardization process needs to be managed properly so that all participating stakeholders remain involved and committed to the process. The *identification* of potential stakeholders is an essential first step in getting stakeholders to participate. A widely accepted, broad definition of a stakeholder is given by Freeman, who considers "any group or individual who can affect or is affected by the achievement of the organization's objectives" to be a stakeholder (1984, p. 46). Based on this definition, a standardization process, defined as the development or revision of a standard or a cluster of related standards, usually involves a large and heterogeneous group of stakeholders. Producing firms, customers, end users, certification institutes, societal interest groups, all these stakeholders and more may want to influence the standardization process or may be affected by it. In practice not all stakeholders will have to play an active role in the standardization process. However, given the importance of stakeholder representation in standardization, those responsible for the standardization process ought to be familiar with the full set of stakeholders. Furthermore, it may be helpful to be aware of the positions of these stakeholders towards the standardization process and the issues involved.

Theoretical considerations

The method described below is aimed as a tool for the systematic identification of stakeholders and the determination of their positions (classification). Improving stakeholder identification and classification is expected to contribute to a more balanced stakeholder representation, in the IT sector as well as other sectors. This method, which is based on insights from stakeholder theory, consists of two parts. First a search heuristic is developed to identify all the stakeholders, or as many as possible, in a standardization process. Nine directions for tracing potential stakeholders are identified. Using this search heuristic enables to go beyond the existing network and fixed preconceptions on which actors should be involved in the standardization process. The second part consists of a classification based on stakeholder salience. Applying this classification provides information on the probable roles that stakeholders can play in the standardization process, and can provide insight regarding the actions that need to be taken to involve various stakeholders in the process.

The role of stakeholders in the firm's strategy and operation has received considerable attention in management research over the last two decades. The reasons for advocating the stakeholder approach falls into two broad categories.[2] First, there is the normative argument that the firm has the moral obligation to account for its activities towards those affected by them. The second argument is more pragmatic: firms that take into account the needs and interests of their various stakeholders are financially more successful, according to stakeholder theorists (Beaver, 1999). The attention to stakeholders has resulted in a large variety of stakeholder typologies and other sources for stakeholder identification (Mitchell et al., 1997). Underlying these typologies lie different perspectives on who or what counts as a stakeholder, and why the firm should account for its interests. Some of the main variables in stakeholder identification approaches are the ability of the stakeholder to affect the firm's activities and the existing relationship between the stakeholder and the firm. A pragmatic view on stakeholder involvement tends to limit the identification of stakeholders to those groups and organizations which can affect the firm, while a predominantly normative perspective implies a broad identification of stakeholders as all entities that are affected by the firm. Secondly, some scholars believe that only groups and organizations that have an actual relationship with the firm should be taken into account as a stakeholder. Mitchell et al. (1997), however, argue that stakeholders may also have a latent or potential relationship with the firm: groups and organizations may be affected by the firm's activities without interacting with the firm on a social level, and some stakeholders may affect the firm's activities without having a direct relationship to the firm.

[2] This representation of stakeholder advocate's positions is based on the overviews of stakeholder literature. presented by Mitchell et al. (1997) and Rowley and Moldoveanu (2003).

When applying these insights in stakeholder identification to standardization it should be noted that a standardization organization is in some respects different from a firm, resulting in a different stakeholder approach. In the first place, the principle of openness lies at the heart of standardization: all parties that have an interest in standardization are welcome to participate in the standardization process. This imperative of standardization implies that stakeholder identification should take a broad view, including all parties that may affect and that may be affected by the standardization process or the resulting standard. Secondly, the identity of groups and organizations affected by standards vary considerably. For instance, some standards are primarily related to producer-user relationships, while others mainly affect employees or certification institutes. This implies that the existing constellation of parties involved in standardization in a specific field does not necessarily cover all the stakeholders in a new standardization process. Stakeholder identification for standardization should therefore include stakeholders with actual as well as potential relationships to the existing standardization communities.

Part 1. Identifying stakeholders

These considerations result in a broad perspective on stakeholder identification for standardization processes. In principle, all stakeholders should be identified that can affect and are affected by the standard or cluster of standards produced by the standardization process. In this project, we developed a list of nine search directions for tracing potential stakeholders. These search directions are based on the different ways in which a standard can be relevant to stakeholders. Obviously, not all search directions are equally relevant to all standardization processes. They should therefore be used as a checklist rather than a prescriptive instrument.

The search directions are illustrated by a case study of the revision of the British Code for Information Security Management (BS-7799: 1999), and the translation to Dutch of the revised version. The standard provides a wide range of measures that organizations can take to protect their electronically stored information. Measures include the implementation of an information security policy, the physical protection of information systems, and the training of personnel. Organizations that comply to the standard are not obliged to implement all these measures. Rather, implementing the Code implies that the organization makes a systematic analysis and selection of the relevant measures, and commits to implement this.

A first version of the BS-7799 was published in 1995. In 1997, the British Standardization Institute BSI decided to revise the standard because of developments in electronic commerce, mobile computing and third-party arrangements. The first part of the revised standard, containing the actual Code of Practice, was published in 1999. In 2000, this part has been adopted by ISO by means of a fast track procedure (ISO-IEC 17799:2000). BSI published the second part, called Information Security Management Systems, in 2002. A full revision of the complete standard by ISO is expected to be published in 2004 or 2005. In reaction to the 1999 revision of the BS-7799 the Dutch standardization committee on IT Security Technology re-established the significance of the Code, in particular for the improvement of information security in small and medium-sized enterprises. A working group was established to carry out the translation and adaptation of the Code.

The case of the development and translation of the British Code for Information Security Management will be used here to illustrate the method for stakeholder identification and classification. The nine search directions for identifying stakeholders are presented below.

1. *Production chain*. This search direction includes all firms in the production chain of the product that the standard relates to, from the producers of raw materials and parts suppliers to the firms that make the end product, the users and firms involved in the reuse, recycling or disposal of the discarded product. Also transporters, trade companies, and firms involved in service and maintenance are stakeholders in the production chain. The Code for Information Security Management does not relate to a specific physical product, so the production chain is relatively less important. Nevertheless, producers of IT systems and of physical protection devices can be potential stakeholders.
2. *End users and related organizations*. End users usually have a specific position in the production chain, which is why they are included as a separate stakeholder. Especially in the IT sector, but also in other sectors, end users play a major role in standards setting. Related to end user needs are other organizations, such as firms providing helpdesk services. Regarding the Code, this is a broad category of all stakeholders that are involved in the implementation and use of the measures described in the Code. These can be large companies, small- and medium sized enterprises, public organizations and individual employees.
3. *Designers*. The product that the standard relates to is in many cases designed by stakeholders that are part of the production chain. In other cases, however, separate, specialized companies such as architects design the product. In IT, in general, design and production come in one hand. For the Code, it should be investigated if there are dedicated firms that design IT security systems.
4. *Physical system*. For each step in the production chain the physical interactions with other technical systems can be analyzed. For instance, the chemical composition of a lubricant may affect the engine to which it is applied, and a new piece of hardware must be compatible with the other components on a personal computer. Hardware and software compatibility is also a relevant issue to the development of the Code. The technology and measures described in the Code should not affect the performance of the systems in which they are implemented. Also, a situation may occur where one company's products are compatible with the suggested measures in the Code, whereas the products of a competitor are not. For these reasons, stakeholders involved in the development and production of elements of the surrounding system, should be identified as potential stakeholders. Computer software and hardware producers are an important section of this stakeholde group.
5. *Inspection agencies.* The product itself, or its physical and organizational environment, will in many cases be subjected to inspection. Inspection may be carried out by the producer himself, the customer, or by a dedicated organization: certification bodies, testing laboratories, or governmental enforcement agencies. Many standards are used as direct or indirect guidelines for inspection. Regarding the Code for Information Security Management, certification is likely to become an issue in the inter-organizational exchange of sensitive information. Organizations may want to see their clients to be certified according to the Code before they enter this type of co-operation.
6. *Regulators*. Standards are often related to government regulation on a local, national or even international and global scale. Laws and other regulations sometimes refer directly to specific standards. In that case, regulators are directly affected if a relevant standard is revised. Their cooperation is also an important success factor. First of all standards should comply with existing regulations, and secondly, reference in formal regulation will boost the status and adoption of the standard. There are no plans for reference to the Code for Information Security Management in formal regulation in The Netherlands. Adaptation of the Code to the Dutch legal system was however an important issue in the translation process. Also, the development and dissemination of the Code was strongly

endorsed by both the British and the Dutch government, mainly because of the potential economic damage that can be caused by lack of information security. For this reason, the British Department of Trade and Industry and the Dutch Ministry of Economic Affairs should be seen as stakeholders belonging to this search direction.

7. *Research and consultancy*. Universities, research institutes and consultants have in many cases also a stake in standard setting. Standards influence technological innovations and, on the other hand, the standardization agenda is greatly influenced by innovations, see, for the example of mobile telecommunications, Beckers (2001). In many cases, co-normative or pre-normative research is needed in order to make trustworthy standards.[3] Consultants may have a special stake in creating complicated standards as this increases their work in assisting companies to implement these standards (De Vries, 1999, p. 29). In the Case of the Code for Information Security Management, potential stakeholders are academic, public and industrial research groups involved in relevant research fields such as encryption. Also IT consulting firms, especially those in the field of IT management, are potential stakeholders.
8. *Education*. Standards are frequently included in educational programs, both for students and for professionals. Organizations responsible for education have a specific interest in the accessibility and clarity of the standard. They can also contribute to the standard's diffusion by including it in educational programs. Information security management can be part of IT courses at universities and other educational programs. Therefore, representatives of these organizations should be seen as potential stakeholders. The Dutch national standards body has organized introductory courses about this Code. In this case, therefore, the NSB itself is a stakeholder.
9. *Representative organizations*. Some types of stakeholders have representative organizations that are dedicated to serve the interests of their members. Examples are labor unions, consumer organizations, professional organizations and branch of business organizations. These representative organizations are usually involved in standardization processes rather than their individual members. However, they should be seen as a separate category of stakeholders. The first reason for this is that the needs and objectives of the representative organization are not necessarily similar to those of their individual members. This holds especially for organizations that represent a heterogeneous stakeholder group, such as consumer organizations. Secondly, representative organizations are usually relatively independent in choosing their strategic position in standardization processes. Frequent consultation of their members regarding specific standardization issues does not always take place.

It should be noted that these nine categories serve as search directions when identifying stakeholders. A full listing of all the firms and organizations in each category is therefore not necessary, because not every category necessarily contains stakeholders regarding a specific standard. Some standards are more design oriented, while others primarily relate to the end use of products, or just the testing and certification. In other cases, for instance management system standards, the production chain is hardly relevant. The nine categories should therefore be seen as a search heuristic that enables standardization officers and others not to forget certain groups of stakeholders. The application of these nine search directions to the case of the Code for Information Security Management did show the value of using such a heuristic. A large and heterogeneous group of organizations, both public and

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[3] The European standardization organization CEN, for instance, has established a special unit for bridging the gap between research and standards development, see http://www.cenorm.be/sectors/star/mission.htm.

private, could be identified as potential stakeholders. Also, this range of potential stakeholders goes well beyond a circle of professionals involved in information security on a daily basis. Entering the standardization process with ‘the usual suspects’, without a systematic analysis of potential stakeholders, is bound to result in overlooking some stakeholder categories.

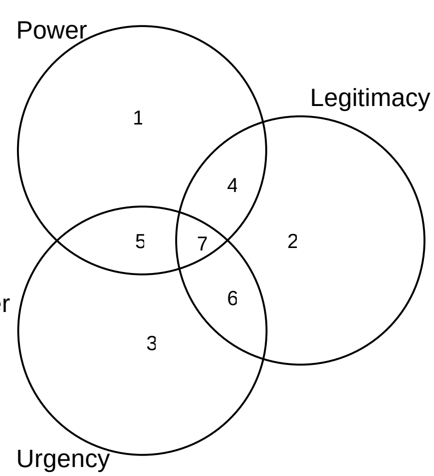
Part 2. Determining stakeholder positions

The first step of stakeholder identification produces a ‘long list’ of stakeholders. In many cases this list will be extensive. The question is now how to deal with this list when attempting to involve these stakeholders. An equal, full representation of all stakeholders will in general not be desirable, both from stakeholders’ perspective as well as from the perspective of the quality of the standardization process. All stakeholders have to be able to participate in the standardization process, but not every stakeholder will be prepared to put time and effort in the standard setting activities. Full stakeholder participation will also cause the process to be complex and time-consuming, which should be avoided if it does not contribute to the quality and legitimacy of the resulting standard. It is therefore important to determine the positions of various stakeholders regarding the standardization process. The level of participation and the effort put into stakeholder involvement can be adapted according to their positions.

For the determination of stakeholder positions we use the stakeholder typology developed by Mitchell et al. (1997). What sets this typology apart is that it is not based on characteristics of the stakeholders themselves, but on determinants of stakeholder salience –“the degree to which managers give priority to stakeholder claims” (Mitchell et al. 1997, p.87). Considering our objective to determine which stakeholders should participate in the standardization process, this is an appropriate starting point.

Mitchell et al. distinguish three variables in the stakeholder-firm relationship that determine stakeholder salience. The first is power, which they describe as the ability of one actor to make another actor do something he would not otherwise have done. Power is usually unevenly distributed among actors in a relationship. The stakeholder can have power over the firm (or, in our case, the standardization process and the resulting standard), or the firm can have power over the stakeholder. The second variable is legitimacy: the degree to which the firm and the stakeholder find each other’s actions “(…) desirable, proper, or appropriate (…) (Mitchell et al. 1997, p.102). The third variable is urgency: “The degree to which stakeholder claims call for immediate attention”. Based on these three variables, Mitchell et al. define eight types of stakeholders; see Figure 1.

1. Dormant stakeholder
2. Discretionary stakeholder
3. Demanding stakeholder



4. Dominant stakeholder
5. Dangerous stakeholder
6. Dependent stakeholder
7. Definitive stakeholder
8. Non-stakeholder

Figure 1. Stakeholder typology (adapted from Mitchell et al. 1997)

For each of these eight types of stakeholders, we analyzed the appropriate level of participation they have in the standardization process, and the effort that should be put into involving this type of stakeholders. The results of this analysis are presented below, and are illustrated by the case of the Code for Information Security Management.

1. *Dormant stakeholder* (P). This stakeholder has power to affect the standardization process, but its participation is not considered legitimate and neither from the stakeholder nor from the standardization process the need is felt to participate. Dormant stakeholders should be monitored, however, in view of their potential to harm the standardization process. In case of the Code, large software firms may belong to this category. Due to the specific nature of the Code and the fact that many of the information security measures are not software related, participation might not be high on their agendas as well as those of the existing participants. Due to the compatibility issue, however, the strategies of software firms can affect the content and effectiveness of the Code.
2. *Discretionary stakeholder* (L). Discretionary stakeholders do not have the resources to affect the standardization process, and feel no urgent need to participate. They do have a legitimate role in the process, however, which is recognized by the other participants or the future buyers of the standard. In this respect it may be useful to try to involve this type of stakeholder despite its lack of urgency. An example can be a research institute that is requested an expert opinion in the standardization process. Regarding the Code for Information Security Management, most small and medium-sized enterprises (SMEs) can be identified as discretionary stakeholders. Other parties involved in the development and translation of the standard are concerned with the lack of information security measures taken by SMEs, which may damage their own security level. Therefore the legitimacy of SMEs as a stakeholder is high. In the United Kingdom as well as The Netherlands, large companies and the government co-financed campaigns to increase SMEs' awareness of information security.
3. *Demanding stakeholder* (U). Stakeholders without power and legitimacy, but with urgency towards the issue are referred to as "mosquitoes buzzing in the ears of managers" by Mitchell et al (1997, p.108). They will not receive more than a passing attention from managers. The same holds for demanding stakeholders in standardization processes. The typical example of this category is a firm that is represented already by its branch of business organization, but still insists upon individual participation in the standardization process. In the case of the Code for Information Security Management, no demanding stakeholders could be identified. This is mainly due to the fact that the subject was strongly endorsed by powerful stakeholders. There were no outsider organizations attempting to call attention to the issue of information security. For demanding stakeholders it is important that the parties already involved in the standardization process re-assess the lack of legitimacy of demanding stakeholders. It is possible that this stakeholder's demands or position require that they become involved in

the standardization process. If not, the stakeholder can be offered a kind of symbolic participation in order to stop their interference in the process.

4. *Dominant stakeholder* (P, L). Like the discretionary stakeholder, the dominant stakeholder itself does not see immediate interest in participating, while its participation is considered desirable from the perspective of the standardization process. Efforts to involve this type of stakeholder should be stronger, because dominant stakeholders also have the power to affect the process or the resulting standard. One way of involving this type of stakeholder is by relating the standardization process to other issues that are urgent to him. For instance, the development of one standard can be combined with the development or revision of related standards that the dominant stakeholder considers to be relevant. In many cases, governmental organizations appear to be dominant stakeholders. This is also the case in the Dutch adoption of the Code for Information Security Management. As the responsible government body for the internal management of Dutch government organizations, the Dutch Ministry of Internal Affairs did have apparent power and legitimacy. Urgency was lacking, however. The Ministry preferred to develop its own guidelines for information security management by government organizations.
5. *Dangerous stakeholder* (P, U). Mitchell et al. (1997, p. 110-111) state that stakeholders that have power and urgency but no legitimacy, will in general take unlawful and sometimes violent action to achieve their objectives. Computer criminals may count as dangerous stakeholders in the case of the Code for Information Security Management. Obviously, these stakeholders cannot be given a formal place in the standardization process, although an assessment of their strategies and capabilities must be taken into account when developing the Code.
6. *Dependent stakeholders* (L, U). The definitive stakeholders are important for the general support of a standard and they see the need to participate in the standardization process. In general, little effort will be needed to involve these stakeholders in the process, provided that the dependent stakeholders are aware of the process taking place. However, dependent stakeholders will in many cases lack resources to properly participate in the process. Financial support, access to technical expertise and other types of assistance will be needed in order to ensure their involvement. SMEs that do see the need of information security belong to this stakeholder category regarding the Code for Information Security Management.
7. Definitive stakeholders (P, L, U). Definitive stakeholders have the power to affect the standardization process, they consider the standard to be important, and their involvement is indisputable. Little effort is needed to involve these stakeholders; in general definitive stakeholders will already have a long-lasting commitment to related standardization activities and are the driving force of the standardization processes. In some cases, efforts should be directed to preventing these stakeholders to become too dominant in the process. Regarding the Code for Information Security Management, this stakeholder group consists of the large companies and government organizations that took the initiative to develop the Code. They have the financial and technological resources to contribute to its development; they recognize its significance as well as each other’s involvement in developing the Code. It is no surprise therefore that the working group responsible for the Dutch translation consisted of these stakeholders.
8. *Non-stakeholders.*

This stakeholder typology enables a selection and prioritization from the ‘long list’ produced by the stakeholder identification step. The remaining question is, however, how to establish the power, legitimacy, and urgency of a stakeholder. Regarding power, the central question is whether the stakeholder has the resources to affect the standardization process or the success of the resulting standards. Relevant resources are time available, financial position, technical expertise, and the position in the network of firms and organizations to which the standard applies. As for legitimacy, a distinction should be made between formal legitimacy –is the stakeholder formally entitled to participate in the process- and perceived legitimacy – do the other stakeholders accept or support the participation of this stakeholder in the process? Given the openness of formal standardization, almost every stakeholder is formally legitimate. The significance of the stakeholder's participation however largely depends on his perceived legitimacy. The urgency of a stakeholder can be estimated by looking at its recent actions in this field: has the stakeholder been active in pursuing his goals regarding this standardization issue? If this is the case, then the stakeholder may be expected to have a high urgency.

Finally, it should be noted that power, legitimacy and urgency are dynamic variables. For example, the legitimacy of stakeholders can change due to controversial decisions and activities. Also a stakeholder's power regarding standardization can diminish if its resources are redirected towards other activities. Determining stakeholders' positions regarding the standardization process is therefore not a one-off activity, but should be repeated regularly.

FIRST EXPERIENCES

The above method of stakeholder identification for standardization was initially developed as a research tool for the ex post evaluation of stakeholder participation in past standardization processes. It has been applied in four case studies of standardization processes.[4] These case studies were aimed at identifying barriers for stakeholder participation in standardization processes in various sectors. To this end, a comparison was made between the full list of stakeholders and their positions, as found by applying the above method, and the actual participants in the standardization process. Subsequently, interviews with participants as well as other stakeholders have been held in order to investigate why some stakeholders, in particular those with high scores on power, legitimacy and urgency, did not participate in the standardization processes. This provided insight in the barriers for stakeholder participation in these case studies.

The method for stakeholder identification described above proved to be valuable in the case studies. The adequacy of the method is difficult to measure in absolute terms: we cannot prove that the method produces the complete list of stakeholders, and that their division in stakeholder types matches their exact empirical positions regarding the standardization process. We can, however, show the added value of the method relative to the stakeholder identification that took place by the standardization officials and committees in the case studies. In all four cases, we were able to identify additional stakeholders that had not been identified by the actors involved in the standardization process. In many cases, these stakeholders had not been taken in consideration at all, while interviews with some of these stakeholders learned that they would have been willing to participate.

[4] The cases that were investigated were: the revision of an ergonomic standard concerning office workplaces, the translation and adaptation of the British Code of practice for information security management, the Dutch input in the international standard for determination of release rate of biocides in antifouling paints, and the translation and adaptation of a standard concerning the qualification of welders. Case reports (in Dutch) are available with the authors.

Secondly, the stakeholder typology based on power, legitimacy and urgency also had an added value, especially in providing additional insights in the positions of stakeholders regarding the standardization process. In particular, the typology has provided additional insight in the position of ‘weak’ stakeholders such as trade unions, consumer organizations and environmental groups. These stakeholders are generally believed to lack power, and for that reason have difficulties in participating in standardization. However, in terms of the typology the main problem of these organizations appears to be lack of urgency rather than lack of power: they do not give priority to standardization and therefore do not use their power to invest in it. They have sufficient resources to participate in standardization, but these resources have to be divided between many issues, processes and networks. Whether sufficient resources are devoted to standardization depends largely on the urgency of the standardization issue.

In the third place, the method appears to be easy to apply. Master’s students and junior project assistants carried out the four case studies, and they were able to apply the method to their case studies without major difficulties. We therefore expect that standardization officers and committee members will in general be able to apply the method. The ease of implementation is strengthened by the fact that the method does not have to be fully applied for each new standard to be developed or revised. The constellation of stakeholders in a certain field of standardization is relatively stable. However in some cases a full stakeholder identification exercise is needed. Examples are standards that are anomalous to an existing committee. If a standard deals with issues that are unusual to the committee, then probably the standard will also involve different stakeholders. Also, a stakeholder analysis should be included in a periodic evaluation of standardization committees. Especially in dynamic sectors like IT, the stakeholder positions may change over time. This calls for a regular check on stakeholder representation in existing committees and processes. Furthermore, if the standard deals with controversial issues or if it has a wide effect on many sectors, then a full stakeholder analysis is recommended. In other cases, the method can be used as to support a ‘quick scan’ regarding the stakeholder representation. We believe that standardization officers will also internalize the method if they apply it frequently. The method will then be used implicitly in other standardization processes as well.

These positive experiences with the method are confirmed by the fact that NEN, the Dutch standardization organization, has already started to use it to evaluate stakeholder involvement in standardization committees.

CONCLUSIONS AND DISCUSSION

In this paper we presented a method for stakeholder identification to be used in standardization processes in general, which can be also used in the information technology sector. A secondary analysis of literature showed strong indications of unbalanced stakeholder representation in IT standardization processes. A systematic identification of stakeholders is a crucial first step in achieving an adequate representation of all stakeholders. The method presented here can contribute to this. It first generates long lists of all potential stakeholders, whose position towards the standardization issue is then analyzed. This second step makes it possible to differentiate between stakeholders whose participation is essential, and stakeholders that are dispensable. This increases the efficiency of activities to involve stakeholders in the process. First experiences with the method are promising; also the fact that NEN, the Dutch National Standardization Organization, has started implementation of the method indicates the method’s relevance and potential.

However, applying a method for stakeholder identification will only contribute to a more balanced stakeholder representation in standardization if other barriers for participation are taken away as well. The research project for which our method had been developed showed that unbalances in stakeholder representation are not only caused by the difficulties in identifying stakeholders. One of the main barriers we found is the professional culture that dominates standardization processes. In that sense our cases confirm the findings of Schmidt and Werle (1998) and Mallard (2000). Standardization committees often consist of professionals sharing the same area of expertise. In general, they appear to perceive the standardization issue as a complex technical task, which needs to be executed in a project environment. This professional attitude is in line with the technical complexity of many standardization processes, but it conceals the fact that standardization is also a negotiation process in which stakeholders with various aims and perceptions attempt to realize their objectives. In many cases, insufficient attention is paid to stakeholder identification and involvement, simply because the participants are not aware of the importance of this. There are some exceptions (NSSF, 2003; Olshefsky & Hugo, 2003; Waloff, 1996), but these lack a systematic stakeholder inventory, let alone a catagorization of stakeholders. We believe that adopting our method for stakeholder identification can also contribute to a shift within standardization committees towards more focus on stakeholders and their stakes.

We propose our method to be used at three occasions. First, before starting a new standardization committee, in order to get a balanced stakeholder representation in this committee. In our research project we found that the longer standardization committees exist, the more there is a danger that they just continue their work without paying enough attention to their external orientation. Standards are reviewed after a few – often five – years, but in general this is not done for the committees. In our project we therefore recommend regular evaluation of standardization committees and the stakeholder methods should be used in this evaluation to evaluate the committee composition. Both the committee's program and the market situation may have changed. The third way to use the method is less explicit: standardization officers should have the method in mind when a new work item is added to the program of an existing committee. They should ask themselves whether or not the new topic would be of interest to stakeholders not yet represented in the committee. In the case they expect more interest they or their committee members could take action to invite the missing stakeholders.

Although further research into its application options and effects, it appears that this method for stakeholder identification can contribute to the important task of increasing stakeholder participation in IT standardization.

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See http://web.eur.nl/fbk/dep/dep6/members/devries.

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DESIGN, SENSE-MAKING AND NEGOTIATION ACTIVITIES IN THE "WEB SERVICES" STANDARDIZATION PROCESS

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ABSTRACT

This study constitutes a preliminary attempt to refer to Design, Sense-making and Negotiation activities in the investigation of an ongoing standardization process. The D-S-N model, recently proposed by Fomin, Keil and Lyytinen, integrates fragments of theory to better understand standardization processes. The three typologies of activity are explained on the basis of designers' cognitive behaviour theory (D=design); sense-making theory (S=Sense-making) and actor-network theory (N=Negotiation). We are applying the D-S-N model (still under development by the authors) on the "Web Services" case study, by analysing the emergence of a series of technological standards for distributed software components. The preliminary results of our ongoing analysis of the Web services standardization process seem to confirm the validity of the D-S-N approach, and encourage to proceed extending and deepening the investigation.

Keywords: standardization processes, technology, diffusion, adoption, Web Services.

INTRODUCTION

The D-S-N model, recently proposed by (Fomin, Keil and Lyytinen 2003) and still under development by the authors, integrates fragments of theory to better understand standardization processes. The three typologies of activity are explained on the basis of designers' cognitive behaviour theory (D=design); sense-making theory (S=Sense-making) and actor-network theory (N=Negotiation).

To better understand the nature and the interaction of the D, S and N-type activities identified in the model, we investigate the "Web Services" standardization process, orchestrated by the W3C consortium. The choice of the Web Services case study comes from two main reasons. First, this technology is one of the most relevant recently appeared in the software market (for example, it is at the basis of the Microsoft .Net platform, their core strategic investment of the last years). Second, the main standardization activities in the W3C consortium usually occur via face to face meetings, distributed meetings (teleconferences) and mailing lists. For the WS standardization process, all the main sessions transcripts are available on line. However, this potentially rich set of information has not been analysed before.

The preliminary results of our ongoing analysis of the Web services standardization process seem to confirm the validity of the D-S-N approach, and encourage to proceed extending and deepening the investigation. The paper is organised as follow: in the following section, the D-S-

N model is presented and discussed; then, after some methodological notes, the Web Services case study is presented and the exploratory analysis of the sample transcripts and documents is accomplished. Three out of five of the statements outlined by (Fomin, Keil and Lyytinen 2003) are briefly analysed here. Some preliminary conclusions and indications for the completion of the research work are offered in the final section.

THE D-S-N MODEL

The D-S-N model is a preliminary attempt to define a “process model of standardization” (Fomin, Keil and Lyytinen 2003). Its basic assumption is that any standardization process may be characterized by three typologies of activities: design (D), sense-making (S) and negotiation (N).

The “Design” activities are accomplished during the rational analysis and definition of the technical specifications and physical properties of the technology object of standardization. The “Sense-making” activities are accomplished in order to prefigure situated scenarios of the potential uses of the new technology. The “Negotiation” activities involve the different groups of stakeholders participating in the standardization process (technology designers, vendors, users) with their proper interests and visions.

Three different streams of literature are referred to in the D-S-N model: the designs activities are interpreted in the light of rational planning studies (Simon, 1981); the concepts developed by (Weick, 1995) are used to deal with the sense-making activities; the negotiation activities are taken into account on the basis of the actor-network theory, (Latour 1995; Callon and Law 1989).

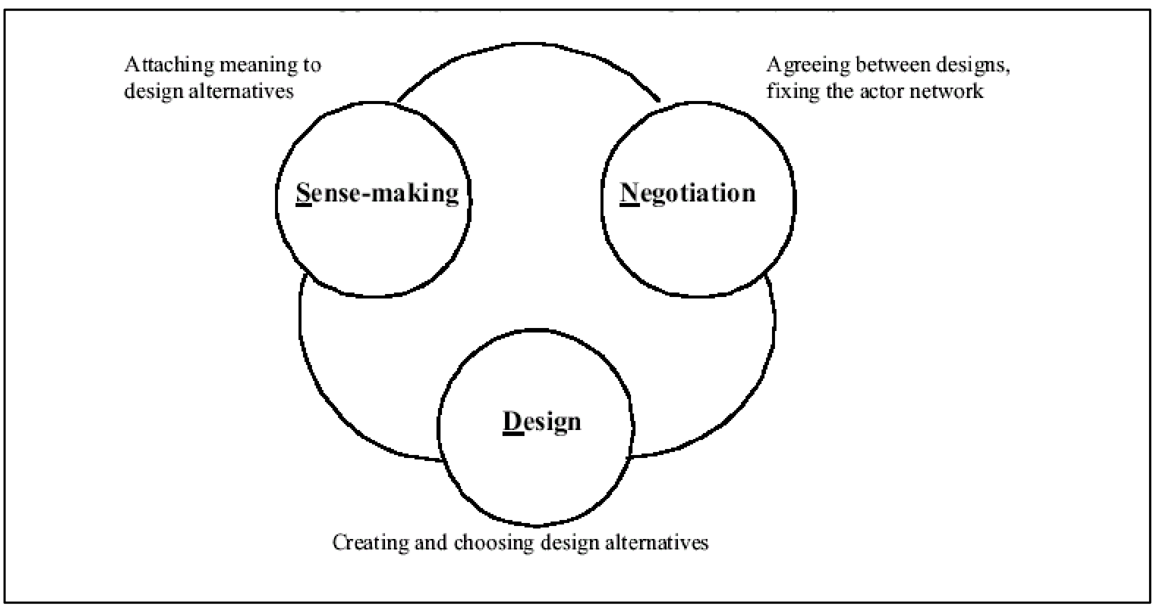

Figure 1: Standardization activities according to the D-S-N model. From (Fomin, Keil and Lyytinen, 2003, page 10, figure 1)[1].

[1] One of the reviewers noticed that “attaching” meaning could sound like meaning was not present in the D cycle. It would be better to say that new meanings are produced in the S cycle, so that Sense-making could be better regarded as “negotiation of meaning” rather than “attachment of meaning”.

Figure 1 illustrates how the three components of the D-S-N model reciprocally interact in the standardization process. According to the authors, the D, S, and N-type activities do not follow any coherent linear and sequential development, but rather a series of iterative, irregular cycles, and in a recursive way, usually starting at a general level of specification of the technological standard and getting into more detailed versions over time.

However, the D-S-N analytical framework is still under development: in (Fomin, Keil and Lyytinen, 2003) it is applied to three cases of standardization in the telecommunications sector but such empirical application is still entirely exploratory.

METHODOLOGY AND RESEARCH QUESTION

Our aim is testing the explanatory power of the D-S-N model in order to challenge and eventually refine it. The research question is: "How can the D-S-N model explain the Web Services standardization process?" Web Services is an emerging standard technology for distributed software development that is capturing increasing attention by the market.

From the methodological point of view, the choice of election is a case study (Yin, 1994), structured and analysed with a phenomenological perspective. The empirical investigation has been conducted limiting theoretical constraints as much as possible, trying not to enslave the case to the theory. Therefore our approach is eminently exploratory, although still connected to the chosen theoretical framework.

The connection between theory and observation was accomplished taking into account the five main statements proposed by (Fomin, Keil and Lyytinen 2003):

1. Standardization processes can be broken into design, sense-making, negotiation activities.
2. Design, sense-making, and negotiation can unfold in a non-linear fashion.
3. To proceed the cycle of design, sense-making, and negotiation needs to be complete.
4. D-S-N are recursively organized.
5. The D-S-N model results more appropriate than linear sequential models, to explain standardization processes.

The work presented here is still in progress. At the moment, the empirical investigation of the "Web Services" case study is still partial and it takes into account only the first three statements. The aim of the project is to investigate also propositions 4 and 5 and to carry out the present analysis more in depth. These five propositions are just a preliminary outcome of an early version of the D-S-N theorization. In the final analysis, further developments of the studies on the subject will be considered. Moreover, a wider sample of documents with the transcripts of the standardization working groups meetings, teleconferences and mailing list will be examined, by using more extensive and accurate text analysis methods.

THE WEB SERVICES CASE STUDY

What are Web Services

On the 11th of April, 2001, 52 companies conveyed at a workshop in San Jose, California. Among them there were well known names in the IT industry like IBM, Microsoft, Sun, HP, SAP, Computer Associates, Oracle, Cisco, Novell, Adobe, Nokia, Ericsson, Fujitsu, and also big IT "power users" like Boeing, Chevron, Reuters, Charles Schwab and others. The aim of the San Jose workshop was to arrange a common definition of an emerging technology, so called "Web Services". For this purpose, 64 position papers were presented and discussed. That day has marked the official start of the process of standardization of the so-called " Web Services ". The

San Jose workshop is wholly documented at the Web address: http://www.w3.org/2001/01/WSWS[2].

The "Web Services" architecture is based on a complex system of technical specifications, on which companies like Microsoft, IBM and Sun Microsystems have made heavy investments (Sullivan and Scannell 2001). For instance, the vision of the "software as a service" underlying the Microsoft architecture ".Net ", (formulated and announced in the year 2000 and now adopted all over the main Microsoft products), is dependent on the success of the Web Services technology. The Microsoft vision was initially raising doubts and skepticism among observers (Deckmyn 2000).

What are Web Services? The underlying idea is very simple, and it is an evolution of the “component based” software development paradigm, that was already known and implemented by Microsoft (COM, DCOM models), by IBM (SOM model) and for the Unix platforms (CORBA model). According to this paradigm, software applications may be modularly “assembled” combining several standard software “bricks”. In the past, the component-based software development was severely limited by the fact that the small “software bricks” built according to models like DCOM or CORBA were not documented and often difficult to use.

A DCOM software component is basically a black box which accepts data and messages in input and gives back results as output. What is usually difficult, especially if the component was written by somebody else, is to deeply understand the component functionalities (what it does) and how it is intended to be used. Therefore, it is not easy to build a software application as a “puzzle”, just assembling software components built by third parties according to the traditional models like DCOM.

The architecture of the Web Services was born to overcome the limitations of the traditional component based software, adding new potential uses, leveraging the Web as a mean of communication. The basic aim was to create an on line market of software components, based on three elements: an on line directory; a standard system of documentation to describe the software component; a set of communication rules to access the software components via Web.

All these three aspects (i.e. the index, the language of description and the Web access protocol) were missing in the classical models like COM and CORBA and have been proposed with the Web Services architecture. Using Web Services it is possible to decide that a specific part of a software application (for instance the function that produces a fiscal code) could be located out of the application itself: when it is necessary to call for the functionality, the application sends data to be elaborated over the Web to the remote software component (e.g. the customer details) and gets back the results (e.g. the fiscal code). This idea, briefly mentioned here, is called by-the experts “functional decomposition" (Castro-Leon 2002).

In synthesis the Web Services standard is based on two fundamental principles:

1) the functional decomposition of the applications in several independent software components;

[2] For instance, the 64 positions papers are publicly accessible to the address: http://www.w3.org/2001/03/WSWS-popa/, and it is possible to access the records of the discussions http://www.w3.org/2001/04/wsws-proceedings/minutes, to download the program and presentation slides http://www.w3.org/2001/03/wsws-program and to consult the mailing list archives, at the address http://lists.w3.org/Archives/Public/www-ws.

2) the use of the WWW infrastructure for inter-application communication: software application are enabled to access remote software components over the Web.

For an analysis of the important strategic implications for the organizations see e.g. (Hagel III and Brown 1999; Hagel III and Singer, 2001); some peculiar aspects of Web Services in eGovernment are depicted in (Virili and Sorrentino 2002); the potential use of Web Services for knowledge sharing in the Public Administration is treated in (Bolici, Cantoni, Sorrentino and Virili 2003), while an analysis of the potential impact of this technology on the information systems development methodologies in the emergent organizations is conducted in (Bello, Sorrentino and Virili 2002). For a basic introduction and a review of the most important technical concepts refer to (http://www.Webservices.org/index.php/article/archive/61).

The W3C consortium and its role

The W3C consortium (the acronym stands for WWWC, that is World Wide Web Consortium) was founded in 1994 and it is still directed by Tim Berners Lee, the inventor of the Web,

"[…] to lead the World Wide Web to its full potential by developing common protocols that promote its evolution and ensure its interoperability. W3C has around 450 Member organizations from all over the world and has earned international recognition for its contributions to the growth of the Web. […].

W3C concentrates its efforts on three principle tasks:

- **Vision**: W3C promotes and develops its vision of the future of the World Wide Web […].
- **Design**: W3C designs Web technologies to realize this vision, taking into account existing technologies as well as those of the future.
- **Standardization**: W3C contributes to efforts to standardize Web technologies by producing specifications (called "Recommendations") that describe the building blocks of the Web. W3C makes these Recommendations (and other technical reports) freely available to all." (from http://www.w3.org/Consortium/#background[3]).

The organizational structure of the W3C

"To meet its goals (universal access, semantic Web, Web of trust) while exercising its role (vision, design, standardization) and applying its design principles (interoperability, evolution, and decentralization), W3C process is organized according to three principles: vendor neutrality, coordination and consensus" (from http://www.w3.org/Consortium/#background).

These three organizational principles have been used for planning and to draw the organizational structure of the W3C, illustrated in the so-called "process document" (http://www.w3.org/Consortium/Process/), that describes in detail the organizational structure of the consortium (Members, Advisory Committee, Team, Advisory Board, Technical Architecture Group), the activities and the working groups for each activity.

Every technology object of standardization in the consortium W3C corresponds to an "activity". For each activity there may be several workings groups, each one focused on the production of a technical specification.

The attention is here focused on the "Web Services Architecture Working Group", which has the objective to define the technical specifications of a standard architecture for the Web Services.

[3]All the text cited is directly reported from the referenced web page; the ellipses […] indicate that a part of the original text was skipped at that point.

Every working group has one or two leaders. To get job done, there are two modalities of interaction in the groups: the first one is the mailing list; the second one is group meetings (they can be either face to face (F2F) or distributed, i.e. via teleconference). The charter document specifies that "to be effective every working group should have from 10 to 15 active participants" (charter of the group WSA, section 4.5).

The F2F meetings don't have a predetermined frequency, they are settled by the group leader according to the matters to be treated, to the deadlines and the opportunities of co-location of side events (e.g. conferences, other W3C meetings, etc.). The distributed meetings are scheduled at least once a week (twice when required by the deadlines). The participation to the F2F meetings is limited, on invitation of the group leader. Guests or external experts may be occasionally invited. All these forms of discussion and negotiation (mailing list, F2F meetings and teleconferences) are recorded, and the scripts are publicly accessible via the working group Web site[4].

This collection of documents, eventually integrated with external information sources like specialized press articles and news, may be used for the application and verification of the D-S-N model. At this research stage, a systematic analysis of all the available material was not yet accomplished; however, a preliminary exploratory analysis was carried out on the basis of a limited sample of the available documents.

In the following sections the first three statements proposed by (Fomin, Keil and Lyytinen 2003) for the D-S-N model are verified.

Statement 1: standardization processes can be broken into design, sense-making, negotiation activities

A preliminary verification of this statement could be done on the basis of the definition of the "ideal role" of the W3C, as reported at the beginning of the previous section, "The consortium W3C and his role". The role of the consortium is centred on three fundamental points, "Vision, Planning and Standardization." We could argue that these points closely reflect the three constitutive hinges of the D-S-N model: the promotion of the W3C vision could be regarded as a sense-making (S) activity; planning as a design (D) activity, while production of technical specifications (that have been shared by all the members) usually requires an intense activity of negotiation (N)[5].

Therefore, the D-S-N model seems to well explain the three fundamental hinges selected by the consortium as the basis of its activities, confirming their different nature but also their intrinsic and reciprocal connections.

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[4] The WSA group meeting transcripts are published at the address http://www.w3.org/2002/ws/arch/#records). For the teleconferences sometimes the log files are directly published "as they are" (like in the distributed meeting of April 18th, 2002: http://www.w3.org/2002/ws/arch/2/04/18-minutes); more often, they are edited to make them more readable (as for instance in the first distributed meeting of the group, held in February the 6th, 2002: http://www.w3.org/2002/ws/arch/2/02/06-minutes).

[5] As noticed by a reviewer, assertions here are often simply stated and not justified. The same is true in most of the samples reported from the transcripts: there is much assertion and too little analysis. This is due to the preliminary and exploratory nature of this report. The author is planning to carry out the analysis on a more solid and methodologically grounded basis, using text analysis techniques.

The recordings of a few distributed meetings are now taken into consideration. The first distributed meeting was held on February the 6th, 2002. In figure 2 the transcription is reported, as from the original records published in http://www.w3.org/2002/ws/arch/2/02/06-minutes.

Distributed Meeting, February the 6th, 2002: Agenda

```
1. Roll call, scribes for minutes/action items (11.00 + 5)

2. Agenda review, and AOB (11.05 + 5)

3. Review of Charter, modus operendi and initial plan of work
(11.10 + 15)

4. F2F planning (11.25 + 10)

5. Call for editors (11.35 + 10)

6. Round table discussion, initial requirements
     gathering  (11.45 + 35)

7. Subteam formation and next steps (12.20 + 10)
```

Figure 2: First distributed meeting of the WSA group: agenda (from http://www.w3.org/2002/ws/arch/2/02/06-minutes).

The meeting is planned from 11 to 12.30. What kind of decisions have been taken? There is a series of organizational duties (points 1 and 2: roll call, nomination of the scriber, agenda review; point 4: organization of a F2F meeting; point 5: call for editors). The most interesting topics are in the second part of point 3 (initial plan of work) and at point 6 (round table discussion, initial requirements gathering).

Thereafter, as regard to the initial plan of job, the chair of the group (Chris Ferris, from Sun Microsistems) proposes:

> We need requirements and a framework. With the framework we can address how the parts fit together.

We are at the very beginning of the group activity, and it is not yet clear what should be done in order to produce the specifications of the Web Services architecture, (the objective of the working group). The two fundamental elements to define the architectural specifications are: the requirements and a framework. The definition of these two unknown elements is the main activity of sense making of the group. How to proceed? For the framework there is a proposal of a group member:

> Roger Cutler - brought up are there other frameworks already available. we need to understand what other groups are doing.

Cutler proposes to start verifying the already available frameworks, also trying to understand what the other working groups are doing. Concerning the requirements, the initial requirements' gathering is planned in agenda at point 6: the participants start to freely launch some proposals for the architectural requirements. We include here a fragment of the transcript:

> Igor Sedukhin - they are trying to stay neutral - meaningful architecture standards. for the technical side they are concerned about management and security.
>
> Roger Cutler - messaging and reliability are important - they are concerned about co-ordination with other groups such as OASIS - and to keep things understandable.
>
> Sandeep Kumar sees an evangelizing role for this group. how to we evangelize this to our own organizations and partners. technically - the messaging and transactions - orchestrations and routing of services.
>
> Yin-Leng Husband - Web services architecture... co-ordination of ws framework. co-ordination between ebXML and w3c…
>
> Dave Hollander - we need to make this understandable to "the normal person" this needs to be understandable to avoid arcane known.

The transcription could go on, there were 33 interventions in that occasion. The following teleconference, held on February 14, 2002, had in agenda the review and the discussion of the requirements proposed in the previous meeting. One of the group members, Daniel Austin, collected and synthesized them into a high level architectural goals list that was submitted for discussion.

> Daniel Austin has synthesized[3] the high-level goals and concerns expressed in last week's telcon. We'll discuss this list and refine it such that we can have as a baseline a core set of goals that can be used to guide our work going forward.
>
> Daniel's list is intended as a discussion starter.
>
> a) interoperability and reduction of divergence among vendors
> b) extensibility and modularity to encompass the future evolution of Web services
> c) platform independence with no assumptions regarding communication among architecture components
> […]
> From Daniel's note:
> Proposed Goals for the Web Services Architecture Working Group
>
> To develop a standard reference architecture for Web services that:
>
> AG001 ensures the interoperability of Web services software products from different implementors based on well-defined standards

```
AG002 provides modularity of Web services components,
allowing for a level of granularity sufficient to meet
business goals

AG003 is sufficiently extensible to allow for future
evolution of technology and of business goals
…
```

The whole list comprises 14 architectural goals, only the first three (AG001, AG002, AG003) are reported here above. At this point an articulated discussion was initiated, finally bringing to the shared definition of the preliminary basic architectural elements. It is important to underline two aspects:

First, the “choral” nature of the group negotiation process: decisions are generally taken with the consensus of everybody. For instance around 40 group members participated in the initial requirement gathering discussion; almost half of them advanced proposals or at least expressed opinions. Therefore, this working group was able to collect contributions from a quite large community. We should also consider that the results were then submitted for evaluation and suggestions to an even wider assembly, through the mailing list.

Second, some typical sense-making activities could be identified in accordance to the D-S-N model: the objective AG002 for example prefigures the need for an appropriate level of granularity of the Web services components, in order to meet business goals. Here the actors are foreseeing the future components “at work”, pointing out that it should be possible to combine more components in a modular fashion, in order to achieve growing levels of dimension and complexity, to meet business goals in a flexible way.

This futuristic scenarios, where a new technology will be used in creative ways, requires a sense-making effort that (Fomin, Keil and Lyytinen, 2003) call "proactive". Therefore, in these two distributed meetings, we may identify “S” and “N”-type activities. “D”-type activities of rational design and planning, instead, are typically accomplished during the production of the architectural specifications, whose last version is published in http://dev.w3.org/cvsWeb/~checkout~/2002/ws/arch/wsa/wd-wsa-arch.html.

Statement 2: the nonlinearity of the standardization process

According to the model the D, S and N-type activities don't necessarily follow a linear and sequential path, but they can alternate cyclically without any particular pre-arranged order (with the exception of statement 3 below). In the Web Services standardization process the alignment of interests seems to play an important role in the composition of the actor-network system, driving the process in a non-linear way. This is testified by the words of Bob Sutor, IBM’s director of standards strategy, who defends IBM from the accusation of willing to impose royalties on the Web Services technologies:

"If you look at what IBM has done, and it's certainly true that IBM and Microsoft have taken a leadership position in terms of driving these standards, all the specifications have ended up in standards organizations. SOAP and WSDL, which are at the core of Web services, are at the W3C and both royalty-free. WS-Security, which we brought to OASIS in June, is also royalty-free. I really don't think there's any merit to any of those concerns." (MacIsaac 2003, pag. 11).

The standard definition group in the initial phases of the standardization process was much smaller and not coordinated by the W3C consortium: simply IBM and Microsoft reached an agreement to jointly develop a first version of some (but not all) of the technical specifications. Only later they decided to extend the negotiation by opening it to the W3C consortium. Therefore, the standardization process could not follow a linear development, because in the initial phases the activities of sense-making, negotiation and planning were accomplished in a smaller group, while subsequently the decisions have been discussed in a wider assembly.

Statement 3: the first D cycle is preceded by S and N

A synthetic and effective update of the status quo of the Web Services standardization process is depicted in (Kotok, 2002). Kotok's report can show what could happen when statement 3 is not verified, that is when the rational planning activities precede, instead of following, those of sense making and of negotiation[6].

Kotok comments the announcement of December the 18th, 2002, about the availability of new technological standards for the Web Services. According to Kotok, there is no lack of commitment or investments on Web Services technologies by IT companies. What is actually lacking is a common vision that would allow the development of a unique and common shared technological system, available for everybody. Instead, the general specifications that currently define Web Services architecture have been developed independently by the single actors. This means that the D activities of rational planning happened before the sense-making and negotiation cycles were closed[7].

As Pavel Kulchenko effectively states, "Facing the need of standardization in this field, different competitors have proposed their own sets of specifications as a basis of a complete Web Services architecture: Microsoft with the "Global XML Web Services Architecture" (the basis of Microsoft .Net); IBM […] with the "Web Services Component Model" (WSCM); Sun with his "Open Net Environment" (Sun ONE) and HP with his "Services Framework Specification" (Kulchenko 2002, pag. 1).

Kulchenko lists and classifies 23 different Web Services specifications, dividing them in four categories. The lack of a unique and shared vision of the Web Services technology is, according to Kotok, due to the nature of the process of negotiation itself, that is characterized as emergent and bottom-up rather than planned and top-down, as it happened for other technologies.

In the light of the D-S-N model, the bottom-up nature of the Web Services standardization process could be due to the fact that the D activities of rational planning started before the initial cycles of sense making and negotiation were closed, violating the condition stated in statement 3 above. This phenomenon did not happen, for example, with the standard ebXML:

"One can contrast the methods used in the development of Web services specifications with those of the ebXML consortium, as a case study of these two approaches. For Web services, individual companies or small groups of companies wrote the first versions of the specifications,

[6] This statement is somehow challenging, and it has been revised in later versions of the D-S-N studies. One of the most evident aspects here, as noted by two reviewers, is that the sense-making and negotiation activities could happen in different social worlds: for example, "there could have been plenty of S and N" in Microsoft and IBM *before* the D-S-N process started in the W3C consortium. It may be necessary to expand the analytical framework to take into account the different levels of analysis involved at different points in the D-S-N process.

[7] As noticed by a reviewer, the notion of "closure" of a D-S-N cycle may be unclear. How do we know when the process is closed? More investigation should be devoted to better understand this issue, also in the light of concepts mediated by the actor-network theory and of the further developments of the D-S-N studies.

to get them in the hands of the implementers and in the public consciousness. The companies then handed them over to the World Wide Web Consortium (W3C) or OASIS for standardization. The ebXML initiative began as a joint UN/CEFACT and OASIS endeavor, and spelled out the overall architecture for its e-business specifications. Individual industry groups and solutions vendors then began recommending or implementing the specifications." (Kotok 2002, pag. 2).

PRELIMINARY CONCLUSIONS AND RESEARCH DIRECTIONS

The D-S-N model seems to be a potentially interesting analytical tool, for its ability to gather three fundamental determinants of standardization processes that no single theory has jointly analyzed till now: rational planning (D=Design), sense making (S), and negotiation (N) activities. The Web Services case study may represent a good field of investigation to confirm the explanatory power of the D-S-N model: the preliminary empirical indications seem to be encouraging.

This analysis is still ongoing: a wider sample of documents with the transcripts of the standardization working groups meetings, teleconferences and mailing list is taken into account, using more extensive and accurate text analysis methods.

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THE NETWORK EFFECT HELIX[1]

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ABSTRACT

The development and diffusion of network markets and underlying standards is an important domain in IS research. Yet, there is no sound theory nor practice to fully understand the complex mechanisms behind networks of users who are tied together by compatibility requirements as is frequently witnessed in information and communication networks. The goal of this paper is to identify key determinants of the diffusion of network effect goods by studying the battle between two mobile communication standards to propose possible diffusion paths. In the early phase of diffusion, the adoptor of the new standard benefits from direct network effects with other adopters and the estimated indirect network benefits when additional content and services will be provided. The diffusion process starts therefore with early adopters due to the existence of direct network effects in the first place and force-up by additional indirect network effects which attract further adopters. We call this effect the network effect helix, with positive feedbacks on the ongoing diffusion process.

Keywords: Standardization, network effects, ICT, diffusion, innovation, direct network effects, indirect network effects.

INTRODUCTION

Standards and Network Effects

Network analysis is often based upon the theory of positive network effects which describes a positive correlation between the number of users of a network good and its utility (Katz, Shapiro 1985). A common finding is the existence of *network effects*, i.e. the increasing value of a

[1] The simulation model was part of a paper presented at the 36th Hawaii International Conference on System Science (HICSS-36), January 6-9 2003, Big Island, Hawaii: Beck, R., Beimborn, D., Weitzel, T., “The German Mobile Standards Battle”

network as the number of its participants increases (demand side economies of scale) leading in many cases to unfavorable outcomes (Pareto-inferior results of diffusion processes). Network effects describe "the change in the benefit, or surplus, that an agent derives from a good when the number of other agents consuming the same kind of good changes" (Liebowitz, Margolis 1995; see Thum 1995, pp. 5-12 for different sources of network effects). Katz and Shapiro (1985) first differentiated between direct network effects in terms of direct “physical effects” (Katz, Shapiro 1985, p. 424) of being able to exchange information and indirect network effects, arising from interdependencies in the consumption of complementary goods (Braunstein, White 1985) (Chou, Shy 1990) (Church, Gandal 1992) (Teece 1987). Indirect network effects can also be established by be the availability of after sales services (Katz, Shapiro 1985, p. 425) (Katz, Shapiro 1986, p. 823), learning effects, uncertainties about future technology availability or the existence of a market for used goods (Thum 1995, pp. 8-12). Since network effects are especially found where *compatibility* is important, according to our definition above, the term network often describes the “network of users” of certain technologies or standards such as the network of MS Word or SAP R/3 users (Besen, Farrell 1994, p. 117). Therefore, compatible technologies (or standards) are considered to constitute networks.

The pattern of argument in network effect theory is always the same: the discrepancy between private and collective gains in networks under increasing returns leads to possibly Pareto-inferior results. With incomplete information about other actors’ preferences, *excess inertia* (“start-up problem”) can occur as no actor is willing to bear the disproportionate risk of being the first adopter of a technology and then becoming stranded in a small network, if all others eventually decide in favor of another technology. This renowned *start-up problem* prevents any adoption at all of the particular technology, even if it is preferred by everyone.

While the traditional models contributed greatly to the understanding of a wide variety of problems associated with the diffusion of standards (the evolution of networks), more research is still needed, especially when trying to develop solutions to the aforementioned problems (Liebowitz, Margolis 1994). Additionally, there are only a few contributions supporting standardization decisions on an individual level. Furthermore, the specific interaction of potential technology adopters within their personal socio-economical environment and the potential decentralized coordination of network efficiency are neglected. As a result, important phenomena of modern network effect markets such as the coexistence of different products despite strong network effects or the fact that strong players in communication networks force other participants to use a certain solution cannot be sufficiently explained by the existing approaches (Liebowitz, Margolis 1994) (Weitzel, Wendt, Westarp 2000).

Other areas of research are also concerned with networks. In contrast to *network effect theory* focusing on compatible technologies constituting networks, *diffusion theory* analyses relational and structural interaction patterns to explain the diffusion of innovations. Besides these essentially economic research approaches, many (mostly empirical) studies of network phenomena in the form of diffusion processes can be found in various research areas such as anthropology, early sociology, rural sociology, education, medical sociology, communication, etc. (for an early overview see Rogers, Shoemaker (1971, p. 44-96)). Other related areas include actor network theory emphasizing the social construction of networks (Callon 1991) (Giddens 1988), contributions concerning the dispersion of the Internet (David, Steinmueller 1996), policy issues in networks (David 1995) (Liebowitz, Margolis 1996) and inter-temporal coordination problems when building infrastructures (Thum 1995).

Network Effects as Externalities

When discussing network efficiency, quite often the objective is an overall measure, such as duration of production processes throughout an entire value chain or aggregate (i.e. supply-chain-wide) cost efficiency (centralized solution). Still, in corporate reality such an overall solution, derived from an implicitly assumed collective utility function, does not describe the strategic investment decision of all the particular actors or agents. Instead, they seek for an individually rather than collectively optimal decision (decentralized solution). This discrepancy is partly responsible for many network infrastructures to stay far behind their potential and is known as start-up problem in network effect theory. This start-up problem can also be described as the not yet totally described components of a network effect good. In traditional neoclassical economics, there is no difference between these settings if the validity of the fundamental theorems of welfare economics (Hildenbrand, Kirman 1976) can be proven. This is the case when certain premises are fulfilled as especially the absence of externalities. Unfortunately, network effects as a constituting particularity in networks are a form of externality, thus disturbing the automatic transmission from local to global efficiency (Weitzel, Wendt, Westarp 2000).

In economics, an *externality* is considered to be present whenever the utility function $U_i(.)$ of some economic agent *i* includes real variables whose values are chosen by another economic agent *j* without particular attention to the welfare effect on *i*'s utility. Generally speaking, in accordance with traditional literature on economics, a *network externality* exists if market participants fail to somehow internalize the impact of a new network actor on others; with positive network externalities the private value from another actor is smaller than the social value, leading to networks smaller than efficient. Thus the question arises how to internalize these effects, or in other words, how to find coordination designs to build better networks. The answer to this question may be found in a more differentiated analysis of the *Penguin effect* (Farrell, Saloner 1986, p. 943). Hungry penguins are sitting on a floe and waiting until the first one jumps into the water because they fear the presence of predators. Each prefers to wait and see what happens with the first one. This *wait-and-see* behavior occurs with each new standard adoption decision, but it is still unsettled, why the first one jumps into the water. In presence of network effects, there is no real *stand-alone* utility of, e.g., being the only one with a telephone device. Analogue to the first moving penguin, which has seen the first fish, or a special dish only he prefers while the rest is waiting for the dish of the day, there are also heterogeneous preferences and network market determinations responsible for the first-mover to lock in a new standard which are different from the determinants of the following adaptors. As the network grows, the ratio of achievable direct and indirect network benefits grows and varies in an upwards spiral with positive feedback to each other. This *network effect helix* phenomenon will be described in more detail in the following sections, with the mobile commerce market as example.

NETWORK BATTLES: THE MOBILE NETWORK MARKET

The development of cellular phone networks attracted a lot of attention in recent scientific publications (Funk 1998), sometimes supposed to be a killer application in ICT markets. Unfortunately, these discussions are often motivated solely by a pure technological or normative political focus. The absence of a sound theory of networks leaves quite substantial gaps when trying to forecast (intermediate) results of imminent technological diffusion battles or decision guidelines for potential customers or suppliers.

While the public property characteristic of network elements providing compatibility among its elements has been discussed mainly in contributions to network effect theory and diffusion of innovations theory, the externality property associated with network effects establishes quite a complex coordination problem. Network effects can derive from both, vertical compatibility requirements (like between the (proprietary) cellular phone and its application software, sometimes termed the "hardware-software-paradigm" in network economics, or indirect network effects, as a prerequisite to use standardized services (Katz, Shapiro 1985)) as well as horizontal compatibility requirements (like communication partners supporting compatible software). While network effect theory can offer valuable insights into general patterns of behavior in networks it is difficult to apply these findings to real networks such as cellular telephone markets and associated services, firstly, due to the overly general nature of the existing models and difficulties in applying them to practical problems and secondly, because the qualitative evaluation of recent technologies is sui generis difficult. Hence, it is most unlikely to find unanimous opinions on whether technology A is superior to B or vice versa. There are many famous discussions in the literature concerning the question if in battles such as nuclear power technology or keyboard layout the better technology is chosen. Since network problems and the bridging of informational, economic, and social networks and methodologies are widely considered to be among the core research domains of IS, the combination of the paradigm of agent-based computational economics and relevant technological considerations associated with a particular technology battle seems to be a fruitful contribution to the domain. The chosen standards' "battle field" is the competition between i-mode and WAP to discuss the network-relevant components which form the motive for customers abandoning WAP for i-mode.

The Standard Battle

The diffusion and usage of new mobile commerce applications has been prophesied an amazing future which is accompanied by a dramatic change in all areas of life. The rapid uptake of cellular phones' diffusion together with the ability of using the end-devices as mobile Internet portables led to rising forecasts of mobile commerce. In spite of the large number of cellular phones and the heavy usage in the fields of telephony and SMS, the non-voice or mobile commerce business has not yet lifted off. Two standards are competing in this area in Germany, The Netherlands and Japan: i-mode and WAP. While WAP offers only a restrictive usage of possible Internet applications, i-mode is based on cHTML (a subset of HTML) and therefore offers regular Internet-like browsing experience. Furthermore, i-mode comes with a billing business model which allows consolidating charges for the usage of third-party content providers' services into the single telephone service invoice. Choice of matured technology (cHTML-based) coupled with a liable business model in the case of i-mode can be seen as an improvement or innovation compared to WAP.

Indirect network effects in this case result from the existence of complementary products, content and/or services for an installed base (Farell, Saloner 1986) of users of a special technology, e.g., the availability of WAP content services depends on the number of WAP capable cellular phones. But Internet access is also possible with i-mode. After the full specification of cHTML in XML, i-mode will also operate with WAP 2.0. Offering i-mode today as mobile services provider (MSP) means to gain probably a competitive advantage by installing an early market entrance towards 3G services in the future. I-mode mobile Internet content includes a large variety of different resources such as route planners, city guides, on-line brokerage, newspapers, weather information and adult entertainment.

While Internet content is part of possible positive *indirect network effects* for adopters the multilateral exchange of data in form of Short Messaging System (SMS) or now i-mail between adopters is part of direct network effects. Compared to i-mode, WAP is not accompanied by a special WAP mail service. A comparable standard in the GSM world is SMS. Generally, SMS allows cellular phone users to send and receive short messages up to 160 characters. In contrast to i-mail or Enhanced Messaging Service (EMS), SMS is restricted to a monochrome alphanumeric display without the possibility of attachments. The current introduction of Multimedia Messaging Service (MMS) can be seen as a technological progress resulting in higher direct network effects but can not compensate the still low quality of Wireless Markup Language (WML) based Internet pages of WAP. The current widespread usage of SMS is driven by the relatively inexpensive pricing due to the low transferred data volume. Low marginal costs per adopting communication partner (neighbor) to exchange SMS with are accompanied by relatively low marginal network benefits in comparison to i-mail. With up to 1000 possible characters i-mail provides six times more characters per mail than SMS. Both technologies support the push-channel solutions based on GSM/GPRS, the always on-line functionality guarantees incoming and outgoing mails instantaneously. Due to the higher transferable data volume, i-mail is in comparison to SMS more expensive, but allows gaining a higher marginal network benefit than SMS per adopting neighbor. Therefore, the standards' battle in this contribution is SMS (for WAP adopters) vs. i-mail (for i-mode adopters).

Simulating the Diffusion of Standards in mobile service markets

Due to the strategic pricing models of mobile service providers, the simulation model considers primarily qualitative aspects of the different technologies. Strategic pricing to gain monopoly or oligopoly benefits (Economides, Himmelberg 1995) (Katz, Shapiro 1986) are not modeled. The simulation model combines both, the direct and indirect network effects of adopters. The resulting utility depends strongly on the network topology and communication preferences of each user (Wendt, Westarp 2000).

Parameterization of the factors for the description of the considered i-mode diffusion scenario leads to the following computer based simulations, which generate qualitative statements about the impact of each parameter on the speed of i-mode diffusion:

Assumed is a network of n independent actors using WAP enabled cellular phones as installed base. Due to the broad distribution of WAP enabled mobile phones, nearly all users can be seen as potential WAP customers. Each actor i has to decide in each period (i.e. one month) to continue to use only WAP or to shift to a new standard such as i-mode, i. e. adopting an i-mode cellular phone (i-mode capable devices also support WAP). Due to this, actors are able to decide in each period anew for i-mode or against it. According to their bounded and dynamically adapted information set deriving—among others—from past technology adoption decisions of the direct neighbors of i, actors can adopt i-mode in one period and drop it in the next.

Furthermore, the actors use mobile data services such as SMS or i-mode mail to communicate directly with their nb_i neighbors. Visualized, actors and their relations can be illustrated as nodes and edges in a graph. To create a close network topology, the participating actors are randomly located in a unit square. Afterwards, actor i activates a vectored communication to the nearest neighbors nb_i in Euclidian distance. Such a graphical illustration represents the social network of actors and does not determine the geographical location.

The calculus of decision of each actor is to evaluate the monthly benefit surplus using i-mode in comparison to WAP and SMS as counterpart. The following cost and benefit aspects are of importance for the adopting decision:

Set-up costs: In comparison to the widespread penetration of WAP capable cellular phones as quasi standard, adopters of i-mode have to invest in new mobile end-devices. In 2002, only one

i-mode cellular phone model was available (which also enables WAP) for a retail price of EUR 249.- , including a 24 months contract and subsidized by the MSP. Under negligence of an interest rate and regarding the contract period, this results in a basic price of EUR $\frac{249}{24}$ per month. Besides these set-up costs, an adopter has to pay EUR 3.- per month as additional fee for i-mode services in 2002. Due to the subsidization by the MSP, it is assumed that the costs for adopters repurchasing an only WAP capable end-device during the regarded period are negligible. Furthermore, adopters of the WAP service have to pay no further monthly basic fees.
Two adoption phases are distinguished: Prior to the adoption of an i-mode end-device, the actor is in phase 1. After the adoption (phase 2), the decision relevant basic costs are reduced to the monthly fee of EUR 3.- in each following period. Ex post, the investment into the cellular phone can be regarded as sunk costs. The simulation model does not consider any additional stand-alone benefits of an i-mode cellular phone, compared to not i-mode capable cellular phones. The integration of any conceivable stand-alone benefits into the simulation model would accelerate the speed of adoption.

Direct network effects: Due to the usage of i-mail, the i-mode adopter *i* gains more benefits from the new mobile standard through communicating with i-mail capable neighbor *j* in comparison to the usage of SMS. The valued additional direct benefit u_{ij}^{D}, using i-mail per period per communication with neighbor *j* , is calculated as the difference of $u_{ij}^{D,i-mail}$ less $u_{ij}^{D,SMS}$:

(1) $u_{ij}^{D} = u_{ij}^{D,i-mail} - u_{ij}^{D,SMS}$

Analog to the benefits, the additional direct costs c_{ij}^{D} can be described as the additional costs of the communication relations between *i* and its neighbors *j*:

(2) $c_{ij}^{D} = c_{ij}^{D,i-mail} - c_{ij}^{D,SMS}$

The resulting additional net benefit coefficient nu_{ij}^{D} is:

(3) $nu_{ij}^{D} = u_{ij}^{D} - c_{ij}^{D} = u_{ij}^{D,i-mail} - c_{ij}^{D,i-mail} - \left(u_{ij}^{D,SMS} - c_{ij}^{D,SMS}\right)$

subject to: $nu_{ij}^{D} \geq 0$

Indirect network effects: The model describes an unique monotonously increasing correlation between the diffusion of a new technology in an existing network and the offered i-mode services and content. The strong usage of i-mode services and content (and therefore the increase of adopters) will motivate content and service providers to augment their supply, what again leads to further network effect benefits (and costs). As the network grows, the ratio of achievable direct and indirect network benefits grows and varies in an upwards spiral with positive feedback to each other. A self-perpetuating *network effect helix* occurs. Due to the compatibility of i-mode end-devices with WAP content sites, the indirect network benefit is ≥ 0 for i-mode adopters in each period.

The resulting indirect network effect benefits per period accompanied with the usage of the technology or standard are therefore a function of all standard adopters $B_{q,t}$ of the same technology *q*:
For WAP adopters:

(4) $U_{WAP,i,t}^{N} = U_{WAP,i}^{N}\left(B_{WAP,t}\right)$ with costs

(5) $C^{N}_{WAP,i,t} = C^{N}_{WAP,i}\left(B_{WAP,t}\right)$

For i-mode adopters:

(6) $U^{N}_{i-mode,i,t} = U^{N}_{i-mode,i}\left(B_{i-mode,t}\right)$ with costs

(7) $C^{N}_{i-mode,i,t} = C^{N}_{i-mode,i}\left(B_{i-mode,t}\right)$

The simulation model uses the absolute number of i-mode users instead of the fraction of users mobile commerce users today as well as the (growing) number of users in the future is hard or nearly impossible to predict. In fact, in networks, a provider not only wants to cannibalize users from other MSPs but wants also to attract new adopters. Furthermore, the interpretation of used functions (or in more detail: the used coefficients in equations (8)-(11)) would be quite difficult. The computer based simulation model uses a linear proportional function. The influence of an assumed sigmoid function curve will be part of further research.

(8) $U^{N}_{WAP,i,t} = u^{N}_{WAP,i,} \cdot B_{WAP,t}$

(9) $C^{N}_{WAP,i,t} = c^{N}_{WAP,i} \cdot B_{WAP,t}$

(10) $U^{N}_{i-mode,i,t} = u^{N}_{i-mode,i} \cdot B_{WAP,t}$

(11) $C^{N}_{i-mode,i} = c^{N}_{i-mode,i} \cdot B_{WAP,t}$

Under side condition:

$u^{N}_{WAP,i}\,;\, c^{N}_{WAP,i}\,;\, u^{N}_{i-mode,i}\,;\; c^{N}_{i-mode,i} \geq 0$

Using equations (8) and (9), as well as (10) and (11), the following net benefit coefficients $nu^{N}_{WAP,i}$ (12) and $nu^{N}_{i-mode,i}$ (13) can be derived:

(12) $nu^{N}_{WAP,i} = u^{N}_{WAP,i} - c^{N}_{WAP,i}$

(13) $nu^{N}_{i-mode,i} = u^{N}_{i-mode,i} - c^{N}_{i-mode,i}$

The term "net benefit" is orientated on each technology benefit regarding indirect network effects while the direct network effects are defined as the difference of the technology orientated net benefit coefficient nu^{D}_{ij} (see equation (3)). The substitution rate describes the substitution relation of i-mode services in comparison to WAP services. *sub=1* means, e.g., that there is no WAP service an i-mode adopting actor will use any more.

The overall individual net benefit deriving from indirect network effects is defined as $U^{INE}_{i,t}$ (equation 14).

(14) $$U^{INE}_{i,t} = \begin{cases} \left(nu^{N}_{i-mode,i}\right)\cdot B_{i-mode,t} - sub_i \cdot \left(nu^{N}_{WAP,i}\right)\cdot B_{WAP,t} & if \;\; U^{INE}_{i,t} > 0 \\ 0 & if \;\; U^{INE}_{i,t} \leq 0 \end{cases}$$

Decision Calculus: The overall i-mode adoption benefit (in phase 1) is defined in equation 15:

(15) $$U_{i-mode,i,t} = -\frac{249}{24} - 3 + \sum_{j \in NB_i}\left(nu^{d}_{ij} \cdot x_j\right) + U^{INE}_{i,t}$$

subject to:

$x_j \in \{0;1\}$ (Indicator for the i-mode adoption by actors' j)

$0 < sub_i \leq 1$ (Actor i's substitution behavior using i-mode instead of WAP)

$n = B_{i-mode,t} + B_{WAP,t}$

The adoption decision is based on uncertain and imperfect information about the adoption decision of other users, so adopter *i* has to estimate the adoption decisions of neighbor *j* heuristically. The decentralized standardization model (Westarp et al. 1999) describes the probability p_{ij} as actor *i* believes that actor *j* will adopt a technology. If $E[U_{it}] > 0$ then actor *i* will adopt. If actor *i* is certain about the behavior of his communication partners, p_{ij} corresponds to 0 or 1. Every communication edge *ij* with costs c_{ij} contributes to the amortization of the adoption costs of the incidental actor *i*. The decentralized standardization model furthermore assumes, that the technology adoption costs K_j and the information costs c_{ji} are the only costs regarding *j* known to actor *i*. Therefore, actor *i* can assume that the edge *ji* is representative of all of *j's* edges. Combining all assumed data, actor *i* can then develop the following probability estimate p_{ij} for the probability of technology adoption on behalf of actor *j,* where c_{ji} is equivalent to nu_{ij}^{d} and K_j equivalent to $\frac{249}{24}+3$ in phase 1:

(16) $$p_{ij} = \frac{c_{ji} \cdot (n-1) - K_j}{c_{ji} \cdot (n-1)}$$

Further structural adaptations of the decentralized standardization model are necessary for the simulation model. In the case of the mobile service markets, a low density of related actors (similar to few communication edges) is assumed to perform the computer based simulation. The standardization model assumes communication edges among all actors. This seems to be unrealistic for the observed cellular phone case. The term *n-1* is therefore replaced by nb_j which describes the number of communication partners or neighbors *j*. The used heuristic estimation has to consider the indirect network effects of the technology adoption decision by neighbors. Therefore, the numerator in this model is extended to the expected indirect network effect net benefit of the neighbors ($E\left[U_{jt}^{INE}\right]$).

(17) $$p_{ijt} = \frac{nu_{ji}^{D} \cdot nb_j - \left(\frac{249}{24}+3\right) + E\left[U_{jt}^{INE}\right]}{nu_{ji}^{D} \cdot nb_j}$$

If neighbor *j* uses i-mode in the previous period, p_{ijt} is equivalent to 1. Actor *i* believes that it is absolutely implausible for neighbor *j* to switch the currently chosen new standard immediately in the next period. A simplification of the model is the supposed assumption, that actor *i* has complete information about the direct and indirect net benefits components of its neighbors *j*.

The impact of the indirect network effects depends on the total number of adopters. To forecast the adoption rate, estimations of the diffusion theory can be used. This simulation model refers to a restrictive estimation for adopting i-mode ($B_{i\text{-}mode,t}$), orientated on the installed base of i-mode users in the previous period:

(18) $$E\left[B_{i-mode,t}\right] = B_{i-mode,t-1}$$

The anticipated benefit of indirect network effects in period *t* is:

(19) $$\begin{aligned} E\left[U_{i,t}^{INE}\right] &= \left(u_{i-mode,i}^{N} - c_{i-mode,i}^{N}\right) \cdot B_{i-mode,t-1} \\ &\quad - sub_i \cdot \left(u_{WAP,i}^{N} - c_{WAP,i}^{N}\right) \cdot \left(n - B_{i-mode,t-1}\right) \end{aligned}$$

The calculus of decision of a risk neutral actor *i* in period *t* depends on the estimated total benefit $E\left[U_{i-\mathrm{mod}\,e,i,t}\right]$. If the benefit is >0, then actor *i* will adopt an i-mode mobile end-device. Each actor can decide once per month (i.e. per period).

The calculus of adoption in phase 1 (20):

(20) $$E\left[U_{i-mode,i,t}\right] = -\frac{249}{24} - 3 + \sum_{j \in NB_i} \left(nu_{ij}^{D} \cdot p_{ijt}\right) + E\left[U_{i.t}^{INE}\right]$$

The calculus of adoption in the phase 2 (after the investment in an i-mode cellular phone):
(21) $E\left[U_{i-mode,i,t}\right] = -3 + \sum_{j \in NB_i}\left(nu_{ij}^{D} \cdot p_{ijt}\right) + E\left[U_{i.t}^{INE}\right]$

Implementation: The model is implemented in Java 1.4. The used parameters of the simulation are chosen in a restrictive and conservative way. 1,000 actors are defined as the network population *n*. This is in comparison to the large potential WAP user market a relatively small population but a necessary assumption for a better performance of the model. The substitution rate was $sub_i = 1.0 \quad \forall i$, as defined above. The closeness of the network topology was assumed with $nb_i = 5 \quad \forall i$ (that means that actor *i* has 5 direct neighbors). Setup costs occur in phase 1 (EUR $\frac{249}{24} + 3$) and EUR 3 in phase 2. The net benefit expectations for direct and indirect network effects are assumed as normally distributed. The expectation varies in the following ranges (equation 22 and 23), while the variation coefficient is constant to 0.2 for all parameters:
(22) $E\left[nu_{ij}^{d}\right] = [1.00;\ 8.00]$ for direct network benefit
(23) $E\left[nu_{i-mode,i}^{N}\right] = [0.004;0.5]$ $E\left[nu_{WAP,i}^{N}\right] = [0.003;0.5]$ for indirect network benefit

The assumed values of the parameters vary by small incremental steps of 0.05 (nu^D) and 0.02 (nu^N) during the simulation to provide a (ceteris paribus) sensitivity analysis. Each simulation run is equivalent to one simulated network. After generating the close network topology, the actors' behavior is simulated over multiple periods until a stationary state is reached. The total number of simulation runs was 45,825. The Java applet written for the simulation is available at www.it-standards.de/applet1/index.html. The authors invite everyone to use the applet with different parameter values according to the respective assumptions. Any suggestions or feedback is highly appreciated.

The Network Effect Helix

The first simulation results presented in figure 1 provide the number of i-mode adopters in the stationary state (a period after the last standardization activities were measurable). During the simulation, the expectations of the normally distributed direct and indirect additional benefits nu_{ij}^{D} , $nu_{WAP,i}^{N}$, $nu_{i-mode,i}^{N}$ have been varied, while $nu_{i-mode,i}^{N}$ had to be greater than $nu_{WAP,i}^{N}$ .The results depend directly on the expectations of net benefit nu_{ij}^{D} and $\Delta nu_i^N = nu_{i-mode,i}^{N} - nu_{WAP,i}^{N}$. It must be pointed out that the conducted transformation is only possible if sub_i is equal to 1 for every actor *i*.

In figure 1, the cumulative number of i-mode adopters is represented in the stationary state, depending on nu_{ij}^{D} and Δnu_i^N . Each data spot represents the result of a single simulation run. Two main sections and a small interfacial area can be identified. On the lower section, nobody standardizes or adopts i-mode. The results are only slightly influenced by the marginal indirect network effects. Starting with $E\left[nu_{ij}^{D}\right]$=3.5, the network will be completely equipped with i-mode end-devices. The most interesting region is the interfacial area around $E\left[nu_{ij}^{D}\right] = [2.9;3.4]$. Inside this region, the frequency of mixed solutions (i-mode and WAP) is maximal and the typical standardization dilemma occurs, such as the start-up problem respective penguin effect (Farrell, Saloner 1986) or tippy networks (Shapiro, Varian, 1998, p. 176).

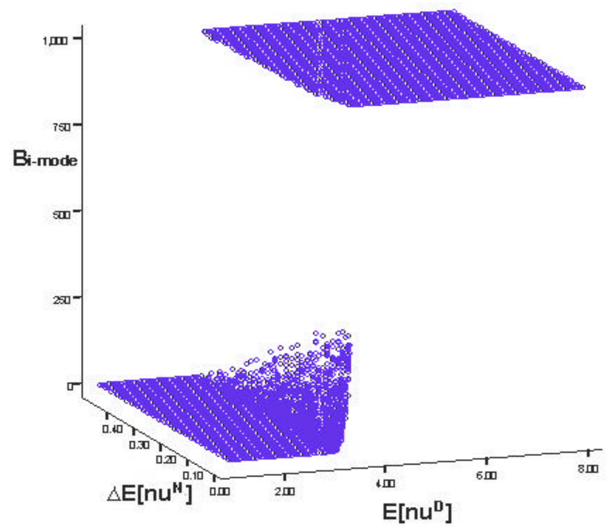

Figure 1. Number of i-mode users in the stationary state, depending on the net utility parameters

The influence of Δnu_i^N in this region forces the tippiness of the network, which means, that an increase of Δnu_i^N does not raise the number of i-mode adopters ($B_{i\text{-mode}}$) in mixed networks but enforces the shift towards an i-mode monopoly. Due to the low variance of marginal benefits (similar to homogenous interests of network participants), only few mixed networks occur. By raising the variation coefficient from 0.2 to 0.5, the percentage of oligopoly solutions (mixed networks) increases by factor 1.12. Steady networks are observable with less than 50 WAP users in the stationary stage. In most cases, the adoption process is finished after a very short time (figure 2), depending on the variation coefficient and disregarding existing diffusion time lags in reality. In the region of $E\left[nu_{ij}^D\right]=[2.9;3.4]$, the simulations need the most processing time up to 22 periods. The correlation between Δnu_i^N and t_{stat} is slightly negative in this region with a significant Pearson correlation coefficient r = - 0.179.

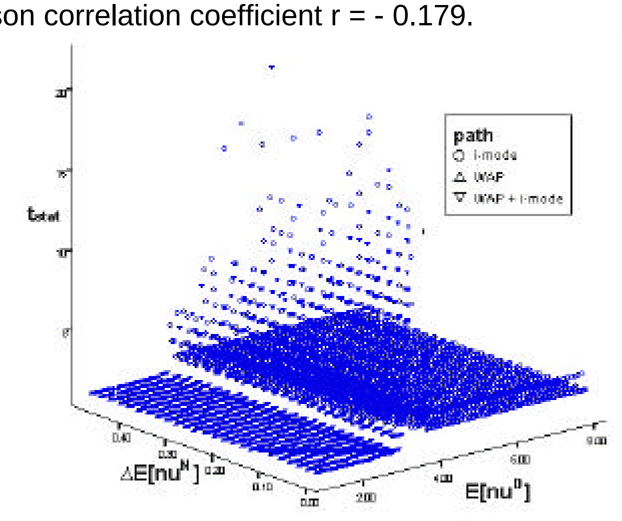

Figure 2. Stationary state access, depending on the direct and indirect net benefit parameters

Figure 3 provides an exemplary diffusion path, based on a particular parameter constellation, depending on the adoption behavior in each period. The diagram in figure 4 provides the expected user benefit (neglecting setup costs) on average, based on direct and indirect network effects ($E\left[U_i^{INE}\right]$). In the initiation periods 1 and 2 the diffusion process is only driven by the expected direct network benefits. After the second period the expected indirect network benefits $E\left[U_i^{INE}\right]$ become more important for the adoption decision, based on the restrictive estimator for B_t (see equation 18).

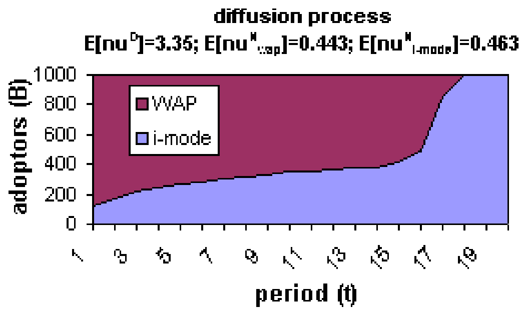

Figure 3. Diffusion process of WAP vs. i-mode

It could be a dominant supplier strategy to offer a variety of services even without having customers in the first period. This can be regarded as virtual indirect network effects, based on expected services in future, if a critical mass of adopters occurs. The i-mode provider has to signal that there will be enough services. Due to the importance of direct network effects in the start-up phase, a subsidized i-mail offer would increase the speed of adoption. Such strategies could be implemented easily in this simulation by valuing an exogenous parameter $B_{i\text{-}mode,0}$>0 as estimator for $B_{i\text{-}mode,1}$ to simulate the benefits of a virtual installed base.

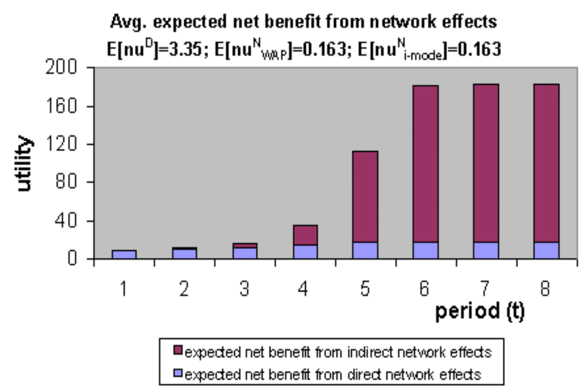

Figure 4. Diffusion process and progression of net benefit, based on direct an indirect network effects

Figure 5 provides a view on the expected total net benefits per actor in average. The average expected total net benefit for one actor in the stationary state is *avgE*[U_i], depending on $E\left[nu_{ij}^D\right]$ and $\Delta E\left[nu_i^N\right]$.

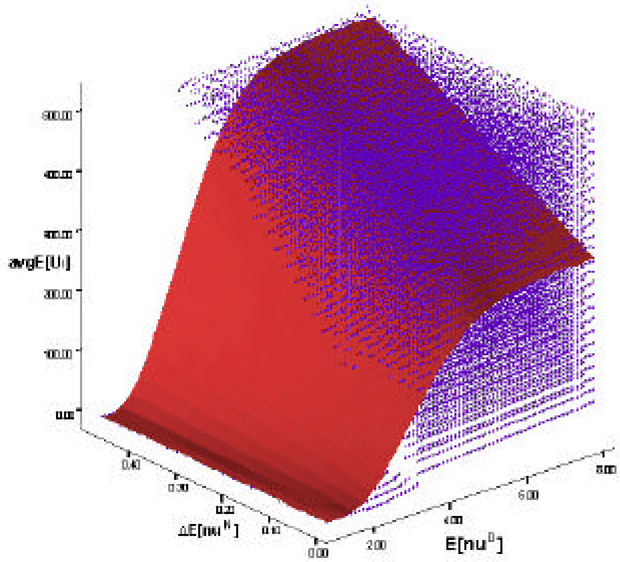

Figure 5. Average expected total net benefit per actor in the stationary state

The diagram provides the break in the region around $E\left[nu_{ij}^{D}\right]=[2.9;3.4]$. Under this interval, there are no standardization activities observable (the expected net benefits were similar to 0). If $E\left[nu_{ij}^{D}\right]$ is greater than 3.4, the average net benefit per actor is >0 and the networks are mostly complete equipped with i-mode. Within this interval, various solutions exists with different result levels of *avgE*[*U*$_i$] for each combination of $E\left[nu_{ij}^{D}\right]$ and $\Delta E\left[nu_{i}^{N}\right]$. This is due to the different absolute benefit levels of $E\left[nu_{WAP,i}^{N}\right]$ which are not visible in the diagram. The higher the values of $nu_{WAP,i}^{N}$ the greater are the benefits of indirect network effects, even when $\Delta E\left[nu_{i}^{N}\right]$ is equal to 0, because in equation (19) $nu_{WAP,i}^{N}$ will be multiplied with 0 while $nu_{i-mode,i}^{N}$ will be multiplied with 1000.

The increase of *avgE*[*U*$_i$] is almost proportional to $\Delta E\left[nu_{i}^{N}\right]$ due to the large benefits from indirect network effects as the largest part of the total benefit (see figure 5), while the direct network effects started the adoption process in the early periods.

CONCLUSION

Using the case of the mobile standards battle, we demonstrate the significant influence of often neglected direct network effects in the early phase of diffusion. In the case of mobile commerce standards, provider strategies of MSPs have often focused on strategic promoting of indirect network effects such as “mobile“ content while ignoring the importance of direct network effects like those deriving from SMS or i-mail exchange, which has often resulted in serious and costly market problems after an initial market entrance.

If a new standard like i-mode has not reached the critical mass of adopters in the early phase of market introduction, then the probability increases that the standard cannot be established in the market at all. The simulations have shown that to reach this critical mass a MSP has to take care about the changing composition or ratio of direct and indirect network effects. The crucial adoption reasons of the early adopters mainly driven by direct network effect benefits are no longer sufficient or available, in order to serve and attract additional adopters and their preferences. These adopters take further, now available indirect network benefits into account for their adoption decision. This phenomenon of an interdependent system of direct and indirect network effects that amplifies the number of adopters stabilize the ongoing diffusion process. We call this empirical observation the network effect helix.

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STANDARDIZATION OF XML-BASED E-BUSINESS FRAMEWORKS

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ABSTRACT

The purpose of e-business frameworks is to enhance the interoperability of communication. Are there dependencies between e-business frameworks and their standardization? How are vendors, users, and institutions involved in the standardization of e-business frameworks? To what extent are the different frameworks complements or substitutes? How does e-business framework standardization relate to economics of standardization? This paper answers these questions by presenting four propositions on e-business frameworks that use Extensible Markup Language (XML). We also claim that some economic findings and suggestions related to vendor driven standards on physical products are irrelevant, as the e-business framework specifications are end products of standardization and they are used by end-user companies instead of individuals.

Keywords: standardization, XML-based e-business frameworks, economics of standardization

INTRODUCTION

Companies produce their documents and perform their processes in different ways, using heterogeneous information systems. Heterogeneous systems cannot exchange information without considerable manual work. To operate across organizational boundaries, organizations must have shared understanding of the way of doing business. Standardization brings order into the uncertainty by reducing variety (David 1995).

Automated business transactions between two organizations require that their information systems are capable of communicating. The organizations must agree on what information to share, when and how. This can be achieved through interoperability of business documents, business processes, and messaging. An e-business framework is a standard for this purpose (Nurmilaakso and Kotinurmi 2003). A framework often combines other standards, specifications, and classifications and covers both the business and technical aspects of communication. The literature provides a number of studies on e-business frameworks (Hasselbring and Weigand 2001, Li 2000, Nurmilaakso and Kotinurmi 2003, Shim et al. 2000). Some of the e-business frameworks presented in the articles, such as the BizTalk Framework, have been later officially closed down by their creators, and many, such as the XML/EDI framework, have been inactive for a considerable time. We focus here on XML-based e-business frameworks supporting industrial procurement, production, or distribution.

In this paper, we first present some theories and studies in economics of standardization and then introduce three different e-business frameworks, XML Common Business Library (xCBL), RosettaNet and electronic business XML (ebXML), which in our opinion are the most prominent e-business frameworks presenting different standardization approaches. After this, we categorize these three frameworks with six other widely cited frameworks. Based on this categorization we present four propositions related to the e-business frameworks and discuss how economics of standardization match our observations of the e-business frameworks. Finally, we present our conclusions and suggestions for further work.

ECONOMICS OF STANDARDIZATION

The economic gains from compatibility are the driving forces for standardization. They result from the avoidance of costly handling of information. With regard to standardization, economic theory has focused much on network externalities (Katz and Shapiro 1985), standard adoption (Farrell and Saloner 1985, Katz and Shapiro 1986), standardization by committees versus markets (Farrell and Saloner 1988), and path dependence resulted from lock-in by the history (Arthur 1989). These studies present a number of theoretical findings, especially for public policies.

(1) If the costs of compatibility fall more heavily on some than others, the free-rider problem biases away from compatibility.
(2) If the information is incomplete, an obsolete standard may prevail, although a better alternative is available.
(3) Standardization by market is faster, but standardization by committee causes fewer errors. A hybrid system of committee and market outperforms both.

Liebowitz and Margolis (1994, 1995) argue that network externalities and path dependence suffer from empirical shortcomings. In addition, some network effects are simply manifestations of technological progress, and knowledge of some initial endowment alone can never tell much about the eventual path of economies over time. Therefore, theories relying on network externalities or path dependence provide little support for an occurrence of a market failure.
Economic studies also deal with standardization from the viewpoint of corporate policy. Shapiro and Varian (1999) suggest that:

(4) Adoption dynamics work to the advantage of large networks and against small networks.
(5) Expectations are vital to obtaining the critical mass necessary to fuel growth.
(6) Introducing new products faces a trade-off between performance and compatibility.
(7) Introducing new products faces a trade-off between openness and control.

How well do the e-business frameworks and their standardization fit in with findings for public policies and suggestions for corporate policy?

E-BUSINESS FRAMEWORKS

E-business frameworks facilitate the interoperability of business processes, business documents and messaging. Not all frameworks define these on the same level, and only a few frameworks specify messaging.

Business processes specify activities to be carried out in a given order, for example, when a business document should be sent and how and when it should be answered. The frameworks define these using diagrams and/or textual descriptions.

Business document specifications define the structure and contents of business documents exchanged in a commonly understood fashion. For example, a “purchase order request” business document guides how products, dates, financial amounts and currencies are presented. This is achieved by schemas provided by the e-business frameworks for validating the contents of business documents.

Messaging defines secure and reliable communication when exchanging business documents in business processes. Messaging specifies the envelope for the business document as well as the packaging, security, and transportation standards to be used.

CASE E-BUSINESS FRAMEWORKS

Since the emergence of the XML standard, many organizations have started defining XML-based standards for use in e-business. We present here three important XML-based e-business frameworks: xCBL, RosettaNet and ebXML in the order of their initiation. We chose these frameworks for the case study because they have been much in the limelight. In addition, the first impression is that they differ from each other with regard to standardization, as xCBL represents standardization by markets and ebXML by committees. RosettaNet is a hybrid, in which end-users are more important than vendors and institutions.

The xCBL standardization effort began in 1997 before the XML specification was officially released in 1998. RosettaNet was initiated in 1998 and it took process standardization as its focus. The ebXML project started in the late 1999 to provide complete infrastructure for e-business needs and to answer the need to standardize the use of XML in e-business.

xCBL

xCBL is one of the first e-business frameworks, having originated in 1997 at Veo Systems. xCBL was originally called Common Business Library (CBL) and developed in a research project to test the limits of XML for e-commerce. In January 1999, CommerceOne acquired Veo Systems and the CBL technology. This led to the creation of xCBL 2.0, the first publicly available version of xCBL. xCBL is fundamentally a collection of XML-based business document specifications for use in e-business. It provides cross-industry vocabularies, but does not define business processes or messaging in detail.

xCBL 2.0, released in January 2000, consisted of 12 different business document specifications in 5 different categories. These were mainly meant for use in business-to-business procurement scenarios. xCBL 2.0 was based on existing Electronic Data Interchange (EDI) standards, to ease the migration from EDI to xCBL and thus promote the adoption of xCBL.

xCBL 3.0, released in November 2000, represented a major broadening of scope by allowing users to build their own customized business documents from standard components. xCBL 3.0 also introduced several new business document specifications, as well as new categories.

xCBL 3.5, released in October 2001, contains all the business documents found in xCBL 3.0 as well as nine new ones. Organization for the Advancement of Structured Information Standards (OASIS) took this version as the starting point for defining business documents in Universal Business Language (UBL).

xCBL 4.0, released in March 2003, is the latest version of xCBL. It consists of 44 business documents in eight categories. These categories are Order Management, Preorder Management, Financial, Material Management, Message Management, Application Integration, Catalog, and Statistics and Forecasting areas.

CommerceOne has dominated the standardization of xCBL. Although the xCBL framework is an open standard, its standardization is not transparent. The differences between the xCBL versions 2.0 and 3.0, as well as 3.5 and 4.0 indicate that backward compatibility has played a minor role in the standardization of the xCBL framework.

RosettaNet

RosettaNet is a consortium founded in February 1998 by 40 information technology companies. Currently, it has more than 500 member organizations representing Information Technology (IT), Electronic Components (EC), Semiconductor Manufacturing (SM), and Telecommunications (TC) industries.

The corner stone of RosettaNet are the specifications for Partner Interface Processes (PIPs). PIPs specify the public processes between organizations and associated business documents. RosettaNet has published more than 100 different PIPs, which are sorted into the following categories on the basis of their characteristics: Partner Profile Management, Product Information, Order Management, Inventory Management, Marketing and Support, Service and Support, and Manufacturing.

In addition to PIPs, RosettaNet includes two dictionaries, which provide a common set of properties for the PIPs. These dictionaries are RosettaNet Technical Dictionary and RosettaNet Business Dictionary. RosettaNet Implementation Framework (RNIF) is the messaging framework used to execute PIPs between organizations securely over the Internet. RosettaNet leverages existing standards in the partner and product identification codes used.

The different parts of RosettaNet have been developed somewhat separately, and they are still evolving. The increasing amount of RosettaNet implementations in production, however, indicates a certain overall maturity of the standard. Soon after RosettaNet was founded, it published at a quick pace almost one hundred different PIPs. Currently the standardization process focuses on implementations. RosettaNet has two kinds of programs for the advancement of the RosettaNet framework. Milestone programs, such as The Global Billing Milestone Program, focus on reaching an implementation goal within the related PIP specifications. Milestone programs require approval from RosettaNet, and commitment from the members to provide resources to the program and to implement its results. Foundational programs, such as the “PIP specification format”, encompass the development and evolution of all RosettaNet specifications, e.g. introducing new XML-technologies such as XML Schemas to define RosettaNet business documents and making the process descriptions computer-readable. The RosettaNet members can vote on standards developed in the programs and they can become open standards available for everyone only after they have been approved. In this respect, the current standardization process resembles the process proposed in Jakobs (2002), where feedback is provided to the process and the standards are validated by implementations before the specifications are released as open standards.

RosettaNet marks each PIP with maturity level information such as “in production” or “waiting validation”. Most of the published PIPs before the Milestone programs have not yet reached the highest maturity level of “in production”, which means that the PIP has been used in production by the members. RosettaNet has published several versions of the Business Dictionary and Technical Dictionary, as the dictionaries may require updating when introducing new PIPs. RNIF 2.0 is the second and latest version of RosettaNet Implementation Framework. It was published in July 2001 and replaced RNIF 1.1, which was the first public version of RNIF.

Overall, RosettaNet is rather pragmatic with regard to what it standardizes and how. It leaves many things, such as trading partner discovery, not standardized, and it has been relatively slow in the adoption of new implementation technologies such as XML Schemas. The existing implementations make the process of introducing big changes slow. However, RosettaNet has promised future support for new technologies and emerging cross-industry standards.

ebXML

The United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) and OASIS sponsored the ebXML project started in November 1999 as an 18-month project. The mission of ebXML is to provide an open XML-based infrastructure enabling the global use of electronic business information in an interoperable, secure and consistent manner by all parties. ebXML is targeted for every sector of the business community, from international conglomerates to small and medium sized enterprises. The first specifications were released in the end of the original project in May 2001. During the original project, many standard developing organizations (SDO) announced plans to support certain parts of the standard.

ebXML has defined a set of specifications designed to meet the common business requirements and conditions for e-business. The ebXML Business Process Specification Schema (BPSS) is an XML-based specification language that can be used to formally define the public business processes that allow business partners to collaborate. The ebXML Registry provides a set of services that enable sharing of information between interested parties. The two specifications describing the use of registries are Registry Information Model and Registry Service Specifications. Collaboration Protocol Profiles and Agreement (CPPA) are used to encode a company's e-business capabilities and technical agreements. The ebXML messaging services (ebMS) provide a general-purpose messaging mechanism to allow reliability, persistence and security. The ebXML Core Components (CC) provide the way business information is encoded in the business documents exchanged. Core Components was the only group that failed to publish any approved specification in the original project.

After the original 18-month project, further development of the ebXML framework continued in committees coordinated by UN/CEFACT and OASIS. The OASIS technical process develops further the specifications for ebMS, Registries and Repositories, CPPA as well as Implementation, Interoperability and Conformance work. UN/CEFACT developed further the CC and the BPSS specifications. One reason for adopting a temporal consortium form of several different consortia may be due to difficulties experienced in agreeing on the standards. The editorial board of XML.com, a popular XML-related website, nominated ebXML as a runner-up for "The Most Spectacular Incidence of Committee/Project In-fighting in 2001".

The OASIS working groups have since published new versions of every specification they are developing further. The first specification for the Core Components from UN/CEFACT was published in August 2003. In August and September 2003, UN/CEFACT and OASIS separately announced completion of the second phase of ebXML technical standards work on defining the specifications further. UN/CEFACT will no longer participate in ebXML development. OASIS will develop ebXML standards further, but details on the developed specifications were not clear when writing this in November 2003. In September 2003 the OASIS ebXML Business Process Technical Committee was formed to proceed standardization based on the BPSS version 1.01. In October 2003, UN/CEFACT published BPSS version 1.1. This is a good example on the confusion with the current situation.

The idea with the ebXML specifications has been that software industry can make their products conform to the specifications, and there are products to support the specifications. The specifications are quite general in nature, as they have been designed to support many different technologies. Since the publication of the specifications, only ebMS has gathered notable industry support and industrial implementations. The standardization process has been open, so the specifications are open for public commenting. The standardization process has not required implementations of the developed specifications.

Summary

The xCBL framework represents standardization by market, the ebXML framework by committee. RosettaNet is a hybrid, in which end-users are more important than vendors and institutions. The organizational form and involvement are not the only differences. xCBL is developed by making large changes, while RosettaNet progresses through incremental changes. ebXML standardization has been the most open process, and after the initial development process the individual specifications have gone through incremental changes.
Of the three frameworks studied in detail, xCBL seems to lack major end-user companies promoting the usage. The framework seems to have adapted the strategy of co-operating with other frameworks such as UBL.

RosettaNet seems to be the most successful of the three frameworks. The current standardization process emphasizing implementations seems to be working well. Those who wish to benefit from the improvement of the specification, have to be willing to pay to bring the improvement about. This commitment seems to work and is something that might be usable for other e-business standardization efforts as well.

The ebXML framework is ahead of its time in some respects. The market is probably not ready for the registries and automated negotiations yet, as even a single integration between partners is still hard to achieve. In addition, the adoption of the specifications seems currently hard. Trying to cover all the needs of every industry can lead to complexity and overly general specifications. The existing ebXML specifications seem indeed quite general and do not thus significantly reduce uncertainty. So far, the major support for standards has been received from government agencies. ebXML has gathered support from industry consortiums and vendors, but the actual implementations seem few, apart from ebMS. The current situation where UN/CEFACT and OASIS approve the specifications individually can also cause confusion.

ANALYSIS OF STANDARDIZATION

In addition to xCBL, RosettaNet and ebXML, our analysis covers Chemical Industry Data eXchange (CIDX), commerce XML (cXML), Open Applications Group Integration Specification (OAGIS), papiNet used in pulp and paper industry, Petroleum Industry Data eXchange (PIDX), and UBL. These XML-based e-business frameworks are still active in 2003, and important vendors, e.g. Microsoft, or end-users, e.g. DaimlerChrysler, are involved in their development, or use at least one of these frameworks. In addition, vendors such as webMethods, Microsoft, Fujitsu, BEA and IBM provide support for all or at least some of these e-business frameworks in their products. UBL is still an evolving e-business framework and not supported by products.

Classification of e-business frameworks

As Farrell and Saloner (1998), and Jakobs (2002) note, committees and markets are alternatives for defining standards. The committee or institutional approach works through SDOs, such as American National Standards Institute's ASC X12 and United Nations EDIFACT in Electronic Data Interchange (EDI) standardization. The market or business-driven approach allows companies to do the standardization work independently. In the hybrid approach, companies form a consortium to set the standard. There are many industry consortiums, such as RosettaNet and papiNet, defining e-business frameworks. In table 1 of e-business framework categorization, the main drivers of the e-business framework are distinguished.

The literature on standardization economics concentrates on situations where equipment manufacturers or institutions drive standardization. In these cases, the end-users of the standardized products are individuals. This is not the case with e-business frameworks, as the end-users of standards are companies. These companies can represent standard-supporting product vendors and consultants, or they can be end-users of the standards. Industry associations can represent the end-users. Companies such as IBM and Fujitsu can represent both the end-user and the vendor in a framework. This vendor and end-user distinction is worth making, as these participants in the standardization have different expectations for the framework. The involvement column in table 1 represents this aspect of the e-business framework.

The different e-business frameworks can have differences in how they specify business processes, business documents and messaging. Not all frameworks specify all these, and some e-business frameworks are much more detailed that other.

As it seems that not all e-business frameworks target all industries (cross industry), the distinction is made here as well. Some frameworks concentrate on just one or a few specific industries (single/multi). Sometimes this distinction of the target industry is called horizontal and vertical.

Table 1. e-Business framework categorization

Framework	Driver	Involvement	Content	Industry
CIDX	Consortium	User-intensive	Documents, Processes (messaging)	Single
cXML	Business	Vendor-intensive	Documents, Processes	Cross
ebXML	Institution	Neutral	Prosesses, Messaging (documents)	Cross
OAGIS	Consortium	Vendor-intensive	Documents, Processes (messaging)	Cross
papiNET	Consortium	User-intensive	Documents, Processes (messaging)	Single
PIDX	Consortium	User-intensive	Documents, Processes (messaging)	Single
RosettaNet	Consortium	User-intensive	Documents, Processes, Messaging	Multi
UBL	Consortium	Vendor-intensive	Documents, Processes	Cross
xCBL	Business	Vendor-intensive	Documents, Processes	Cross

() Provides only guidelines for how it is accomplished, not actual specifications

CIDX, papiNet and PIDX are consortiums that define e-business frameworks for their respective industry sectors. Industry associations and large companies represent the end-users in these frameworks. There are also some vendors represented, but their role in the standardization is smaller. The three frameworks all define the business documents and processes in detail and guide secure messaging by utilizing the RosettaNet or the ebXML frameworks.

cXML and xCBL are business-driven frameworks with a clear vendor focus. The e-marketplace software vendors CommerceOne and Ariba are the driving forces behind these frameworks. They both target their specifications for all industries and concentrate on defining the business documents. The guidelines for the processes are very general.

ebXML is an institutional framework, as UN/CEFACT and OASIS have been behind it. It intends to provide specifications for all industries. ebXML provides guidelines for defining inter-company processes and core components (CC) for business documents, but no definitions to take into use as such, e.g. a standard purchase order. ebXML also specifies registries and automated partner discovery and agreement specifications, and thus covers the widest area.

Large enterprise system vendors originally formed the OAG consortium behind the OAGIS framework. OAGIS has currently also end-user companies and industry associations as members, but the vendor companies still dominate it. OAGIS defines business documents intended for cross-industry usage and provides support for associated processes. OAGIS also gives guidelines on how to use the RosettaNet messaging specifications.

The RosettaNet consortium includes many vendors that provide software and services for the RosettaNet framework. However, the number and importance of end-user companies in the RosettaNet IT, EC, SM and TC industry boards makes the framework end-user oriented. RosettaNet defines processes, business documents and messaging in detail.

The goal of UBL is to provide common cross-industry business documents leveraging ebXML CC methodology to enable convergence of existing e-business frameworks. The OASIS organization is behind the UBL effort and its members are mostly vendor companies.

Propositions for e-business framework standardization

On the basis of our experience in studying and classifying these e-business frameworks, we have developed the following propositions.

Proposition 1: End-user companies prefer to participate in industry-specific frameworks, and cross-industry framework development relies on institution-driven or vendor-intensive standardization.

End-user companies seem to concentrate on just one framework. By participating in the standardization, end-user companies can affect the result and concentrate on issues important to their situation. As the main business partners represent the same industry, the end-users do not have to participate in lengthy cross-industry standardization. For institutions and vendors, the existence of a framework can be important, but they do not provide very specific requirements. Vendors such as webMethods, Microsoft, SAP, Fujitsu, BEA and IBM participate also in standardization organizations that target all industries.

Proposition 2: Industry-specific frameworks deal with business documents, business processes, and messaging in more detail than cross-industry frameworks.

The industry-specific frameworks cover all the aspects of business communication in detail. Cross-industry frameworks such as OAGIS, xCBL, cXML and UBL concentrate mostly on defining the business documents, they just assist in the processes, and only OAGIS defines secure messaging. The ebXML framework covers all the aspects and even provides help for partner discovery and agreements, but does all this on a very high level.

Proposition 3: Standard competition between the e-business frameworks is not very intensive, because the frameworks have differing main goals.

In many ways, the different frameworks are complementary, as certain parts, such as messaging can be acquired from another standard. All frameworks are somehow interrelated with at least one other framework and there have been many promises for future support. RosettaNet has announced potential support for ebXML messaging and BPSS in the future. OAGIS publicly supports the ebXML specifications BPSS and CPPA, and it is aligning its documents according to CC methodology, as do xCBL and UBL. CIDX and PIDX have a lot in common with RosettaNet. papiNet uses ebXML messaging with its own guidelines.

The different e-business frameworks compete for company usage with each other. A typical source of competition among standards is the way the business documents are described. Fensel et al. (2001) point out that e.g. aligning xCBL and cXML document structures is no trivial task. The same kinds of problems are probable with also other frameworks. This means that companies cannot easily support different business document specifications simultaneously. Messaging standardization is clearly not a major competition factor for e-business frameworks, because the requirements for it do not seem to vary. The competition there is mostly between the underlying technologies used to encrypt or package the exchanged business documents.

Proposition 4: E-business frameworks differ from general IT protocols or traditional product standardization.

As the end-users are companies with bargaining power, the situation is different from traditional standardization. Jakobs et al. (1998) point out that companies with different cultural backgrounds are likely to provide very heterogeneous needs and requirements, as they represent their own organization instead of end-users in general. The different requirements of end-user companies make it unlikely that a single e-business framework would gain control. The EDI standards are very fragmented and the same seems to hold true also for XML-based e-business frameworks.

Economic findings and suggestions

The e-business framework standardization practices support the following claims related to the economic findings:

(1) The free-rider problem does not necessarily lead to non-standardization. Since large enterprises benefit much from the e-business frameworks, they are willing to pay the costs of standardization.

(2) Incomplete information can slow down the adoption of a better standard, as e.g. companies do not abandon their investments in EDI until uncertainty over XML is dispelled. In addition, the large number of e-business frameworks causes problems because adoption of a framework is not costless. Which framework to support, if any?

(3) Most of the studied e-business frameworks seem to be driven by consortiums. This indicates that consortiums outperform business and institution driven organizations in the standardization of the e-business frameworks. The BizTalk framework driven by the vendor Microsoft has closed down and ebXML is not doing very well.

(4) The adoption of an e-business framework depends on its value, which is affected both by the size and by the density of the network. A framework that is very intensively used by a small number of companies may be more valuable and, therefore, more interesting than another framework that is used less intensively by a large number of companies. The large number of industry-specific frameworks against the small number of cross-industry frameworks provides indirect support for this.

(5) The pre-announcement strategies used by the frameworks indicate that expectations are vital. For example papiNet, RosettaNet, and xCBL have published information on current implementations of the framework. Positive history strengthens positive expectations. The frameworks also announce future support to other emerging standards to boost the expectations for future interoperability.

(6) There can be a trade-off between performance and compatibility when introducing a new version of an e-business framework. For example, RosettaNet has proceeded through incremental changes not significantly endangering backward compatibility with the existing implementations. This is a challenge for conformance work between the different e-business frameworks.

(7) Openness plays a key role in e-business frameworks. Except for PIDX, the frameworks follow an intellectual property right (IPR) policy that a standardization organization has a copyright to its framework that is an open standard. The standardization organization as a licensor has and can grant a perpetual, non-exclusive, royalty-free, worldwide right to use, publish, copy and distribute the framework as well as to implement and use the business documents, business processes and messaging included in the framework for the purpose of computer programs. This requires that the contributors agree not to assert any IPR against the standardization organization or any other to implement and use the framework. This also applies to licensees as conditions of the license.

In all, our findings of e-business frameworks do not seem to support all the existing economic findings and suggestions on standardization, e.g. (1), (4) and (7), although for many, it is too early to say anything definite.

CONCLUSIONS AND FURTHER RESEARCH

In e-business standardization, the end-users of the standards are companies. Some economic findings and suggestions related to vendor-driven standards on physical products are irrelevant to this situation, as the end-users of the standards affect choices. The purpose of the e-business frameworks is to lower the transaction costs and to enable better communication between the end-user companies. Standards specifications in the e-business domain are not goods to be sold, but are freely available for use.

The different frameworks do not compete in all respects, but very often complement each other. So far, it seems that the industry-specific frameworks such as RosettaNet, which have a clear focus, are more successful. The current situation with many e-business frameworks and technological standards increases the uncertainty over the e-business frameworks and can slow down the adoption of the frameworks in industry.

The limited data available on e-business frameworks poses challenges to methodology in doing this kind of research. The reliability of the conclusions made here could be improved by collecting information on the usage of different e-business frameworks, the numbers of partners and connections. Our future work includes collecting usage information and identifying the success factors of the e-business frameworks. We aim to conduct comparative case studies to analyze how well different XML-based e-business frameworks do support, e.g. order management and engineering change management.

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REFLEXIVE STANDARDIZATION. INTERPRETING SIDE-EFFECTS AND ESCALATION IN STANDARD-MAKING

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ABSTRACT

In this paper, we address the general question proposed by the symposium: "What historical or contingent events and factors influence the creation of ICT standards, and in particular, their success or failure?" Based on a case study conducted over a period of two years in a Norwegian hospital on the standardization process of an Electronic Patient Record (EPR), the paper contributes to the current discussion on the conceptualization of standard-making in the field of Information Systems. By drawing upon the concepts of reflexivity (as in Reflexive Modernization as theorized by Beck) and unexpected side-effects, the paper makes two key contributions: firstly, it shows that in complex socio-technical settings, standardization processes may induce side-effects hampering the standardization itself; secondly, in such settings side-effects may be interpreted as apparitions of the reflexive nature of the standardization process. Accordingly, attempts to standardize may reinforce complexity. The research question is addressed by providing an historical and contingent analysis of the dynamics emerging from the case.

Keywords: standards, reflexive modernization, side-effects, socio-technical theory, Electronic Patient Record.

INTRODUCTION

The trend towards establishing larger and tighter information infrastructures for control and rationalization implies efforts of massive standardization and integration (see Weill and Broadbent, 1998; and for a critical perspective see Ciborra et al., 2000). However, as integration becomes tighter and as the infrastructure grows in scope and reach, the complexity also inevitably grows. When previously unconnected systems, elements or networks are being connected, new interdependencies will be introduced. This allows novel consequences and side effects to emerge and to propagate in the network.

In this paper we claim that standardization in such settings will proceed in a radically different manner from more isolated settings. When a standardization process is undertaken in a large, diverse, and tightly integrated information infrastructure, the new standard will have to adapt to existing standards through a long-term process. This demand for interaction/negotiation/adaptation greatly increases the complexity of the undertaking, and our claim is that this complexity may severely hamper the attempts to achieve standardization. Rather than reducing complexity, fragmentation, and heterogeneity, the attempts to standardize may actually reinforce or recreate these characteristics. This is the paradox which we attempt to illustrate through an empirical case study, and subsequently to analyze. For this sake, we adopt a socio-technical perspective on processes of standardization and propose the concept of *unexpected side-effect* from the theory of *reflexive modernization* (Beck et al., 1994; Beck, 1999) to interpret specific complexities.

The research presented in this paper is based on a case study conducted in a major Norwegian hospital over the period of two years (2001-2003) on the implementation of an Electronic Patient Record system (EPR). The standardization process which we describe in the paper is centered on this software product. We mean that this product, commonly intended as a communication and collaboration medium for individuals, groups, and institutions, can be seen as a shared convention/system and consequently can be seen as a standard. The process, through which this software product is being specified, prototyped, developed, implemented and redeveloped, as well as integrated with a broader information infrastructure, is what we call a standardization process. The difficulty of this standardization process to come to a closure and define the EPR as a complete standard makes it an ideal case to show dynamics and complexities of standard-making in the field of Information Systems.

Thus this paper contributes to the current debate on standard-making in the Information Systems field by providing a theory based empirical study of standard development and addressing the general question suggested by the symposium:
“What historical or contingent events and factors influence the creation of ICT standards, and in particular, their success or failure?”

The paper is structured as follows. We will first provide our conceptualization of standards and standard-making extending the theoretical perspective from economical to socio-technical. Secondly, we will describe the methodological approach and provide an account of the role of the theory in our research. Thirdly, the case will be described. Subsequently, the empirical evidence will be analyzed and findings discussed in the light of reflexive modernization. Finally, conclusions will be drawn and suggestions for further research will be given.

THEORETICAL FRAMEWORK

The aim of this section is to delineate the theoretical framework used to interpret the process of standardization observed in the case. By doing so, we position ourselves in the current debate on theories of standardization: we support the claim for the integration of the traditional economical discourse with a social perspective (Fomin et al., 2003).

We recognize the importance of the economic perspective on development and use of standards and specifically the importance of concepts as: path dependency , externalities, lock in (David, 1985; Arthur, 1989; Antonelli, 1992; Arthur, 1994). The focus of the economic perspective is in general on models of standards development and their consequences on firms and markets. Standards are accordingly defined as technical elements, while little attention is given to the social shaping of standards and their social and political implications. For instance, David and Greenstein (1990) define (technological) standards as “a set of technical specifications adhered to by a producer, either tacitly or as a result of a formal agreement” (page 4). Moreover the economic focus is much directed towards process of adoption and diffusion of standards, and not on standard making processes (Fomin et al., 2003).

Acknowledging the economic contribution, we would like to point at other aspects of the process of standard making specifically emerging from our case study. The case shows evidence of peculiar characteristics that altogether make it hard to be included in the existing economical discourse on standardization. Standardization is not a purely technical process, and is not a process that inevitability lead to closure as definition of a complete technical standard. We believe is important to analyze not just the social impact of technical standards, but to contribute to the conceptualization of the socio-technical process of standard-making and of what a socio-technical standard is. We turn then our attention to the socio-technical approach, where we recognize four elements important to our understanding.

First, we conceptualize standards as representing always *local* universality (Timmermans and Berg, 1997). By this concept it is emphasized that universality always “rests on real time work and emerges from localized processes of negotiations and pre-existing institutional, infrastructural, and material relations” (p. 275). There is no rupture between local and universal, but it is from the very local that universality emerges, and in turn transforms back the local. Understanding local universality, means therefore to commit to the understanding of the historical dimension, or trajectory, along which a standard is construct and reconstruct (Dosi, 1982; Strauss, 1993). This implies also to look at aspects of adaptation of the universal into the local (Hanseth and Braa, 1999)

Second, we conceptualize the process of standardization as a process of technology generation as discussed by Schmidt and Werle (1992; 1998) in their study on committee standards and telecommunication technology. They discuss how technology, and the process of standardization, are not neutral, but defined through an intermingled with social, political and economic factors. Similarly, Bowker and Star (1999) point out that standards are always embedded into local networks which inscribe specific believes and assumptions on the reality. This perspective is informed by the social construction of technological system approach (e.g. Bijker et al., 1987).

As third element, we see standards not as isolated elements, but as always embedded into a network of standards: one standard’s order can be another standard’s disorder (Berg, 2000).

Fourth, we recognize the significance of concepts (from STS and ANT literature) as closure (Law and Bijker, 1992), stabilization (e.g. Bijker, 1993) and alignment (e.g. Callon, 1991) in understanding processes of standardization (Hanseth et al., 1996). Specifically, closure indicates a status where a consensus emerges around a particular technology. Closure stabilizes the technology by accumulating resistance against change. In this situation, the actor network where the technology is embedded can be said to be aligned. As we will see, in our case the alignment, stabilization and closure appear not to be reached: the process at case seems to continuously be open (no closure) and negotiated (no final alignment or normalization).

Finally, we would like to highlight the specificity of standardization processes in the health care sector as indicated by Berg and Timmerman in their recent work (the golden standard). To unfold the intermingling of different standards, they propose four ideal categories of standards:

design standards, terminological standards, performance standards, procedural standards. They are presented in Table 1.We will adopt this classification in the analysis of the case.

Table 1. Four ideal typical categories of standards

Category	**Specification**	**Example**
Design	*Structure*	*Size of hospital beds*
Terminological	*Stability of meaning*	*ICD 10*
Performance	*Outcome*	*Level of complication rates for a specific operation*
Procedural	*Processes*	*Clinical practice guidelines*

Yet, when the process of negotiation to achieve standardization become so complex and diversified as our case empirically shows, we see the need to push the analysis forward to unfold the dynamics of emerging standards. We believe that what at a first glance may appear as transitional exceptions essentially hide complex dynamics that need to be analyzed, and which may tell us more about the nature of the process itself. In the analysis, we will dig into such aspects by using concepts from the theory of reflexive modernization.

METHODOLOGY

The research reported in this paper is grounded in the interpretive approach to case study in IS (Klein and Myers, 1999; Walsham, 1993, 1995). For data collection, we employed ethnographically inspired methods conducting 30 interviews, 8 instances of observations of daily work and users training sessions, documents analysis, and participation in several discussion meetings. As research group, we also met on weekly basis to report on each other fieldwork, and discuss both theoretical and practical implications and findings. The head of research of the IT department of the hospital has joined regularly these meetings to update on the project, and to suggest interesting area for further research.

Our fieldwork is the continuation of a long research cooperation between our Department of Informatics at the University of Oslo and the IT department of the hospital. Between 1996 and 1999, the implementation of the EPR has been the topic for course project in an Advanced Systems Development course. Each year around 5 groups of 5-7 Master students studied and reported on some aspects of the design and implementation process in the hospital.

The process of writing this paper from the perspective of socio-technical standard-making and reflexivity has helped us to look both at micro and macro level phenomena, and at the intertwining of the two. The socio-technical perspective on processes of standardization provided us with the conceptual and analytical tools to understand the complexity of the problem. Whilst, Beck's theory on reflexive modernization has guided us to the understanding of particular mechanisms of the standardization process of the information infrastructure in the making. In particular, it has helped us to conceptualize how the emerging uncertainties and difficulties of the implementation process were not due to external factors, but internally and reflexively produced. The reflexive modernization theory has directed our attention to the central role of side effects, and their mechanisms of production, in creating a situation perceived as risky and out of control.

CASE DESCRIPTION

Background

The case deals with the implementation of an Electronic Patient Record (EPR) in a major Norwegian hospital. An EPR is a computer-based information system for storing and presenting patient clinical data. It is intended to be the electronic equivalent of the paper-based patient record, and for decades it has been a major concern in the field of Medical Informatics because of the considerable complexity that its design, development, and implementation entail (e.g. Berg and Bowker, 1997; Ellingsen, 2002). Still, successes of deployment of EPR systems in GP (General Practitioners) offices, smaller hospitals, and specific clinical departments in larger hospitals are common. But developing a hospital wide centralized EPR substituting or integrating and homogenizing (read standardizing) the local systems and practices has proven to be a quite different task. Let alone developing a common system to replicate in several hospitals, as we will see this case is about.

In 1995 five University Hospitals in Norway started a project for the common development and implementation of an EPR, which we will call MedEPR. At that time in Norway, several local initiatives aiming at creating a computer-based support for storing and handling patient clinical data were already running. The new project merged the local efforts with the aim to share costs and risks, and to push cooperation and coordination between hospitals across the country. A vendor with adequate experience and resources was chosen and the deadline for the delivery of the system was set to be 1999.

As of today, summer 2003, the project is still running and the final product is yet to be delivered. All five hospitals have managed to implement and scale up the current versions of the system to cover the whole organization. At Rikshospitalet, where the research was conducted, roughly all 3500 potential users had been reached by the end of 2002. Behind the apparent success, the implementation (despite the delay) hides a long list of compromises, ongoing negotiations, and incomplete tasks. Moreover, in these eight years of implementation, not only have some key goals been renegotiated, but also the efforts to reach them have often produced opposite effects. Furthermore, in the same period the role of the IT department in the hospital (leading and managing the implementation process) has dramatically changed with the effect of pushing the range and scope of negotiations surrounding the MEDEPR project well outside the boundaries of the hospital.

In the following sections, we shall give an account of the observed dynamics of the implementation. We have selected three particular snapshots or stories which we think help to unveil aspects of the complexity of the implementation process.

From unity to fragmentation

The first story tells about the observed outcome of the attempt to migrate from a unified system on paper to a unified system on computer avoiding and reducing fragmentation.

In the very same year the MEDEPR project started (1995), Rikshospitalet centralized the paper-based patient record. Previously, each department kept a separate record, so that the same information was stored, displayed and used in a variety of ways and places, with serious problems of consistency and redundancy. The centralization consisted of an intense standardization process, where hundreds of paper forms in use in the different departments were merged and gathered in a structured paper record organized in 10 chapters containing predefined forms. Basically, the aim of the MedEPR project was to replicate and replace the centralized paper record, while allowing for workflow and statistics to route and crunch the information. In the envisioned scenario the MedEPR would substitute paper and constitute the preferred medium and system for storing and using the patients' clinical data.

Since the project started, new components of the MedEPR were delivered regularly, but the full transition from the paper to the electronic record was never accomplished. As of today, both systems (paper-based and the incomplete MedEPR) are still running in parallel. We have identified three main problem areas related to the incomplete transition.

Firstly, the challenges involved in the design and development of the electronic version were expected to be less complex. As a result, the MedEPR, after eight years of development, is only storing and displaying text, while much critical clinical non–text-based information is still on paper forms.

Secondly, the MedEPR project team had to engage in numerous technical and political negotiations with the departments already owning local EPRs. Often, users perceived the local systems to better support their work routines. Thus, substitution was not a viable solution; neither was technical integration. Technical integration with local systems may be eventually pursued, but is for the moment too time consuming. Currently the systems have functional overlap and coexist, while doctors and secretaries need to perform double entries and cut and paste information between the systems. Moreover, the paper-based record never really threatened the existence of "local" solutions, but it often simply stored its output on the standardized paper form.

Thirdly, the transition from paper to electronic media included also documents previous to 1995 and not standardized. In order to address this issue, the IT department decided to scan older and relevant information and link it to the MedEPR.

Thus the MedEPR has emerged in the years as a partial, continuously negotiated and reinvented artifact striving to substitute and complete the transition from the centralized paper-based patient record. As a result, clinical patient-related information is stored in the central paper record, in the MedEPR as text (as partial copy of the paper record), in local systems, and soon as scanned forms (Table 2). Apparently, the attempt to reduce existing and avoid new fragmentation had instead the effect to increase it. Our evidence shows that it is a *chronic* temporary transitional situation.

We may summarize the described situation in the following table:

Table 2. Summary of current situation of the MedEPR implementation

	Centralized paper record	**MedEPR Vision**	**Current Situation**
Location of Clinical Information	All on paper	All on MedEPR	Most text on MedEPR. Drawings and Graphs on paper or on local systems. Old information scanned and linked to MedEPR. Concurrently, the central paper record has a copy of all the clinical information.
Relation with Local EPR systems	Co-existing with paper record	Substituted with central MedEPR	Loosely integrated with central MedEPR. Negotiations still ongoing.

The quest for integration

The second story provides an account of the results of the attempt to integrate the hospital infrastructure of clinical systems under MedEPR.

The MedEPR, in its original conception, is the ultimate system for storing and routing patient centered clinical information. Ideally, its implementation in a hospital places it in the middle of a hierarchy of systems: upwards it has to integrate with the central Patient Administrative System (PAS), downwards it has to integrate with all sorts of laboratory systems (e.g. EROS, a system for storing and delivering test results). Additionally, as we have mentioned, it has to undergo lots of “horizontal” negotiations with competing local systems (e.g. Berte, a local EPR system developed in the pediatric cardiology department). This vision is a qualitatively different vision (in terms of ambition) compared to the original one, where the MedEPR was supposed to be the one system in the hospital substituting or integrating all the others. As the complexity of the integration slowly emerged, the vision of MedEPR changed and evolved accordingly. Yet, still in this more humble vision, the role of the MedEPR as the central integrated system to access all clinical data needed to be adjusted again (Figure 1).

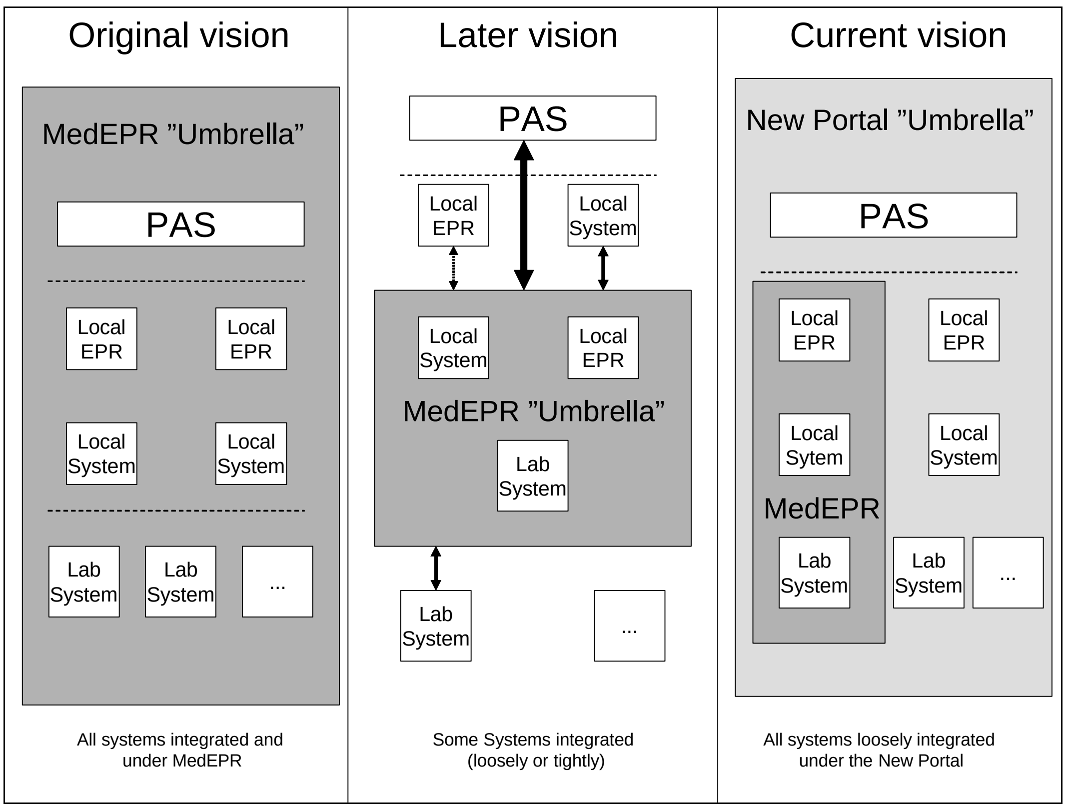

Figure 1. Three stages of the envisioned role of MedEPR

In order to address the growing complexity of integrating MedEPR with the other systems the IT department at Rikshospitalet started a new integration project. The project aimed at loosely integrating the many clinical (including the MedEPR) and laboratory systems into one portal. The portal is a software application specifically dedicated to providing a single point of access to the variety of systems present in the organization. The systems are separately accessible through separate windows while their access is negotiated once for all as a “single-sign-on”. While visualization and access to the systems are integrated, the systems themselves need not to be integrated with each other. This solution, which is currently under development, tries to gap one of the shortcomings of the MedEPR, i.e. the ability to integrate all systems acting as a portal. Moreover, it expands the envisioned role of MedEPR which it substitutes, by providing a new range of services (e.g. activity handling) which were not yet present in MedEPR.

Apparently, the effort to integrate the clinical systems in the hospitals (including PAS) through the MedEPR required yet another integrating system to be implemented and integrated.

Escalating the standards war

The third story describes how the project has progressively enrolled a larger number of stakeholders to assure its survival.

In order to better understand the role of the MedEPR project in the trajectory of the information infrastructure in the hospital, the historical perspective needs to be considered. At Rikshospitalet the MedEPR project represents the first serious attempt to create a common platform across the clinical department for storing and accessing patient-centered clinical information. On the one hand, enough knowledge and competence for developing EPR solution was available in the vendor. On the other hand, the existing IT infrastructure based on LAN and PCs made the project technically feasible. The decision to embark in such a project affected the mission and organization of the IT department. Throughout the 1990s, the IT department acquired employees with medical and administrative background (until then there were only employees with technical knowledge) and grew in size and budget. At the beginning of 1990s the IT departments' staff was approximately 20 persons on a budget of approximately 10-15 MNOK (NOK 10 ≅ $ 1.35). Currently over 80 people are running projects on a budget around 80 MNOK. Moreover, for the next four years (2003-2006), the IT department has set up a budget of 267 MNOK alone for development and implementation of clinical information systems. The budget for similar projects before 1995 was 0 MNOK. The competence of the department expanded from the development of administrative systems to the development of clinical systems.

On another level, the range of strategic influence was enlarged from a departmental scope to a regional scope. Historically, we may identify three phases of the role of the IT department concerning its strategic influence.

1. Before 1995: the IT department mainly served as IT technical support and maintenance
2. 1995-2001: the IT department struggled to create a common IT platform (the MedEPR) between clinical departments
3. After 2001: the conditions in the health sector change. IT strategies need to be orchestrated at regional level.

The last phase implied that the survival of MedEPR was dependent on the ability of the IT department (representing Rikshospitalet) to impose it as a common strategy at regional level. We have already mentioned as the MedEPR project was the product of a national effort between 5 regional hospitals. In the current configuration of the health sector, each of the hospitals participating to the project is in a separate region, while strategic decisions are taken for each region separately. Thus, each hospital adopting MedEPR is "alone" in its region and has to fight to impose their system to the other hospitals in the same region.

The implementation of EPR solutions pushed further and enabled cooperation and integration of the IT infrastructure between hospitals in the same region. At the same time, as different hospitals owned different EPR solutions, the need to rationalize the variety of systems in a coherent regional IT strategy emerged. As a result, the IT department at Rikshospitalet decided to push MedEPR as the standard to be adopted by other hospitals as well. Moreover, Rikshospitalet applied to become the center for delineating and implementing regional IT strategies. MedEPR is in this situation presented as a defined standard, while in fact it is still incomplete: its integration with the rest of the infrastructure still ongoing, its use fragmented, its design and development under continuous change. MedEPR more than "a" standard may be seen as an evolving system of interrelated standards.

This last account of the case lets emerge how the implementation of MedEPR as a process of standard making tended to escalate in order to guarantee its survival. While the IT department is still struggling to develop it and implement it inside the hospital, it is using it as a finished product to be adopted and imposed at regional level. In other words, while still in-the-making and in order assure its existence, MedEPR is *blackboxed* as a finished standard and used as argument in the political and power struggle at regional level.

DISCUSSION

In this section, we start the discussion by justifying the relevance of interpreting the implementation of MedEPR as a standardization process. Subsequently, we highlight its peculiarities. Then, we will propose an interpretation of the phenomena emerging from the case as side-effects. Finally, we contextualize such interpretation in the larger framework of Reflexive Modernization.

MedEPR Implementation as a Standard-making process

The implementation of an Information System may not be necessarily always seen as a process of standardization. Nor is an Information System necessarily always a standard (as often with ERP solutions; see Pollock et al. 2003). Yet, the Electronic Patient Record is a kind of Information System which is in continuous negotiation with standards, and the effort to develop it and implement may be seen as a process of standardization. In our case, we can interpret the implementation process of MedEPR as a threefold process of standardization:

1. Standardization as integration of existing Standards (e.g. medical and technical, local and global)
2. Inter-departmental Standardization
3. Inter-hospital Standardization

Firstly, the implementation of MedEPR (and EPR systems in general) is a process of integration of a variety of standards into a single solution (Berg 2000). In this sense, instead of being a single standard, MedEPR can be seen as a set of interlinked standards. Using the classification of medical standards proposed by Berg and recalled in the theory chapter, it is evident from the example in table (Table 3) that MedEPR involves all sorts of standards, ranging from technical to medical, from local to global.

Table 3. Example of multiplicity of standards in MedEPR

Category	**Example**
Design	*-Clinical information organization in chapters* *-Electronic forms layout* *-Departmental templates for discharge letters*
Terminological	*-ICD 10: international diagnosis coding system* *-Formal and informal abbreviation systems for hospital, departments, or disciplines*
Performance	*-Availability and completeness of information according to national laws* *-Security levels* *-Database performance*
Procedural	*-Workflow routines between doctors and secretaries* *-Departmental agreements on documentation procedures* *-Request and reply routines between departments and laboratories*

The development and implementation of MedEPR tries in fact to align, incorporate and link a great variety of medical coding systems, hospitals security standards, formal and informal abbreviation systems, departmental adaptations, national guidelines and policies and so forth. The implementation tries to achieve a *closure*, a stable *alignment*, and *normalization* of this heterogeneous network of actors representing standards (Hanseth et al. 1996).

Secondly, the implementation of MedEPR constitutes a standardization process between the clinical departments, as it performs the integration of existing standards (point one) in each department in a coordinated and centrally controlled fashion.

Finally, MedEPR is the result of a national common effort of standardization of multiple EPR initiatives ongoing in the five main hospitals. It is now pushed at regional level in other hospitals to favor cooperation and information exchange.

Accordingly, we may conceptualize the development and implementation of this very information system (and of EPR systems in general) as a process of standardization. Yet, there are some characteristics of the process at case which tend to challenge its categorization as a traditional technical standardization process:

- The process seems to never come to a *closure* (Hanseth et al. 1996)
    - o *Empirical evidence:* after eight years of the development, including four years delay from the planned final delivery, MedEPR is covering 30-40% of the clinical information contained in the paper-based record. The role of the MedEPR has changed, so have the requirements. The changes in national regulations are also affecting further development.
- It is hard to define the boundaries of the network of actors involved in the process of alignment and normalization (Timmermans and Berg 1997).
    - o *Empirical evidence:* Actors influencing the development and implementation are active at departmental, hospital, regional, national, and international level. The source of influence ranges from negotiation and adaptation to medical protocols, to laws and regulations on patients' rights to own information.

- It has proven to be extremely difficult to define in advance the full specification of the EPR standard (Hanseth & Braa 1999)
  - o *Empirical evidence:* Never in the eight years of development did the vendor of MedEPR or the hospitals managed to create a complete specification of what MedEPR should be. The process has always been emergent and dynamic.

Hence, it is meaningful to interpret the implementation process as a dynamic trajectory, that is, looking at its change, evolution, adaptation and emergence over time, as the result of continuous tensions and negotiations in the socio-technical network (Hanseth et al. 1996). This trajectory entails aspects of socio-technical complexities which need to be investigated. We sustain that it is relevant to study and understand the dynamics of this process of standard-making, and develop interpretive theoretical frameworks.

For this purpose, we will now highlight particular phenomena observed in the case (side-effects), and we will propose a sociological theoretical framework for their interpretation (reflexive modernization).

SIDE-EFFECTS OF STANDARD-MAKING

In the first part, the case presented two particular accounts of the implementation process. It highlighted the struggle to reduce fragmentation and increase integration, and their apparent contradictory effects of increased fragmentation and increased need for integration.

In the story on fragmentation, the attempt of achieving the same unity of medium and location present in the paper-based record system (all information on paper located in the same single folder) in electronic form (all information in digital form accessible through one single system) produced fragmentation in the type of media used and the location of clinical information. What we called here “attempt” is indeed the whole process of design, development and implementation of MedEPR. This process had to engage on the social level as much as on the technical with a great number of actors: from single users in the hospital, to political institutions involved in defining strategies at regional level; from departmental established work routines and traditions, to tensions between professional categories. Our concern is the understanding of how the described complexity of the implementation process of MedEPR generated effects in the opposite direction to the intended one; and how those effects in turn affect and change the way the problem (or challenge) of standardization is conceived.

In the story on the quest for integration, the attempt of integrating all clinical systems (including PAS) under the “umbrella” of MedEPR produced the need for the implementation of yet another integration “umbrella”. Also in this case, more than a mere technical limitation or an unforeseen obstacle, the integration effort brought to light the underlying (and thus maybe not always visible) complexity of links, dependencies, and trajectories of the existing technical and social systems. In this sense, the attempt to integrate generated a greater need to integrate, while changing the envisioned role of some of the actors. For instance, the role of MedEPR changed from one of integration system to that of a component system to be integrated.

The last story of the implementation process presented in the case description regards the escalation of the scope and ambition of the MedEPR project. As we have shown, the escalation was not merely the attempt to expand the influence and acceptance of an established standard. It was used as a strategy to assure the survival and sustainability of a standard which was still in the process of making. In other words, the attempt to address the already complex local standardization required the redefinition of the ambition and scope of the standardization attempt, thus increasing its very complexity and eventually its risk of failure.

We can summarize the three observed aims and actions of the implementation process and their outcome in the following table (Table 4):

Table 4. Aims and Actions of the MedEPR Implementation Process

Aim and action	Observed effect
Achieve unity of media and location of clinical information	Clinical information fragmented in different media and (physical and logical) locations
Achieve integration of systems under MedEPR	Need to implement new integration framework over MedEPR and other systems
Achieve closure of standardization by managing its complexity	Increase complexity of standardization by escalating its scope and ambition

Reflexive Standardization

In order to make sense of these manifestations of the observed phenomenon, we will apply the concept of *unexpected side-effect* borrowed from the theoretical framework of Reflexive Modernization as delineated by Ulrich Beck (Beck 1994, 1999).

In his analysis of contemporary society, Beck underlines the increased importance of *side-effect* of human actions. He identifies an increased *unawareness* or *non-knowledge* at the basis of *side-effects*. As the modern world becomes more and more integrated and interconnected, it is increasingly difficult for humans to be fully aware of all effects caused by their actions. As side-effects become acknowledged, they challenge and question the basic knowledge of the modern society.

In our case, increased fragmentation, increased need for integration, and escalation appear as side-effects that contradict the actions which have generated them, and increase the complexity of the problem those very actions were trying to solve. They could not be predicted: the initiators were *unaware* of how their actions could propagate. In this discourse, a process of standardization can be interpreted as a process that aims at achieving greater *awareness* by developing control. Reflexivity tells us instead, that the more we try to become aware of our society by modernizing it (e.g. by processes of standardization), the more we will cause unawareness, thus side-effects. That is, the more we try to standardize the information infrastructure in the hospital, the more difficult and complex such standardization process will become.

This reflexive dynamic provides an explanation of why the standardization process of MedEPR seems to never come to a closure, and instead evolves over time in an unpredictable trajectory.

CONCLUSIONS

In this paper we have engaged in the discussion about the conceptualization of standard-making processes in the field of Information Systems. For this purpose, we have presented a case of standardization of the information infrastructure in a major Norwegian hospital. Applying the concept of *side-effect* from the theory of *reflexive modernization*, we have proposed an interpretation of the complex dynamics emerging from our empirical material. We submit that the *side-effects* are inherent to the nature of standardization as attempt to control a complex reality. We believe that the proposed framework has proved useful for unveiling the mechanism behind paradoxical outcomes of standardization processes.

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IDENTIFICATION OF DIFFERENT TYPES OF STANDARDS FOR DOMAIN-SPECIFIC INTEROPERABILITY

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ABSTRACT

Communication is at the core of society, and a networked society needs to adopt standards to achieve effective communication. However, from a practical point of view, it is often hard to find out what a particular standard actually has to offer. This problem becomes even more serious when it comes to domain specific standards. To what extent different domain specific standards cover the same ground and lead to the same results is often not easy to find out. This paper explores the nature of available standards with respect to the contribution they make toward standardizing the communication within a specific domain. To achieve this, the notion of interoperability is expanded beyond the computer science definition towards an organizational context, in which the interoperability has to demonstrate itself. In addition, different kinds of communication between organizational systems and different levels of interoperability are defined. To this end the paper addresses the different kinds of issues that need to be tackled and illustrates to what extent different standards can actually fulfill these needs. The ultimate aim is to focus the attention of standards development organizations on the type of standard they want to produce and also to provide for a more clear understanding of the possibilities to attain true interoperability given the (set of) standards that are available for a particular domain.

Keywords: Domain-specific interoperability, standards, communication, socio-technical systems.

INTRODUCTION

Communication is at the core of society, and a networked society needs to adopt standards for communication if it wants to be able to communicate effectively (Chauvel, 2003; Iakovidis, 1998; McDonald, 1997). The world of standards for communication is a complex one. Various organizations are actively developing standards and are trying to get them recognized and implemented in the marketplace. The number of proposed and de-facto standards is overwhelming, and discussions about the need for yet another standard surface on a regular basis. Of course, the goals and motivations of different standard developing organizations are often quite different. However, from a practical point of view, it is often hard to find out what a particular standard actually has to offer. Not so long ago, people advocated that XML would make a number of other standards redundant, as XML provided a way to communicate not only the message itself but also the message structure, hence eliminating the need to standardize the message structure. The plethora of XML-based standards that have emerged over the last years seems at least to contradict this notion (Eysenbach, 2003; Kuhn & Guise, 2001; Omelayenko & Fensel, 2001). From a practical point of view it might be helpful to get an insight into the generic capabilities of a standard from the point of view of its usefulness to the problem at hand. ISO has tried to define such a framework with the Open Systems Interconnection standard (see e.g. (Tanenbaum, 2003)). This has led to a very useful way of typifying different standards, albeit the standards will hardly ever be limited to exactly one layer of the ISO/OSI model. Also, on the application side there is only one level defined, which seems to be insufficient for our current requirements. We are building more levels of standards all within the framework of the 7th layer, but the distinctions are often not clear.

Taking the perspective of domain specific standardization, the picture becomes even less clear (Mykkanen et al., 2003). For instance, in the healthcare domain a vast amount of standards is available from different communities (see e.g. (Klein, 2002)). This ranges from standard interfaces for medical equipment in order to combine the outputs of different devices on a shared platform to the development of an international classification of diseases to monitor the health of the global population. Some of these standards do not restrict themselves to the actual domain, but also specify more generic technical issues. Apparently there was a need for that at the time, but currently domain specific standards are building upon well-established layers of technical standards to carry out these generic tasks. To what extent different domain specific standards cover the same ground and lead to the same results is often not easy to find out, without actually looking into the finer details of the standard or actually implementing it and trying to communicate with another implementation.

In practice, it turns out that a lack of specified implementation details of standards is a major obstacle for true interoperability of systems (Harrington et al., 1998). This is hardly a new phenomenon, as even implementers of the old X.25 transmission protocol found themselves in a bind as to how to handle certain exceptional situations. The fact that devices using the same IEEE 802 network protocols are not always interoperable is also a well-known fact of life. Still, this becomes increasingly problematic, as the scale on which standards are being used is becoming more global everyday, both on the technological side and on the domain specific side. Wireless networks in hotels have to deal with equipment from all over the world and in response to the recent SARS outbreak the centers for disease control had to be able to access and process information from a wide variety of global sources (Eysenbach, 2003).

Our objective is to explore the nature of the standards available with respect to the contribution they make toward interoperability within a specific domain. Healthcare is the domain chosen for this study, given the familiarity of one of the authors with this domain. We start out with a somewhat scattered overview of available standards within the healthcare domain and provide a first indication of the different types of standards that have been developed from a goal-oriented perspective. Next we elaborate upon the concept of interoperability, extending the computer science definitions to an organizational context in which the interoperability has to demonstrate itself. Finally we present a framework that is meant to identify the different types of standards needed to achieve such domain specific interoperability.

STANDARDS IN THE HEALTHCARE DOMAIN

There is a large variety of standards within the healthcare domain. An extensive review of healthcare standards can be found in Klein (Klein, 2002). A recent study of international standards that might be helpful in the interoperability of computer based patient record systems (VIZI 2001) revealed that the available standards roughly fall into four different categories. These categories are listed in Table 1. Some families of standards form a coherent set of standards covering the full spectrum from method to operational standard.

Table 1. Categories of standards found relevant for interoperability of computer based patient record systems (based on VIZI, 2001)

Category	Description	Sample question
Method	A common way of thinking, working, and modeling during the development or use of an artifact	How do I define a communication interface between two systems?
Meta-model	A generic description of the domain, to be used in projects that adhere to a chosen method	Which generic functions can be discerned in an architecture of communicating computer based patient record systems?
Concrete model	A specific description of the interactions and data to be exchanged, having a one on one relationship with the relevant reality.	Which patient data is to be exchanged with respect to a patient referral from one care provider to another?
Operational standard	A detailed specification of the interactions and data to be exchanged, that can be used without further detailing or interpretation in the implementation of communication links between computer based patient record systems.	How do I exchange data between different parties and their systems?

A lot of effort has been poured into method and meta-model standards, but their use in achieving interoperability is limited, since it only works in a project in which application software and communication interfaces are developed according the specified method and meta-model (e.g. see (Deftereos et al., 2001)). Interoperability outside the scope of the project is not guaranteed when using these standards, as was demonstrated by projects using the CEN[1] 13606-4 method standard and the CEN 13606-1 meta-model standard. Similar projects were undertaken both in Stockholm (Sweden) and on the Greek isle of Crete, with very promising results within their respective areas. However, interoperability between systems across these two regions was out of the question. Similar experiences can be found with different implementations founded on the CorbaMed[2] set of standards. These standards have been developed from the point of view of outlining a method and architecture which use leads to a well founded network of interoperable computer based patient record systems, clearly defining the roles and respective functionalities of the individual systems discerned and the way to define proper communication between them.

Other initiatives, such as HL7[3] and DICOM[4], started from a different perspective, leading to more concrete and operational standards. Their development arose from the necessity to connect different specialized information systems that all contributed in some way to the overall data processing needs of hospitals. As such they replaced the ad-hoc interface specifications

1 CEN: Comité Européenne de Normalisation, European Committee for Standardization
2 CorbaMed: the Medical industry specialization of the Common Object Request Broker Architecture CORBA
3 HL7: Health Level 7, referring to the ISO-OSI 7th layer
4 DICOM: Digital Image COMmunication

developed for an individual pair of information systems that needed to communicate with each other. However, the standard development process could be characterized as a consensus based process that would leave enough room to accommodate the specific needs and idiosyncrasies of individual vendors and hospitals. Hence, no truly operational standards were developed and much negotiation and detailing still had to be done when implementing the standard.

A more in-depth discussion of the similarities and differences between CEN, CorbaMed and HL7 is provided by Blobel (Blobel, 2000; Blobel & Holena, 1997). Further, Harrington (Harrington et al., 1998) looks at barriers to diffusion of standards for interoperability. From their conclusions one can infer that, in order to provide 'plug-and-play' interoperability, there is a definite need for operational standards. Fairly recent developments point out that these standards should not only address the interactions and the data structures, but also the vocabularies to be used when populating the data structures (Kuhn & Guise, 2001). For instance, what good is it to order a specific lab-test from a (commercial) laboratory, if the test code that is used by the doctor to identify the type of test, is not understood by the laboratory? HL7 has adopted the view that it need not specify these standards as vocabulary standards are readily available from a variety of sources, in particular scientific communities that standardize their vocabularies in order to carry out their research. Another important source for vocabularies is the World Health Organization, which has a long- standing tradition with its International Classification of Diseases (ICD). Rather than developing vocabulary standards, HL7 incorporates a mechanism to refer to existing standards as part of their message structure. However, there is a lack of thorough understanding of the types of standards needed to achieve "true" interoperability. To this end, we discuss in the next paragraphs a number of different notions on the nature of interoperability.

INTEROPERABILITY IN A DOMAIN-SPECIFIC CONTEXT

The discussion in the previous paragraph suggests that standards have been and are being developed with a number of different characteristics. In order to understand their contribution toward interoperability, we need to understand the nature of the communication these standards support and the role this communication plays in achieving interoperability within a specific domain. We limit our notion of domain interoperability to an organizational setting in which two organizations communicate with respect to objects and transactions within a specific industry (e.g. healthcare) or within a specific business function (e.g. finance). This is the kind of interoperability that is the focus of many business-to-business relationships, which seem to lend themselves to substantial efficiency gains when supported by modern eBusiness technologies (Hamminga et al., 2002).

As a starting point for our discussion on interoperability we choose to use the definition of the IEEE. Interoperability is defined by IEEE as: "The ability of two or more systems or components to exchange information and to use the information that has been exchanged". Two distinct issues will have to be addressed when trying to apply this definition to the notion of domain interoperability. The first one is the notion of 'systems or components', which are to exchange and use the information. The second one is the notion of 'use the information', because of the different interpretations this notion may have in different contexts. We will discuss both issues below.

When we are talking about domain interoperability, as mentioned above, one has to enlarge the (implicit) definition of system from a purely technical system to a socio-technical system (see also (Mykkanen et al., 2003; Stamper, 1996; Warboys et al., 1999)). Similar to Warboys et al. (1999), we recognize three different subsystems of the socio-technical system: the human subsystem, the process subsystem, and the technology subsystem. Together they form an operational organizational system, in which people work together towards a shared goal, using a common set of processes to carry out and coordinate their tasks. Technology is available to support (parts of) these processes. When we view interoperability from this enlarged scope of the systems that have to exchange information we can identify seven different kinds of communication. This is depicted in Figure 1. Without providing an exhaustive account of all the possibilities, we would like to provide some background on the most important ones. The IEEE definition of interoperability (implicitly) applies to the communication between the technological systems. The ISO-OSI model was developed for these kinds of interconnections and is not suitable to describe the human-to-human communication (Bauer & Patrick, 2002). . Human to human communication needs a common language and a common frame of reference or interpretation to become meaningful. We have to turn to the field of communication studies to interpret the notion of interoperability with respect to the human subsystem. On the intersection of the process and technology subsystems, one can position workflow management systems and the ways in which these systems can work together. When looking at the intersection between the human and technology subsystems, one should be aware of the limiting, distorting, and enhancing effects technology can have on human communication.

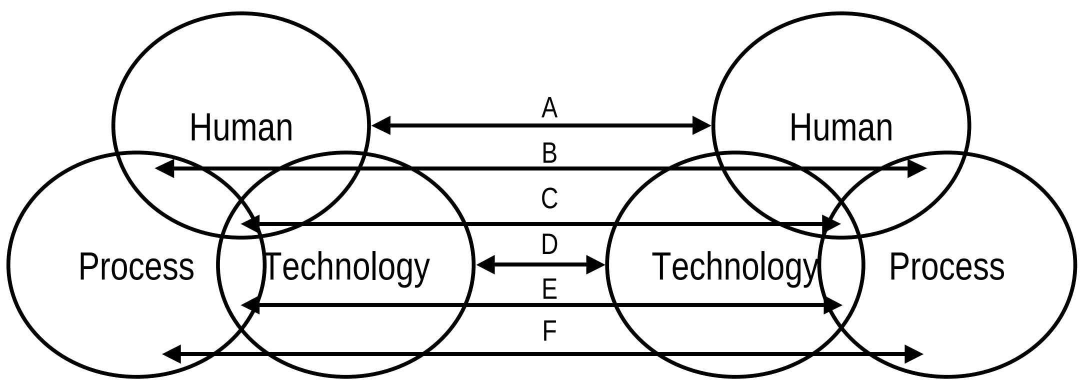

Figure 1. Identification of different kinds of communication between organizational systems

With respect to a specific domain, one can say that this adds another dimension to the communication between organizational systems, since each of the subsystems may have very specific traits within this domain. For instance, in healthcare the technology subsystem may include advanced imaging systems that have to exchange large series of image data that have to be rendered exactly the same to human interpreters at both ends of the interaction. Also, in pointing out specific structures of the human body in these images, a common language is needed that goes well beyond daily natural language. Finally, a number of protocols govern healthcare processes and these protocols are not to be found in a more generic description of processes.

Now that we have identified the different kinds of communication between organizational systems, we turn to the interpretation of 'use the information' in each of these cases. Below we will discuss this interpretation for each of the identified subsystems, leaving out all possible combinations of subsystems.

Technology

As was mentioned in section above, the ISO-OSI model can be used to analyze interoperability on a technology level. The ISO-OSI model has been discussed in detail by Zimmerman (see (Zimmerman, 1980)). Further this model has been widely addressed in research and practice (see e.g. (Dolan, 1984; Popescu-Zeletin, 1983; Tanenbaum, 1981; Znati et al., 1991)). For the purpose of this paper we refer to the upper three layers of the ISO-OSI model to address the communication between technical systems. According to the model, two systems can communicate in a technical sense as long as they use common protocols from levels 1 through 5. When we want not only a faithful rendition of the bits that are transferred, we also need a common protocol on level 6 (level 6 is also called the presentation layer and it's function is to perform transformations on data, before they are sent to the lower levels). Finally, to actually use the information, we need to employ a common understanding at the application level, level 7.

Human

A similar exercise can be carried out with respect to human communication. To this end we employ a semiotic perspective of communication, distinguishing between the syntactic, semantic, and pragmatic aspects of communication. (see (Morris, 1938; Stamper, 1996; Ulrich, 2001)). The syntactic level addressed grammatical structures and rules. At a syntactic level, humans can recognize the language that the other person speaks. However, the terms used in the communication must relate to objects and concepts known to each of the communicating parties in order to understand the meaning (semantics) of what has been said (See also (Ogden & Richards, 1972)). Finally, the pragmatic aspect (see also (Austin, 1962)) has to do with the intention of the message that is communicated: is there a common understanding of what the required reaction, in terms of organizational tasks and outputs, is related to the message being exchanged? Other semiotic levels are also possible. In the field of organizational semiotics for example, Stamper (1996) distinguishes six levels: physical world, empirics, syntax, semantics, pragmatics, and social world. He refers to the first three levels as related to the IT infrastructure and the latter three levels as related to the human information functions, stressing again the importance of looking at an organization as a socio-technical structure. However, for the purpose of describing the human-to-human this paper we limit our analysis to syntax, semantics, and pragmatics.

Process

With respect to differences in communication levels between the process subsystems we have been unable to identify a precise match with the levels identified for both the technology and human subsystems. However, some of the literature on workflow management (Aalst, 1999; Grefen et al., 2000; Klingemann et al., 1999; Ludwig & Hoffner, 1999) suggests that a distinction can be made between the following.

Inter-organizational processes may allow for communication, in terms of passing the flow of control over to the next process and waiting for that process to return control back. Remote process invocation should be possible at this primary level. A next level would indicate that the pre- and post-conditions of a process be known, such that the process invocation leads to a well defined result which is passed back to the invoking process. On a yet higher level the invoking process has, to a certain extent, control over the execution of the process that it invokes. This may be in terms of actually prescribing the exact process to be carried out, or it may be limited to providing predefined control handles on the process to stop or alter the flow of the process at the other end. The idea to define interoperability at a workflow level is supported also by the work of Van der Aalst (1999). The author defines six levels of interoperability, taking into account also the business partners' resources that participate in the workflow. However, if we concentrate only on the communication between processes, the six types of workflow interoperability can be translated to the three types of process interoperability defined in this paper.

IDENTIFYING TYPES OF STANDARDS

Now that we have detailed the different types of communication between organizational systems and have identified the respective levels of interoperability for each of the subsystems, we arrive at a tentative framework for the types of standards that play a role in realizing domain specific interoperability. The framework identifies the three subsystems and the levels of interoperability. For the sake of clarity we have given the three levels identical names:

1. *Interconnectivity* for the ability to exchange information at a network, syntactic, and process flow level;
2. *Interchangeability* for the ability to use information at a presentation, semantic, and input/output level;
3. *Interoperability* for the ability to use information at an application, pragmatic, and process control level.

This leads us to the framework in Table 2, in which we have provided examples of available standards for each of the cells in the table, except for the process subsystem. However, the process subsystem is definitely included in many standards, but we are unaware of pure process standards. A number of standards have been developed to describe and communicate the process itself, for instance the Interface 4 definition by the Work Flow Management Coalition (WfMC, 1995) or XRL (Aalst & Kumar, 2003). But as these provide a means for description of a process, they do not actually standardize the process itself.

Table 2. Identifying types of standards

Type	Purpose	Technical	Human	Process
Interconnectivity	Enables two systems to communicate with each other	Communication standards, like TCP/IP or X.25	Communication systems like speech and writing	Providing for external inputs and outputs
Interchangeability	Enables two systems to exchange information	Data representation standards, like ASCII or HTML	Language systems like natural language and vocabularies	Displaying the same behavior in terms of input/output
Interoperability	Enables two systems to operate together as one	Interaction standards like SMTP or SOAP	Behavioral scenarios and procedures, attached to e.g. military orders	Providing for external controls on process behavior

Up till now we have talked about standards that cover the communication on the levels of technology-to-technology, human-to-human, and process-to-process. It is important also to focus the attention on standards, which capture the intersections between the human, process and technology (e.g. arrow B or arrow E in figure 1). Some examples of such standards are ebXML (a standard that covers the intersection between Technology and Process at an interoperability level), HL7's HMD (a standard which covers the intersection between Technology and Human at an interconnectivity level), and SMOMED and LOINC (these standards cover the intersection between human and technology at an interchangeability level). It is outside of the scope of this paper, however, to provide a full elaboration on this issue.

CONCLUSION

At the beginning of this paper we addressed the problem that even though standards are vital to achieve effective communication in the networked society, from a practical point of view it is often hard to find out what a particular standard actually has to offer to achieve “true” interoperability. In this contribution we have looked at the role of standards to arrive at interoperability in a domain specific situation. We have provided a framework to help determine the kinds of issues that need to be addressed and to what extent different standards actually fulfill these needs.

This paper aims to contribute in two main directions. First, to stress the importance to adopt a broader definition of interoperability, spanning beyond the interoperability between technical systems to the interoperability between socio-technical systems. Second, we hope that the framework we provide will focus the attention of standard development organizations on the type of standard they want to produce and also provides for a more clear understanding of the possibilities to attain “true” interoperability given the (set of) standards that are available for a particular domain. Further research is needed to assess the completeness of the framework with respect to operational standards in a number of different domains. Also, a deeper understanding is needed of standards that are either more generic in nature (conceptual, meta-model, and method standards) or aimed at the protocol negotiation process rather than the actual communications process itself. “The nice thing about standards is, that there are so many to choose from” is a saying that only makes sense when we actually know that different standards are indeed capable of achieving the same level of interoperability in a given domain.

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EFFECTIVELY MANAGING INFORMATION SYSTEMS ARCHITECTURE STANDARDS: AN INTRA-ORGANIZATION PERSPECTIVE

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ABSTRACT

Most standards research focus on standardization of Information and Communication Technology (ICT) standards across an industry. Prior research has not focused on standards management issues within organizations. It is important for research on ICT standards to consider the issue of how organizations should effectively manage their internal standards. Internal ICT standards are manifested as information systems (IS) architecture standards and frameworks. We differentiate between infrastructure architecture standards and integration architecture standards. We argue that it is important to differentiate between these two types of architecture standards, because of the differences in the focus, scope, and benefits of infrastructure and integration architecture. We make use of the information processing theory to make hypotheses about how the structure and organization of the architecture team and inter-unit coordination and control mechanisms are expected to differ for effective management of integration and infrastructure architecture. For infrastructure architecture standards, the goals and benefits are obvious to the IT department, but not necessarily so for the individual business units. While using the standards will provide long-term benefits to the organization as a whole, each business unit may not observe a direct benefit from using the standards in the short term. We hypothesize that to effectively manage infrastructure architecture standards, projects should be IT driven, architecture teams should be managed centrally, and the necessary inter-unit coordination and control processes should be in place to govern the interactions of architects and IT operations personnel. On the other hand, integration architecture standards provide business-focused benefits, but are more costly, more complex to manage and require more business involvement. We hypothesize that to effectively manage integration architecture standards, projects should be driven by the business goals of one or more lines of business, architecture teams should have a matrix structure, and the necessary coordination mechanisms should be in place to govern the interactions of architects, IT development personnel and line management. In both cases, organizations should ensure that their architects have the necessary experience working on projects that their architecture standards have an impact on. To test our hypotheses, we are conducting a multi-method study that includes both the qualitative case-study method and the quantitative survey method.

Keywords: IS Architecture; IS Integration; Information Infrastructure; Standards.

INTRODUCTION

With the proliferation of different types of technology, the role of standards in managing and developing information and communications technologies (ICT) is becoming increasingly salient. While it is important to examine the role of industry wide standards or open standards in affecting the management of information systems (Chau and Tam, 1997; Chen, 2003; Kahin and Abbate, 1995; Sirbu and Zwimpfer, 1985), research on ICT standards also need to consider the issue of how organizations should effectively manage their internal standards. Internal ICT standards are manifested as information systems (IS) architecture standards and frameworks. IS architecture is a blueprint for an overall portfolio of information resources within an organization (Zachman, 1987). Information resources represented by an IS architecture include data, functions, hardware, system and application software, network, etc.

Managing IS architecture standards has been identified as a critical IS management issue facing IS executives (Niederman, Brancheau, and Wetherbe, 1991; Segars and Grover, 1996). While there are many different types of IS architecture standards that can be used at different levels within an organization (at the project, department, business unit, or organizational level), we focus on enterprise level IS architecture standards. We define an enterprise IS architecture as “the organizing logic for applications, data, and infrastructure technologies, as captured in a set of policies and technical choices, intended to enable the firm’s business strategy” (Ross, 2003, pp. 32). Organizations that build enterprise architecture institutionalize within the enterprise a governance mechanism that enables a holistic view across the enterprise of IT and how it supports business. This distinguishes enterprise IS architecture from project-centric application architecture, that may lead to the optimization of individual solutions, and yet pay no attention to optimizing the entire enterprise. The focus on having IS enterprise architecture standards to govern IS management sets enterprise architecture apart from large IT projects that happen to be of enterprise-wide scope.

Without effective enterprise architecture, applications and systems are designed to local optima which, while achieving the objectives of individual areas (lines of business, or individual agencies), do not necessarily advance the goals of the enterprise. Further, building to a local optimum generates a variety of constraints at the boundary of the local system. These constraints increase cost and time within the IT organization and, to a much greater degree, across the enterprise. To better align the organization’s long term and business objectives to the IT plans and capabilities of the organization, IS enterprise architecture standards act as a “boundary object” (Carlile, 2002; Star, 1989) to align IT to the changing needs of the business and changing technology capabilities. A “boundary object” establishes a shared context between two or more parties (Star, 1989), and provides a concrete means for individuals to specify and learn about their differences and dependencies across a given boundary (Carlile, 2002).

Effective management of enterprise architecture standards can provide many cost and efficiency advantages in the organization. By standardizing across different technologies, vendors, platforms, as well as services and application architecture, organizations can reduce the complexity of their operations, reduce the number of skills required to maintain their IT products, reduce the amount of waste and replication going on within the organization, and enable reuse. These can lead to lower cost and higher efficiency, and also provide organizations with better ability to plan for the future with greater flexibility in their ability to support new functions and better scalability of existing functions. Effective management of enterprise architecture standards also provide the organization with capabilities that were previously not available, more strategic uses of IT, and even competitive differentiation. For example, it could allow an organization to integrate with strategic partners, or enable competitive use of enterprise data such as better information about customers, their inventory, or the success of their marketing tactics.

Despite the advantages, few organizations have been able to reap all the benefits from using IS enterprise architecture standards (Kim and Everest, 1994). Given the variations in the ability of organizations to effectively manage and reap the benefits of managing enterprise architecture standards (Ross, 2003), it is important to determine what are the key factors affecting an organization's ability to effectively manage their IS enterprise architecture standards.

Some prior studies have examined organizations' experiences in implementing enterprise IS architecture standards (e.g. Brancheau and Wetherbe, 1986; Kim and Everest, 1994; Periasamy and Feeny, 1997; Ross, 2003). Several studies have also examined the problems and issues surrounding the use of Strategic Data Planning (SDP), a formalized, top-down, data centered planning approach that builds a model of the enterprise to identify and implement an integrated set of information systems that will meet the needs of the business (e.g. Earl, 1993; Goodhue, Kirsch, Quillard, and Wybo, 1992; Segars and Grover, 1998; Shanks, 1997). Most of this prior research uses case studies to identify the issues surrounding the management of enterprise architecture standards. While these case studies provide useful insights (e.g. scope of architecture standards is too wide; inability to balance long term objectives with short term requirements), none of them have systematically identified and investigated the key factors to the successful management of enterprise architecture standards and they have yet to systematically identify the underlying factors driving these problems (e.g. *why* organizations tend to set architecture standards that are too wide in scope).

Part of the problem is that current research tends to view IS architecture development as more of a one-time planning process (e.g. as advocated by the SDP methodology) rather than an ongoing process. Enterprise architecture, by definition, plays an integrating role in the enterprise. It is not a one-time exercise, but rather it is an ongoing effort within the organization to attempt to rationalize, integrate, and optimize the IT capability within an organization across many projects and business units. Hence, the critical success factors in building an enterprise architecture must focus on the structure, process, and governing mechanisms within the organization for building an enterprise architecture. To this end, we need to draw from organizational theory and apply it to the context of enterprise architecture in order for us to better understand what types of structure, processes and mechanisms organizations need to have in place to effectively manage enterprise architecture standards.

INFRASTRUCTURE VS. INTEGRATION ARCHITECTURE

There is no universally accepted definition of IS architecture (Kim and Everest, 1994; Ross, 2003). Much confusion surrounds the information systems architecture concept (Kim and Everest, 1994). Zachman (1987) first introduced the framework of IS architecture as a two-way matrix consisting of different views and different information sources. Since then, several studies have tried to further clarify the concepts of an IS architecture (Hamilton, 1999; Kim and Everest, 1994; Ross, 2003; Sowa and Zachman, 1992). Common across the various conceptualizations of IS architecture, however, is the theme of organizing the computing resources in the organization, which consists of data, applications, and infrastructure, to enable a firm's business strategy.

There is consensus in the literature that there are two different sets of IS decisions (Brown and Magill, 1998; Brown and Magill, 1994; Olson and Chervany, 1980). One set concerns computer and communications/network operations and infrastructure planning activities. The second set is focused on systems development, including application planning, software acquisition and maintenance (Brown and Magill, 1998). Similarly, Hamilton (1999) distinguished between inter-working at the information technology infrastructural level of networks, computers and operating software, and inter-working at the applications level dealing with organizational business processes and information handling. Accordingly, we make a distinction between infrastructure architecture and integration architecture standards.

Infrastructure architecture refers to the standards and policies created to define the computing technology infrastructure for the enterprise. It establishes technology standards to limit technology choice, to reduce the number of platforms supported, and to define a set of computing resources that organizations manage. This standardization is expected to significantly reduce the number of vendor packages and infrastructure services that perform similar functions (Ross, 2003). Integration architecture refers to the standards and policies created to define the means by which business services, events and information are defined and accessed by the enterprise. It consists of a set of architectural components, such as data, processes, and event models, application architecture and service-oriented architectures (Brown, Johnston, and Kelly, 2003) that specify how different data, processes, and applications relate to each other across the enterprise. As the integration architecture standards become more completely defined, the enterprise evolves from an application programming interface (API) based integration model to an integration model that leverages shared data and services across different applications. Programming an interface for each application system that needs to interact with another system may solve the short-term transaction processing and data integration problem, but it becomes cumbersome to manage as the number of applications and the number of interfaces between the applications increases exponentially. On the other hand, an integration model that leverages shared data and services across different applications would define set of data and services that is common across different business processes. This would allow the organization to have better integration of data and transaction processing in the long term and better ability to scale its operations and support new functionality as the number of applications and functions required increase. Both types of architecture standards are required to effectively manage shared resources among different lines of businesses in the organization. However, it is important to differentiate between infrastructure and integration architecture because these two types of architecture have different characteristics, focus, scope, and benefits. Table 1 lists the key differences between the infrastructure and integration architecture standards.

Table 1. Key differences between the infrastructure and integration architecture standards

	Infrastructure Architecture	Integration Architecture
Focus	Providing common IT platforms, networks, and computing resources	Providing interfaces into and integration of business unit capabilities and information
Scope	Wide and heterogeneous community of users, or entire enterprise	For a limited and focused set of business services, prioritized by business value
Key metrics	Efficiency, cost	Cost and enablement of new business capabilities
Driver (champion) within organization	IT organization (at CIO/CTO level)	Corporate sponsorship for enterprise integration, executive sponsorship within each business unit
Comparable model	Public infrastructure provided by government	Business contracting

MANAGING INFRASTRUCTURE ARCHITECTURE

While the scope of influence for enterprise infrastructure architecture is usually wide, affecting a heterogeneous community of users and IT departments across different business units in the entire enterprise, different business units within the organization usually require the same infrastructure services (Broadbent, Weill, and St. Clair, 1999). Infrastructure services and architecture standards are usually not specific to the requirements of particular business units. There is thus less of a need for deep business insights from the individual business units, and more of a need for the organization's generic IT capabilities to be applied to the management of infrastructure architecture. The primary stakeholders are the IT personnel (in corporate IT or in the business units). The business analysts and line management play a secondary role. This indicates that the infrastructure architecture standards need to be driven by the unit(s) within the organization that constitute the source of IT knowledge, and these unit(s) are typically under the auspices of the CIO or CTO.

Since the goals and benefits from using enterprise infrastructure architecture are IT centric, and often lack the specificity of benefits that can be attributable to each business unit in the short term, the latter may not observe a direct benefit from investing significant resources in leading or participating in the management infrastructure architecture standards, even though there may be long-term benefits to the organization as a whole. Managing infrastructure architecture standards can thus be viewed similarly to managing public goods. To manage public goods, there should be a central authority (e.g. the government) who would take into consideration the welfare of the whole community when making investment and management decisions. Infrastructure architecture standards should, similarly, be driven by the overall long-term goals and objectives of the organization focusing on IT cost, efficiency, reliability and future IT capacity of the organization. If infrastructure architecture standards management is driven solely by the goals of individual business units, the long term sharing requirements for the organization as a whole will be neglected and there would be a lack of consideration of the shared needs and lack of cooperation between different lines of businesses. This would be reflected in the frequent replications of infrastructure services and heterogeneity in IT infrastructure, thus resulting in higher IT costs and reduced integration across different lines of business. This indicates that the infrastructure architecture standards need to be driven by a centralized organization, independent of the business units.

MANAGING INTEGRATION ARCHITECTURE

On the other hand, the scope of influence for enterprise integration architectures is typically limited or focused on a set of business services (e.g. related to customer relationship management, or supplier relationship management). The enterprise integration architecture concerns the integration of application systems and data, which tend to be more specific to individual business units. Hence management of integration standards need to take into account the specific requirements of each business unit, and require the inputs of business analysts and line management who are knowledgeable about the strategy, functions, data, and environment of each business unit.

Managing integration architecture standards is similar to managing business contracts, as integration architecture is a predefined agreement among business units to share application services and data in a specified manner. Managing a business contract require that there are shared values or benefits to all parties of the contract. Similarly, the scope of influence for enterprise integration architectures is typically more specific to and closely aligned with the goals of one or more business units, and tends to be focused on a set of business services. Business input and buy-in therefore becomes critical for the management of integration architecture and individual business units have a greater need to ensure greater control of the management of integration architecture standards.

IMPLICATIONS FOR ORGANIZATIONAL STRUCTURE, PROCESSES, AND MECHANISMS

The differences in the characteristics of these two types of enterprise architecture highlight the need for different levels of information exchange and collaboration between the architecture team and the business units and the IT department. According to the information processing theory, organizations seek to develop strategies and structures that enable them to match their information-processing capabilities with the information-processing requirements of their tasks (Daft and Lengel, 1984). Different task requirements should be handled by using the appropriate structure and mechanisms regulating the interactions between business units. Effective information processing includes the collection of appropriate information, the movement of information in a timely fashion, and its transmission without distortion. Structural characteristics range from the extent of formalization, centralization, leadership style, degree of participation, lateral and vertical communication, to distribution of power and control (Burns and Stalker, 1961; Comstock and Scott, 1977; Mohr, 1971).

It is the key thesis of this paper that the different characteristics of infrastructure and integration architecture influence the type of organizational unit structure, and the formalization and extent of inter-unit coordination and control mechanisms required to effectively manage these two types of architecture standards. We predict that these structural features will be manifested as the organization structure of the architecture team, the formalization of participation of various stakeholders in different standards management processes, the types of stakeholders involved in these processes, and the mechanisms available to provide architects with the necessary knowledge and experience to work effectively. In the following sections, we first define what we mean by effective management of architecture standards for both infrastructure and integration architecture standards. Then, we present our hypotheses about how the structure and mechanisms to effectively manage these standards are expected to differ, and the supporting arguments. Figure 1 shows our overall research model.

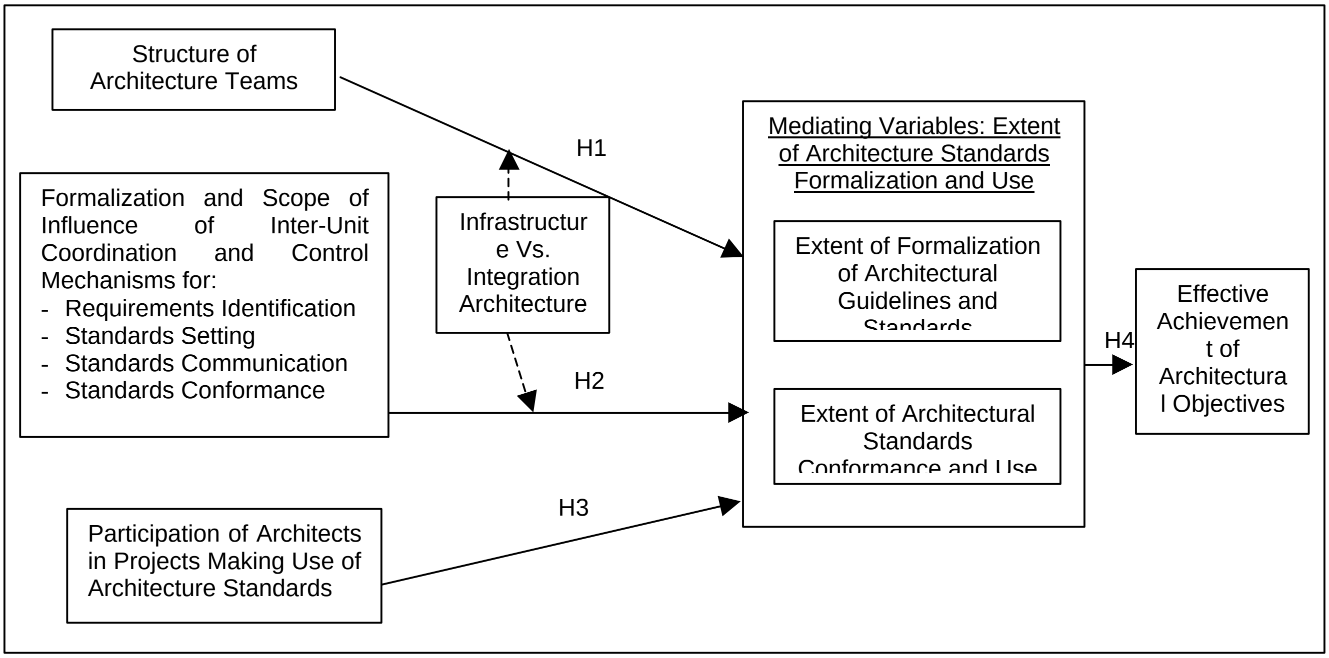

Figure 1. Overall Research Model

HYPOTHESES

EFFECTIVE MANAGEMENT OF ENTERPRISE ARCHITECTURE STANDARDS

Enterprise architecture standards can be expected to provide many benefits and outcomes to the organization. Effective management of infrastructure architecture can result in lower infrastructure cost and provide greater flexibility and reliability in meeting current and future demands and functionality. Effective management of integration architecture can result in lower maintenance and development cost, faster time to market of new products and services, better ability to integrate with strategic partners, and the better management of information resources in the organization. While these are potential benefits of architecture standards, we also recognize that these outcomes are affected by many other factors. For example, development and maintenance cost may be the outcome of other development conditions and factors (e.g. skills and experience of software development and maintenance teams) that we are not measuring in the scope of our study. Hence, we identify the key objectives of infrastructure and integration architecture standards in organizations, and examine the extent to which each organization has successfully achieved each of these objectives as a measure of their effectiveness in managing each type of architecture standards.

We identified three key objectives of infrastructure architecture standards management: to reduce redundancy of infrastructure services provided by different IT groups, to reduce heterogeneity of infrastructure components across lines of business, and to ensure enterprise system reliability, availability, and scalability. We adapted Broadbent and Weill (1997)'s characterization of the technical and human aspects of IT infrastructure by differentiating between the technical IT infrastructure, concerning the IT platforms and technologies in the organization, and the human IT infrastructure, concerning the human resources required to manage and provide infrastructure services. The key objectives of the infrastructure architecture standards are to ensure that there is maximum compatibility and minimum duplication and redundancy of both the technical IT infrastructure components and the IT infrastructure services provided by the human resources within the organization. Moreover, given the need to ensure flexibility and ability to meet the existing and future demands for IT services and capabilities (Byrd and Turner, 2000; Duncan, 2001), we identified the third objective of the IT infrastructure architecture as the need to ensure that the enterprise IT infrastructure is reliable, available, and scalable. We identified the following three key objectives for managing enterprise integration architecture standards: to enable integration of applications across the enterprise, to facilitate ease of communication with external partners, and to manage enterprise data. A summary of the objectives for enterprise architecture is provided in Table 2.

Table 2. Objectives for Effective Management of Enterprise Architecture

OBJECTIVES FOR INFRASTRUCTURE ARCHITECTURE MANAGEMENT

- Reduce redundancy of infrastructure services provided by different IT groups
- Reduce heterogeneity of infrastructure components across lines of business
- Ensure enterprise system reliability, availability, and scalability

Objectives for Integration Architecture Management

- Enable integration across applications
- Facilitate ease of communication with external partners
- Management of enterprise data

We define effective management of infrastructure and integration architecture standards as the extent to which organizations are able to achieve the objectives listed in table 2. In the following sections, we describe our hypotheses about the factors influencing the effective management of infrastructure and integration architecture standards.

CENTRALIZATION OF ARCHITECTURE DECISION-MAKING

According to the information-processing theory (Burns and Wholey, 1993), the basic function of the organization's structure is to create the most appropriate configuration of work units as well as the linkages between these units to facilitate the effective collection, processing and distribution of information. A key dimension of subunit structure that affects its information processing capacity is the extent of centralization of a subunit's decision-making authority. Many prior studies have examined the question of how IT departments should be structured (Ein-Dor and Segev, 1982; Olson and Chervany, 1980; Sambamurthy and Zmud, 1999). Three modes of IT governance arrangements include a centralized governance mode, where corporate IS has the authority for IT activities, the decentralized governance mode, where divisional IS and line management assume authority for all IT activities, and different variations of these two extremes for different IT activities (Sambamurthy and Zmud, 1999). Architecture teams can similarly be structured either in a centralized fashion, where IT architects report to the corporate IT department, or they can be structured in a decentralized fashion, where IT architects report to one or more business units. In addition, they can also be structured in a matrix – where they report primarily to the IT division and secondarily to one or more business units (or vice versa).

Researchers who have examined the costs and benefits of the matrix structure compared to a functional or product structure have highlighted the matrix as providing the benefits of proper coordination within a business unit (or project/product development team) while maintaining a continuing linkage with a functional expertise (Ford and Randolph, 1992). A primary advantage of a matrix structure in an architecture team is that it solves an information-processing problem (Davis and Lawrence, 1977). It creates lateral communications channels and improves communication both within the architecture team and between the architecture team and the IT department as well as the different business units. A related communication benefit of a matrix structure is its ability to handle increased information loads over the more traditional functional structures. The increased contact among departments allows information to "permeate" the organization, improving decision making and response time, which translates into an organization that can quickly and flexibly adapt to a dynamic situation (Davis and Lawrence, 1978; Kolodny, 1979). Improved information flow and flexibility of responses by team members in a matrix can also allow resources to be quickly and easily disengaged from unproductive uses and applied to new opportunities as they are discovered, especially in an uncertain environment. On the other hand, in a matrix, the boundaries of authority and responsibility are split or shared between functional and project managers. This characteristic creates ambiguity and conflict over areas such as resources and technical issues (Ford and Randolph, 1992). Organizations thus have to consider the trade-offs between the coordination cost and the benefits from increased information flow for a matrix structure (Harris and Raviv, 2002).

As infrastructure architecture has more direct impact on IT operations, there is more value in centralizing the infrastructure architecture team with a primary reporting relationship to the CTO/CIO. Given the high coordination costs in a matrix structure (Harris and Raviv, 2002), and the similarity in requirements for infrastructure standards across different business units, there is little value in decentralizing, or creating a secondary relationship with business units for the infrastructure architecture team. Moreover, a centralized structure for architecture decision-making results in easy coordination across all infrastructure architects, and reduces any duplications in infrastructure architecture work across different business units. We thus hypothesize:

> **H1a:** A centralized structure for infrastructure architectural decision-making will enable the organization to be more effective in managing its infrastructure architectural standards.

Integration architecture has greater impact on the work of application developers and business users in different business units than infrastructure architecture. Hence, a centralized structure for integration architecture decision-making may not be an effective approach to managing these architectural standards, as it could result in a tendency for integration architects to come up with architecture decisions without adequate consideration of the impacts to the application developers and business users. Having a matrix organization would bring about greater opportunities for interaction between the architect and stakeholders in business units, while ensuring adequate coordination within the architecture team, and between the architecture team and the CTO/CIO office. We thus hypothesize that a matrix structure where the integration architecture team report to both the CTO/CIO office and to multiple business units is the most appropriate structure for effectively managing integration architecture.

> **H1b:** A matrix structure for integration architectural decision-making where the integration architecture team report to both the CTO/CIO office and to multiple business units, will enable the organization to be more effective in managing its integration architecture standards.

Inter-Unit Coordination and Control Mechanisms

Independent of the organization structure of architecture teams, organizations can put in place processes to ensure adequate involvement of stakeholders who are affected by internal architecture standards. According to the information-processing theory, another key dimension of ensuring information processing capabilities is to make use of coordination and control mechanisms that work to tie interdependent units together. Ensuring adequate coordination and control between the architecture team and the stakeholders who are affected in one way or other by the architecture standards are very important to bring about adequate use and effectiveness of architecture standards. Having a highly connected communication network will permit efficient use of individuals as problem solvers, since they increase the opportunity for feedback and error correction, and for the synthesis of different points of view (Burns and Wholey, 1993). Hence, we identify different types of inter-unit coordination mechanisms and hypothesize about how the extent of interaction between the architecture team and stakeholders, and the formalization of mechanisms would affect effective management of infrastructure and integration architecture.

The more comprehensive the coordination and control mechanisms are between sub units, the greater the ability of the organization to process information and deal with inter-unit uncertainty (Burns and Wholey, 1993). For architecture standards to be useful to the organization, organizations need to implement procedures to coordinate and control the processes of identifying the scope and requirements for architecture standards, as well as setting, communicating and using the architecture standards. These processes are necessary to ensure that the architects and stakeholders have in place the procedures and routines to help them achieve adequate trade-off between short-term and long-term goals of the organization.

Standards Requirements Identification

Even before setting the architecture standards, enterprise architects have to decide the focus and scope of their enterprise architecture standards. It is very important for the architecture team to obtain the inputs of the right stakeholders at this stage where they are identifying the requirements of the organization’s architecture standards. If the stakeholders have a say in which types of architecture standards they think are the most important and that the organization should focus their resources on, they will be better able to recognize the need for the architecture standards. They also will be more willing to participate in the standards management process in the later stages (Ives and Olson, 1984).

> **H2a:** Organizations who ensure that the necessary stakeholders are involved in defining the scope and requirements of enterprise architecture are more effective in managing their enterprise architecture.

Standards Setting

In setting architecture standards, architects should set standards with good feedback and awareness of the current conditions and constraints facing the organization. The views and perspectives of business and IT groups should be factored into the standards setting process. In changing architecture standards, organizations also need to put in place adequate feedback loops to ensure that architecture standards are kept up to date and remain flexible to changing business conditions. We thus hypothesize:

> **H2b:** Organizations who have in place defined processes to ensure adequate stakeholder representation in the standards setting and standards changing process are more effective in managing architecture standards.

Standards Communication

In order for architecture standards to be widely used and adopted within the organization, there should be adequate communication of both the standards and the value of the standards to the stakeholders who are affected by the architecture standards. These include mechanisms and processes to ensure that the architecture standards are available to all that should have access to it and changes to the architecture standards are distributed in a timely fashion. Also included are activities that ensure business and IT users understand the importance of adhering to the architecture and how it impacts their daily business activities. We thus hypothesize:

H2c: Organizations who have in place defined processes to ensure adequate stakeholder representation in the standards communication process are more effective in managing architecture standards.

Standards Conformance

To ensure that architecture standards are effective in governing IT management within the organization, organizations need to have in place mechanisms to ensure adequate conformance to architecture standards. This would include mechanisms and processes to review and approve decisions that should be made in accordance with the architecture, such as formal design and product reviews. There should also be designated means to ensure that exception to standards can be granted where necessary. Such exception mechanisms would include mechanisms and processes to provide a means of appealing architectural decisions and allowing exceptions to the architecture that permit the use of nonconforming technology to meet unique business requirements. We thus hypothesize:

H2d: Organizations who have in place defined processes to ensure adequate conformance to architecture standards and designated means to consider exceptions to standards conformance are more effective in managing architecture standards.

Scope of Influence

It is not only important that organizations have the necessary inter-unit coordination and control processes in place, but it is also important that the scope of the influence of these processes be wide enough to involve the necessary stakeholders. For example, the scope of influence of infrastructural architecture is different than that of integration architecture. While the former would generally include the IT operations, development personnel, and application owners, the latter would additionally include business representation, such as line management, IT business analysts, and perhaps even business strategy. The IT business analysts would be responsible for collecting architecture standards requirements and feedback from the business units and communicating them to the architecture team. We thus hypothesize:

H2e: For the inter-unit coordination and control mechanisms to be effective, the scope of influence for infrastructural architecture decisions need to involve IT development, operations personnel, and application owners. The scope of influence for integration architectural decisions need to additionally involve business personnel, such as line management, business strategy, or IT business analysts.

Participation of Architects in Projects Making Use of Architecture Standards

To be able to set effective architecture standards, architects not only need to have good knowledge of IT architecture, but they also need to have adequate knowledge about the domain that their architectural standards will affect. Common experience reduces communication barriers and provides common referents (Walton and Dutton, 1969). Architecture teams who do not know about the problems and difficulties in implementing the architecture standards may have a tendency to become too theoretical in applying architectural principles, and they may not know what types of enterprise architecture are effective and how they are to be actually implemented. This lack of knowledge can even lead to unreasonable inter-unit demands through ignorance. Hence, it is important for the architecture team to have hands-on experience working with or working on projects that make use of the architecture standards that the team sets, as it will help the architects identify the problems faced by users of the architecture standards. This is thus a key mechanism to: (1) provide a feedback mechanisms so that the architecture team can gain experience in making use of the standards that they set and (2) improve the communication between the architecture team and the stakeholders making use of the architecture standards. We thus hypothesize:

H3: IS Architecture teams that ensure their architects participate in projects that make use of the architecture standards they set are more effective in managing their enterprise architecture.

Control and Mediating Variables

For a more complete research model, it is also important to include other control variables that are expected to affect the ability of the organization to effectively manage their architecture standards. We include organizational level control variables such as organization size, industry, and the extent of IT centralization. We also include variables that measure various aspects of the architecture team that would be important contextual information to consider. These include the extent of top management support for architecture work within the organization, the number of years that different architecture groups have been formed, the level of the lead architect of different architecture groups in the organizational hierarchy, and the types of performance metrics used to evaluate the performance of architecture teams. We also take into consideration the fact that different organizations will place different emphasis and priorities on different architectural objectives, and include, for each architectural objective, a control variable indicating priority that the organization places on each architecture objective.

In addition, we identified two mediating variables that mediate all the independent variables, and the extent to which each organization is able to effectively achieve each of the architecture objectives. These variables provide an indication of the intermediate success of the work done by the architecture team: (1) whether the organization has defined formal architecture guidelines and internal standards to ensure that each architectural objective is achieved, and (2) the extent to which members of the company use and conform to the formal company-defined architectural guidelines and internal standards. On one hand, these are dependent variables that are affected by the independent variables in our hypotheses and control variables, but they are also independent variables that will influence the extent to which the organization can achieve its architectural objectives. We thus hypothesize:

H4a: The extent to which the organization has defined formal architecture guidelines and internal standards to ensure that each architectural objective is achieved mediates the relationship between the independent variables and the extent to which the organization can achieve each architectural objective.

H4b: The extent to which members of the company use and conform to the formal company-defined architectural guidelines and internal standards mediates the relationship between the independent variables and the extent to which the organization can achieve each architectural objective.

METHODS

To test our hypotheses, we plan to use a sequential mixed methods design (Tashakkori and Teddlie, 1998). First, we use a qualitative case-study method to conduct interviews at several organizations to examine how they manage their architecture standards. Subsequently, we plan to use a quantitative survey method to survey organizations to systematically obtain measures of our variables and test our hypotheses.

We have conducted case studies in four organizations so far. For the case studies, we conducted interviews with lead architects and executives overseeing the IT function. These case studies serve as a reality check for our hypotheses and also provide information about the context of various organizations, and helped us to determine how we should operationalize our constructs for the survey. To illustrate the findings from the case study, the following section describes two of the case studies and explains how they relate to our hypotheses.

CASE STUDIES

Case #1: Insurance Organization (IO)

Insurance Organization is an insurance and financial services organization that offers auto insurance, as well as homeowners, health, and life insurance. IO has a highly centralized structure for organizing their IT operations, where all lines of business are supported by the Corporate IT team. Even business analysts who are writing business requirements for applications are also considered to be under the Corporate IT team. This was partly a result of the heritage of IO, as the organization had traditionally been growing from within, and had few mergers and acquisitions. IO has focused on developing their infrastructure architecture standards in the past few years, and has only begun to work on developing their integration architecture standards.

IO has been quite effective in ensuring compliance to their architecture standards, as 99% of the organization's projects are compliant with their infrastructure standards. This has largely been facilitated by their centralized IT and architecture organization structure, such that they can easily institute controls and processes to ensure that all IT operations conform to the standards, and to ensure that they obtain the input of fellow colleagues in the IT group when defining the infrastructure standards. The fact that they are the only IT organization with the necessary expertise to provide the support to IT products also help to ensure they have centralized control of all IT work and projects.

IO has recognized the importance for integration architecture to be closely aligned with business goals and the need to obtain much greater business involvement in developing and managing the integration architecture. An initiative, started by one of their Vice Presidents from line management, was the establishment of an "integration office" that is independent of all business areas to generate an architecture of the business process flows. They have involved representatives from various lines of business and from IT to help in this initiative. The establishment of a business architecture will create strong fundamentals for the integration architecture to build upon. While IO has yet to put in place the governance processes for their integration architecture, they were able to point to some pockets of success within the organization. For example, they had a project to build a database that has a consolidated view of customers, integrating customer data from each major line of business. It took them many years, but at this point, they now have consolidated view of customers that is considered an "authoritative source of information", and a consolidated store of customer relationships that different projects use. This project was championed by the business side of the organization.

The experience of IO provides preliminary support for our basic premise that management of integration architecture requires greater business involvement and consideration of business goals (H1a). Their experience also highlights the importance of a centralized architectural organization structure for the management of infrastructure architecture (H2a) and inter-unit coordination and control processes (H3) for effective architecture standards management.

Case #2: Investment Firm

The Investment Firm (IF) is an investment and brokerage firm that focuses on providing brokerage and investment services to individual investors. IF has a semi-centralized structure for organizing the IT operations, where they have a corporate IT team (Corporate IT), which has an internal structure aligned with the different lines of businesses. IF also has IT personnel who report directly to line management and are independent of the corporate IT team. Within Corporate IT, they have defined roles for architects, and the architects are divided into two teams, in charge of the infrastructure and integration (including application and data) architecture respectively. IF has been moderately successful with setting up their enterprise infrastructure architecture, but has been having problems in setting up the enterprise integration architecture.

IF has institutionalized several processes to ensure adequate review, communication, and compliance to the architecture standards. All projects have to be reviewed by a designated group in Corporate IT to ensure that the projects follow architecture standards. If projects are seeking exemptions from having to adhere to current standards, mechanisms exist for projects to be escalated up to higher management. Communication channels and venues also exist to ensure standards are adequately communicated to and reviewed by all IT staff. While these processes have helped them to effectively manage buy-in and compliance from the IT personnel in Corporate IT, the scope of influence for these processes was not broad enough to include all business-initiated IT projects outside the purview of the IT organization. As a result, purchase and project decisions made in the lines of business were sometimes not aligned with the architecture standards set by IF. To circumvent this problem, the architecture team assigned the role of “gatekeepers” to the contracts department to ensure that any IT purchases made by the various lines of businesses cannot be approved unless they have gone through the project review process in Corporate IT.

IF’s attempts at setting up an enterprise integration architecture have been less successful, mainly due to the lack of involvement of IT development and operations personnel and line management. For example, IF attempted to generate a data model for their business and assigned this task to a data modeling team. The team did not ensure the participation of the stakeholders and was not sufficiently aware of the actual practice of how things worked. As a result, the project based upon the data model failed due to performance issues and the modeling team was ultimately dissolved. Two years earlier, the organization recognized the need better business alignment with the integration architecture. To effect this, they separated the integration architecture team from the infrastructure team, and distributed the integration team across various lines of business. The centralized structure of the infrastructure team worked out relatively well, but due to the decentralized structure of the integration architecture team and the lack of coordination with the infrastructure team, there was a tendency for the integration team to cross into infrastructure issues (their earlier comfort zone), instead of sticking to clearly defined integration issues.

The experience of IF provides preliminary support for our basic premise that management of integration architecture require greater business and IT personnel involvement. Our hypotheses about the need for a centralized structure for the infrastructure architecture (H2a), a matrix structure for the integration architecture (H2b), and adequate scope of governance processes (H3) for effective architecture standards management also found some initial support.

CONTRIBUTIONS AND FUTURE RESEARCH

These case studies provide some preliminary support for our hypotheses. We are currently conducting the second part of the mixed-method study – collecting data for the survey. We expect that this research will be able to contribute to the research in ICT standards development by providing an intra-firm perspective to standards development. Most standards research focus on standardization of ICT standards across an industry. Prior research has not focused on standards management issues within organizations. Given that the ultimate aim of industry standards is organization adoption, we think that it is important for researchers to examine the issues surrounding the management of ICT standards within the organization, which gets manifested as architectural standards.

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MARKET PLACE AND TECHNOLOGY STANDARDS FOR B2B. ECOMMERCE: PROGRESS AND CHALLENGES

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ABSTRACT

This paper identifies and defines standards required for successful eCommerce (EC) architectures. It evaluates the strengths and limitations of current and past systems that have been developed to support EC in relation to these standards. We conclude that there remains an unfilled need for systems that can reliably locate buyers and sellers in electronic marketplaces and also facilitate automated transactions. The notion of a ubiquitous ecommerce network does not currently exist. Such a network would 1) enable sellers to choose to publish product related information in a consistent, predictable way, 2) enable automated agents working on behalf of both buyers and indexing services to find desired information published by sellers without reliance upon human intervention, and 3) enable autonomous agents, when authorized by management, to evaluate products, negotiate prices, and conduct transactions. In the context of these desirable characteristics, this paper evaluates the strengths and weaknesses of the following EC architectures: EDI, company websites, B2B hubs, e-procurement systems, and *web services*. We identify where each of the architectures fails to provide requisite capabilities. Significant attention is given to the strengths and weaknesses of the web services architecture, since if supported by appropriate standards, has the potential to overcome some limitations of other approaches.

Keywords: B2B ecommerce, standards, procurement, EDI, web services, electronic markets, Information Infrastructure, Strategic IS.

INTRODUCTION

For more than three decades, businesses have been using electronic mechanisms to exchange transaction data. Standards have played an integral role in the success of different eCommerce (EC) architectures. In this paper, we propose and discuss a set of standards required in any EC platform and evaluate past and current architectures against these standards.

The development and implementation of standards and technologies has accelerated over the past fifteen years. A seminal event in this evolution was the development of EDI, whereby trading partners established standard formats for the exchange of electronic documents in order to facilitate electronic transactions (Truman 1998). Today, the emerging set of technologies collectively referred to as *web services* has the potential to extend the reach of EC.

Web services offer many advantages not found in earlier technologies, but they have yet to realize their considerable potential because of the lack of industry-wide technology standards. Should suitable standards be developed and adopted, web services could meet the needs of a broader range of EC transactions, including business-to-consumer (B2C), business-to-business (B2B), consumer-to-consumer (C2C), and peer-to-peer (P2P).

This paper focuses on B2B, which accounts for the largest dollar volume of EC, with about $700 billion in transactions in 2001. The Gartner Group estimates that all types of EC transactions will exceed $8.5 trillion by 2005, ninety percent of which will be B2B transactions (McCall 2001). Similarly, Jupiter Research estimates that the combination of B2B and B2C EC transactions will surpass $7 trillion by 2005 (Grover et al. 2001).

Businesses have been engaging in a form of EC known as EDI for a number of years. EDI occurs when one business transmits computer-readable data in a structured format to another business. Standard formats used in EDI afford the same information that businesses have traditionally included in their standard paper transaction documents. Yet EDI was designed to support business transactions between limited sets of known trading partners. Because of this paradigm, EDI does not facilitate discovery of new potential vendors that sell products and services, a significant limitation for firms that wish to extend their reach to participants in the broader marketplace.

Of more recent genesis, the World Wide Web (WWW) has enabled businesses to share documents across a generalized, global network. In several ways, the WWW has been a step forward in facilitating EC. Most notably, sellers have been able to publish company and product information via their web sites. To some degree, search engines have allowed buyers to find and analyze this information. Yet such searches are not reliable because of the diverse systems and data presentations used by various organizations. Moreover, sellers on the WWW generally do not use industry-wide standard transaction templates for accessing product information and for executing purchase transactions. This limits the ability of automated services to reliably find sellers and to conduct automated transactions.

Notwithstanding these limitations, the evolution of EDI and the WWW together with a new set of emerging technologies has the potential to provide a more robust and powerful platform for EC than exists today. However, we argue that these technologies must be supported by appropriate standards to enable automation to effectively and efficiently support buyers and sellers. The combination of currently existing technology, if supported by appropriate commerce-supporting standards, has the potential to provide three automation capabilities not available with past approaches:

First, the platform would enable potential buyers and sellers to reliably find each other. For this to occur, sellers must publish product information in a consistent, predictable way. This will allow automated agents to working on behalf of both buyers and indexing services to reliably find information published by sellers without requiring reprogramming or user intervention. This would help buyers and sellers to efficiently and effectively exchange information on product and services.

Second, the platform would enable automated agents to play a more significant role in ecommerce. With reliable information on products and services and organizations, automated agents, when authorized by managers, could act in the place of buyers and sellers to negotiate deals and evaluate options.

Third, the platform would support a variety of automated transactions, including but not limited to requests for information on products and services, price requests, purchase orders, and sales. This portends a ubiquitous generalized marketplace that will have desirable attributes of EDI, the WWW, and other evolving EC technologies.

This paper addresses the following research questions: First, what automation-supporting standards are required so support ecommerce and autonomous agents? Second, what role do these standards play in terms of supporting ecommerce? And, third, how do existing ecommerce platforms succeed or fail in terms of adoption of such standards.

The objective of the discussion that follows is to identify the essential features of systems that have been developed to support EC across the Internet and to evaluate their capabilities and limitations. This is done with the intent to help clarify how future research and development can improve these systems.

First we define six fundamental standards that must be present in any EC system if it is to support widespread, efficient B2B transactions on a network. Next we examine the extent to which the following EC platforms have succeeded in defining and adopting commerce enabling standards: EDI, company web sites, B2B Hubs, e-procurement systems, and finally web services. We conclude with a discussion on standards that need to be developed for the web services EC platform.

ECOMMERCE-ENABLING STANDARDS

Standards are essential to EC because adherence to uniform presentation allows heterogeneous computers to exchange information reliably and rapidly across a network. Standards are the key to interoperability between EC systems (Pincus 1999). When this occurs, human operators can focus their efforts where they provide real value: specifying search parameters, evaluating options, using judgment to make decisions, and approving transactions. Useful standards, adhered to by all participants, allow computers to better accomplish their supporting role of finding possible suppliers, gathering comparative product and company data, and executing transactions.

Two mechanisms can be used to achieve compatibility between automated systems: standardization and conversion (Farrell et al. 1992; Katz et al. 1994). Standardization requires that all participants use the same technologies or data formats. Standardization may be achieved through independent actions of market participants, through formal coordination of participants in voluntary industry standards committees, or through government action. In contrast with standardization, converters change a format from one form to another (Katz et al. 1994).

Farrell and Saloner (1992) note that standardization and adaptation have different costs. Standardization requires time and coordination expense during the creation and refinement of standards. Standardization also imposes costs on entities that have sunk investment in legacy technology that is incompatible with an emergent standard (Chircu et al. 2001). Thus, standards require high upfront costs. Conversely, the development of converters results in high backend costs, especially when many converters are required because of the existence of many incompatible formats and systems. Each conversion between each pair of incompatible formats requires a converter. And when a system's format changes for any node (system) multiple converters must be updated. Figure 1 illustrates a reason behind the high cost of creating and maintaining converters. Conversion among five formats requires ten two-directional converters.

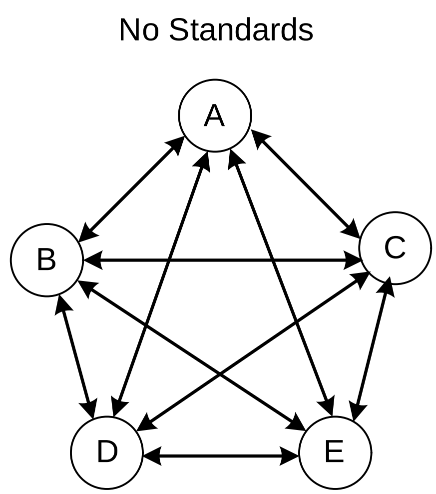

Figure 1: n-way Converters

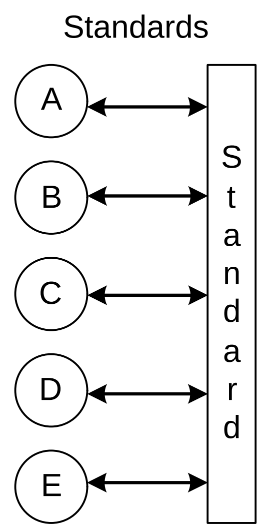

Figure 2: 2-way Converters

When any system's format changes, each related link must be updated accordingly. The cost to develop and maintain converters quickly becomes prohibitive.

Importantly, the existence of standards dramatically reduces the costs of developing and buying converters. Figure 2 reflects the fact that only one two-way conversion is necessary for each system when all systems translate to a shared standard. Examination of the history of EDI reveals another related benefit of a standard. Because of the existence of EDI standards, software firms had an incentive to develop converter software in accord with the standards. Organizations wishing to adopt EDI had greater choice among converter products that now had to compete on the basis of ease of use, ease of implementation, and cost.

In this paper, we describe six EC-enabling standards shown as the bottom two levels in Figure 3. The six standards can be usefully grouped into two areas: foundation technology standards and marketplace standards. We also discuss the implication of these standards for the two application technologies, shown on the top level of Figure 3, that rely on these standards: discovery applications and transaction applications.

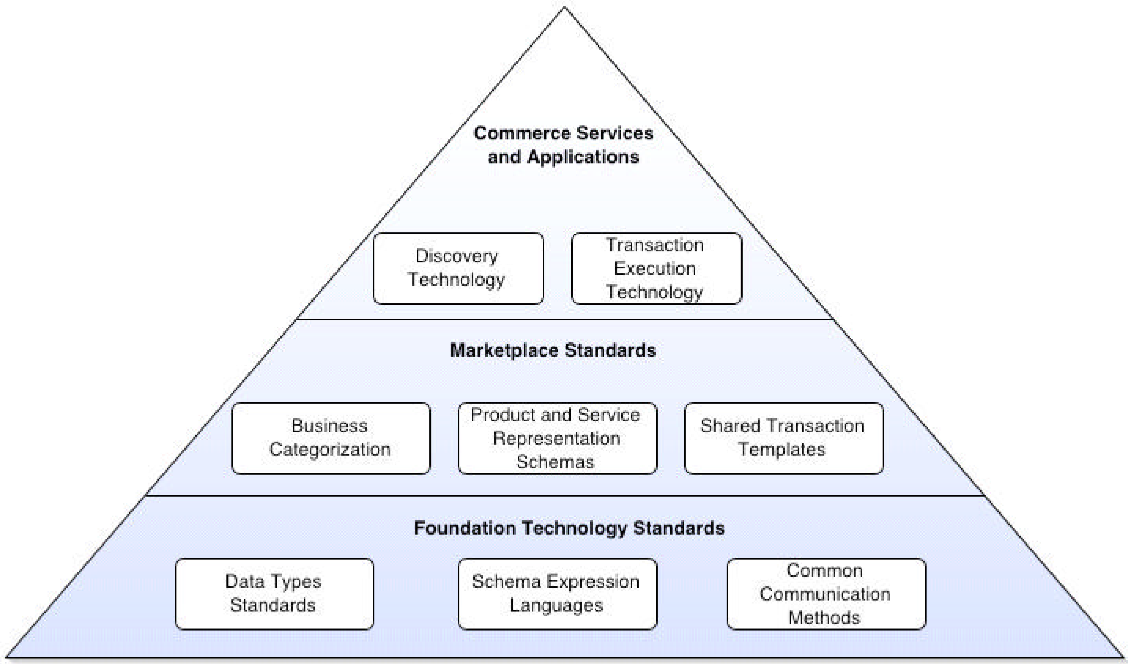

Figure 3: Required Standards and Applications for Generalized Ecommerce

Foundation Technology Standards

Technology standards are foundation standards that serve as building blocks for standards higher in the pyramid in Figure 3. The following three technology standards are the foundation of reliable, predictable EC communication:

- *Data standards* define the possible data types in a system. Participants must share a common definition of string, date, integer and real numbers, and other simple and complex data types.

- *Schema expression languages* (SEL) define rules for data representation. For example, in the XML SEL data is delimited with hierarchical (Walmsley 2001). Conversely, in the CSV (Repici 2002) SEL, fields and records are delimited with commas and hard returns. SEL may be used by designers and standards bodies to define data patterns in forms that enable computers to communicate in predictable and robust ways (Coyle 2002).

- *Common communication methods* define how data is physically transferred from one machine to another across a network. Traditional methods include hypertext transfer protocol, file transfer protocol, and Internet Inter-Orb Protocol.

Marketplace Standards

Marketplace standards include product and service representation schemas, transaction templates, and business categories. The creation and widespread adoption of useful standards for these three areas would have a powerful effect on improving EC efficiency. However, these standards are difficult to define and adopt. Powerful organizations sometimes compete to control the definition of standards, leading to competition among multiple existing standards as to which will be most widely adopted (Shapiro et al. 1999a; Shapiro et al. 1999b). In addition, the diverse needs of participants complicate the adoption of standards. Despite these complexities, definition of the following three standards significantly benefits EC systems:

- *Business categorization schemes* allow discovery technologies to index participants by type and name. Example business categorizations include the North American Industry Classification System (NAICS) (NAICS 2002) and the United Nations Standard Products and Services Code (UNSPSC) (UNSPSC 2002). While a ubiquitous business categorization system is difficult to create because of diverse industries, discovery services must rely upon some type of categorization scheme. Moreover, because organizations are sometimes involved in multiple business lines, an organization must be able to be listed in multiple categories.

- *Product and service representation schemas* allow businesses to describe attributes of the services they offer and of the products they sell. Known schemas are the basis for discovery of specific products and services. Inconsistencies in representation makes it very difficult for computer applications to find and evaluate sellers of specific products and services (McAfee 2000). EC systems become increasingly searchable when organizations within industries describe their services using common schemas. Schemas include field names, field definitions, and data types. For example, fish suppliers need useful schemas to describe the types of fish they sell, whereas accounting firms needs schemas to describe the different accounting services they provide. Many industries buy and sell commodities and quasi-commodities that are well suited for standardized product description formats (Dai et al. 2002; de Figueiredo 2000).

- *Shared transaction templates* group data fields into meaningful combinations to form transactions. The existence of standard transaction templates enables developers of heterogeneous systems to write converter software to translate data to and from the standard transaction format. Because of this, buyers can exchange transactions with many sellers rather than having to write translation routines unique to each seller. Thus, at the transaction level, specific buyers can be decoupled from specific sellers. As noted above, definition of transaction templates was a major focus and contribution of the EDI effort.

Commerce Services and Applications

Discovery service applications and transaction execution applications are necessary to complete a highly-efficient EC architecture. Discovery services would index businesses by type and product offerings. Transaction execution programs on the seller and buyer sides would allow sellers and buyers to execute transactions.

- *Discovery technologies* are market indexing and search applications, enabled by standards. These applications are at the heart of any ubiquitous EC network. Discovery technologies are especially important when buyers and sellers are not known, when offerings from different suppliers need to be found and evaluated, and when markets are fragmented (Bakos 1997; Bakos 1998). The usefulness of a discovery technology fundamentally depends on two factors: First, whether network participants use standard means to make market related information available; and, second, whether a large proportion of participants in the overall market choose to participate (Shapiro et al. 1999b).

- *Transaction execution technology (TET)* supports transactions among organizations. In terms of automated support for EC, two categories of transactions are important: First, *informational transactions* help buyers and sellers evaluate organizations and products. These include transactions that access product features, cost, and availability. Without information transactions, markets are less efficient. Second, *consummation transactions* relate to the actual consummation of purchase. These include transactions that buy, coordinate delivery, and remit payments. It is important to integrate TET with an organization's internal systems. For example, research on EDI systems suggests that a high degree of integration between EDI systems and the organization's internal information systems increases EDI performance benefits (Choudhury 1997; Iacovou et al. 1995; Mukhopadhyay et al. 2002; Riggins et al. 1994; Srinivasan et al. 1994; Truman 2000). TET should support decoupled connections of two types: ad-hoc connections with potential and new trading partners, and privately negotiated agreements between established trading partners (Jap et al. 2002).

CURRENT TECHNOLOGIES: STRENGTHS AND LIMITATIONS

In previous sections we have described and discussed a set of standards and applications that can dramatically increase the efficiency of EC. In this section we examine current EC technology platforms including EDI, Websites, Hubs, e-procurements systems, and web services in relation to how well they currently support B2B. Figure 4 illustrates the architectures of the respective platforms.

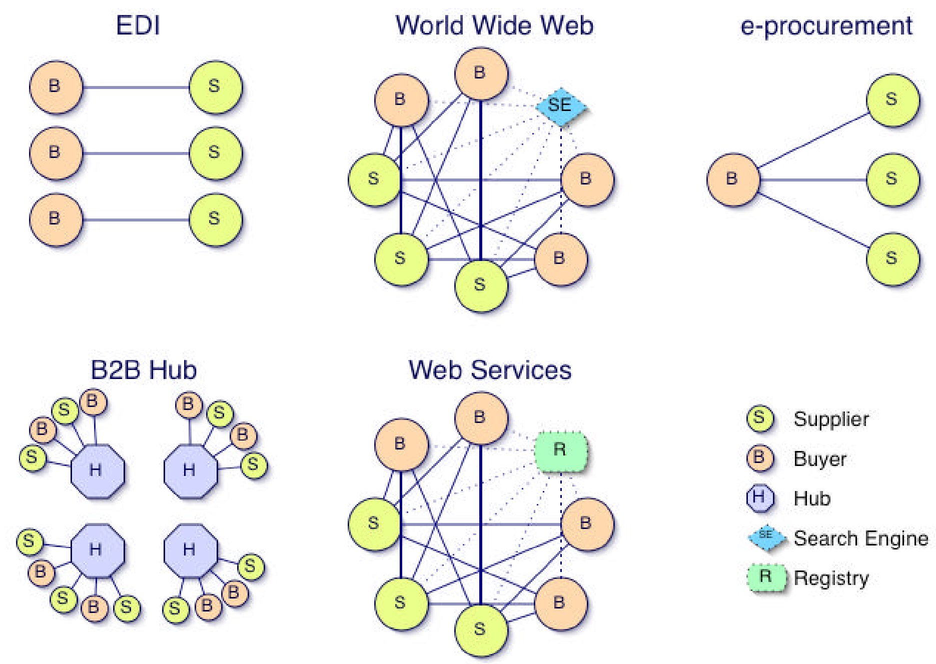

Figure 4: eBusiness Architectures

As noted above, each of these EC platforms has strengths and weaknesses.

Standard	EDI	WWW	e-procurement	B2B Hubs	Web Services
Data Standard	X12	No standard	Proprietary	Proprietary	Limited, basic types
Schema Language	Tags, delimited text	HTML	Proprietary	Proprietary	XML
Communication Method	VAN	Standard HTTP	Standard HTTP	Proprietary	SOAP
Business Categorization	No standard	No standard	None	Proprietary	Several supported
Product/Service Representation	Moderate	No standard	Proprietary	Proprietary	WSDL
Transaction Templates	X12	No standard	Proprietary	Proprietary	No standard
Discovery	No standard	Search engines	Vendor catalog or 3rd Party Catalog	Proprietary	UDDI
Transaction Execution	No standard	CGI forms	Proprietary	Proprietary	J2EE, .NET, others

Table 1: Summary of eBusiness Architectures

Table 2 provides a more detailed summary of these strengths and weaknesses by EC platform. These are described in the following sections.

Platform	Market Reach by Sellers	Entity that sets Data and Transaction Standards	Rigor of data and Transaction Standards	Index Mechanism for Discovery Services	Adequacy of Index	Type of Search Client	Degree of Support for Machine Executable Transaction Services
EDI	Limited to EDI partners	Industry consortium	Good	None	Index is specific to company. Not organized for external market place access.	EDI Software generates price and availability requests exclusively to EDI partners	Good
Company Website	Greater than EDI but hampered by lack of standards	Multi-company standards do not exist	Very Poor	Search Engines (e.g., Yahoo, Google, etc.)	Keyword-based indexing exists but there are no efficient business, business type, or product and service indexes	Browser	Low
Hub	Limited to entities connected to the hub	Hub developer. Standards are not common to other hubs	Varies in quality by specific hub	Hub index	Some categorization by the hub. The hub creates and maintains the index	Hub specific client enabled through browser	Good, but are not loosely coupled
e-procurement Systems	Limited to e-procurement Partners	E-Produrement software provider	Quality varies for different e-procurement systems	e-procurement system	Categorized within the e-procurement system. Sellers maintain product catalogs	e-procurement system client enabled through browser	Good, but are not loosely coupled
Web Services with UDDI	Large Companies who list themselves on UDDI	UDDI Consortium	Data and transaction standards need further development	UDDI index	Multiple business category indexes, product category indexing, no indexing and comparisons for specific product and services	Browser	Low

Table 2: Ecommerce Platform Comparison

EDI

EDI did not originate with the Internet, but was motivated by the need for electronic data standards between trading partners. In particular, EDI was developed to reduce the cost, delays, and errors inherent in the manual exchange of transaction documents. This effort was largely driven by large entities, such as General Motors, Sears, and Kodak in order to facilitate transactions with their many suppliers when buying direct materials to assemble into products. EDI is also used by some large retailers like Wal-Mart, to buy from wholesalers. A company's reach through EDI extends to only one trading partner at a time rather than the entire market (Table 2). Moreover, these trading partnerships between two firms are limited to relationships supported by legal contracts that typically specify trading partner obligations. Thus, market wide presentation of product information and use of indexing by discovery services has not been available through EDI (Truman 1998).

EDI standards for data interchange evolved from early proprietary agreements between pairs of trading partners, to industry-wide standards, to the more comprehensive and flexible ANSI X12 standards, which can support both intra-industry and inter-industry transactions. These standards focused on the Marketplace Standards denoted in (Figure 3). X12 Standards were flexible enough to accommodate the specialized information requirements of automotive, petroleum, transportation, and many other industries. Templates were designed for all the major transaction documents, such as purchase orders, and remittance advices, etc. A data dictionary was created that defines the field names and data definitions comprising each transaction.

Trading partnerships between two firms using EDI are well defined and generally stable. This stability means that EDI is sometimes used for automated replenishment and for the maintenance of efficient supply chains (Clark et al. 1996; Clemons et al. 1993). Since EDI predated the Internet, transport historically occurred over value-added networks (VANs), which served as the common communication method. VANs provided reliability, translation capability, security, and electronic mailboxes for trading partners. VANs could be very costly, however, with a fixed cost in the range of $250,000 for a mainframe installation and variable usage fees as high as $0.70 per transaction.

Today, the EDI telecommunications vehicle is changing from the VAN to the Internet. Indeed, some of the larger VANs now offer Internet services as well as their traditional connectivity methods. In addition, some industry groups are adopting XML as the language for communicating EDI transaction information via the Internet. Actual implementations of XML are few in number today, but substantial growth is expected in the future (Coyle 2002).

Table 1 depicts EDI standards in the four major areas. The strength of EDI stems from its well-defined data and transaction standards. With these standards, EDI software has been able to provide transaction services so that it has been possible to execute viable commercial transactions among two firms. EDI has been limited however, because EDI does not scale easily to include new participants, nor is it well suited for operating in efficient electronic markets where buyers would like to be able to search for products, prices, and related information from all sellers in a dynamic broader market.

Company Websites

Although an increasing number of companies have a presence on the Internet, their sites lack standard product and service representations. They also lack standard transaction templates.

Web pages lack standards for field names and field definitions used to provide information for specific products and services. This means a computer cannot reliably search multiple vendor sites for the same or similar products, nor can searchers use predictably specified product attributes to narrow their searches. For a system to compare information programmatically across multiple company sites, it must overcome this problem. Although improvements have been made in automation that can “scrape” web pages for information in limited domains (Embley et al. 1999), page scraping is not practical for application to the many diverse product types on the web (Bergmark et al. 2001). Consequently, humans must still conduct inefficient and often ineffective searches instead of using computers that could query and compile results from all possible sellers.

Search engines, such as Google and Inktomi, which provide discovery services for websites, are significantly limited by the lack of product and service schemas. Search engines use algorithms based upon co-occurrence of words to index information rather than consistently presented product attributes. Spiders, deployed by search engines, “crawl” and index diverse and incomplete HTML representations and therefore return incomplete and unreliable results. The lack of reach is another problem for search engines; not all potential suppliers and web pages are indexed (Glossbrenner et al. 2001).

Today's commerce web sites also lack the ability to execute standardized transaction templates. Once a site is found for a company that sells the desired product, human operators must search the site to find the desired product. Then, they purchase products through the shopping carts at the site or call the seller to arrange terms of the sale. Standardized data and transactions, common to EDI, such as requests for bids and purchase orders, are not commonly supported by company web sites.

Table 1 shows the standards the web provides for EC. Its use of free-text does not provide the needed level of standardization, representation, discovery, or categorization that is required for computer-to-computer interaction in general EC applications.

B2B Hubs

Over the last several years, some EC analysts and developers of B2B software expected that B2B hubs would radically reduce purchasing costs and provide comparability across vendors. As shown in Figure 4, B2B hubs bring buyers and sellers together and automate business transactions (Kaplan et al. 2000). B2B Hubs are electronic market places that play the role of *digital intermediaries* (Bailey et al. 1997; Bakos 1997). Ideally, B2B hubs facilitate product and information exchange and support product search, initial contact, negotiation, and settlement (Bakos 1997; Bakos 1998).

B2B hubs were expected to dramatically change commerce because they would be good for both buyer and seller. Hubs were expected to aggregate supplier’s product offerings, and help buyers search for desired products. Hubs offer their own catalogs or link to the product catalog of sellers, thereby providing indexing services (Baron et al. 2000). The ability to easily compare offerings from many vendors was expected to put downward pressure on prices (Jap et al. 2002; Kaplan et al. 2000). Sellers could achieve greater market reach and aggregate fragmented demand thereby allowing sellers to achieve greater sales and economies of scale. Hubs also represented the promise of reduced automation costs. Ideally, each buyer and seller would need only to incur the cost of connecting to one or a few hubs rather than sustaining the cost of developing links between individual market participants.

Figure 4 shows the contrast between the specific link between each buyer and supplier with EDI and the single link required by each firm for connection to a hub. Once buyers and suppliers were connected to the hub, the hub would be the instrument through which data would be shared on products and services. Hubs would also automate standard commerce transactions. These lofty expectations, however, have not materialized. Over the last few years, many hubs have failed, and those that survive have struggled to achieve critical mass. A number of factors have hampered hubs only some of which are directly related to the lack of standards. Non standards related problems were related to limited market reach and concerns about market information availability.

First, hubs are not built on common, ubiquitous standards. Diverse data definitions and transaction definitions hamper the adoption of hubs. Moreover, hubs typically do not connect to other hubs. As reflected in Table 2, data and transaction standards are specific to a hub, but are not universal across hubs. To connect to multiple hubs, companies have to incur the cost of implementing multiple translation pathways between their purchasing and sales databases and the hubs. Thus, the n-way problem described in Figure 1 still exists. It is costly to connect each business to multiple hubs.

Second, because hubs are proprietary, they have limited market reach. When a company connects to the hub, it has automated access only to other companies connected to the hub. Competition among hubs for subscribers results in market fragmentation (Wise et al. 2000). In addition, many suppliers and buyers are not convinced that hubs will reach critical mass, causing self-fulfilling expectations. Because of these limitations, the promise of broad market reach and the ability to easily compare offerings from many vendors often failed to materialize.

Third, some suppliers are reluctant to subject themselves to the price comparison that is possible in a hub (Jap et al. 2002) and others already benefit by lack broad market reach. Some hubs support public pricing, but do not support closed, secret price negotiations between specific buyers and sellers. This is unattractive to sellers who charge lower prices for large centralized buyers and higher prices for small decentralized buyers (Jap et al. 2002). This can be remedied by inclusion of public and closed pricing provisions in hubs. Some buyers like Wal-Mart have strategic sourcing and coordinated replenishment agreements with suppliers (Clark et al. 1996; Kurt Salmon Associates 1993). These types of buyers have already invested in automated EDI links to suppliers and therefore are more efficient than most competitors. This benefit could be somewhat lessened by more broadly available automation. Also, Clemons (Dai et al. 2002) notes that while some hubs focus on liquidity, many lack channel coordination ability. That is, they lack the ability to coordinates the production schedule of suppliers with the production schedules of buyers (Clemons et al. 1993).

These combined factors put pressure on the hub industry. For example, Ariba and CommerceOne, companies that were the focus of high expectations, have failed to achieve profitability and large market reach. These firms have subsequently refocused their efforts toward creating purchasing management tools rather than trying to become hubs in their own right. Not all B2B hubs have failed, however. FreeMarkets.com, for example, after years of significant financial losses, finally realized a net gain in the last quarter of 2001, largely because it was able to sign up enough supplier and buyers to provide savings to some buyers and market reach to some sellers.

E-procurement Systems

E-procurement systems have recently been adopted by a number of organizations to purchase indirect goods not typically purchased through EDI systems. A direct good is an item that becomes part of an end product, such as a motor used to assemble a washing machine. An indirect good is an item that is not part of the production process, but rather in other processes, such as operations, selling, maintenance, and administration (Eichler et al. 1999; Subramaniam et al. 2002). Examples of indirect goods include office supplies, computer equipment, cleaning solvents, and office furniture. E-procurement systems provide online product catalogs or links to vendors' catalogs. E-procurement systems enable organizations to distribute purchasing decisions to specific people across the organization. Moreover, automated linkages to suppliers allows buyers to reduce paperwork and overhead associated with the buying process and to shorten the time required to complete the purchasing cycle (Eichler et al. 1999; Subramaniam et al. 2002). While eProcurement systems can result in reduced inventory and consolidation of buying through fewer vendors which gives buyers more power to negotiate lower prices (Subramaniam et al. 2002). Like Hubs, eProcurement systems are subscription-based proprietary systems that lack a ubiquitous standards and wide market reach.

WEB SERVICES

Web services are a new approach that organizations can use to expose data and enable EC transactions over the WWW. While several evolving standards exist, such as RosettaNet (RosettaNet 2001) and ebXML (ebXML 2001), this section focuses on web services (WSDL/SOAP/UDDI) because of its wide industry backing. Web services is given its own section because of its likely acceptance as the new standard for EC over the next few years.

Web services attempt to solve some of the problems associated with traditional eBusiness technologies. The platform takes advantage of the ubiquity of the WWW primarily by using the HTTP protocol for transport, XML for data and service description, and UDDI for service discovery. Web services use open standards and has undergone submission to the World Wide Web Consortium (W3C) (W3C 2002), the primary organization that maintains WWW standards.

Web Service Components

The web services architecture is composed of three technologies: The Web Services Description Language (WSDL), the Simple Object Access Protocol (SOAP), and the Universal Description, Discovery and Integration registry (UDDI) (Bellwood et al. 2002). These are discussed in the following sections.

Web Services Description Language

The Web Services Description Language (WSDL) specification provides a set of rules for defining XML schema to describe the behavior, data, and bindings of different services. It was developed by Microsoft, Ariba, and IBM and has been submitted to the W3C. In short, a definition of a service in WSDL is a machine-readable fingerprint that describes an automated service and its attributes including method names, data field names, and data types associated with those fields. It is loosely analogous to an interface or header file used to describe the interface and behavior supported by a module in a computer program. Client software can query services for their WSDL definition. If the client software is prepared to make use of the methods and fields described in the WSDL, it can interact with the services accordingly through specific predefined calls to those services. WSDL data typing is superior to that specified for EDI. WSDL defines XML definitions for basic data types that are stronger and more specific than those defined by EDI. Whereas EDI standards defined specific field lengths, WSDL includes specific common data types (string, integer, decimal, date, etc.) that can be associated with specific data fields. As described earlier, standard data types associated with named data fields are essential for efficient and reliable communication among applications.

Simple Object Access Protocol

Simple Object Access Protocol (SOAP) is responsible for transferring XML-encoded information from one computer to another. Because SOAP uses standard HTTP, web servers allow it to pass through firewalls with relative ease, though companies are currently exploring ways to support SOAP and at the same time maintain adequate security (Albrecht, Forthcoming). SOAP also supports standard data types that can be used for requests made to services and it provides for asynchronous messaging and event notification to help the host and client programs communicate efficiently. Because of their use of XML for representation, WSDL and SOAP are widely supported in many different languages. Implementation libraries exist in languages such as Java, .NET, Perl, Python, Visual Basic, and many others (O'Reilly 2002a).

Universal Description, Discovery, and Integration registry System

UDDI, the Universal Description, Discovery, and Integration registry provides a central point for registering and finding services within the web services architecture. Currently, public UDDI services run by IBM, Microsoft, SAP, and HP replicate registrations and provide redundant lookup services for businesses using web services. Because of registration replication, participants only need register with one registry to be included in all UDDI servers. Table 3 presents the four components of the UDDI registry (Bellwood et al. 2002).

Type of Listing	UDDI Component	Description
Business Information	White Pages	Organizations list information about the organization such as name, address, and contact information.
Business Categories	Yellow Pages	Organizations can list themselves by one or more business categorization schemes.
Product and Service Categories	Yellow Pages	Organizations can list categories of the products and services they offer. Organizations cannot list specific product instances within product categories.
Service Description Listings	Green Pages / *tModels*	Organizations can describe the automated services and interfaces to those services that can be used by programs deployed by external organizations to access information on the organization and the product and service classes it offers.

Table 3. Types of Listings within UDDI

The UDDI system has been criticized because it relies too heavily on a centralized registry (Baker 2002). Moreover, functioning public directories, used to conduct business, may take several years to develop (Masood 2002). While there is considerable potential for this technology(Coyle 2002; Lawrence 2002), the lack of standards is a significant limitation. The next section describes how the lack of standards limits web services usefulness.

Limitations of Web Services

While the web services architecture represents a step forward, significant limitations still exist for automated services. 1) Business categorization is unreliable and variable, 2) product and service representations are nonexistent or inconsistent, 3) transaction templates are nonexistent or inconsistent, 4) discovery services are limited because of a lack of standards.

	Standard	Web Services Support	Comment
1	**Data Standard**	basic types	adequate
2	**Schema Language**	XML	adequate
3	**Communication Method**	SOAP	adequate
4	**Business Categorization**	Several supported	variable and unreliable
5	**Product/Service Representation**	WSDL	Different tModels exist, so it is impossible for search agents to infer meaning without human guidance
6	**Transaction Templates**	No standards	Variable and unreliable
7	**Discovery**	UDDI	Indexing is limited because of the lack of standards in items 4,5, and 6. The existence of such standards would support creation of superior indexes.
8	**Transaction Execution**	J2EE, .NET, others	A variety of implementations would work if based upon appropriate standards

Table 4: Web Services Weaknesses in Light of Framework Summarized in Table 1

Product and Service Representation and Transaction Templates

Together, WSDL and SOAP provide a framework for the definition and execution of remote calls on services, but standards for these calls and the methods that are called have not been agreed upon. This currently limits the usefulness of web services. For example, assume a seller wants to implement an automated service on the sellers' systems that can be used to both publish data and execute transactions. Standards for data and methods have not been defined and adopted by industry participants. Standards don't exist for field names, data types associated with field names, and names and definitions of automated program interfaces used to make calls to automated services. Because transaction templates have not been defined….

Field names to be used in these exchanges have not been standardized, such as "product code" or "product description." Moreover, standards have not been defined in terms of which of the WSDL data types will correspond to each field. For example, one service might use a string to represent product codes while another might use an integer. The lack of a standard for method names and what methods will do is also a significant limitation. As a specific example, if Amazon & Barnes and Noble do not use the same method names, parameter types, and return values, common access methods cannot be used by client applications. Because of different interfaces and methods, agents will not be able to communicate with new services without reprogramming. Amazon's hypothetical *getBookInformation(…)* method may or may not be synonymous with Barnes & Noble's hypothetical *queryBook(…)* method. These kinds of decisions and inferences require human knowledge and experience, resulting in the reprogramming or training of agents and client applications for each new service found.

This is industry problem. WSDL definitions don't exist for classes of products and services that should have equivalent or similar descriptive fields. WSDL definitions do not exist for automated services to access information on those product classes. Nor do standard transaction templates exist within web services to support common transactions such as purchase order and shipment requests. Rather, WSDL definition is left to each participant. While some industries may standardize their WSDL signatures or use existing WSDL from the existing "pool" of signatures, formal involvement with the UDDI system does not directly encourage participants to standardize or adopt standards that are being defined by other organizations (such as RosettaNet). This lack of standardization significantly impedes the usefulness of web services (O'Reilly 2002b).

Discovery and Indexing

The UDDI system finds organizations that belong to specific business type such as TV manufacturer, accounting firm, web hosting company, etc. However, since organizations can register with a variety of categorization schemes, such as such as a North American Industry Classification System (NAICS) code (NAICS 2002) or a Universal Standard Products and Services Classification (UNSPSC) code (UNSPSC 2002), the UDDI registry doesn't support economical and reliable searching for all businesses of a given type. Searchers must query according to the multiple different possible business categorization schemes to find businesses of a specific business type.

Jewell and Chappell (Jewell et al. 2002) have written the following about the anticipated limited market reach of the UDDI system:

> It's probably not realistic to expect software to dynamically discover and use new businesses on the fly in the near future. Realistically, human analysts need to browse a UDDI portal that allows customized searches and queries to discover the businesses they are interested in working with. It's more likely that software will contain the logic necessary to locate and integrate with web services for companies that have been predetermined. It's also likely that businesses will set up private UDDI registries that they can share with their approved partners to facilitate B2B integration.

Because of the UDDI yellow pages, the UDDI system can help searchers find businesses that offer a certain class of products or services, but UDDI does not support automated searches for specific products and comparisons of products and prices across vendors. For example, with UDDI it is possible to find registered companies that manufacture TVs, but it is not possible to find all vendors who sell high-definition, stereo, 27" color TVs.

Implications

There are important implications for these deficiencies relative to both the server (seller) side and the client (searcher) side. On the seller side, companies lack defined product and service representation schemas and transaction template definitions to guide their development of automated commerce support software. This significantly impedes the development of automation for both sellers and buyers. In effect, different sellers will expose different automation interfaces, even though they might wish to sell similar or even exactly the same products or services.

This lack of standards on the seller side leads to significant problems on the client side: namely, it is difficult to search and discover competing vendor services when different vendors offer heterogeneous interfaces. Without common field names and transaction templates for different products and service, search clients cannot be developed that reliably exploit these fields. Moreover, indexing services cannot use standard interfaces to collect product and service information across vendors to create a useful index that can be used to facilitate commerce.

Because of this heterogeneity, clients will need to be programmed specifically to interact with seller interfaces—effectively coupling the two which will make the network fragile and extremely difficult to maintain. Lacking standards, the goal of a single, simple client that can connect to many competing sellers (using the same interface), query for pricing and other information, and evaluate choices, is not possible.

While UDDI provides the *tModel* structure [UDDI Version 3], which can be linked by many different businesses, the structure allows any number of external schemes to be used for categorization. Since any registered entity can define *tModels*, many different specifications for the same business or product will still exist. For example, since not all tire manufacturers will publish under the same WSDL definition in the UDDI registry, it will be resource intensive to write search clients that will allow potential buyers to compare products across multiple vendors. Consider the problems a client application searching for tire suppliers will encounter using existing web services technology. First, it may not even be able to find all tire manufacturers on the network because they may be registered under different categorization systems. One supplier might register using the NAICS categorization system while another might use UNSPSC product codes. Still other suppliers might register only by their specific service APIs (*tModels*). Second, when the client application finds a tire manufacturer, it must query the service for the current tire price and availability. Since each tire manufacturer may be using a different method name with different data types, the client application must be programmed to communicate with each manufacturer's respective API, resulting in coupling between client applications and remote services. This approach is so resource intensive that it will limit the development of useful clients. This severely limits the general usefulness of the discovery mechanism.

In summary, the web services architecture provides emerging standards and technologies for most areas, but it still has significant limitations. UDDI supports business categorization schemes, but the diversity of these schemes makes it difficult for searchers to reliably find businesses within a category. The emergence of XML and WSDL has created a way to define product and service schemas, transaction templates, and automated service definitions in very specific machine readable terms, but industries still need to share WSDL and transaction signatures. Without these standards it will be difficult to develop clients that can economically search and execute transactions. It will also be difficult to develop comprehensive and effective indices that serve as the basis of discovery service.

CONCLUSION AND FUTURE RESEARCH

The overarching purpose of this paper has been to present evidence of the need for marketplace and technology standards through examining and contrasting the major platforms that have been developed to enable EC. To facilitate this investigation we have developed an evaluation schema (Figure 3) incorporating six fundamental standards that must be present in any EC system if it is to successfully support widespread, efficient B2B transactions on a network.

Using this schema, it is found that no single technology provides a complete solution for all components of a standardized, loosely-coupled marketplace. Each EC platform has strengths, but also weaknesses. EDI excels in transaction definition, but lacks market reach. The WWW has increased overall network (inter-network) connectivity and has provided a common, though limited, network indexing scheme. Development of B2B hubs has increased the feature set of useful web catalogs, but hubs have different data and transaction formats and limited market reach.

While the web services architecture is a major step forward technologically, the lack of required standards limits its usefulness and widespread adoption. The technology toolbox of today is sufficient to support EC, but the standards that must be developed are conceptual standards required for efficient technological implementation. This paper has helped clarify this relationship.

A shared set of APIs should support representation definition from top-down industry consortiums as well as bottom-up participants. It should enable a standard API for specific transactions and industries over time, while allowing evolution to meet individual and changing needs. Fortunately, standards efforts do not need to start from scratch. Future efforts should build upon the significant technical and standards work that has already been developed to support EDI, Rosettanet, and on other EC platforms. It should provide a semantically-meaningful set of terms that enable loosely-coupled, run-time connections between (Repici 2002) disparate clients and servers. Standards would also enable third party tool developers to economically create systems and converters that could be used by many organizations.

Since standards need to be developed, we recommend future research in three fundamental areas. First, research should be conducted in the area of incentives for industry participants. Different individual businesses and industries have varied incentives. Market reach is more important to some suppliers and buyers than others. The power of buyers and sellers also varies. Under what conditions can specific participants gain benefit from development and agreement upon a standard? Under what conditions do incentives and disincentives exist? Answers to these questions could help facilitate the development of standards. The recommendation of a standard set of APIs is not a trivial problem. Issues such as business compatibility, competition, and specialization complicate the solution. For example, one author recently spoke with a senior executive of one of the largest manufacturers in the world about EC with accurate, efficient, worldwide searching, connecting, and transacting of business by agents. The executive was less than thrilled with truly efficient platform because it provided the means to partially level the playing field for smaller and new competitors. This executive's business had already set up efficient EDI connections with preferred buyers and sellers, just-in-time agreements, and preferred pricing. Because of this the company recognizes that its private EC network is a significant competitive advantage.

Second, research should focus on efficient processes for developing standards. This includes who and how should players be involved in efficient ways. Lessons learned from research in the field of collaborative systems requirements definition (e.g., Dean, et al. 1998; Hickey et al. 1999) could be fruitfully applied to the area of standards development.

Third, the object-oriented paradigm provides insight into how standardization and specialization can be supported at the same time. An object library, such as the Java Foundation Classes or the Microsoft Foundation Classes, provides a standardized core of data types, methods, and relationships that all participants share and depend upon. Participants *extend* appropriate objects in the core system to provide specializations that meet their needs and yet maintain compatibility with existing applications. Applications programmed to the API of the super-service are still able to interact with the specialized service using the inherited methods. Over time, assuming the new specialization is accepted and adopted by others in the system, new clients increasingly take advantage of the new functionality of the specialized service type. We are researching methods of applying the base concepts of OO—most notably inheritance and polymorphism—to the web services architecture.

Our conjecture is that there are substantial research and application opportunities for loosely-coupled EC architectures, and we anticipate interesting developments from these efforts in the coming years.

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A CONCEPTUAL MODEL FOR COMPARATIVE ANALYSIS OF STANDARDIZATION OF VERTICAL INDUSTRY LANGUAGES

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ABSTRACT

In today's global economy and E-commerce, there is increasing need to integrate application systems within and across organizations. Additionally, to lower the cost of application development and maintenance, increase reuse, and support outsourcing, the application development is moving towards component-based development and Web services. While great stride has been made in standardization to achieve interoperability and integration at hardware, operating system, data communication, messaging, and common syntax level, the common semantics required for application integration has not been developed. The standardization of common semantics depends on particular vertical industries such as insurance, banking, healthcare, and manufacturing. The standardization in each of the verticals has proceeded in ad-hoc and very unique ways. Additionally, they are at different stages of development. In some industries, multiple consortia or groups are developing standards, which significantly overlap with each other. Many vertical industries have developed standards that overlap with each other and with horizontal industry standards. The objective of this research is to develop a conceptual model for comparative analysis of standardization of vertical industry languages, which can be used to evaluate the current standardization practices and recommend ways to improve the standardization processes in the vertical industry domains. A pilot study in the insurance industry has been performed, where representatives of two members of the dominating industry standard, ACORD, were interviewed. The interviews are summarized and reported in this paper.

Keywords: standardization; application interoperability; web services; semantics; vertical industry language.

INTRODUCTION

As our ability to build information systems continues to grow, so does the need for integrating the systems we build. Legacy systems developed over time in different sections of an organization need to be integrated for decision support purposes. Business mergers and acquisitions force systems previously owned by different institutions to be merged. Systems operated by cooperating enterprises in a value chain need to cooperate with each other. The rapid growth of E-commerce and the increasing globalization of businesses further boosted the need for system cooperation and integration. Such need for application interoperability is becoming ubiquitous, within and across organizations, in almost every domain. Additionally, there is increasing pressure to reduce application development and maintenance cost, achieve quicker application development, increase use of off-the-shelf applications, components and services and support outsourcing. This is moving application development more towards component-based development and services oriented architecture based on web services (Vitharana et al. 2003; Jain et al. 2003).

Years of standardization efforts in Information and Communication Technology (ICT) have achieved tremendous success in realizing interoperability at hardware, operating system, data communication, messaging and common syntax levels. Additionally, World Wide Web has resulted in common presentation and user interaction mechanism. However, inter and intra organizational interoperability and integration of applications additionally requires common semantics. While the standardization at hardware, operating system, data communication, messaging, and common syntax levels has been pursued independent of industry domains, the standardization of common semantics necessarily depends on particular industry verticals such as banking, insurance, health care, and manufacturing, as evidenced by the various XML.org Focus Areas (www.xml.org/xml/focus_areas.shtml) working on XML standards for particular vertical industries. The development of standards in industry verticals has proceeded in ad-hoc and very unique ways. In some industries, multiple consortia or groups are developing standards, which overlap with each other, e.g., the standards developed at IFX Forum (Interactive Financial eXchange Forum, www.ifxforum.org) and FSTC (Financial Services Technology Consortium, www.fstc.org) for the financial services industry. In addition, many vertical industries have developed standards that overlap with each other and with horizontal industry standards, e.g., XBRL (eXtensible Business Reporting Language, www.xbrl.org), ebXML (electronic business XML, www.ebxml.org), and OFX (Open Financial Exchange, www. ofx.net). Consequently, the extents of standardization in different industries vary substantially.

The objective of this research is to develop a conceptual model for comparative analysis of standardization of vertical industry languages, which can be used to evaluate the current standardization practices and recommend ways to improve the standardization processes in the vertical industry language domains. A pilot study in the insurance industry has been performed, where representatives of two members of the dominating industry standard, ACORD, were interviewed.

The paper is organized as follows. Section 2 presents a conceptual framework for application interoperability and a concrete architecture. Actualization of this conceptual framework based on the emerging web services technology is presented. The status of standardization of the various layers in the architecture is reviewed. The deficiency in standardization of vertical industry languages is outlined. Section 3 proposes a conceptual model for comparative analysis of standardization of vertical industry languages. Section 4 reports a pilot study in the insurance industry. Section 5 concludes the paper and describes the plan for future research.

STANDARDS NEEDED TO ACHIEVE APPLICATION INTEROPERABILITY

It is obvious that standards are critical in achieving successful interoperability or integration of heterogeneous application systems, as the different parties need a lingua franca to communicate with each other. In the following sub-sections, we describe the various technical layers that need to be standardized for the purpose and an emerging approach, that is, web services.

A Conceptual Framework

In order to successfully cooperate with each other, multiple application systems must share common communication mechanism, common application-level messaging mechanism, common syntax, and common semantics. The common communication mechanism allows systems to communicate raw bits and bytes over a network. The common application-level messaging mechanism allows distributed applications to interact with each other on a higher abstraction level. The common syntax specifies the structure of the messages between applications. The common semantics provides a common definition of what is to be communicated and is used to interpret the meaning of the communicated messages. The applications interacting with each other need to agree on the terminology used to describe concepts in the application domain. Some concepts common in multiple industries may be specified in some horizontal language, which covers multiple industries. Concepts unique for a particular industry need to be specified in a vertical industry language. Figure 1 outlines the technical layers that need to be standardized for applications to successfully and meaningfully cooperate with each other.

<table>
<tr><td rowspan="2">Common Semantics</td><td>Vertical Industry Language 1</td><td>Vertical Industry Language 2</td><td>...</td><td>Vertical Industry Language n</td></tr>
<tr><td colspan="4">Horizontal Language</td></tr>
<tr><td colspan="5">Common Syntax</td></tr>
<tr><td colspan="5">Common Messaging Mechanism</td></tr>
<tr><td colspan="5">Common Communication Mechanism</td></tr>
</table>

Figure 1. A Conceptual Framework for Application Interoperability

An Infrastructure for Application Interoperability Based on Web Services Technologies

The conceptual framework for application interoperability can be implemented using different technologies. Indeed, different approaches have been implemented in the past, with EDI (Electronic Data Interchange) as a classical example. EDI allows distributed applications to communicate with each other via a (usually expensive) proprietary value-added network (VAN). The expensive adopters need to be added to the applications and they are hard to maintain. These difficulties have restricted the adoption of EDI to large organizations. Small to medium sized companies have often felt EDI prohibitively expensive to implement (Ramamurthy et al. 1999; Deitel et al. 2003).

Firmly supported and actively advocated by influential computer companies such as IBM, Microsoft, HP, and Sun, web services technology is emerging as an important trend in web-based application interaction and integration (Kreger 2003; Miller 2003; Williams 2003). Based upon open standards such as SOAP, WSDL, UDDI, and BPEL4WS, web services allow web-based applications to communicate through standardized XML messaging (Gottschalk et al. 2002). Contrast to the traditional EDI technology for application integration, which tightly couples the components via dedicated networks and proprietary messaging protocols, web services can be loosely coupled using open, text-based standards over the Internet, thus significantly reducing the costs of application integration. Web services technology provides a new computing model, which greatly eases application integration within and across enterprises and is getting increasing adoption (Gottschalk et al. 2002).

Figure 2 outlines an actualization of the conceptual framework for application interoperability described in the previous sub-section based on web services technology. Web services exchange messages over the Internet. Internet protocols, including the TCP/IP networking protocol and transport protocols such as HTTP and FTP, comprise the common communication mechanism. XML is the chosen syntax for marking up web service messages. A set of standards, such as SOAP, WSDL, UDDI, and BPEL4WS, are being developed for passing messages between web services and describing, publishing, and assembling web services. At the same time, various XML-based languages encoding business semantics are being developed both horizontally and in particular vertical industries.

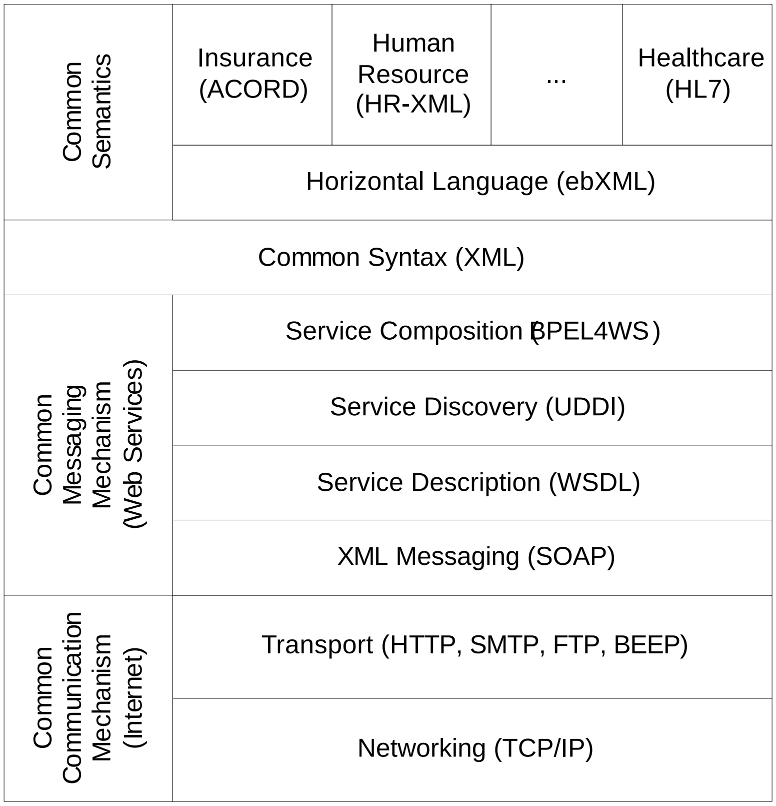

Figure 2. An Infrastructure for Application Interoperability Based on Web Services Technology

The layers up to common syntax have been standardized and are widely adopted. Internet protocols such as TCP/IP, HTTP, and FTP have become well-accepted standards. XML (Extensible Markup Language) is becoming a common standard syntax for describing data on the Internet and generating markup languages. XML originated from SGML (Standard Generalized Markup Language). The XML version 1.0 specification became a W3C (World Wide Web Consortium, the most influential standards body promoting web technologies) Recommendation (W3C's term for standard) in 1998 and was revised (in the second edition) in 2000. The XML version 1.1 specification is currently a candidate recommendation at W3C. SOAP (Simple Object Access Protocol) is currently supported by majority of the computer industry as the standard messaging protocol for web services. SOAP originated from a collaborative development of several companies, including IBM, Lotus, and Microsoft. W3C released SOAP 1.2 as a W3C Recommendation in June 2003. Microsoft and IBM collaborated to develop WSDL (Web Service Description Language) and submitted WSDL1.1, jointly with Ariba, to W3C in 2001. W3C released WSDL 1.2 working drafts in 2003. IBM, Microsoft, and Ariba led the UDDI (Universal Description, Discovery and Integration) project, which released the version 1.0 specification in 2000. OASIS (The Organization of the Advancement of Structured Information Standards), another key standards body promoting web services technologies, has approved UDDI version 2 as an OASIS Open Standard. BEA, IBM, and Microsoft developed BPEL4WS (Business Process Execution Language for Web Services), which superceded two prior languages for web service composition: XLANG and XSFL. OASIS formed a technical committee in April 2003 to continue work on the process language based on BPEL4WS 1.0 specification.

While the standardization of the common syntax and the common mechanisms for web services can be considered in relatively healthy shape, the standardization of the common semantics is lagging far behind. Semantics alignment is considered a major challenge for application interoperability (Dodd et al., 2003; Hansen et al., 2002; McIlraith and Martin, 2003). The standardization of vertical industry languages has particularly proceeded in ad-hoc and unique ways in different industries. OASIS has formed Focus Areas through xml.org for several industries, including insurance, human resources, and printing & publishing, and is in the process of forming more Focus Areas, to facilitate the standardization of XML and related languages for vertical industries. However, the current extents of standardization vary substantially across industries. The standards being developed at multiple consortia or groups of a single industry sector or in different industries overlap with each other and with horizontal industry standards. Resources are unnecessarily wasted and effort duplicated. Research is needed to identify the critical factors that engender or inhibit successful standardization of vertical industry languages and gain insights in the reasons of the current situation. Unfortunately, our comprehensive literature search shows that there has been virtually no published research in standardization of vertical industry languages in the literature.

A CONCEPTUAL MODEL FOR COMPARATIVE ANALYSIS

We have developed a conceptual model for Comparative Analysis of Standardization of Vertical Industry Languages, based on analysis of information available from the web sites of various relevant standards bodies or organizations and a pilot study in the insurance industry, which we will describe in the next section. The model is outlined in Figure 3.

We have identified the following factors related to the business environment of a vertical industry that may influence the standard development process and the extent of standardization.

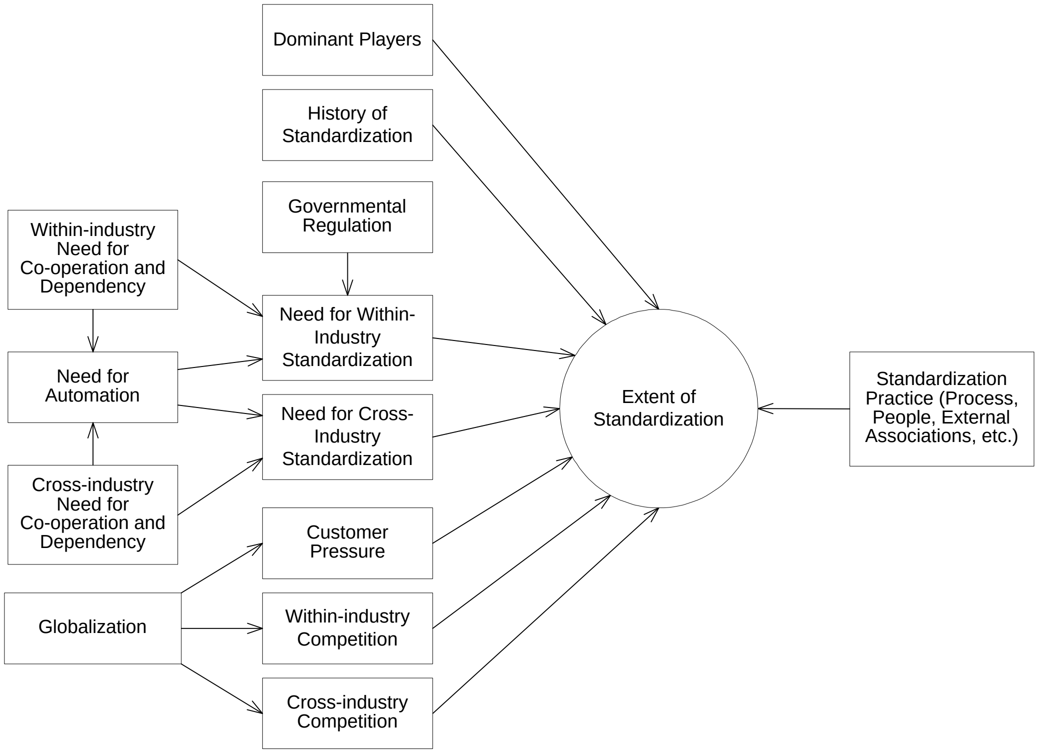

Figure 3. A Conceptual Model for Comparative Analysis of Standardization of Vertical Industry Languages

- *Within-industry competition (price pressures):* The nature of competition among competitors within the industry can impact the standardization effort. If the competition within the industry is based mainly on price, the standardization may benefit all the companies in reducing the cost and may be easier to achieve. However, if the competition is based on either some proprietary technology or unique way of doing business, which creates customer lock-in and raises entry barriers, standardization may be difficult to achieve (Mata et al., 1995), because in this case companies are less likely to give up their proprietary processes in the fear of loosing customers.

- *Cross-industry competition (price pressures):* The nature of competition among competitors across industries may also impact standardization. The boundaries between some industries are becoming blurred. For example, insurance companies and financial services companies are getting into each other's businesses, similarly banks and financial services industry are getting into each other's spaces. Here again if the competition is based on taking advantage of existing relationships with the customer to offer expanded set of services and to offer one stop service, companies will be less motivated to support standardization in the fear of loosing customers. On the other hand, if the competition is based on economies of scale and lower cost of serving the customer, the standardization is more likely to happen.

- *Within-industry need for co-operation and dependency:* The need for co-operation and dependency among partners in a value chain within the industry plays an important role in standardization. For example, insurance companies need to co-operate with agents and re-insurance companies to conduct their business operations. Similarly, manufacturing companies need to co-operate and need co-operation of various layers of suppliers in the supply chain. In this case, standardization is likely to benefit the company and the business partners by reducing the cost of integration and the cost of doing business. This is especially true if the companies do not have exclusive relationships with business partners, e.g., exclusive supplier of an item to a company or an exclusive agent of an insurance company.

- *Cross-industry need for co-operation and dependency:* The need for co-operation and dependency among partners in a value chain across industries impacts the standardization. For example, insurance company's need to co-operate with hospitals, auto repairers and financial services companies such as banks increases the motivation for standardization. In this case, standardization can support much higher level of automation at lower cost, flow through processing and significantly reduced delays. The cross industry business partners are more likely to implement automated flow through processing, e.g., electronic receipt of invoices and payment, if same systems can be used with multiple business partners.

- *Need for automation:* The need for automation of workflow with business partners within and across the industry to improve efficiency and reduce cost is a powerful motivation for standardization. This need tends to be correlated with both the need for within-industry co-operation and dependency and cross-industry co-operation and dependency.

- *Dominant players:* The existence of a dominant player in the industry may impact standardization efforts. The dominant payer may attempt to establish de-facto standards of its choice and may seek to strengthen its position. In such a case if other companies decide to go along with the de-facto standards, then the standardization can happen easily. On the other hand dominant player may frustrate the standardization effort by not supporting the proposals of standardization body, e.g., in 1970's and early eighties the efforts of CODASYL in standardizing database languages were opposed by IBM (a dominant player at that time). This ultimately resulted in failure of CODASYL database standards.

- *History of standardization:* The history of standardization in the vertical industry and the existence of an established standardization body play a very important role in determining the level of standardization. A well-established and respected standardization body provides an easy forum for discussion on the increased level of standardization within the industry. It also facilitates communication between major players, as there exists an established history of companies working together.

- *Globalization:* The trend of globalization of the industry may also impact standardization effort. Globalization and global competition can add another dimension to the standardization. The international trade relationships and national pride and interests can further complicate the establishment of global standards. For example, the establishment of global cellular standards has been complicated by global competition and national interest. On the other hand multinational corporations doing business in many countries like to see global standards to simplify and ease the management of their operations.

- *Governmental regulation:* The extent of governmental regulation of the industry has significant impact on standardization. Highly regulated industry has extensive and expensive government reporting requirements. In this case the government agencies and companies alike have interest in standardizing the reporting formats to significantly reduce the cost of reporting by using off-the-shelf products or services.

- *Customer pressure:* Customer pressure for standardization can play a significant role in standardization. This is especially true in an industry where you have one or more customers that are dominant like government in the case of defense industry or big three in the case of auto industry. In this case, the dominant customers can force all their business partners to follow certain standards. For example, big three auto companies asked all the suppliers to follow EDI standards or follow ISO quality standards. Even in the industry with no dominant customers, if significant cost reduction or simplification of operation can be achieved customers can collectively push for standardization e.g. the open system movement within the computer industry.

The trend of globalization of economy influences a number of factors, including (within-industry and cross-industry) competition and customer pressure which in turn influences the extent of standardization. In addition, the history of standardization and dominant players also influences extent of standardization in a vertical industry. Within industry and cross industry dependency and need for co-operation can influence the need for automation and need for within and across industry standardization respectively. The need for automation can be a major driving force in determining the need for across and within industry standardization, which in turn can influence the extent of standardization of a vertical industry domain. Government regulation can also influence the need for within-industry standardization.

Besides the above factors related to the business environment of the industry, the standardization practice per se, including the adopted process, the people sitting in the committees, and associations with other SDOs (standards developing organizations), also influence the extent of the output. While these factors are more likely common in any standardization effort and have been studied in the literature (e.g., Jakobs et al., 1999; Jakobs et al., 2001; Jakobs, 2003; Bach, 1995; Oksala et al. 1996; Rada, 1998; Updegrove, 1995), it is interesting to see whether the findings of previous research in other domains hold in standardization of vertical industry languages.

A PILOT STUDY

Based on the above conceptual model we have performed a pilot study to analyze the state of standardization in the insurance industry. Established in early 1970, ACORD has become the dominating global XML standards developer of the insurance industry. ACORD has a large body of members, including over 70% of the top 10 and 60% of the top 25 life and annuity carriers, over 75% of the top 50 property and casualty carriers, and 70% of the top 10 reinsurers, as well as the Top 5 reinsurance brokers representing 80% of the top 20's gross revenue (http://www.acord.org/about/ourmembers.aspx). These members are categorized into Insurance Carriers, Reinsurers, Distributors, Solution Providers, Associations, and User Groups.

In order to get inside into the state of standardization efforts within insurance industry, we interviewed representatives of two member companies of ACORD. Both interviewees joined ACORD in recent years and are currently serving in an observer role. They plan to participate in some of the sub-committees and working groups in near future. Since these interviewees joined ACORD relatively recently (less than two years), they provided good insight into the motivation for their companies to join ACORD. One of the member company interviewed is a service-oriented solution provider for the insurance industry. It participates in ACORD to enable the company to provide products and services that are certified by ACORD as ACORD-compliant and to reach a larger client base. The other company interviewed is a large insurance carrier. Its motivation to join ACORD is described as to increase flexibility, reduce cost, and save time in internal project development by using the standard as a starting point. It may consider adopting off-the-shelf ACORD-compliant software in the future. Based on the above interviews, analysis of business environment (one of the author has experience in insurance industry) and extensive study of the history and current status of ACORD and standardization within insurance industry, we have analyzed the state of standardization in this vertical industry using the conceptual model described in previous section.

Evaluation of factors related to the business environment:

- *Within-industry competition (price pressures):* The competition is increasing within the insurance industry.

- *Cross-industry competition (price pressures):* The competition across industries is also increasing. For example, insurance companies and financial services companies are getting into each other's businesses.

- *Within-industry need for co-operation and dependency:* The need for co-operation and dependency among partners is increasing. For example, insurance companies need to co-operate with agents and re-insurance companies to efficiently conduct their business operations.

- *Cross-industry need for co-operation and dependency:* The need for co-operation and dependency among partners in a value chain across industries is increasing. For example, insurance companies need to co-operate with financial services companies such as banks, hospitals, and auto repairers to reduce their operation cost and compensate for increasing cost of health care and auto repair.

- *Need for automation:* The need for automation of business workflow with business partners within and across the industry is increasing. Information increasingly needs to be electronically communicated among insurance companies, agents, reinsurance companies, financial services companies, and customers. This has become important as there is increasing price pressures and increased expectation of service by the customers.

- *Dominant players:* The existence of a dominant player in this industry is diminishing.

- *History of standardization:* ACORD has a long history of serving the insurance industry. ACORD started with developing forms in the 70s, moved into EDI technology in the 80s, communication standards in the 90s, and XML in the late 90s.
- *Globalization:* There is increasing trend of globalization in this industry, which had relatively low level of globalization.
- *Governmental regulation:* The industry has significant regulations and reporting requirements. Many regulations vary from state to state in USA and by country globally.
- *Customer pressure:* There is no significant customer pressure for standardization. However, there is increasing expectation of fast and 24X7 service by customers.

Factors related to the standardization practice:
- Process: ACORD operates an open process, in which any interested party can initiate a maintenance request or new standard proposal, participate in the working groups of their interest, and contribute to the development of the standard. High-level Steering Committees of ACORD is composed of senior persons form member companies. Subcommittees are formed to focus on different areas of insurance industry, such as Life & Annuity, Reinsurance, and Property & Casualty. Subcommittees can in turn form working groups for

detail work and resolution of technical issues. The average size of sub-committees is about 20-25. Subcommittees meet about once a month via teleconferencing and semi-annually face-to-face. The work of all the working groups under a Subcommittee are discussed, further developed, and voted for approval at the semi-annual Subcommittee meetings. The Steering Committee has the authority for final approval of all standards. While the standards development process is open, only ACORD Members and Associate Members have the voting rights (http://www.acord.org/Standards/Process.aspx).

The standardization process has been more cooperative than competitive (or political) and more open-minded than conflicting. Many requests for new proposals have been due to lack of understanding of the existing mechanisms in the current standard and can be resolved via education. There is no dominating party, but certain dominating people, who are experienced experts in the field and sometimes represent multiple organizations, in the process. Insurance companies do not have concern about losing their competitive edge due to standardization, but see standardization as an opportunity to reduce cost and improve service. Insurance companies strive for uniqueness in their interfaces to customers, while the internal raw data are mandated by the standard.

- People: Unlike in the standardization processes of other technologies, where users are extremely underrepresented, as reported in the literature (e.g., Jakobs et al. 2003), user participation in the ACORD standards development process has been reasonably high. Although ACORD works closely with W3C in developing XML specifications, requirements have largely come from users. Insurance companies and agencies guide the standardization process and are the driving forces. The trend of the insurance industry is that there will be more independent agents, who work with multiple insurance companies and appreciate a uniform, standardized interface to communicate with different insurance companies, although the particular insurance company we interviewed is maintaining contracted agents who exclusively work for it.

- External associations: Around 2000 to 2001, ACORD carried out a major change in its scope. Its coverage was extended via integration with other business areas, such as financial services and human resource, and alliances with other standards bodies, such as IFX (Interactive Financial eXchange Forum) and HR-XML. It also built relationships with WISe, a European standards body involved in reinsurance, and other international standards bodies, to move towards global reach. ACORD was used for external information exchange between insurance companies and agents before. Now it has a broader scope, and is used for external communication between insurance companies, reinsurance companies, agencies, and other financial services companies such as banks, as well as internal communications across departments within insurance companies.

Overall, ACORD is considered successful and is indeed in a much more advanced state than many other industries, such as healthcare, retail/wholesale, and government. The process has been a little bit slower than the members wished it to be, because of the large group of members and wide scope. It is expected to become faster in the future. The standards development process is ongoing, without an end in the near future.

CONCLUSIONS AND FUTURE RESEARCH PLAN

While standardization of vertical industry languages has not been adequately investigated in the literature, this research aims at developing a conceptual model for comparative analysis of standardization of vertical industry languages. Such a model is potentially useful in evaluating the state of standardization in vertical industries and in suggesting ways to improve the current practice.

This research is still at an early stage. We are planning to further proceed in several directions. While a pilot study in the insurance industry has been performed this analysis is based on only two interviews. Based on the above pilot study we are revisiting the conceptual model and trying to find additional theoretical support for the model from the organization and strategy literature. We are planning to conduct more interviews and collect additional data through other means. Similarly, we plan to analyze other major vertical industries, interview and survey some key players in each of these industries. We plan to specifically focus on the semantics and XML standards for vertical industries. This study will allow us to get a feel of state of standardization in major vertical industries and help identify the critical factors that engender or inhibit successful standardization of vertical industry languages and gain more insights into the reasons for the current state.

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OPEN E-BUSINESS STANDARD DEVELOPMENT AND ADOPTION: AN INTEGRATED PERSPECTIVE

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ABSTRACT

The recent growth of e-Business has called for open standards for inter-organizational electronic information sharing. Many firms form consortia to facilitate the development and adoption of open e-Business standards (OEBS). In this paper we study the consortium-based open e-Business standard development and adoption from an integrated perspective that recognizes the fact that firms have the choice of 1) joining the development of the standards; 2) being an adopter only and 3) not adopting at all. We consider the network effects and the interaction between the developer network and the adopter network. We find that the size of both the developer network and the adopter network is positively related to the network effect of the standards. The developer network's size is also positively related to the "insider" effect of being in the development. Furthermore, by increasing developer firms' "insider" effect and reducing the myopia for developers, the total value of the standards can be increased.

Keywords: Consortium-based standard development, standard adoption, network effects, economics of standardization.

INTORDUCTION

Standard development and adoption has critical implications on e-Business. Fuelled by penetration of the Internet in business operations, the growth of e-Business has transformed the way business is done between trading partners. Thanks to the highly dynamic formation of business relationships made possible by e-Business, firms have shifted their partnerships from a linear fashion, such as a supply chain, to value webs (Mathias and Kapur 2002) and enterprise networks (Zhao et al. 2002). The proliferation of e-Business technologies, especially the eXtended Markup Language (XML), has laid the foundation for firms to share information electronically with partners in the enterprise network. Such information sharing is the key to better interoperability, inter-firm coordination and collaboration, all of which are among the most important factors of e-Business. Yet, the lack of common open e-Business standards (OEBS), a specific set of IT standards for e-Business, has greatly hindered electronic information sharing among companies. The high developing cost due to the enormous scope of such standards, together with the uncertainty of adoption, has made it economically infeasible for the development to be done by any single firm. When multiple firms are involved in the development of any standard such as OEBS, the incentives have to be set carefully to induce optimal effort from participating firms, which is a necessary condition of wide adoption and the eventual success of the OEBS.

We refer to OEBS as the type of IT standards that facilitate Web-based business information sharing in an enterprise network, such as ebXML (the E-Business eXtensible Markup Language) (Marchal 2003) and RosettaNet standards (Greenemeier 2002). OEBS has some special characteristics that set it apart from traditional standards, which call for a different approach when it comes to developing the standards. First, firms involved in the development of the standards are the actual future adopters[1], in addition to the firms that adopt after the standards are developed. This is the case because adoption of e-Business is embraced by many firms as a strategy to survive and succeed in today's extremely competitive market, therefore the potential users of a set of e-Business standards have strong incentives to develop it themselves. By contrast, existing research on the economics of standards typically treat the creator and users of a standard as separate entities. In this setting, the standard developer first create a standard, then has to win the standard war (Shapiro and Varian 1999), i.e. to convince potential adopters why it is worth the cost and risk to adopt it, when other competing standards are also available. Second, the development and adoption of OEBS are extremely interactive. Yet to our knowledge, the previous economics of standards literature all take standards as exogenously developed (David 1985, Farrell 1996, Shapiro and Varian 1999). Third, as argued above, OEBS cannot be developed by a single firm. Thus it is not an option, but a requirement, that multiple firms collaborate in the development. Furthermore, the standard development process has to be perceived fair and neutral by the consortium's member firms and does not favor any firm(s) (Berners-Lee 2003)[2].

The e-Business standards of concern in this paper also differ from EDI, the Electronic Data Interchange. EDI mainly facilitates business-to-business communication on transactional data. By contrast, a set of e-Business standards cover many aspects of the business partnership, including shared business processes such as product development or joint inventory management between trading partners. Business process sharing requires that partnering firms maintain a close and active relationship with one another. It opens up new opportunities for firms to jointly improve their overall operations efficiency and even create new business opportunities. Furthermore, open e-Business standards that are adopted by a sufficient number of firms will enable them to establish business relationships on a real time basis in the highly dynamic enterprise network.

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[1] For example, Intel is a board member of RosettaNet, a non-profit consortium to develop a set of XML-based e-Business standards. Intel and all 90 of its trading partners in 17 countries use RosettaNet e-business standards (Greenemeier 2002). The Interactive Financial eXchange (ifxforum.org), a consortium to develop financial web services standard, is made up of banks, mortgage companies, financial services companies, etc. who want to use the standard in their business. The Open Travel Alliance (opentravel.org), a consortium for web services standards in the travel industry, has 124 member companies such as airlines (AA, United), car rental companies (Thrifty, Dollar) and hotel chains (Hyatt), who will be using the standards to share information between them.

2 It is not coincidental that standard-developing consortia, such as RosettaNet and OASIS (http://www.oasis-open.org), are the leading forces to define and promote OEBS. Farrell and Saloner (1996) show that committee-based standard setting, as is the case in these consortia, is more likely to achieve coordination than under a pure market mechanism.

In this paper, we propose an integrated framework to study OEBS by capturing both the development stage and the adoption stage, as well as the interactions between the two. We endogenize the formation of the two networks, i.e. firms choice of which network to join is modeled. Therefore, the size of the two networks is not known ex ante, but is an outcome of the model. Firms' decision of which network to join is determined by the reciprocity between the standard development and adoption. Through analyzing the equilibrium of an economic model, our goal is to answer the question: *in an open, neutral standard-setting consortium where participation in development and adoption is voluntary, what are the factors that drive the development and adoption?*

In the next section, we use RosettaNet as an example to highlight the issues in consortium-based standard development and adoption.

ROSETTANET: A CASE FOR CONSORTIUM-BASED E-BUSINESS STANDARD DEVELOPMENT

As mentioned earlier, RosettaNet is a non-profit standard setting organization in the hi-tech industry. Set up by 40 companies in1998 as a consortium to facilitate e-Business standard development and adoption, RosettaNet has grown rapidly to have more than 400 companies as its members. The hi-tech industry, known for its high growth rate, fast depreciation and complexity of products, was in dire need of efficient inter-firm communication and information sharing. The founding companies, recognizing the inefficiency, determined that an open e-Business standards, based on XML, would be the first step in removing the barriers of seamless communication between firms.

The e-Business standards developed by RosettaNet encompass many aspects of an e-Business trading partnership. It covers operations ranging from pre-sale inquiry to ordering to post-sale services. Semantically, the RosettaNet standards are made up of three major components: data dictionaries that provide common set of properties in business transactions much as words in a language, the RosettaNet Implementation Framework (RNIF) much as the grammar, and the Partner Interface Processes (PIPs) as the dialog. Each part is further decomposed into many modules. For example, there are seven clusters within PIPs: partner profile management, product information, order management, inventory management, marketing and support, service and support and manufacturing (RosettaNet 2003a). The standards not only apply to firms' internal operations but also inter-firm communications, such as PIPs, specifications for shared business processes in the relationship between two partners. Therefore, its development as well as adoption entails a high level of collaboration among the trading partners.

The enormous scope of the standards also calls for cooperation of multiple firms in the development. It is the collective effort of member firms that determines the quality of the resulting standards.

In RosettaNet, member firms can choose to participate in two levels, as a board member or a partner[3]. Being a board member entitles, and requires, the firm to devote personnel and financial resources to actively participate in the development of the standards, as well as implementing the standards within the company and with its trading partners (RosettaNet 2003b). A partner does not directly get involved in the standard development but can adopt the draft submitted by developers before it becomes part of the standards (RosettaNet 2003c).

[3] Although one can choose to participate as an Alliance partner, it is mainly for governmental, academic and non-profit organizations (RosettaNet 2003d).

Obviously a board member has more involvement thus more impact on the forthcoming standards. Nevertheless, the highly interactive development process, with communications within the developers (the board members) and the adopters (the board members and the partners) ensures a high quality for the resulting standards.

This bi-level membership structure also differs from traditional standard setting consortia that treat all members homogeneously. In the latter, the resulting equality of members' rights cannot address the different aspects and levels of interests, which typically leads to a much elongated development process. By contrast, the idea of the RosettaNet approach is to provide differentiated incentives to parties with various levels of valuation of the standards. Its goal is to induce maximal incentives from firms that place a high value on the upcoming standards by giving them more influence in shaping it, while giving the firms with a relatively lower but still significant value an opportunity of early adoption before a draft is incorporated into the standards.

ISSUES CONCERNING STANDARDIZATION PROCESSES OF OEBS

The above observations on RosettaNet highlight the research issues of OEBS development and adoption in a consortium context. The endogenous formation of the developer and adopter networks, as well as the interdependence between the standard development and adoption, are two critical and unique features of OEBS and they will influence firms' decisions as to how to participate in the consortium. In this paper, to analyze the dynamics of this process, we adopt the concept of enterprise networks (Zhao et al. 2002). In this setting, two enterprise networks form sequentially: the developer network and the adopter network. In the RosettaNet case, the board members form the developer network and the partners including all board members compose the adopter network. Both networks are a special case of the enterprise networks proposed by Zhao et al. (2002). Firms have to first decide which network to join. By joining a network, a firm becomes a part of a network and can have a “link” with any other firm in the same network, in the form of collaborating in the development or sharing the same standards in the adoption stage. If a firm chooses to join the developer network, it also needs to select a level of participation, i.e. how much effort to exert in the development.

On the one hand, the size of the adopter network and the resulting network externalities will affect the developer firms' business value of the standards. Previous research on network externalities (Katz and Shapiro 1985, Liebowitz and Margolis 1994) has shown that network externalities have critical strategic implications for standard adoption (Shapiro and Varian 1999, Kauffman et al. 2000). As a typical network technology, OEBS had positive and indirect network externalities among adopters. That is, the business value for an OEBS adopter increases with the number of firms within the adopter network. With more firms adopting the same OEBS, the fears of being locked in from small companies will be eased and with reduced switching costs, it is easier to locate new trading partners and collaborate dynamically. In addition, network externalities intensify the interdependence between the developer network and the adopter network. The size of the adopter network will determine the developers' payoff, which serves as a determining factor for firms' decision to join the developer network.

On the other hand, the developer network also has impacts on the adopter network formed later. The quality of the standards is an increasing function of the overall effort level in the developer network. It will influence firms' adoption decisions, which in turn determines the size of the adopter network. The collaborative development of OEBS requires coordination of efforts by multiple individual firms. This can be viewed as a collective action problem (Sandler 1992) as the outcome is a function of the collective action. Therefore, the resulting quality of OEBS will be determined by the aggregate effort of all developers. For an individual firm, its utility is dependent on the other firms' efforts. It is the standard setting consortium's task to coordinate and promote the collective actions between firms involved in establishing OEBS.

In the following section, we create a game theoretical model to analyze the standardization process of OEBS in a consortium setting. The model reflect our observations drawn from the RosettaNet case and incorporate the unique characteristics of OEBS we identify before. We take into account the network externalities among adopters and collective action problem within the developer network. Specifically, our model aims to answer the following research questions:
(1) What kind of companies will be likely candidates of leading developers and which are expected to be following adopters in an OEBS setting process?
(2) For firms that choose to be developers, how much effort will each firm invest in the process of standard development?
(3) How to induce firms' incentive to participate the standardization process of OEBS to maximize the total value of the standards?

THE MODEL

In this model, we assume there are *N* firms and a consortium is proposed to develop a new OEBS. Firms have three choices. They can voluntarily participate in the development of the standards, adopt them after they are developed or not adopt at all. A firm's participation in development will be viewed as a commitment of human and financial resources for development as well as a promise for future adoption.

The Model Description

The players in the game theoretical model are the *N* firms. The game is made up of three stages.

Stage 1: (Developer Network Formation) Firms simultaneously determine whether to participate in a joint standard setting effort. A developer network is formed by those determined to join.

Stage 2: (Standard Development) Firms in the developer network determine the optimal individual effort level to invest in the development. The standards are developed jointly, with the quality determined by the aggregated effort of all firms.

Stage 3: (Adoption) The remaining firms outside the developer network make their individual decision as to whether to adopt the new IT standards. The adopters enjoy the value of OEBS.

Note that by our definition, a developer always adopt the standards in Stage 3.

The business value of the standards for an adopter is the sum of the direct benefit from adopting OEBS, the network effect as a function of the number of total adopters and the quality of the standards as a function of the collective efforts from all developers.

In this model, the *N* players are all interested in a forthcoming OEBS. However, the players are heterogeneous in that the benefits they can derive from the standards, i.e. their valuation, are not the same. Without loss of generality, we assume that firm i's valuation of OEBS, q_i, has a uniform distribution between 0 and 1. The assumption of the uniform distribution is not critical in the model, which we will prove in the following section. The difference can result from firms' heterogeneity in size, sophistication in technology and product category. In general, firms with high valuation have incentives to participate the developer network because: (1) they can speed up the development/adoption process; (2) they can become insiders in shaping up the standards, which will further increase their payoff in the future. Firms with higher valuation on the standards tend to be more sophisticated e-Business wise and have stronger preference on the content of the standards as they are more likely to have a related practice in place.

In the developer network, firms determine their individual effort level e_i with cost $C(e_i)$. We assume that $C(e_i)$ is a convex function of e_i. Developers' direct benefit from the standards, once they are adopted, is dq_i, where $d > 1$ represents the benefit of being an "insider". As we indicate before, the quality of OEBS is a function of the collective effort $Q(\sum e_i)$, which is a strictly concave function of e_i. All adopters will incur the same adoption cost C_a. We use a linear function " $a * \text{proportion of adopters}$ " to represent the benefit from positive network externalities, where $0 < a < 1$.

The Equilibria and Their Implications

We use backward induction to compute the equilibria of the game and derive the following implications.

Recall that a firm's payoff function is:

1. If firm i is a non-adopter, $U_i = 0$.

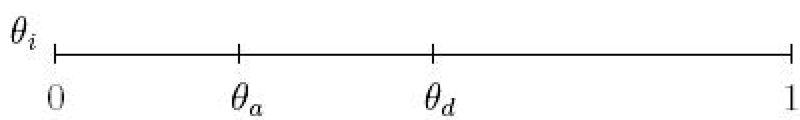
2. If firm i is a following adopter:

$$U_i = q_i + a * \text{proportion of adopters} + Q(\sum e_i) - C_a \qquad (1)$$

3. If firm i is a leading developer:

$$U_i = dq_i + a * \text{proportion of adopters} + Q(\sum e_i) - C(e_i) - C_a \qquad (2)$$

The utility function we use in the paper is a natural extension of the one proposed by Katz and Shapiro (1985). To simplify the computation, the externality function is a linear function of the proportion of adopters among the total *N* firms. From the payoff function, we can see that the firms with higher q_i tend to be more active in the OEBS setting game. In addition, we use q_i to represent individual firms and visualize the two enterprise networks in the following figure.



In the figure, q_d is the firm that is indifferent between being a developer or not, and q_a is the firm that is indifference between adopting and rejecting the new OEBS. Under the assumption of the uniform distribution, $1-q_d$ is the proportion of firms within the developer network, which is the line between q_d and 1 in the figure. Analogously, $1-q_a$ is the proportion of firms that belong to the adopter network. Moreover, we can easily relax the assumption of the uniform distribution based on the same approach. For any type of distributions, the size of the developer network is $1-F(q_d)$ and the size of the adopter network is $1-F(q_a)$, where $F(q_i)$ is the cumulative distribution function of q_i.

Step 1: The size of the adopter network

To calculate the size of the adopter network, we only need to find the value of the marginal adopter, q_a. Because he is indifferent between adopting and non-adopting, we have:

$$q_a + a*(1-q_a) + Q(\sum e_i) - C_a = 0$$

$$q_a = \frac{C_a - a - Q(\sum e_i)}{1-a} \qquad (3)$$

Therefore, the size of the adopter network is:

$$1-q_a = \frac{1+Q(\sum e_i) - C_a}{1-a} \qquad (4)$$

For OEBS to be successfully developed in such a joint setting, it must satisfy the condition that $1+Q(\sum e_i)-C_a \geq 0$. Otherwise, even the firm with highest valuation is not willing to develop the standards.

Proposition 1: The size of the adopter network is positively related with the network effect and the quality of the standards; however, it is negatively related with the adoption cost.

The size of the adopter network increases when the marginal adopter q_a can realize higher utility from the network effect and improved OEBS quality. The higher network effect means the larger value an additional user brings to the other adopters as well as to itself. Similarly, lower adoption costs encourage more lower end firms to implement OEBS, since they are relatively smaller in size and firm resources.

While this result may not be surprising, it is not entirely obvious. The model assumes simultaneous move of the potential adopters in the third stage. Intuitively, without possibility of coordination, non-participation could be an equilibrium outcome, if the potential adopters fear that adoption benefits from the network effect will not materialize without coordination.

Step 2: The optimal investment level in the developer network

Each firm in the adopter network determines their optimal effort level to maximize its payoff:

$$\max_{e_i} \; dq_\mathrm{i} + a(1-q_a) + Q(\textstyle\sum_{-i} e_j + e_i) - C_a - C(e_i)$$
$$= dq_\mathrm{i} + a\,\frac{1+Q(\sum_{-i} e_j + e_i) - C_a}{1-a} + Q(\textstyle\sum_{-i} e_j + e_i) - C_a - C(e_i)$$
$$= dq_\mathrm{i} + \frac{a}{1-a} - \frac{1}{1-a}C_a + \frac{1}{1-a}Q(\textstyle\sum_{-i} e_j + e_i) - C(e_i)$$

Note: $\sum_{-i} e_j = \sum_1^{N_d} e_i - e_i$, which is the sum of all the other developers' efforts.

From the first-order condition, we find that:

$$\frac{1}{1-a}Q'(\textstyle\sum_{-i} e_j + e_i) - C'(e_i) = 0 \qquad (5)$$

Under our assumption of the homogeneous cost function, i.e. the function form of $Q(.)$ and $C(.)$ are the same for all firms, the above equation represents the symmetry among firms. In equilibrium, all firms in the developer network will have the same optimal investment level. So we can further simplify the equation as $\sum_{-i} e_j + e_i = N(1-q_d)e_i$ to the following:

$$\frac{Q'(N(1-q_d)e^*)}{C'(e^*)} = \frac{1-a}{N(1-q_d)} \qquad (6)$$

The second order condition $\frac{1}{1-a}(N(1-q_d))^2 Q''(N(1-q_d)e) - C''(e) < 0$ ensures the maximization of the equation (6). Notice that the left hand side of equation (6) is a decreasing function of *e*.

Proposition 2.a: The optimal individual effort level of a developer firm is positively related with the network effect and the total number of firms interested in the forthcoming OEBS.

Higher network effect means that the size of the adopter network is more valuable for developer. In that case, developers are willing to increase the quality of OEBS so as to attract more adopters at the final stage. *Q* is an increasing function of the collective effort level. A large N implies more firms in the developer network and even slight change of the individual effort level will trigger a significant change in *Q*. So the total number of firms is aligned with firms' investment incentive.

Proposition 2.b: The individual valuation of the standards will not influence the optimal individual effort level.

We obtain a slightly counterintuitive result. Firms' heterogeneous valuation will determine their participation choices. However, once firms join the developer network, their objective is to maximize their business value, which is the same across firms under the symmetric assumption.

Step 3: The size of the developer network

We assume that *N* is large enough that any one firm dropping from the developer network does not influence its size. To find the size of the the developer network, we need to find the type of the firm that is indifferent between being an active developer and being a passive adopter.

$$dq_d + a*(1-q_a) + Q(N(1-q_d)e^*) - C_a - C(e^*) = q_d + a*(1-q_a) + Q(N(1-q_d)e^*) - C_a$$

which is equivalent of:

$$1-q_d = 1-\frac{1}{d-1}C(e^*) \qquad (7)$$

Because $C(e^*)$ is an increasing function of a, we obtain the following proposition:

Proposition 3.a: The size of the developer network is positively related with the insider effect and the network effect.

The developer's utility is an increasing function of the network effect and the insider effect. Under the higher a and d, the marginal developer's valuation q_d can be lower. The impacts of the network effect have been discussed before. And the insider effect is a key incentive component for developers. If firms can influence the developer process and let the forthcoming OEBS match their individual interests, they will have incentive to participate the developer network despite the costs incurred. In addition, from equation (6) we obtain that the increased insider effect will not only increase the size of the developer network, but also will increase the optimal investment level at stage 2.

Let e^{**} denote the myopic optimal investment level, when firms only consider the network effect within the developer network at step 2.

$$\begin{aligned}
&\max_{e_i}\; dq_i + a(1-q_d) + Q(N(1-q_d)e) - C_a - C(e) \\
&= dq_i + a\left(1-\frac{1}{d-1}C(e)\right) + Q(N(1-q_d)e) - C_a - C(e) \\
&= dq_i + a - C_a + Q(N(1-q_d)e) - \frac{a+d-1}{d-1}C(e)
\end{aligned}$$

The first order condition is:

$$\frac{Q'(N(1-q_d)e^{**})}{C'(e^{**})} = \frac{a+d-1}{d-1}\frac{1}{N(1-q_d)} \qquad (8)$$

Because that $\frac{a+d-1}{d-1} > 1-a$, we obtain that $e^{**} < e^*$.

Proposition 3.b: If the firms in the developer network are myopic, the optimal effort level will be lower.

If developers myopically expect that the potential adopters are just current members of the developer network, they will underestimate the value from positive network externalities realized at the final stage. That impact parallels a lower network effect. So similar to Proposition 2.a, firms' incentive to invest will be lower. To increase firms' motivation, the consortiums should educate the firms on the long-term value of standards, so they do not act myopically.

DISCUSSION AND CONTRIBUTION OF THE MODEL

The standard-developing consortium, founded by multiple firms, is an entity with its own agenda and policies. Its goal is to maximize the total value of the standards to be developed brought to its member firms, which is the sum of all the firms' payoffs. Note that each firm has the freedom to choose which network to participate in, or not to join the consortium at all, before the development starts, therefore the formation of the networks is endogenous in our setup. Suppose we denote the developer network as *D* and the pure adopter network as *A*, the consortium's objective function can be derived as follows:

$$\max \sum_{j\in A} U_a(j) + \sum_{j\in D} U_d(j)$$
$$= \max \int_{q_a}^{q_d} [q_j + a(1-q_a) - Q(\sum e) - C_a] dq_j + \int_{q_d}^{1} [dq_j + a(1-q_a) - Q(\sum e) - C_a - C(e)] dq_j$$
$$= \frac{q_d^2 - q_a^2}{2} + \frac{d(1-q_d^2)}{2} + a(1-q_a^2) + (1-q_a)Q(\sum e) - (1-q_a)C_a - (1-q_d)C(e) \qquad (9)$$

If we know the value of the "insider effect", d , the network externalities, a , the functional form of $Q(.)$ and $C(.)$, the objective is a quadruple function of firms' efforts, e, as both q_a and q_d are functions of e. One can solve for the optimal e_c^* that maximizes the consortium's objective.

The same can be applied to any individual developer firm, as we have done. The individual developer i's objective function is:

$$U_d(i) = dq_i + a*(1-q_a) + Q(\sum e) - C_a - C(e) \qquad (10)$$

Again, if the value of the "insider effect", d , the network externalities, a and the functional form of $Q(.)$ and $C(.)$ are known, through backward induction, we can find the optimal e_I^* that maximizes this individual firm's payoff. It is usually not the e that the consortium prefers most, i.e. it might be that $e_C^* \neq e_I^*$. The reason is that the overall benefits are closely related with the size of the adopter network and the developer network, and the consortium wants to induce the investment level that trigger the right network size, which is not an issue considered by individual developers. Since the effort is either non-observable by the consortium or non-contractible, the consortium cannot force a firm to exert any given effort level if that does not coincide with the firm's preference. The consortium's problem, then, is how to change the conditions it can control so as to reduce the gap between overall value resulting from firms' optimal effort and the optimal overall value. The consortium, for example, can change the "insider effect", d , by giving developing firms more freedom and control in shaping the standards.

Based upon our model, we can conceptually show the difference between the individual optimal investment level and the consortium optimal investment level.

Our setup assumes that there are two networks in the consortium, the developer network and the adopter network. Since we also assume that developers will always adopt, the former is a subset of the latter[4]. This assumption reflects the fact that a company is willing to become a leading developer by incurring addition costs only if, ex ante, its expected payoff is higher than being a following adopter. Furthermore, adopting at the adoption stage is a sub-game perfect strategy for the developer firm, as it will always find adopting a dominant strategy when it comes to the adoption stage--otherwise its payoff is negative.

The most unique and desirable characteristic of our setup is the endogenous formation of the two networks. Without it, the problem can be viewed as a classic agency problem, with the consortium being the principal and firms in the two sub networks being agents. The firms maximize their own objectives, which may result in a solution different from the overall optimal from the consortium's perspective. In reality, however, the agency approach is inapplicable as the networks are not fixed ex ante but formed voluntarily by the firms. The coupling of the payoffs of the two groups, due to the quality of the standards as a function of developer efforts, complicates firms' decision as to which network to join. Our model, by incorporating the endogenous strategic formation of the two networks, better captures the reality as firms have to weigh the tradeoff and choose an action before the development begins. This phenomenon is very important in consortium-based IT standard setting efforts as firms always look to find the best form of engagement in these initiatives[5].

SUMMARY AND FUTURE EXTENSION

OEBS, being important emerging IT standards, have strong interaction between the development process and the adoption process. The unique characteristics of OEBS make previous research frameworks inapplicable. Our three-stage game theoretic model provides an integrated perspective to study the new IS phenomenon.

During the standardization process of OEBS, three types of firms will emerge in a market: active developers, following adopters, and non-adopters. Heterogeneous valuation of individual firms, which can be a function of their size, sophistication in IT and scale of suppliers/business clients, determines firms' participation decisions. The marginal adopter and the marginal developer are identified so that we can predict the category each firm belongs to. Firms with a valuation higher than the marginal developer value the benefits of being an “insider” more than others and find it worthwhile to devote financial and human capital to participate in the development. Firms with a relatively lower valuation of the standards, which is between that of the marginal developer and the marginal adopter, will choose to be adopters only. Firms with yet lower valuation than the marginal adopter stay out of the adopter network altogether. In addition, our propositions analyze the critical factors, such as the network effect, that will influence the number of firms within each category.

[4] The pure adopter network, as appeared before, is the set of adopters that are not developers. The adopter network, therefore, is made up of the developer network and the pure adopter network.

[5] Chen (2003) reports that at GM, “four people work full-time deciding what standards are important to the company and what kind of participation in standards groups is appropriate.”

Through backward induction, the optimal investment level that maximizes individual developers' business value is calculated. Under the symmetric assumption, the optimal investment levels within the developer network are homogenous and are not affected by individual valuations.

Successful OEBS should be able to maximize the collective benefits of all adopters. Our model indicates that the increased optimal investment level at the second stage will improve the quality of OEBS as well as enlarge the size of the adopter network. So the incentive mechanism is a critical issue during the voluntary collective development. Our research have strategic implications are generated to achieve successful consortia formed in the OEBS setting, such as RosettaNet. The first is to clarify and increase the “insider” effect. When the firms are convinced about their privilege as insiders in the developer network, they are more willing to put effort in the collective action. This addresses the issue of coordination failure often encountered in a setting with high network externalities. To attract more firms to the consortium, the organizers of the consortium should ex ante clarify the rights and potential benefits that members can enjoy. In the RosettaNet case, board members have more power to design standards that are consistent with their business need. This is done by dividing the standards into fine, easier-to-manage and relatively independent modules so the number of developers on each module is very small so as to give firms more freedom thus more “insider” benefits. The second is trying to avoid “myopia” of the developers. When firms realize that the benefits will come from future adopters other than existing members in the current developer network, firms will have a higher optimal effort level at the development stage, which is socially beneficial. The appropriate estimation of the future network impacts should be shared by all members within the developer network, which is part of the responsibilities of the consortium.

Our framework highlights several interesting properties of OEBS and offers managerial implications to better manage strategies in the standard setting. Future study can be extended to the asymmetric and private information game.

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WHY FIRMS ADOPT OPEN SOURCE PLATFORMS: A GROUNDED THEORY OF INNOVATION AND STANDARDS ADOPTION

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ABSTRACT

There is a rich stream of research that studies technology adoption by individuals and organizations (Rogers, 1962; Tornatzky and Fleischer, 1990; Cooper & Zmud, 1990). This research considers factors such as the nature of the technology, the organizational and environmental context in which adoption decisions are made, and the processes by which users adopt and implement new technologies. Research on open source software has focused mainly on the motivations of open source programmers and the organization of open source projects (Kogut & Metiu, 2001; Lerner and Tirole, 2002; Benkler, 2002). Some researchers portray open source as an extension of the earlier open systems movement (West and Dedrick, 2001). While there has been some research on open-systems software adoption by corporate MIS organizations (Chau and Tam, 1997), the issue of open source adoption has received little attention. We use a series of interviews with MIS managers to develop a grounded theory of open source platform adoption. We then place our findings within the contexts of diffusion of innovation and economics of standards theories.

Keywords: Open source; standards adoption; computing platforms; grounded theory; diffusion of innovation; economics of standards; MIS organizations.

INTRODUCTION

For technology users, standards adoption decisions have important consequences. Adopting a winning standard enables users to benefit from a sustained stream of producer investment in the technology and access to a large supply of complementary assets. For instance, users of Microsoft Windows benefit from R&D in computer hardware and software on the Windows platform, as well as access to the immense library of Windows applications. By contrast, adopters of a losing standard face the choice of having to switch to the winning standard or living with a much smaller supply of complementary assets and smaller levels of producer investment (David, 1987; Farrell and Saloner, 1985; Katz and Shapiro, 1986).

While standards theories imply that user adoption decisions are critical to standards outcomes, most researchers treat user choice as a black box, in which exogenous variables (complementary assets, first-mover advantage, vendor strategy) go in and individual standards decisions come out. Over time, the economics of positive network externalities, switching costs, and fear of being orphaned on a losing standard can change users' calculations in ways that reinforce or weaken commitment to a standard. But because the actual decision process is a black box, standards theory does not consider the relative importance of its own variables in determining user decisions, nor how they are moderated by characteristics of adopters and the environment in which they adopt.

By contrast, diffusion of innovation (DOI) theories of innovation (e.g., Rogers, 1983; Tornatzky and Klein, 1982; Tornatzky and Fleischer, 1990; Davis, 1989) offer rich explanations of how new innovations are adopted, and how adoption decisions are affected by perceptions of the technology itself as well as the character of the adopters (individuals or organizations) and their environment. Alas, this literature looks almost exclusively at adoption of new innovations and pays little attention to the process of choosing among different standards within a given technology.

We expect that actual standards decisions will be influenced by factors posited by both literatures, as argued by Fichman and Kemerer (1993), and that a richer framework for understanding these decisions can be developed through a qualitative study of a specific standards adoption case. Linux is an especially interesting case because it has succeeded as a newcomer in competition with powerful existing standards, Unix and Windows, and because it is an open source standard not sponsored by any company or formal organization. Using a grounded theory approach, we study the Linux adoption decisions of MIS departments in order to answer the following questions:

- What are the major factors influencing the adoption of Linux by information systems departments?
- To what extent do these factors correspond to existing theories of standards adoption or innovation diffusion?
- In what ways does the open source nature of Linux influence the adoption decision?

We conclude that the major factors are cost, perceived reliability, compatibility with existing technologies in use, presence of boundary spanners in the organization, availability of complementary assets, and fear of being “orphaned” by a losing standard. The first four of these are consistent with innovation diffusion theory, while the last two correspond to standards theory.

THEORY

Diffusion of innovation theory

The theoretical foundation for most technology adoption research is found in the diffusion of innovation literature (Tornatzky and Klein, 1982; Rogers, 1983) which studies the process of technology diffusion and the factors influencing technology adoption decisions. Tornatzky and Fleischer (1982: 32) present a process view that moves from research and development to deployment, adoption, implementation and routinization. Research, development and deployment are carried out by technology developers (or producers), while adoption, implementation and routinization are carried out by technology users. Rogers (1983) focuses on the adoption process itself, classifying users according to the point in time at which they adopt, from innovators to early adopters, early majority, late majority and laggards.

A major stream in diffusion of innovation literature theorizes about the characteristics of innovations that influence whether, and at what rate, such innovations are adopted. Rogers lists five technology characteristics that influence the adoption decision: relative advantage, compatibility, complexity, trialability, and observability. In a meta-analysis of prior studies, Tornatzky and Klein (1982) concluded that three of these variables were consistently linked to technology adoption: *compatibility, relative advantage,* and *complexity*. Compatibility with existing technologies and relative advantage over current technologies were positively related to adoption, while technological complexity was negatively related to adoption.

Organizational Adoption of Innovations

Much of the technology diffusion literature focuses on the adoption decisions of individuals, either for themselves or for their employers. But for organizations, many technologies are "too big and complex to be grasped by a single person's cognitive power—or usually, to be acquired or deployed within the discretionary authority of any single organizational participant" (Tornatzky and Fleischer, 1990: 133). Thus, a more robust framework is needed to study organizational adoption.

An influential framework for understanding technology adoption in an organizational context has been developed by DePietro, Wiarda and Fleischer (1990).[1] Their model defines a "context for change" consisting of three elements:

- *Technology.* The model subsumes the five innovation attributes that Rogers (1983) argues influence the likelihood of adoption. The authors also note that radical innovations increase the relative advantage but reduce the compatibility of the innovation.

- *Organization.* Adoption propensity is influenced by formal and informal intra-organizational mechanisms for communication and control. The resources and innovativeness of the organization also play a role.

- *Environment.* Consistent with Porter (1980), a firm's strategic technology decisions will depend in part on industry characteristics such as rivalry, relations with buyers and suppliers, as well as the stages of the industry life cycle (DePietro et al, 169-171). Organizational adoption of new technologies depends on having the prerequisite skills for effective deployment, so as Attewell (1992) found, the availability of external skills (such as through integrators or consultants) is essential for adoption by some organizations.

These three elements (cited in subsequent research via the anagram "TOE") are posited to interact with each other and to influence technology adoption decisions (De Pietro et al, 1990: 153). In fact, the TOE framework as originally presented, and later adapted in IT adoption studies, is little more than a taxonomy for categorizing variables, and does not represent an integrated conceptual framework or a well-developed theory. On the other hand, it is a useful analytical tool for distinguishing between inherent qualities of an innovation itself and the motivations, capabilities, and broader environmental context of adopting organizations.

Adoption of Computing Platforms

There has been considerable research regarding organizational adoption of information systems, including studies of MRP (Cooper and Zmud, 1990), EDI (Iacovou, et al. 1995; Kuan and Chau, 2001; Chwelos, 2001), and e-commerce (Zhu et al, 2002). However, despite the importance of standards in the IT industry, the role of standards in adoption decisions has rarely been considered.

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[1] The work of DePietro, Wiarda and Fleischer in developing the TOE framework is often cited as that of Tornatzky and Fleischer (1990), but we hereafter we credit the actual chapter authors.

One of the exception is Chau and Tam (1997), who conducted in-person surveys of organizations considering adoption of Unix-based open systems. Studying various technology, organizational and environmental factors, they found that two factors (barriers to adoption and satisfaction with existing systems) were statistically significant (and negatively correlated) to the open systems adoption decision.

Economics of standards

When considering standards adoption, such barriers to adoption have previously been classified in economics research under the category of "switching costs" — part of a much larger body of research on the economics of standards. Among the first to consider such costs was von Weizsäcker (1984), who modeled how users would consider the net present value of anticipated future switching costs. Klemperer (1987) classified switching costs into three categories: transitory transaction costs, learning costs (e.g. IT worker skills), and contractual costs (e.g. contract termination penalties) deliberately introduced by vendors to build barriers to subsequent competitors.

The other hypothesized factor in the economics of standards adoption is the role of positive network effects that accrue to all adopters of a popular standard. Katz & Shapiro (1985) showed how an indirect network effect — the availability of software to support a given hardware standard — would make the more popular standard more attractive to future adopters. Such benefits may be captured by subsequent consumers, or the producer of the good, or spill over to society at large.[2]

Prior organizational adoption studies have not considered the interrelationship of an architecture of computing standards to form a computer "platform." For a general-purpose computer system, such architectural standards typically encompass a processor, operating system (OS), and associated peripherals. Some have also extended the concept of a "platform" to include multiple layers of software, so that applications can be built upon a "middleware" tool such as Java or a database (Morris and Ferguson, 1993; Bresnahan and Greenstein, 1999; West and Dedrick, 2000).

Control of the value of the platform rests with the control of complementary assets, which for a personal computer means the programming interfaces for pre-packaged application software (West and Dedrick, 2000). Historically, vertically integrated computer companies controlled all layers of the platform, but with Unix (and later Linux) firms outsourced provision of the operating system, while "Wintel" PC makers delegated control of the entire platform to suppliers (West 2003).

Among the few to combine standards theory with diffusion of innovation theory were Fichman and Kemerer (1993), who analyze three cases of adoption of software development tools in the light of both theories. They employ five innovation attributes (relative advantage, complexity, compatibility, trialability and observability) from Rogers (1983) and four factors from standards theory (prior technology 'drag', investment irreversibility, sponsorship, and expections) to analyze when innovations in software development are likely to be widely adopted. They argue that innovations are most likely to become dominant technologies when they score highly on both diffusion of innovation and economics of standards criteria.

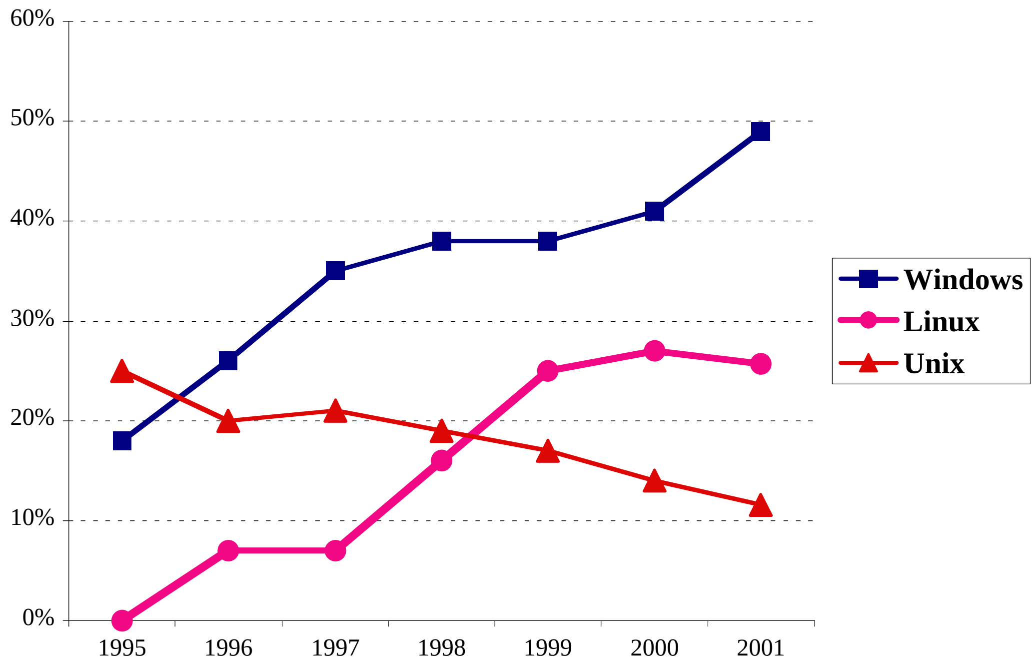
[2] Liebowitz and Margolis (1994 and 1995) argue that theories of switching costs and path dependency are not supported by empirical evidence.

Open-source Software Adoption

An interesting case of technology standards selection involves the choice between proprietary and open source software. Open source software has gained a great deal of attention recently, as applications such as Apache, Perl and Sendmail have gained widespread adoption, in particular for Internet-based applications.

The best-known open source software is Linux, a Unix-compatible operating system created in the early 1990s by Finnish programmer Linus Torvalds and developed by a large community of programmers around the world. Linux has been the fastest growing operating system in recent years, and has surpassed the various proprietary versions of Unix (e.g., Sun Solaris, HP Unix, and IBM's AIX) in the market for server operating systems (Figure 1).

Figure 1: Global server market share, 1995-2001



Source: International Data Corp., as reported by West & Dedrick (2001): IDC (2002)

When considering open source-based platforms, there are at least two crucial differences when compared to more traditionally proprietary platforms such as those offered by Microsoft, IBM or Sun. First, the R&D, sales and support for the proprietary solution is the responsibility of a well-defined profit-making enterprise that receives income from its products, while the open source solution uses collaborative R&D and support in cooperation with firms whose role is far less central or defined. Second, the fundamental difference of open source software is that the source code is widely disseminated to all and thus adopting organizations have the opportunity (whether valued or not) to modify the software to suit their own needs.

Most of the prior research on open source software has focused on the motivation and organization of the programmers providing the free R&D (Markus et al., 2000; Kogut & Metiu, 2001; Lerner and Tirole, 2002; O'Mahony 2003). A few have examined the role of for profit-firms to act as change agents supporting the adoption of open source products, marking this as an extension of the earlier open systems movement (West and Dedrick, 2001; West, 2003).

Comparatively little work has been done to see how the organizational adoption of open source differs from that of other technologies. An exception is Franke and von Hippel (2003), who surveyed the motivations of webmasters who had adopted the Apache open source web server application, showing that the more skilled users who modified the source code were most satisfied with their decision.

Research Design

Our study examines the adoption of platforms based on open source operating systems such as Linux and FreeBSD (hereafter "open source platforms"). The choice of a computer platform is far more complex than that for a single application package. The platform decision involves the mutually-dependent choice of both hardware (e.g. Sun Fire vs. IBM R/6000 vs. Dell PowerEdge) and operating system (Windows, proprietary Unix, Linux, FreeBSD), since not all operating systems are available with all hardware systems (Table 1). That platform decision both constrains and is constrained by the choice of application software, hardware peripherals, and related skills and services. As such, the decision to adopt a new platform has broad implications for the overall technology direction of an organization.

Table 1: Representative server platforms

	Proprietary		Open source
Platform	Sun	"Wintel"*	"Lintel"*
System			
Name	Sun Fire	*PC-compatible*	*PC-compatible*
Producer	Sun	*commodity†*	*commodity†*
Operating System			
Name	Solaris	Windows 2000	Linux/BSD
Producer	Sun	Microsoft	*open source*
APIs	Unix	Windows	Unix
CPU			
Name	UltraSparc	Pentium	Pentium
Producer	Sun	Intel§	Intel§

* "Wintel" = Windows/Intel; "Lintel" = Linux/Intel
† Available from both branded (Dell, HP, IBM) and unbranded suppliers
§ Available from competing suppliers

METHODS

Because the organizational adoption of computer platform standards and open source software are not well understood, we have chosen to use a theory-building approach grounded in the context of rich data. This draws on established procedures for generating theory from qualitative data (Glaser and Strauss, 1967), as well as management studies that employ the inductive method to draw theory from a set of case studies (Harris and Sutton, 1986; Bourgeois and Eisenhardt, 1988; Eisenhardt, 1989). Such rich data is an accepted way of capturing the complexity of an organizational IT adoption decision (e.g. Orlikowski, 1993).

We gathered as much context as possible on a wide range of organizations through a series of depth interviews conducted from November 2002 through August 2003. Such an approach naturally complements the TOE framework, in that we can identify which technological, organizational or environmental factors are salient for each firm's adoption decision. Finally, because non-adoption is comparatively under-studied (e.g. Rogers 1995: 100) we sought out a wide range of possible outcomes — complete adoption, partial adoption and non-adoption — for open source platforms.

The adoption decision being studied might apply to an entire organization or one of its divisions. The actual decision could be made by the MIS department acting autonomously, or in consultation with client departments or top management. We interviewed the CIO or other senior MIS executive, and — where possible — another person in the MIS department who is closer to the actual technical issues raised, such as a system administrator. We hoped that by doing so we could develop a more complete picture, incorporating the view of both top management and those "in the trenches."

We sought a stratified sample of organizations, segmented by size, task, and technological orientation. Our sample is summarized in Table 2. The primary data consisted of semistructured interviews based on a common protocol. Interviews were conducted either in person or by telephone, were tape recorded and partially transcribed, and typically lasted from 45 to 90 minutes. Basic organizational data was collected via questionnaire, with background data for companies compiled from standard sources such as Hoovers and Dun & Bradstreet. As needed, follow-up questions were asked by phone or e-mail.

Table 2: Characteristics of sample firms

Name	Business	Org. (unit) Size†	Primary Platform	OSS Platform Adoption	Inform-ants
FastFood	Restaurant chain	200,000	Mixed	None	1
Semico	Semiconductor design	2,500	Mixed	Limited; evaluating further use	2
ISP	Internet service provider	11	Linux	Since founding	1
NewMedia	Content provider	35	Unix	Partial transition	2
North U	Public university professional school	114,000 (325)	Mixed	Replacing Unix, but mainly Windows	2
South U	Public university professional school	114,000 (300)	Windows	Abandoned previous limited use	2
Biotech	Pharmaceuticals	1,000	Unix	Internet and database applications	2
Bio Branch	Pharmaceuticals	560 (150)	Linux	Predominant	1
E-data	Online database	2,700 (1,500)	Linux	Phasing out Unix	1
Beach Co.	Rec. equipment	80	Windows	Website only	1

† Size of parent organization (unit) in number of employees

Outcome: Server Platform Choice

In studying organizational adoption of open source standards, we chose to focus on the selection of platform standards for computer servers for two reasons.

First, at the time of our study there was a wide range of economically viable server platforms. Unlike on the desktop — where one platform has held more than 90% share since 1997, for servers there were three major categories — Unix servers using proprietary RISC-based processors, servers based on Microsoft Windows and commodity Intel-compatible commodity hardware ("Wintel"), and those based on open source operating systems using the same commodity hardware — the most popular being Linux on Intel ("Lintel"). The platforms shown earlier in Figure 2 are representative of those used in our sample, and their patterns were generally consistent with overall industry trends for the three major platforms.

Second, the server market is one in which open source platforms have had notable success, as measured both by market share and public notice. In 1999, the number of Linux servers passed the number of Unix servers (West & Dedrick 2001) From 1999 to 2002, IDC estimated that annual shipments of new Linux servers increased from 173,000 to 598,000, while revenue from their sales increased from $749 million to $2 billion (Shankland, 2003). Coming in direct competition with Microsoft, Sun, IBM and HP, this success has captured a good deal of attention in both the trade and business press.

RESULTS

An analysis of the interviews completed shows some consistent patterns. These are summarized in Table 3, and further explained below.

In looking at organizational decisions on technology adoption, we found that a distinction needs to be made between the adoption of an "innovation" (as defined by Rogers 1995 or Wolfe et al. 1990) and the adoption of a different variant of the same fundamental technology.

In Table 3, we've attempted to subdivide characteristics of open source server platforms into those that are inherent to most or all open source packages (and thus characteristic of the open source "innovation") and those that are characteristic of specific open source platform standards such as Lintel, which we classify as "products". We classified the following adoption factors as tied to the open source innovation *per se:*

- willingness to take risks on a new, unproven technology
- need for organizational slack to evaluate the new technology and to self-support unsponsored technologies
- tendency of open source software to be inexpensive if not free
- inherent trialability of "free" software distributed on the Internet
- availability of external sources of support and expertise

The other factors are identified as influencing the selection of the specific platform, in this case Lintel, and are not inherent characteristics of open source software.

Platform Decision Process

While server platform decisions have important implications for the IS department, they are likely to be easier in some ways than other technology choices — because the server decision is only loosely coupled to other decisions in the organization. As such, a decision to adopt a new server platform would be classified as a Type I innovation under Swanson's (1994) taxonomy, in that it is restricted to the functional IS core.

Unlike a "desktop" adoption of Linux, the choice of the server platform had little direct impact on the day-to-day computing experience of ordinary workers. As the CIO of Biotech stated, users "don't know, don't care." If the company or division had certain application needs, switching the platform "underneath" the application would be transparent to end-users. The size of the hardware and labor investment to install a new platform made the choice of a new platform an infrequent decision.

Table 3: Factors impacting adoption of open source platforms

Context	**Factor**	**Attribute of**	**Relevant theoretical concept**		**Im-pact ***	**Explanation**
			DOI	Standards		
Technology	Hardware cost	Product	Relative advantage		+	Lintel runs on commodity hardware
	Software cost	Innovation	Relative advantage		+	OSS operating systems are "free"
	Reliability	Product	Relative advantage		+/-	Varying perceptions of OSS platform reliability
	Availability of 3rd party apps	Product	Compatibility	Network effects	+	Prerequisite to adoption, depends on platform popularity
	Portability of own apps	Product	Compatibility	Switching costs	+/0	Increases adoption where such apps exist
	Skills of existing IT workers	Product	Compatibility	Switching costs	+/-	Increases adoption if and only if existing skills are compatible
	Fit to task	Product	Compatibility		+/0	Increases adoption for certain tasks
	Difficulty in administra-tion	Product	Complexity		-	Perceived complexity decreases adoption
	Ease of ex-perimenting	Innovation	Trialability		+	Reduces risk
Organization	IT capital budget	Innovation	Slack		-	Large budgets allow choice of more expensive options
	IT staff time	Innovation	Slack		+	Slack required to evaluate new technologies
	Innovative-ness of IT org.	Innovation	Innovative-ness		+	More innovative firms take more risks, want to be "cutting edge"
	Worker experience with new platform	Product	Boundary spanning		+	Linux knowledge that workers bring to organization prior to adoption
Environment	Industry maturity	Innovation	Industry life cycle		-	Infant industries not committed to old ways
	Availability of skilled IT workers	Product	Support infrastructure	Network effects	+	Availability essential to adoption, more likely with popular platforms
	Availability of external support services	Innovation	Support infrastructure	Sponsorshi p	+	Support needed to run in critical environments and to reassure management
	Platform long-term viability	Product		"Angry orphan" (switching costs)	+	Organizations avoid (re)investment in technologies that may become unsupported

*Legend:
+ increases propensity for adopting open source platform
- decreases propensity for adopting open source platform
0 has no effect

Also, the wide acceptance of standard Internet communications protocols across all server platforms reduced the potential incompatibility problems of having multiple server platforms. A given application might have a path dependency — as when a company has adopted Microsoft's IIS web server and is unwilling to pay the switching costs to Apache. But in most cases, the adoption of a particular server platform for one use did not preclude the ability to choose from several available platforms for other uses. In fact, some of the organizations studied were operating both proprietary and open source server platforms for different functions.

The decision to adopt (or switch) platforms corresponded to three cases:

- new uses – of which the most common reason for adopting Linux is Internet infrastructure, used by seven of the 10 companies. Others used Linux for file or print servers, and in one case (Biotech) for databases and a scientific application.
- hardware retirement – for an existing use, the current hardware is "orphaned" (aka "end of life") or the cost of keeping it running was prohibitive (in the case of Semico).
- hardware expansion – additional capacity was being added to an existing use (as in the case of E-data)

Finally, we want to emphasize the salience of the platform decision, involving operating system, processor and the overall computer system. Studies of platform competition generally emphasize the highest level of the system architecture; this level is crucial because the application programming interfaces (APIs) control access to complementary assets such as application software (Bresnahan and Greenstein, 1999; West and Dedrick, 2000). The salience of the related issues of OS, API and application compatibility in platform was certainly evident in our sample.

At the same time, the hardware component of the platform was also important. So we saw three patterns — organizations that chose the operating system first,[3] those that chose the hardware first, and those that selected a platform based on the availability (or vendor certification) of a key third party application such as Oracle or SAP.

Technology Factors

Several characteristics of Linux were consistently mentioned as influencing the adoption decision. Consistent with Rogers (1983) and Tornatzky and Klein (1982), these included relative advantage, compatibility, complexity and trialability.

Relative advantage

The relative advantage of Linux compared to proprietary operating systems is perceived by IS departments almost entirely in terms of cost and reliability.

Cost. The cost advantage of Linux consists of two factors—hardware and software cost. For the Lintel platform, the use of commodity PC hardware gives it a cost advantage over proprietary RISC-based Unix systems, but not over Wintel servers which run on the same Intel hardware. Six of the ten companies interviewed mentioned hardware cost as an important relative advantage of Linux.

[3] For the various Unix-compatible operating systems (Solaris, HP-UX, AIX, Linux, FreeBSD), in some cases firms had an *a priori* preference among the operating systems, but in other cases the firm selected "Unix" and then selected the hardware which constrained the selection of the specific flavor within the Unix family.

Some specifically mentioned the importance of multiple suppliers. FastFood described Linux as

> a platform neutral decision, so that if the major vendors—Sun, HP, IBM—all support Linux, I don't care what kind of servers I have, I can go with what fits my price point…We get a lot of the benefit on our desktop and laptop environment with Windows. We can go to Compaq, HP or IBM and play them off on each other and get the best prices.

The second advantage is software cost. Linux can be downloaded for free, making it cheaper than either a proprietary Unix OS or Windows.[4] Upgrades are also free, so there is no ongoing cost to stay with the latest version of Linux, unlike Unix or Windows. Perhaps surprisingly, only three of the ten companies stated that the cost of software was a significant factor in their decision whether to adopt Linux, while one (Semico) stated that the cost of software licenses was not high enough to be a factor. Only South U explicitly included the evaluation labor and human switching costs in the adoption cost, although all of our sample knew such costs existed. Of course, the evaluation and retraining costs would vary by organization, depending largely on the existing skills of its IT workers.

Reliability was another often cited factor, but one in which interviewees had more mixed views. Lintel platforms were perceived as more reliable than Wintel by six respondents, but generally considered less reliable than proprietary Unix platforms. Several organizations were unwilling to switch mission critical applications such as Oracle or SAP to Linux without convincing evidence that the Lintel platform reliability matched that of proprietary Unix systems. Two informants said they would enjoy little cost advantage from such a switch, because the Oracle license cost ($40,000 list per CPU) was the same between Lintel and RISC-based Unix servers.

Compatibility

The decision to adopt open source platforms appears to be greatly influenced by the compatibility of the new technology with current technologies, skills and tasks.

Technologies: Compatibility with current applications is a major concern in the adoption decision. All of the firms mentioned this issue. For most, the issue was running third party applications. For ISP, the only question was whether Linux would run Apache web server, which it did at the time of ISP's founding in 1996. For Semico, the current issue is SAP's support of Linux, which is partial at this time (some modules are certified). For FastFood, the lack of Linux support by PeopleSoft and SeeBeyond applications was a barrier to adoption. For NewMedia, the critical application is a proprietary media delivery application, and the issue was the cost and difficulty of porting that application to Linux. Biotech has adopted Linux for several applications, but has not moved to Linux for critical applications that are used for drug validation, as the relevant industry organization has yet to accept Linux as a platform for such applications.

The importance of compatibility with applications is consistent with the arguments in standards theory about the importance of complementary assets (Farrell and Saloner, 1985; Katz and Shapiro, 1986). However, in this case it is not the size of the overall pool of complementary

[4] The increasing price of some Linux distributions (specifically Red Hat Advanced Server) eliminates this cost advantage, leaving open the question as to whether customers would pay for the distribution or move to a less expensive or inherently free (e.g. Debian) distribution. The role of price could be seen in North U and South U, who said that Linux did not have cost advantage because Microsoft's education discounts meant that its server products cost almost the same as Red Hat's products.

assets, but the availability of specific key applications, a finding more consistent with the conclusion of West (forthcoming) that for platform adoption, many users satisfice (require only a minimum number of applications) rather than always prefer the platform with the largest variety of applications.

Skills: Compatibility with current skills is another key issue, and one that involves a characteristic of the technology (its Unix roots), and the organization (the skill sets of the IT staff). Among organizations, we saw a definite polarization between organizations that primarily used Unix-based servers — so-called “Unix shops” — and those that were primarily Windows-based (“Microsoft shops”). In Tushman and Nadler’s (1986) terms, the transition to Linux is incremental for Unix shops where skills are easily transferable, but discontinuous for Microsoft shops that lack such skills.

Three of the companies (Semico, Biotech and NewMedia) were already heavy Unix users and stated that this made the shift to Linux more manageable if not trivial A fourth (ISP) selected Linux at the time of inception, largely due to the Unix background of the top technology worker (our informant).

By contrast, FastFood has a mix of mainframe, Unix and Windows servers, but is predominantly a Microsoft shop with Windows skills: the interviewee predicted this would be an obstacle to widespread adoption of Linux. Both FastFood and South U felt that it would be more difficult to find system administrators with the necessary skills to handle the more complex requirements of a Linux environment, while BeachCo was unwilling to pay the associated wages.

Task: For ISP, Linux fit the task of providing Internet service very well, as the task consists of supporting a simple set of applications such as providing POP services, serving up web pages and delivering e-mail. For Semico, the technology was considered appropriate for some tasks and not others, while for FastFood, it was not considered appropriate for any but the simpler tasks such as file or print serving For Bio Branch, Linux is compatible with the wide variety of scientific applications that are primarily developed for Unix platforms.

Trialability

The ability to try out Linux at a very low cost was frequently cited, because the software could be run on existing commodity hardware and could be downloaded for free from numerous websites. For organizational trials there was no evidence that the difference between “free” and a nominal cost had any direct impact on trialability. However, there appeared to be an indirect effect, as in several organizations a programmer first learned how to use Linux by casually trying it at home, and such programmer knowledge both reduced the perceived risk of open source adoption and steered the organization towards using Linux in their open source platform. This finding is consistent with Rogers (1983) and Eveland and Tornatzky (1990), who argue that technologies are more likely to be adopted if they can be tried and assimilated in small chunks over time.

Organizational Factors

Several organizational factors appear to influence the Linux adoption decision. These included the organization’s general stance toward IT innovation, the strategic importance of IT to the business, the presence of boundary spanners in the organization, and the nature of slack resources available.

IT Innovativeness. Each of the companies had some view of itself in terms of its approach to IT innovation. Semico’s CIO said his company is not an early leader, but a fast follower: “Once the tornado hits, we’ll be there.” ISP stated that his company was a leading edge adopter in

1996, when the whole ISP business was new and Linux was still little known in the mainstream IS world, but that the business was mature and they were no longer looking to be an innovator. This self-definition in terms of innovation orientation appears to be an important factor in terms of the timing of adoption, and also in terms of the kinds of cues that are relevant to the decision to adopt.

Centrality of IT. Another organizational factor that appears correlated to the willingness to adopt is the strategic importance of IT to the firm's business. For ISP and NewMedia, IT is at the core of the business strategy and accounts for a large share of the firm's cost structure. As such, any strategic advantage gained is more important, and a decline in IT costs have a greater impact. For Semico, IT plays an important supporting role in strategic areas such as product design and supply chain management, but IT is not a source of strategic advantage. Therefore, the adoption of Linux is being considered mainly in terms of potential cost savings in the IT function. For FastFood, IT is even less central, and the potential advantages of open source are seen as intriguing, but not anything that requires immediate action. These findings are consistent with Eveland and Tornatzky (1990), who argue that firms that are more dependent on technology for competitive advantage will be more open to new technologies and have the capability to absorb them, and Swanson's (1994) proposition that adoption of IT innovations is more likely when IT is strategic to the business.

Boundary spanners. In several cases (ISP, Biotech, South U, Bio Branch), the presence of IT staff with previous Linux or other open source experience was a factor in the decision process. As Biotech's associate director of IT infrastructure (who had modified Linux source code in his previous job) stated, "the fact that I'm here means that Linux is at least considered when these decisions are made." Biotech's CIO agreed that this person was an advocate for Linux within the IT organization. At South U, the CIO expressed his wariness about adopting open source applications, and in fact has standardized entirely on Windows servers, yet for a key web-based application has adopted ModPerl and Apache. In explaining this decision, the CIO stated that "the primary architect for [the application], recommended that and has skills in that, and I trust him." Our interview with that developer confirmed that he had significant experience with open source software. These findings support the role of boundary spanners in innovation adoption posited by DePietro, Wiarda and Fleischer (1990: 159-160)

Slack. Informants articulated two dimensions of slack resources — financial and human — that pushed them in different directions. For firms with slack human resources and limited financial resources, a free operating system that comes with little support makes sense, if the skills exist to install and operate that system. So at their founding, both NewMedia and ISP selected Unix technologies for their Internet infrastructure: the venture-funded NewMedia bought Sun servers, while the lack of financial slack drove ISP to Linux, as its CTO explained:

> [The founding partners] all pretty much agreed that Unix was the way to go — it's one of the core infrastructures for the Internet, and so they just realized that that's where all the Internet services and products were most mature, and so they wanted to continue with that. Originally we thought we would going to go with Sun equipment, but because of cost etc. [we couldn't]. … And so we started right from the start with Linux.

NewMedia started with Sun's platform, but later switched some applications to FreeBSD and Linux when it desperately needed to save money, yet still had some human resources with slack time, in particular an operations person who had time to play with Linux during stretches between systems crashes. For Semico, financial pressures pushed the consideration of wider use of Linux as the telecommunications crash of 2001 cut deeply into profits and forced retrenchment.

The relevance and impacts of slack resources in technology adoption has been a source of contention in the literature. While slack is argued to provide the room needed for experimentation, it is also argued that too much slack can reduce discipline and lead to investment in pet projects with limited economic value (Nohria and Gulati,1996). The interesting point in our findings is the fact that slack can take different forms (financial versus human resources) with different impacts.

Environmental Factors

Linux is a standard not sponsored by any one organization, implying a higher level of risk (for at least some MIS managers) than one directly controlled and sponsored by a major IT firm. As a consequence, various analysts have postulated risk would be reduced by third party sponsorship by independent distributors (e.g. Red Hat, SuSE) or hardware firms (e.g. IBM, HP) that supplied the remaining layers of open source platforms, including hardware and support services (Wagner 2000, West and Dedrick 2001).

We sought to ascertain whether third party sponsorship was important to existing and potential adopters in one of two ways.

Available technology skills and services. While users of proprietary software can turn to the vendor for technical support, there is no vendor of open source software—only a loose community of developers who are not on call when a system crashes. Three larger companies (FastFood, Biotech and Semico), cited vendor support as being important. Support from major vendors such as IBM and HP was mentioned by Fast Food as a factor that would make them more comfortable with adoption. On the other hand, for ISP and NewMedia, support from large vendors was not an important consideration. It is probably not surprising that vendor support is more important to larger organizations that are used to having the financial means to buy technology and support contracts from major IT vendors. Small firms rarely have the resources to pay for integration or maintenance services from the likes of IBM or HP, and are more likely to rely on their own skills and the free online support available from open source communities.

Legitimacy. Given how often such sponsor-driven legitimacy is mentioned in the discussion of Linux and other open source technologies, we would expect to find it frequently cited as a factor in adoption decisions — over and beyond actual support. Semico's CIO stated that "the fact that HP is committed to Linux is comforting." North U chose Dell first and then chose the Linux distribution that was fully supported by Dell.

Meanwhile, the value of commercial distributions (notably Red Hat) was also unclear. One site (North U) required support as a condition of selecting its platform. Another site (ISP) used only free downloads, while two others (Bio Branch and E-data) paid for Red Hat Advance Server on key high-end servers but mainly used the free version.

The sites without support cited the success of the open source community in providing ongoing support and updates as a major attraction of Linux. Typical was the Semico CIO, who said that with its existing proprietary operating systems, they "have to go through enormous effort to ensure patch compatibility. With Linux you get the latest patches every day." On the other hand, Semico's datacenter manager stated that they needed support from a reliable vendor such as HP, Sun, Dell or IBM if they were going to run Linux in a critical environment, as the support people from those companies could better handle problems that arise than his own staff.

In summary, we found several factors influencing Linux adoption decisions that are consistent with the diffusion of innovation literature. First, Linux was perceived to have an important *relative advantage* over competing standards in terms of cost. Second, the issue of *compatibility* with existing technologies in use was important. Third the *trialability* of Linux was considered an advantage. Beyond those technology traits, there were organizational traits that seem to influence the decision. One was the importance of *boundary spanners*. Second was the level of *complementary skills* in the organization, particularly Unix skills. In addition, consistent with the TOE framework, there were two environmental factors that affected the decision. First is the perceived *availability of Unix/Linux skills* in the external environment, either for hire in the labor market, or for contracting from IT services companies (consistent with Attewell 1992) Second is the importance of *support for Linux by major vendors* such as IBM, HP, Dell and Red Hat, not only for the services they provide, but also for the legitimacy the confer on Linux investments within the organization.

DISCUSSION

Implications for Standards Research

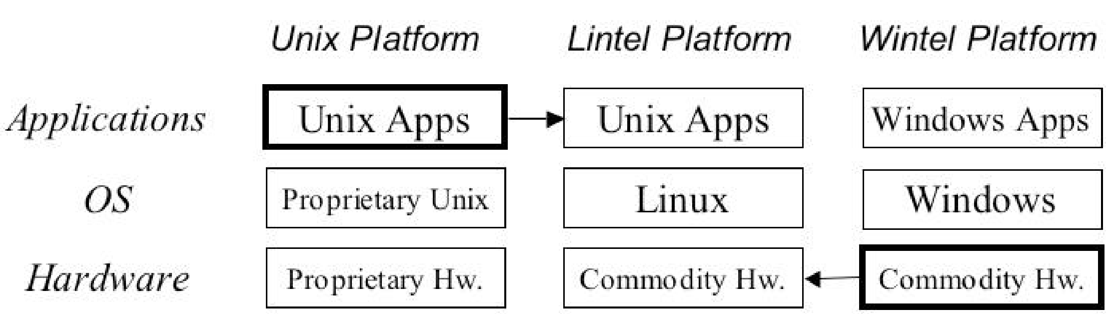
Our findings provide empirical support for both standards and diffusion of innovation theories in explaining Linux adoption decisions by corporate IT departments.

Economics of standards

Economic research holds that a key barrier to the adoption of a new standard is the barrier to entry created by existing standards through complementary assets. Specifically, the installed base of users give an established standard an advantage through positive network effects and switching costs.

As a new server platform in the 1990s, Lintel was able to build a large base of complementary assets in a relatively short time. Our data suggests that the key reason for this rapid adoption of Linux for servers has been its ability to leverage the supply of complementary assets from both of its major rivals (Figure 2).

Figure 2: Reuse of complementary assets between Windows, Linux and Unix platforms



In evaluating the Lintel platform, our respondents overwhelmingly cited the ability to use the wide range of commodity hardware — microprocessors, systems, peripherals — developed for the Wintel platform. Such hardware enjoys global economies of scale and is available from a large number of competing suppliers, while Intel and PC vendors encouraged its adaptation for use with the Linux operating system (Dedrick & Kraemer 1998; West & Dedrick 2001).

The other major attraction of the platform was the wide availability of software, most originally developed for earlier Unix-compatible systems. Systems vendors such as Sun attracted software developers through direct appeals as well as cross-platform API standards to provide a larger market for potential software developers (Garud & Kumaraswamy, 1993). The success of Unix-based systems created a wide range of what Teece (1986) classifies as co-specialized complementary assets — not just packaged software, but custom software, documentation, training and skilled workers. The conscious choices of Richard Stallman and Linus Torvalds to "clone" pieces of Unix enabled Linux to bootstrap adoption using the Unix-specialized assets.

As our sample demonstrated, these decisions meant lower Linux-related switching costs for Unix shops than Windows shops, but those switching costs acted differently for different types of software. For custom (in-house) software, a slightly different Unix would require an investment in converting the software to Linux APIs — an investment that our respondents recouped due to lower hardware costs. For open source applications, the large (by this point) user base meant that the conversion had already been done by earlier Linux users. For applications from commercial software developers, conversion by the developer was easier for Unix to Linux (versus, say, Unix to Windows XP), but whether such software was converted was under the developer (not the user's) sole control.

Finally, Linux adopters were not worried about the risk of being "angry orphans". In fact, Linux had so successfully co-opted most of the Unix-specific assets that several interviewees predicted Linux might be the only Unix-based platform to survive.[5]

Standards adoption is not always innovation adoption

While the DOI and economics of standards research have been applied independently (Fichman and Kemerer, 1993 being a rare exception), they can play a potentially complementary role. But any attempt to study adoption of technology standards needs to make an important distinction in defining the dependent variable.

The limited MIS literature on organizational adoption of standards has tended to treat the adoption of any new standard as an innovation adoption. However, the adoption of a particular standard is not always an "innovation" in the sense of Rogers (1983) or Eveland & Tornatsky (1990). The distinction between innovation and standards adoption is more than semantic. Rogers (1995: 11) defines "an innovation is an idea, practice or object that is perceived as new by an individual or other unit of adoption" and adoption as "a decision to make full use of an innovation as the best course of action available" (p. 21). In the Rogers framework, early adopters differ from late adopters based on their personal (or organizational) traits, whereas for standards subject to indirect network effects the perceived value of a standard increases for everyone only if its increasing popularity attracts a better supply of complementary assets (such as software).

In the computer industry, different types of platforms may not reflect innovation but competing flavors within the same type. Greenstein (1993) studied government agencies that had adopted mainframe computers, but then switched between platform standards. The relational database innovation studied by Fichman and Kemerer (1993) has enjoyed widespread adoption since their study, but the battle between competing proprietary database standards (with incompatible file formats and APIs) continues to this day. Similarly, in Chau and Tam's (1997) study of open systems adoption, high perceived performance for multivendor standards would be a characteristic of the open systems innovation, but many of their barriers to adoption are

[5] During our study period, the *SCO v. IBM* lawsuit was filed attempting to prevent Linux from supplanting Unix. While respondents mentioned it, due to skepticism about the eventual outcome we did not find that it changed the attitudes of existing adopters.

measures of switching costs from an existing (mainframe-based) platform to a Unix-based platform.

Thus we believe that for many technologies, researchers will be produce a more accurate picture of IT innovation adoption if they separate the two constructs — the innovation adoption decision and the issues associated with switching between standards.

Insights into Open Source Adoption

“Free Speech” vs. “Free Beer”

What have we found thus far explaining the adoption of an open source platform such as Linux as compared to proprietary platforms? No one claimed that Linux offers any important performance advantages over other forms of Unix, which is not surprising since Linux is little more than a variation on a mature technology. Instead, the most important driver of adoption was cost — both of hardware and software.

The organizations we studied focused on open source platforms that used commodity, Intel-compatible PC hardware.[6] Such hardware had always been available for “Wintel” servers, and thus the “Lintel” solution did not provide a hardware advantage for existing Microsoft shops. However, for Unix shops, the hardware substituted for expensive proprietary RISC-based servers, allowing firms to reduce capital equipment costs for their information systems.

What about the freedom provided by “free” software? The movement’s founder, Richard Stallman, has always maintained that source code control is the central benefit:

> “Free software” is a matter of liberty, not price. To understand the concept, you should think of “free” as in “free speech,” not as in “free beer.” (Free Software Foundation, 2000)

For server platforms, we saw little evidence that the ability to modify the Linux source code was valued. To the contrary, both Semico and FastFood specifically said that they would not want their IT people getting involved with modifying Linux source code. As FastFood’s Director of Enterprise Architecture stated:

> We wouldn’t want anybody mucking with that; it’s something we would discourage. Maybe some other organization would do that, but that’s definitely not us.

Two organizations mentioned rare occasions where the Linux source code documented variations in APIs among Unix family platforms — helpful for porting from proprietary Unix to Linux. This might either be a strength of open source or merely a work-around to one of its weaknesses, the lack of formal documentation.

We recognize that our findings are at odds with prior research on the value of open source. Former Red Hat CEO Bob Young said that when they asked customers about adoption motivations in the late 1990s,

> “The answer never was because it was cheaper, or because it was faster, or because it was cleaner. The answer was always for the serious users [that] for

[6] While we have a small sample, both secondary research and our interviews with various I.T. firms lead us to believe that this finding is representative of the larger pattern of server adoption, i.e. that open source servers are primarily “Lintel” machines.

> the very first time they had control over the technologies they were using." (Speech, MIT Sloan School, June 19, 2003).

However, we believe that by studying the phenomenon four years later, we are seeing a more mature market that (like other mature markets) more highly values cost. Also our sample suggests that the most cost-sensitive organizations might be Red Hat users (via free download) but not Red Hat customers.

Similarly, other studies (e.g. Franke and von Hippel 2003) have identified users who value the ability to modify source code. Based on our respondents — who did not modify the operating system but in some cases modified open source applications — we believe again that these are a matter of how complete and rapidly changing the implementation is. For an immature product such as a web server in the mid-1990s (or, for that matter, any product needing rapid updates to patch security holes as in the Franke and von Hippel study), sophisticated users value the ability to finish or extend the incomplete work of the program author. But Linux's success as a 10-year-old clone of a 30-year-old operating system meant that users not only did not want to modify the code, but in many cases they waited long periods to update to freely available newer versions.

Linux users totaled roughly 5 to 15 million by various estimates as of 2000 (Linux International, 2001), whereas the company that has hosted the Linux kernel repository since 2002 estimated that there are about 2,500 developers of the Linux kernel (www.bitkeeper.com).[7] Even at the most optimistic assumptions and ignoring growth from 2000-2003, this is a 2,000:1 ratio of users to modifiers, meaning that very few adopters are actually modifying the code.

So in considering industry maturation, the nuanced source code attitudes of our respondents and some common sense ratios, we would suggest adoption by source code modifiers is primarily a factor for "innovators" (the first 2.5%) in the Rogers (1983) typology, but as the software gets more mature and more popular, the subsequent adopters are mostly free riding on the work of the open source community rather than fighting for free speech. In fact, the CIO of Biotech made the connection explicitly, saying "We want to be free riders."

Other Adoption Motivations

Total Cost of Ownership. Some of our informants noted that the open source platform freed them from sizable annual fees for OS usage and upgrades. However, there were other costs. Speaking for others in our sample, South U's web applications programmer noted that while "free beer" triumphed over "free speech", open source software was not exactly free:

> It's "free" — licensed free, but it's not free to use. You guys have heard the saying, "free as in beer"? It's not free as in beer… You have to have the people there to maintain it and develop it and foster it and all those things, and that costs money. And that costs *more* money than the actual licenses for the software.

While the relative advantage of Linux was clearly defined in terms of cost, the willingness and ability of organizations to adopt this lower cost technology depended on a range of factors consistent with some of the key predictions of diffusion of innovation theory. These include

[7] A few such as Richard Stallman suggest that an operating system consists of a kernel plus associated tools. The reality is that most tools (such as Stallman's own *gcc* compiler) are applications which can run on multiple operating systems, and thus are more akin to complementary assets than attributes of any specific operating system *per se.*

compatibility with current technologies and skills, organizational resources and tasks, and the availability of external technological resources.

Path Dependency. The complex adoption stories of our informants illustrate the linkage between switching costs and path-dependent technology adoption trajectories of Arthur (1989). When they made their initial server adoption decision, some chose Windows, some chose Unix and a few chose mainframes. The Linux option was far more attractive for the Unix shops — not for the reason normally cited in standards research (an investment in application software) — but because of investments made in hiring and training skilled IT workers. Among Unix users, we saw evidence of a nascent "tipping" effect toward Linux, as they increasingly see Linux as the likely long-term winner. This perception may influence Unix shops to adopt Linux, to avoid the possibility of being orphaned — a problem Semico faced as one of its current technology platforms was being cancelled. Linux support from powerful technology vendors for Linux may be fueling such a perception, as well as providing more direct benefits to adopters.

Limitations

The use of multiple qualitative case studies provides a rich opportunity for building theory in emergent areas that is grounded in empirical data. Such theory always runs the risk of being idiosyncratic and not generalizable to the entire population (Eisenhardt, 1989). There is also the risk of attempting to generalize from a still-emergent process: the adoption of open source — both by business end-users and proprietary hardware companies — is still comparatively recent phenomenon.

We are particularly wary at this time of generalizing from open source operating systems to open source applications, for two reasons.

First, as noted earlier, Linux is more mature than most open source applications, and thus the benefits of source code access are lower.

Secondly, open source operating systems are re-implementations of Unix, at one time the most widely adopted platform for Internet computing (cf. Dibona et al 1999). Thus it is not surprising that Linux and other Unix clones have proven popular for Internet servers, because (as ISP noted) that was the Internet's core OS. West and Dedrick (2001) identified Linux as among several software packages (along with Apache, Sendmail, and Perl) that both helped support Internet infrastructure and were dependent upon it for their virtual collaborative development. One might expect that standards decisions not related to Internet servers would lack such an exemplary fit to task, and thus the perceived compatibility of Linux (or other open source package) could easily differ from that identified in our study.

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THE ADOPTION AND DIFFUSION OF INTERORGANIZATIONAL SYSTEM STANDARDS AND PROCESS INNOVATIONS

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ABSTRACT

Interorganizational system standards are reaching a new era in industry. When asked about interorganizational systems, invariably most people think of electronic data interchange (EDI) standards (ANSI X12). Albeit EDI still remains the preeminent type of interorganizational system, IOS solutions have been overhauled since the mid-1990s. IOS solutions are now collaboratively developed, structured around discretely defined cross-company business process standards and able to be distributed via the web. Compared with EDI technology from the past, the notions of open standards, modularity, scalability, and interorganizational business process reengineering have become embedded in modern-day IOS development. This paper is intended to examine assimilation levels of interorganizational system standards and process innovations (IOS SPI) among members of an industrial group where an IOS standards development organization (SDO) exists. A Conceptual IOS SPI Adoption and Innovation Diffusion Model is developed, defined and nine hypotheses are proposed and empirically tested based on firm-level cross-sectional surveys of 102 firms from 10 different industrial groups (encompassing 15 different SDOs). Using the organizational - technological - environmental framework (with the addition of the SDO construct), the significant determinants of IOS SPI adoption were found to be; top management support, feasibility, technology conversion, competitive pressure, SDO participation level, and SDO Architecture. Using the same framework, the significant determinants of IOS SPI deployment were found to be; feasibility, competitive pressure, SDO participation level, compatibility, shared business process attributes, SDO Architecture and SDO Governance. A rich discussion is then provided regarding findings in the areas of industrial coordination of IOS standards, consequences of IOS standards diffusion, and SDO measures of success (including governance and management practices). Numerous recommendations are provided to practitioners and researchers for future consideration in this critically important and emerging research frontier.

Keywords: Interorganizational system standards, XML, IOS diffusion model, industrial group interoperability.

INTRODUCTION

Interorganizational system standards are reaching a new era in industry. An era that could be on the verge of immense widespread diffusion. When asked about interorganizational system standards, invariably most people think of electronic data interchange (EDI) standards (ANSI X12). Albeit EDI still remains the preeminent type of interorganizational system, IOS solutions have been overhauled since the mid-1990s. IOS solutions are now collaboratively developed, structured around discretely defined cross-company business process standards and able to be distributed via the web. Compared with EDI technology from the past, the notions of open standards, modularity, scalability, and interorganizational business process reengineering have become embedded in modern-day IOS development.

This era will entail achieving integration levels of information technology with cross company business processes that have rarely been experienced. Rather than piece meals of interoperability between certain business segments (payments or inventories), this new era will encompass a broad scope of interoperability needs between organizations (collaborative engineering, concurrent research and development, supply chain management, parallel manufacturing, integrated customer relationship management and beyond.). Rather than providing only portions of information exchange needs within a business segment (goods manufactured status), this new era would encompass the full depth of tasks associated with a cross-company business process (manufacturing forecasts, receipt acknowledgement, work in progress, spoilage, actual versus forecast, etc.). Rather than ignoring small to medium sized organizations, this new era would encompass the full breadth of members from the extended industrial group (small down-stream suppliers, small up-stream distributors, industry action groups, research centers, non-profit organizations) and beyond.

The enabler of this era is the extraordinary integration of information technology standards with cross company business processes. With levels of cooperation rarely witnessed, industrial group members are jointly decomposing cross company business processes into the lowest common tasks that occur between organizations. They are agreeing on common sets of parameters that enable choreographing cross company processes that are in compliance with contractual agreements, industry practices, governmental regulations and technical requirements. If inconsistencies or inefficiencies are detected, consensus is reached and the processes are reengineered. Utilizing an industry-wide data dictionary, they are developing common sets of business terms, definitions and forms. By integrating these process standards with recent technological innovations (XML, WSDL, SOAP and other APIs) industrial groups are developing a comprehensive set of interorganizational system standards structured around discrete cross company business processes (here after referred to as interorganizational system standards and process innovations (IOS SPI)).

The benefits of this new era could be profound. The rich scope, depth and breadth of interoperability and information sharing have rarely been experienced. At the system level, the benefits to participating members would include tactical direct operational enhancements (improved response times, reduced standards negotiation efforts with new trading partners, reduced system development efforts). At the firm level, the benefits to participating members would include strategic business and operational advantages (improved compliance with contractual obligations, greater access to new customers or suppliers, technology awareness, reduced research and development expenditures). At the industrial group level, this new era could fundamentally shift the dynamics from a supply-chain versus supply-chain level of competition, to an industrial group versus an industrial group level of competition. The degree of which extends beyond most notions of pie expansion and competition to co-opetition.

Fundamentally, this work is intended to introduce the need for bridging the research gap between prior studies in IOS adoption and diffusion (based predominantly on EDI technology) versus modern-day IOS solutions. Pragmatically, this paper is intended to examine assimilation levels of interorganizational system standards and process innovations (IOS SPI) among members of an industrial group where an IOS standards development organization (SDO) exists. What practices are used to develop and deploy modern-day IOS standards through out an industrial group? What are the antecedent conditions leading towards greater adoption and diffusion of IOS standards in an industrial group? What are the consequences of deploying IOS standards? The intent of this study is to address these research questions by examining the development and deployment of modern-day IOS standards throughout an industrial group. A conceptual innovation adoption and diffusion model is developed, defined and the proposed hypotheses are empirically tested in a real work environment. The innovation under study is a grouping of related and emerging technologies referred to as interorganizational system standards and process innovations (IOS SPI). Components of this technology group include eXtensible Mark-up Language (XML), simple object access protocols (SOAP), web-services description language (WSDL) and other application programming interfaces (APIs) that have become integral in the development and deployment of cross-company business process IOS standards. The scope of this study examines the adoption and diffusion of these technologies specifically in an interorganizational system context.

The contributions from this study are substantial. First, this study will provide insights into industrial coordination, development and deployment of a new and emerging area in IOS technology standards (e.g. XML, SOAP, WSDL and other APIs). Including results from a theory-based empirical study into the significant antecedent conditions leading towards adoption and sustained diffusion of IOS technology standards. Third, this study will examine consequences on an industrial group as a result of deploying IOS standards (ordered in three tiers based on time since deployment). Fourth, this study will provide insights into SDO governance, management practices and standards architecture, including discussions regarding measures of success and the SDO value-proposition. Fifth, this study will provide recommendations to practitioners towards improving industrial coordination of IOS technology standards. Sixth, recommendations to researchers are provided for conducting future lines of inquiry into this important and emerging research frontier. This discussion will include initial thoughts and analysis regarding horizontal convergence (referred to as the 'holy-grail' of interorganizational system standards) which offers a unique niche for researchers to make significant contributions.

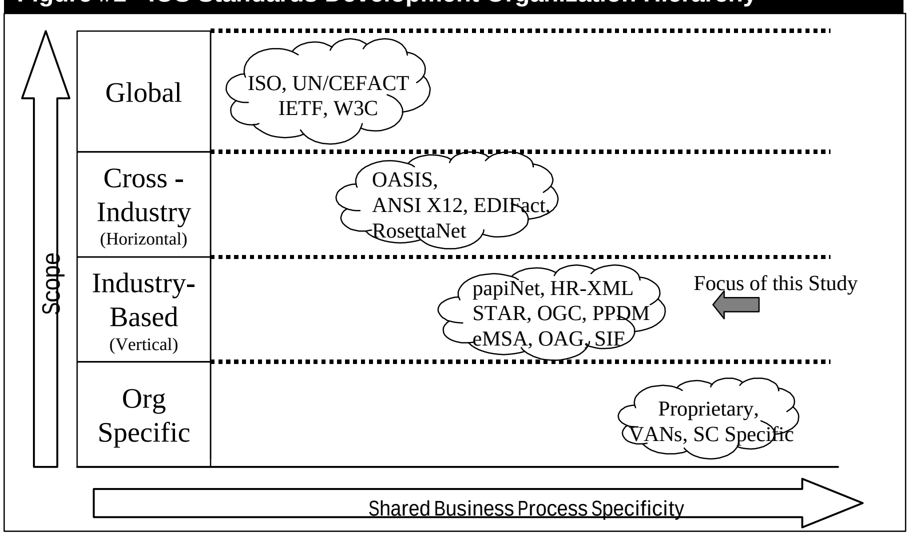
To address the research questions and accomplish the objectives, the paper is organized as follows. First a brief background is provided regarding the hierarchy of information technology standards organizations. This will identify where an *industry-based* standards development organization (SDO) fits in the information technology standards setting context. Second a comparison will be made of several industry-based SDOs including identification of the IOS SPI development process based on a synthesized review of ten SDOs participating in this study. Third, results and key findings from prior IOS diffusion studies are summarized. Fourth, a conceptual model of IOS SPI adoption and diffusion is proposed. Theoretical support and definitions are provided for the twelve measurement variables, three diffusion measures and nine hypotheses comprehended in this study. Fifth, the research setting, methodology and results of administering firm-level cross-sectional surveys to 102 firms from 10 industrial groups encompassing 15 SDOs are reported. Sixth an extended discussion ensues regarding the academic and managerial implications of the study's results, including numerous points regarding industrial coordination efforts. This paper concludes with numerous recommendations to practitioners and researchers, including future research recommendations and limitations of this study.

BACKGROUND

Information Technology Standards Hierarchy

Figure #1 provides a hierarchy of standards development organizations that influence the development of interorganizational system standards. Admittedly, one must travel far down this hierarchy to reach the type of SDO in consideration for this study. Briefly, to distinguish between the tiers of standards organizations, Internet Engineering Task Force (IETF) develops bit-orientated standards for the Internet. The World Wide Web Consortium (W3C) develops syntactic standards (that ride atop of the IETF's standards) for the World Wide Web (HTML, XML, etc.). ISO is described to have a top-down or structuralist approach with standards development (Libicki 2000). Structuralist-based SDOs develop comprehensive sets of standards in hopes of encompassing all current and future endeavors in relation to their constructs. Industry-based SDO's, on the other hand, are depicted as minimalist towards their standards development activities. Minimalist-based SDO's develop standards in small sub-sets (develop a little, test a little) and only after there's a sufficient and demonstrated need for the standard by the targeted user group(s). Development of specific semantic standards is the scope of consortia organizations that either have a horizontal (cross-industry) or vertical (single industry group) focus. ANSI X12 and OASIS are two of the most publicized horizontally focused (cross-industry) SDOs. ANSI developed X12 standards for formatting EDI business messages and OASIS is developing ebXML and UBL for the formatting of XML-based business messages. Vertical focused SDO organizations include papiNet, CIDX, PIDX, and many others and are the type of SDO under consideration in this paper. RosettaNet, which is also included in the scope of this paper, is an SDO that transcends both vertical and horizontal concentrations. Although RosettaNet focuses its' IOS standards development efforts across three high-technology industries (semi-conductor, electronics, and information technology), RosettaNet's Interoperability Framework (RNIF v2) has been adopted (or leveraged) by a host of additional industrial groups. In fact, in June 2003, OASIS and RosettaNet announced the formation of a Standards Development-to-Implementation Alliance. Finally, several organizations have developed IOS technology standards privately (e.g. within their organization) to be utilized throughout their private supply chain or their extended enterprises. These proprietary solutions typically consist of a hybrid of EDI (or EDI-like) technology standards and are outside the focus of this study.

Figure #1 - IOS Standards Development Organization Hierarchy



Industry-based, Voluntary-Consensus IOS Standards Development Organizations (SDO)

Researchers in the mid-90's were calling for the inclusion and examination of the SDO's role towards the adoption and diffusion of IOS solutions (Grover 1993; Premkumar 1995). Table #1 provides a comparison of eight of the industry-based SDO's that participated in this study. Despite variations in membership size, year incepted, and completed messages many similarities exist. Participation in the SDO is voluntary, decision making is consensus driven (typically based on voting rights associated with the type of membership), the IOS standards are made freely available to the public, and they all have a non-profit orientation. In addition, SDO members include stakeholders from the entire industrial group (producers, distributors, retailers, non-profit industry interests groups, universities and other governmental units).

Table #1 - Industry-Based Standards Development Organization (SDO) Examples

Example SDO	HR-XML http://www.hr-xml.org	papiNet http://www.PAPINet.org	Open GIS http://www.opengis.org	PIDX http://www.pidx.org
Industrial Group	Human Resources	Paper	Geo Spatial	Petroleum & Oil
Profit Orientation / Partnerships	Non-Profit	Partnered with Idealliance. Non-profit orientation.	Non-Profit	American Petroleum Institute's (API) committee on Electronic Business. Non-profit orientation.
Membership Fee Structure	Fixed annual fees based on Charter, General, Associate or Academic membership types. Fees also vary by end-user versus technology vendors.	Annual fees based on firm revenues. Fees also vary by technology vendors and industry champions.	Fixed annual fees based on Strategic, Principle, Technical Committees, Associate or Academic and Governmental membership types.	Annual fees based on firm revenues (distinctions made for governmental and academic institutions).
Industry Participation	Voluntary	Voluntary	Voluntary	Voluntary
Development Process	Consensus based on membership voting rights.	Consensus based on membership voting rights.	Consensus based on membership voting rights.	Consensus based on membership voting rights.
Standards Availability	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public
Members	150	47	258	27
Year	1999	1999	1994	2002*
Messages Completed	27	28	7	11
Pending (In Review)	not known	5	12	5
IOS SPI Solution Examples	Background Checking Benefits Enrollment Competencies Contact Method Education History	Credit Debit Note Goods Receipt Availability Order Confirmation Business Acknowledgment	Imagery Mark Up Language Spec Image Coordinate Transform Web Map Service Interfaces Grid Coverages Gazetteer Service Interface	FieldTicket FieldTicketResponse Invoice InvoiceResponse OrderCreate

Table #1 - Industry-Based Standards Development Organization (SDO) Examples

Example SDO	STARS http://www.starstandard.org/	IMS http://www.imsglobal.org	eMSA http://www.emsa.org	RosettaNet http://www.rosettanet.org
Industrial Group	Automotive	Education	Marine	Semi-Conductor Mfr
Profit Orientation / Partnerships	Non-Profit	A project within the National Learning Infrastructure Initiative of EDUCAUSE	European Marine STEP Association (EMSA). Non-Profit orientation.	Merged with UCC in 2002. Non-profit orientation.
Membership Fee Structure	Fixed annual fees based on organization type (Dealerships, Mfrs, SIG) and membership status (active versus associate).	Annual fees based on firm revenues.	Annual fees based on firm employee count. Distinctions made for academics.	Fixed annual fees based on geography and voting privelages.
Industry Participation	Voluntary	Voluntary	Voluntary	Voluntary
Development Process	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.	Consensus based on membership category voting rights.
Standards Availability	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public	Freely Available to the Public
Members	39	64	15	500
Year	2001	1997	1994	1998
Messages Completed	15	9	6	53
Pending (In Review)	not known	3	2	52
IOS SPI Solution Examples	Parts Inventory Delivery Reporting Financial Statement General Acknowledgements Labor Operations	Learner Information Package Question & Test Interoperability IMS Vocabulary Definition Learning Design IMS Digital Repositories	Hull Structural Design Data Society type approval & product Quote machinery product data Integration & catalogue procuremer Machinery design data	Notification of Failure Distribute Design Engineering Info Distribute Product Master Request Quote Request Purchase Order

Members of an SDO management team are in a very precarious position. They are bound to upset some members all of the time, and rarely have the opportunity to exceed expectations any of the time. They are independent moderators in managing a shift from competition to co-opetition among industry-wide participants. They are the facilitators in coordinating a transformation from company versus company competition, to a supply-chain versus supply-chain competition (or, their case, an industrial group versus an industrial group). The SDO management teams are the enablers towards true pie-expansion among members of an industrial group.

IOS SPI Development Process

The notion of understanding, documenting and (if necessary) reengineering the underlying business process prior to applying technology is commonly accepted in academia and industry (Laudon 2003; Hammer 1990). This effort involves more than simply providing common business semantics in data exchanges. In fact, in all stages of the Systems Development Life Cycle (SDLC) reference the underlying business process (Hoffer 2002). In industry, if technology is deployed without first addressing the underlying business process needs it is referred to as Naked Technology. Forrester estimates that the deployment of Naked Technology resulted in technology overspending of $65 billion in the United States from 1998 to 2000 (Forrester 2002). This practice of understanding the business process first, prior to deploying the technology, is all the more important when confronted with cross-company business processes (here after also referred to as shared business processes). In fact, Hammer predicted that "streamlining cross-company processes is the next great frontier for reducing costs, enhancing quality, and speeding operations. It's where this decade's productivity wars will be fought" (Hammer 2002). Each organization participating in an IOS must agree on a host of common business terms, definitions, and forms. They need to choreograph and synchronize the flow and timing of information associated with the shared business process to insure its compliance with contractual agreements, industry practices, governmental regulations and technical requirements. This results in a host of standards associated with the shared business process that the interorganizational system is intended to automate.

Figure #2 depicts the major steps in the development of industry-based IOS standards (based on a synthesized understanding from 10 of the industrial groups participating in this study). The IOS standards development process works as follows: (1) Choreograph business data flows and modularize these flows into shared business processes that need to occur between partners in the industrial group. (2) Reach consensus and prioritize which shared business processes will be documented, standardized and the associated timing. (3) Standardize and document the common business fields, terms and definitions, including the development of document type definitions (DTD), XML messages and ISO compliance checks. A discrete (modularized) shared business process that has completed step three is commonly referred to in industry as a message. Upon completion of the initial version of a message, they proceed through development with (4) Testing & Reviews, (5) Deployments and (6) Certifications and Compliance.

An illustration of this can be briefly explained in the chemical industry. CIDX is a non-profit IOS SDO for the chemical industry. In late 2000, CIDX members voted to ratify new by-laws thereby broadening and transforming the association into a neutral standards body focused on improving the ease, speed and cost of transacting business electronically between chemical companies and their trading partners. As of August 2003, CIDX had 75 member firms and had developed IOS standards for 52 messages ranging from Order Create, Qualification Requests, and Quality Testing Report. The 52 messages are grouped into 8 broader functional categories (Customer, Catalog and RFQ, Purchase Order, Logistics, Financials, Forecasting, Exchange Interactions, and Product Information). The SDO provides a strict hierarchy of guidelines to following when formalizing their IOS standards. Each of the messages has a DTD (document type definitions) with a hierarchy of messaging guidelines, structure guidelines, and data element guidelines that must be adhered to. Each DTD provides compliance with ISO related guidelines (ISO 8601 is a format for structuring date and time elements, ISO 639-1 is the two-character language code and ISO 639-2/T is the three-character code, not to be confused with ISO 639-2/B). In addition, IOS standards developers provide a corresponding set of sample XML messages for each of the 52 DTDs. Although the messages are modularized around discrete shared business processes, a single data dictionary is used through-out CIDX to insure consistent use and interpretation of business terms, data types, data lengths, definitions, synonyms and so on through-out their current (and forthcoming) messages. CIDX is non-profit, membership is voluntary, the standards development process is consensus-driven, the IOS standards are platform independent, vendor neutral and are based on open standards (made freely available to the public).

Figure #2 provides further description and illustrations of IOS SPI development in industrial groups. The key point of this illustration is the output of this development effort is significantly more than just common data semantics. The effort begins with a shared business process, and ends with a comprehensive set of interorganizational system standards. IOS standards that are ready for implementation by members of the industrial group whom choose to adopt them. For discussion purposes in this paper, the term IOS SPI solution refers to an instance of output from Figure #2. IOS SPI technology refers to a grouping of related innovations that provide the essential tools used during this development effort (e.g. XML, SOAP, WSDL and other APIs).

Figure #2: Interorganizational System Standards & Process Innovations (IOS SPI) Development in Industrial (Vertical) Groups

	STEP	ACTIVITIES	ILLUSTRATIONS
FEEDBACK & UPDATES	Choregraph & Modularize	Choregraph and decompose key cross-company business processes into manageable units.	- CIDX choregraphed 8 broad categories of data flows for organizations in the chemical industrial group (Customer, Catalog and RFQ, Purchase Order, Logistics, Financials, Forecasting, Exchange Interactions, and Product Information). - CIDX then decomposed these broad categories into distinct interorganizational business processes. - For example Catalog & RFQ currently has 3 identifiable cross-company business processes (Customer Specific Catalog Update, Product Catalog Update, Request for Quote)
	Prioritize	Assess, evaluate and reach mutual consensus as to which business processes will be completed and when.	- This is a highly consensus driven event with discussion and debate from all stakeholders from the industrial group. Strict voting rights are enforced and traditionally assigned to the type of firm membership. - It is essential for the SDO's management team to remain neutral and provide an industry-wide perspectives with technology trends in mind. Many SDO's conduct Planning Studies, Insertion Projects, and Feasibility Studies to determine pilot programs. - Low hanging fruit areas are identified based on anticipated development effort, consistency of business process flows (and terminology) through-out the industry, the business need and the likelihood of uptake by the user community. - See Table #2 for examples of higher priority cross-company business processes.
	Standardize & Document	Delegate authority to speciality work groups to establish DTD, XML Messages, and maintain an industry-wide data dictionary.	- Establish working groups responsible to develop common business terms, forms, DTDs, and XML messages associated with each modularized interorganizational business process. - Establish key development milestones, timelines and insure the appropriate authority (and scope) is delegated to working groups. - Maintain a common data dictionary for the entire industrial group - Establish ongoing procedures to evaluate progress, validity checks with the appropriate ISO guidelines and periodic report outs to the extended membership and user groups.
	Reviews & Test	Permit the extended user community to provide reviews and feedback regarding the draft IOS solutions.	- Firms volunteer for testing and parallel processing with the associated IOS SPI solutions. - Most SDO's offer lengthy review and testing periods (including interoperability labs, open publication of test results, and formal versioning procedures and norms).
	Deploy & Implement	Develop procedures for promoting, tracking and forecasting the adoption (up-take) of IOS solutions across the user community.	- IOS SPI adoption (and sustained diffusion) is identified as one of the top priorities in every SDO. All SDOs have assigned project champions for leading adoption initiatives across the industrial group. - Extended 'support networks' are coordinated by the SDO to track key personnel with experience, lessons learned, best practices, implementation guidelines, and total number of deployments.
	Compliance & Certification	Provide a process whereby conformance, certification, and interoperability can be tested and verified.	- The typical intent of these programs is to establish formal procedures concerning certifiable implementations (according to specified standards), protect the SDO's trademark name (and usage), and to document (and forecast) adoption. - Most SDO's have only recently begun to enforce their certification and compliance programs.

IOS Diffusion

If one's objective is to study the adoption and diffusion of modern-day IOS solutions, one of the closest parallels we have towards examining this phenomena in literature is the study of IOS adoption and diffusion (largely based on EDI solutions). Although the sharp contrasts between EDI versus modern-day IOS solutions have been noted (see Table #2) fundamental similarities remain. Modern-day IOS standards development entails choreographing cross-company business processes, codifying common business standards, and developing (and testing) technical messages (including interfaces and protocols). Fundamentally, these similar steps are taken in the development of EDI solutions. As described in Table #1, the differences lie in the scope, exchange frequency, breadth, diversity, transport, protocols and scope of semantics.

The coupling of EDI technology standards and business process reengineering was introduced in prior research (Clark 1996; Fiedler 1995). In addition, Massetti and Zmud's recommendations for measuring EDI adoption and diffusion across trading partners (breadth), business processes (diversity) and volume offers a superb framework for measuring the diffusion of modern day IOS solutions (Massetti 1996). Furthermore, a rich research stream of empirically based IOS adoption and diffusion models does exist.

Based on a literature survey of 21 IOS adoption and diffusion models the following are some findings from the coding and synthesizing of their findings. See Appendix A for a list of the publications included in the literature search. First, six types of IOS solutions have emerged that fit the definition of an interorganizational system, “an automated information system shared by two or more companies” (Cash and Konsynski 1985, p 134). They include (in order from most to least) EDI, EDI-like solutions (including customer-orientated interorganizational systems and proprietary-dedicated IOS), telecommunications based IOS, web-based technologies and open systems. These IOS solutions vary along lines of their business intent, technology and willingness to participate (openness) with external organizations. Second, the most common set of constructs (framework) utilized in the study of IOS diffusion is the *organizational - technological - environmental* framework. This is consistent with Rogers' four main elements in the diffusion of innovations (Rogers 1995). Third, based on coding and summing the significant determinants in prior IOS diffusion studies, the most frequently significant IOS diffusion determinants were found to be *competitive pressure, top management support, relative advantage, market uncertainty* and *power*.

TABLE #2 - EDI VERSUS IOS SPI SOLUTIONS

	Former IOS Solutions (Predominantly EDI)	Modern-Day IOS SPI Solutions
Focus	Supply-Chain (Regional)	Global
Frequency	Batch	Real-Time
Breadth (Trading Partners)	Large Businesses	All Stakeholders
Diversity (Business Processes)	10% of B2B processes	100% of B2B procesess
Transport	VAN-Enabled	Internet-Enabled
Protocols	X.12 / EDIFACT/ JE CALS	XML, SOAP, WSDL, and other APIs
Semantics	Custom Industry Dictionaries	Standard Industry Dictionaries

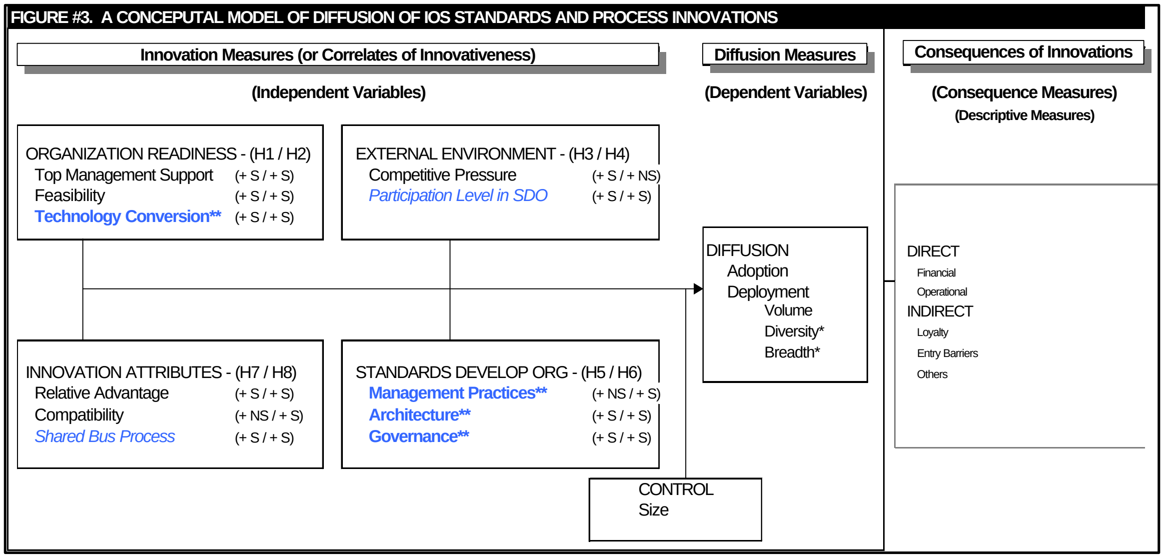
CONCEPTUAL MODEL

Conceptual IOS SPI Adoption and Diffusion Model

This study seeks to introduce a conceptual IOS SPI adoption and diffusion model, empirically compare the model in a real work environment and report the findings. Figure #3 contains the proposed conceptual IOS SPI Adoption and Diffusion model. The model is composed of three parts. Antecedent (independent) variables are on the left and include four constructs (organizational, innovation, environmental and the SDO). The theoretical support and hypothesized impact of these constructs on the diffusion variables are summarized below. The diffusion (dependent) variables are in the middle of the model and include adoption, deployment and assimilation. Adoption is a dichotomous variable and indicates whether the firm has reached a decision ('yes' or 'no') to begin utilizing the IOS SPI technology grouping. Deployment is a dichotomous variable and indicates whether a firm has actually implemented the IOS SPI technology grouping in an interorganizational system context. Assimilation is based on a modified version of the Guttman scale with seven levels of IOS SPI technology assimilation levels is used (0-unaware to 7-general deployment). This use of assimilation levels is similar in structure to Fichman and Kemerer's work with software process innovations (Fichman 1997; Fichman 1999). There are also three descriptive measures of external diffusion that measure the extent of actual implementations of an SDO's IOS SPI solutions across shared business processes with external trading partners. All three external diffusion measures are similar in scope and nature to Massetti and Zmud's recommended diffusion measures (1996). Volume refers to the total number of instances (implementations) of the IOS SPI solutions. Diversity refers to the number of different (unique) IOS SPI solutions implemented. Breadth refers to the number of different trading partners. The far right side of the model includes the consequences of innovation measures. These measures will be used to descriptively examine the effects (consequences) on an industrial group of diffusing (implementing) IOS SPI solutions. Examples of descriptive consequence measures include direct financial measures (expense components, ROI), operational measures (throughput, cycle time) and qualitative measures (trading partner loyalty, entry barriers). Consequence measures have been stratified into three ordered effects based on elapsed time since deployment.

Described below is the theoretical support for each of the four independent constructs; organizational readiness, IOS technology attributes, external environment, and the SDO. Hypotheses will also be presented that seek to predict and explain the relationship (directional and significance) between the independent and dependent variables. Detailed descriptions and definitions of all measurement variables (independent, dependent and consequence measures) are provided in the Research Setting and Methodology section.

FIGURE #3. A CONCEPTUAL MODEL OF DIFFUSION OF IOS STANDARDS AND PROCESS INNOVATIONS



Organizational Readiness

The organizational readiness construct is intended to capture firm level attributes of the organization that assess the overall readiness of the firm towards diffusing the innovations. Assessing an organization's readiness is a fundamental and necessary step prior to launching a new information systems development project (Hoffer 2002). This step is particularly relevant when an organization is considering to join an IOS standards development organization and to begin implementing IOS solutions with external trading partners. Compared with other technologies, IOS are an outward manifestation of an organization's ability to plan, commit and execute according to requirements established with external trading partners. At a minimum, this requires evaluating top management's support, financial and technical feasibility (Iacovou 1995) and the type technology that the organization will be converting from. Top management's leadership and support will be essential for successful participation in an IOS SDO. Examples of top management support include the demonstrated willingness of top management to commit resources (human and capital) to the project and the existence of a project champion who is enthusiastic about the new endeavor and is willing (and capable) to act as the organization's focal point on the project. The risk of failure with IOS solutions could have far reaching impact into supplier contracts, customer contracts and the organization's reputation in the industry. Financial feasibility could include conducting cost-benefit analysis, forecasting total cash expenditures, and estimating the indirect impact of the new technology (product costs, process re-engineering efforts, etc.). Technical feasibility could include assessing skill sets of the IS staff, identifying infrastructure enhancements necessary to accommodate the new technology, and evaluating and prioritizing which shared business processes should be automated. Although the technical feasibility should be conducted first (so as to be able to calculate the financial feasibility), all of these steps will be essential to objectively evaluating the readiness of an organization.

- H1. Organizational Readiness attributes will have a positive (and significant) relationship with IOS SPI adoption.
- H2. Organizational Readiness attributes will have a positive (and significant) relationship with IOS SPI external deployment.

Prior IOS diffusion studies have considered the readiness aspect of organizational attributes (Iacovou 1995). Several studies have considered other organizational attributes such as top management support (Premkumar 1995, 1997; Grover 1993; Chatterjee 2002) and a project champion (Premkumar 1995, 1997; Grover 1993). In addition, Grover's research into COIS considered organizational structure considerations and policy factors (Grover 1993). Also, Chatterjee's research work into e-commerce strategies considered management coordination techniques (Chatterjee 2002).

External Environment

Intuitively, the external environment should be considered a potential significant factor in the diffusion of IOS standards. By it's very definition, Cash and Konsynski utilize an external organization in their definition of an IOS. External environment variables such as competitive pressure, partner power, and market uncertainty have evolved as determinant variables towards IOS diffusion. The majority of prior IOS diffusion studies were conducted using EDI or EDI-like technology. Thus, the overall 'pressure' to adopt IOS technology was primary from one or two dominant firms. In the current business climate (where competition has evolved into an industrial group versus an industrial group) the perceived pressure on a firm to adopt IOS standards will be felt from the entire industry. Thus when comparing the present study to prior IOS diffusion models, the notion of partner power has been dropped and competitive pressure is anticipated to be greater. In addition, expectations of market trends is also considered and its' definition is consistent with Cho's, "Expectation for market trend is the degree of expectation that the target technology will be pervasively adopted in the industry in the future" (Cho and Kim 2002, page 130). Furthermore, participation levels in an industry-based SDO are anticipated to be a significant influence (Teo 2003). Participation levels in an SDO can manifest through several means (e.g. participating in SDO development activities, becoming a member of an SDO, implementing IOS standards from the SDO).

- H3. The external environment attributes will have a positive (and significant) relationship with the IOS SPI adoption.
- H4. The external environment attributes will have a positive relationship with the external deployment of IOS SPI. Participation levels in an SDO will have significant relationship towards IOS SPI external deployment.

Standards Development Organization

The SDO construct is intended to examine attributes of the SDO and its' potential influence towards the diffusion of IOS SPI technology. Since this construct has rarely been used in prior IOS diffusion studies, a survey of critical success factors in alliance organizations was conducted to develop an SDO role continuum. For example, in Monczka's study of strategic supplier alliance organizations found the most important attributes included trust, the notion of "doing what you say you're going to do", actively encouraging bilateral communications, maintaining a joint-solving problem approach with all conflict resolutions, and formalized processes in selection and assessment procedures (Monczka 1998). In Whipple's study of 92 'paired' buying and selling organizations from the health / personal care industry found that buyers and sellers agreed on the top five factors that influence alliance success factors: trust, senior management support, ability to meet performance expectations, clear goals, and partner compatibility (Whipple 2000).

This role continuum then provides a set of criteria to evaluate the SDO with respect to its' organizational attributes and impact on the target technology's diffusion. Components of this role continuum include SDO management practices such as collaboration mechanisms, ability to meet performance expectations, problem resolution techniques, and clarity of goals and objectives. IOS architecture attributes include modularity levels and compatibility with business processes. IOS governance includes attributes related to the structure of the SDO, non-profit status, objectives of the SDO and others.

Researchers have recommended examining the role of an IOS standards alliance organization as their recommendations for future research. For example Grover, in his cross-sectional survey of 216 firms considering adoption of proprietary COIS systems, recommended an in-depth study of a group of firms utilizing an industry-based standards setting organization to enhance the understanding the 'hows' and 'whys' of the decision processes leading to the adoption decision (Grover 1993). In addition, Premkumar recommended the use of industry associations and the establishment of industry-wide standards for better electronic integration and increasing adoption by participating firms (Premkumar 1995, page 326). Premkumar also recommended the integration of process reengineering with IOS technology to fully maximize the benefits of EDI implementations (Premkumar 1995, page 327). The role of an SDO has emerged as pivotal in the development of IOS SPI. Industrial groups are viewing an SDO as a moderator in the IOS standards collaboration process, as an enabler towards generating cost savings opportunities through leveraging IOS development efforts, and as a means towards integrating 'best-in-class' IOS standards through the SDO's effort to stay abreast with the latest technology trends.

- H5. SDO attributes will have a positive relationship with IOS SPI adoption. Governance and Architecture will also have a significant relationship towards IOS SPI adoption.
- H6. SDO attributes will have a positive (and significant) relationship with IOS SPI external deployment.

Innovation Attributes

Attributes associated with the innovation itself have long been the most frequently tested and most frequently found significant determinants in innovation diffusion (Rogers 1995; Tornatzky 1982). IOS technology diffusion models are no exception to this fact, in that attributes such as relative advantage, cost and compatibility of the technology are some of the most frequently examined determinants towards IOS diffusion. This study has three components of IOS technology attributes that include compatibility, relative advantage and shared business process attributes. Compatibility assesses the compatibility of the IOS solution with the organizations IS infrastructure and work procedure needs of the firm. Relative advantage is defined as the extent to which a potential adopting organization views the innovation as offering direct financial and operational benefits over previous ways of performing the same tasks. Since the relative cost to benefits of the innovation is explicitly comprehended in this definition, the direct 'cost' of the technology is not isolated as a separate measurement variable in this study. Other aspects of the technology's cost are considered in the consequence measures portion of the model (direct financial impact of implementing the technology), as well as a perceptual-based variable in assessing the anticipated indirect impact of the IOS SDO organization (system development and standards negotiation effort).

The third component of innovation attributes is associated with the underlying business process attributes (and business requirements) shared between the partnering firms. The premise for including business process attributes is straightforward: IOS solutions are interorganizational technology standards that are fundamentally structured around the shared business processes that they are intended to automate or enhance. Thus, characteristics of the shared business process such as required response times, required exchange volumes, exchange frequency, consistent field terminology and consistent business definitions are all attributes of the underlying business process that could influence an organizations decision to implement one IOS solution versus another. That is to say, if an organization is considering an IOS solution implementation, yet the IOS solution that is presented does not comply with their business definitions and / or provide the response times required by trading partners, they would most likely elect not to implement that IOS solution. One of the potential outcomes from this research is to examine the possibility of replacing the rather generic relative advantage construct with the unique set of business-process specific attributes that drove the adoption of the IOS solution (Tornatzky 1982). The underlying shared business process attributes (and requirements) impact virtually every aspect of an interorganizational information system.

- H7. Innovation attributes will have a positive relationship with IOS SPI adoption. Relative Advantage and / or Shared Business Process attributes will also have a significant relationship towards IOS SPI adoption.
- H8. Innovation attributes will have a positive (and significant) relationship with IOS SPI external deployment.

One final proposition is that the antecedent conditions leading towards IOS SPI adoption versus IOS SPI diffusion will have a different set of significant determinants.

- H9. A different set of significant attributes will be associated with IOS SPI adoption versus IOS SPI external deployment.

RESEARCH SETTING AND METHODOLOGY

The research design is the culmination of a two-year developmental effort. It started with a detailed examination of a single implementation instance of a modern-day IOS solution between a distributor and manufacturer in the electronic components industry in the second quarter 2000. This provided insight into the technology under study, the use of interoperability standards and an understanding of the significant mutual operational and economic benefits provided to firms on each side of the IOS. The number one challenge identified by the members in the study was that of adoption. That is, how to encourage other partner firms to adopt the industry-wide standards and IOS solutions supported by their industry's SDO. These findings fueled the development of an initial conceptual IOS technology standards adoption model. A draft survey instrument was prepared and administered to eight firms (encompassing four IOS solutions) in a single industrial group. This study concluded in the first quarter 2002 and the qualitative findings provided additional insights into the constructs that influence IOS standards adoption and how the mixture of these constructs change when examining the diffusion of IOS standards (as opposed to adoption). This study also provided insight into the pivotal role of the industry's SDO and the performance metrics that should be used to assess consequences of diffusion. Add to these insights the results of a literature survey work in IOS adoption and alliance organizations, and the following research design was crafted.

TABLE #3 - SURVEY INSTRUMENT STRUCTURE AND ITEMS

CONSTRUCT	Hypothesized Impact		Prior / New	Item Count	Item Count
Measurement Variable	Adoption	Diffusion	Variable	Conceptual Model	Descriptive Analysis
DIFFUSION MEASURES					
Adoption / Assimiliation Level			Prior Research	1 item	1 item
External Diffusion:					
Volume			Prior Research		3 items
Diversity			Prior Research		3 items
Breadth			Prior Research		3 items
ORGANIZATIONAL READINESS					
Top Management Support	+ / Sig	+ / Sig	Prior Research	3 items	
Feasibility (Financial & Technical)	+ / Sig	+ / Sig	Prior Research	4 items	
Technology Conversion Type	+ / Sig	+ / Sig	New	5 items	
EXTERNAL ENVIRONMENT					
Competitive Pressure	+ / Sig	+	Prior Research	3 items	
Participation Level in an SDO	+ / Sig	+ / Sig	Derived	4 items	
SDO ORGANIZATION					
Governance	+ / Sig	+ / Sig	New	3 items	3 items
Management Practices	+	+ / Sig	New	5 items	2 items
Architecture (IOS Standards)	+ / Sig	+ / Sig	New	5 items	2 items
INNOVATION ATTRIBUTES					
Relative Advantage	+ / Sig	+ / Sig	Prior Research	2 items	
Compatibility	+	+ / Sig	Prior Research	3 items	
Shared Business Process	+ / Sig	+ / Sig	Derived	4 items	2 items
POTENTIAL CONTROL VARIABLES					
Size	-	-	Prior Research	1 item	3 items
Industry	- / +	- / +	Prior Research		2 items
CONSEQUENCES OF INNOVATIONS					
Direct					
Financial			New & Prior		7 items
Operational			New & Prior		4 items
Indirect			New & Prior		7 items
TOTALS				43 items	39 items

A cross-sectional firm level survey was conducted from May to August 2003 to empirically compare the conceptual model to a real work environment and test the hypotheses. Table #3 outlines the survey structure, item counts and hypothesized impact. The sampling frame includes firms that are members of an SDO or a user of IOS SPI technology, or who are considering the possibility of either. The organizational title associated with the individual respondent from the firm has been Director of IT Standards, Assistant Director of IT Standards, CIO or one of their direct reports (respectively). The identification of specific candidate firms to send surveys was a two-staged approach. First, a candidate list of all firms and SDO organizations that submitted IOS SPI standards to the XML.org registry were identified. The XML.org registry, which was launched in 1999 by OASIS, was utilized since its' mission is to "provide an environment and community where technologists and businesspeople alike are encouraged to unite in the adoption of interoperability standards". XML.org acts as a portal for industries to submit IOS SPI standards in order to minimize overlap and duplication of efforts. As of August 2003, this portal had registered IOS standards from 46 industries and received 16,700 page views from over 4,400 visitors per day. The second stage was to identify firms that are members (or affiliated) with an SDO. In total, 979 firms were identified that fit the sampling profile. The candidate list was then reduced to exclude organizations that were developing SPI for intra-organizational purposes only, no longer in existence, or were individuals (as opposed to a firm). A total of 579 firm level surveys were distributed.

Development of this most recent version of the survey instrument started in the first quarter of 2002 and concluded in March 2003. During this period, the instrument went through multiple reviews with IS Ph.D. students, faculty, the university's Survey Research Lab and Institutional Review Board. In addition, two sets of pre-tests were conducted. The first pre-test was conducted with eight firms from a single industrial group during the second quarter of 2002. As previously discussed, this resulted in significant changes (improvements) to the survey instrument. All responses from the first pre-test were dropped. The second pre-test was conducted with ten firms from three industrial groups during the first quarter of 2003. The second pre-test resulted in only minor changes to the survey instrument (item sequence and minor phrase changes to better enable cross-sectional understanding). Responses from the second pre-test were included.

Instrument Structure

Appendix B includes a summary of the constructs, survey items and descriptions. The survey instrument is structured in four major sections (Organizational, SDO, Industry Consequences and Demographics). The Organizational section includes items referring to the firm's use of IOS SPI technology (strictly in an interorganizational context) and comprehends all items associated with the Organizational Readiness, External Environment, and the Innovation Attribute constructs. All items in the Organizational section are perception-based measurements on a 7-point Likert scale (with the exception of technology assimilation level that was measured on a 7-point modified version of the Guttman scale). For the SDO section of the survey, respondents were asked to consider their firms predominant SDO (one in which they were participants in, or aware of for their industrial group). The SDO section of the survey includes IOS SPI solution diffusion levels for three time periods (current, mid-term and longer term), and 20 items pertaining to the SDO Organization construct and associated measurement variables (perception-based on 7-point Likert scales). Due to the proprietary nature of the survey items in the Consequences section (e.g. revenue trends, expenditure trends, trading partner loyalty trends, entry barrier assessments, and required ROI levels to justify IOS SPI technology expenditure) respondents were asked to assess consequence measures with respect to their Industrial Group (as opposed to a specific firm). A total of 18 consequence measures were assessed by respondents for three time periods (current, mid-term and longer-term) based on time since deployment of IOS SPI solutions through out their industrial group. Each time period utilized a perception-based measure on a 5-point scale (ranging from 1 - significant decrease, 3 - no change, to 5 - significant increase).

Operationalization of Variables

Assimilation Levels (dependent variables)

The diffusion (dependent) variables include adoption, deployment and assimilation. Adoption is a dichotomous variable and indicates whether the firm has reached a decision ('yes' or 'no') to begin utilizing the IOS SPI technology grouping. Deployment is a dichotomous variable and indicates whether a firm has actually implemented the IOS SPI technology grouping in an interorganizational system context. Assimilation is based on a modified version of the Guttman scale with seven levels of IOS SPI technology assimilation levels is used (0-unaware to 7-

general deployment). This use of assimilation levels is similar in structure to Fichman and Kemerer's work with software process innovations (Fichman 1997; Fichman 1999). There are also three descriptive measures of external diffusion that measure the extent of actual implementations of an SDO's IOS SPI solutions across shared business processes with external trading partners. All three external diffusion measures are similar in scope and nature to Massetti and Zmud’s recommended diffusion measures (1996). Volume refers to the total number of instances (implementations) of the IOS SPI solutions. Diversity refers to the number of different (unique) IOS SPI solutions implemented. Breadth refers to the number of different trading partners.

Innovation Measures

Organizational Readiness

The organizational readiness construct considers attributes of the respondent firm. There are three measurement variables included in organizational readiness: top management support, feasibility (financial and technical readiness) and technology conversion. Consistent with Chatterjee’s top management participation dimension, three activity-based items are used to assess this variable; the assignment of a champion, communication of support, and active participation in developing the vision and strategy for the new technology (2001)

Financial and technical feasibility are infrequently used measurement variables in innovation diffusion studies. Iacovou defines financial readiness as the ‘financial resources available to pay for installation costs, implementation of any subsequent enhancements, and ongoing expenses during usage’ (page 469). Technical readiness is referred to as ‘the level of sophistication of IT usage and IT management in an organization’ (page 469). The adequate financial and technical resources to develop, implement, and maintain a new technology is essential for the successful diffusion. Two survey items are used for each of these variables that request respondents to assess the firms financial and technical readiness of developing, implementing and maintaining the technology, as well as the resources to make work-flow changes to accommodate the new technology. Each item has a 7-point Likert scale ranging from strongly disagree (on the left) through strongly agree (on the right).

Technology conversion refers to the extent of older IOS solutions (e.g. EDI or EDI-like) installed in the firm, relative to extent of modern-day IOS solutions installed in the firm. Based on five categories of IOS solutions (manual-based, semi-automated, EDI or EDI-like, proprietary and Internet-based) respondents were asked to indicate the extent of their firms use of these solutions on a 5-point scale ranging from 0-for no use to 4- extensive use. For item loading purposes, the values were summed over the first four categories and the fifth category subtracted.

External Environment

Two environmental factors under consideration include competitive pressure and participation level in an SDO. Competitive pressure was found to be the most frequently tested and significant measurement variable in prior IOS diffusion studies. Competitive pressure is measured at the firm level and its use in this study is similar to that from Premkumar (1997). Competitive pressure is the respondent organizations perceived external influence from trading partners, the industry, and the firms potential for loosing their competitive advantage. Three perceptual based survey items utilizing 7-point Likert scale is used for competitive pressure. The second external environment variable, participation level in an SDO, is based on a logical combination of four types of interactions that could occur between an SDO and a firm. These interactions include the firms membership status in an SDO (dichotomous with 'member' or 'non-member'), the firms participation in the SDO's developmental efforts (dichotomous with 'yes' or 'no'), the firms user status of the SDO's IOS solutions (dichotomous with 'user' or 'non-user') and the firms projection of whether they will implement an IOS SPI in the next 12 months (on a 7-point Likert scale).

Technology Attributes

Three measurement variables are utilized to assess attributes of the specific technology in study: relative advantage, compatibility and attributes associated with the underlying shared business process. All items in the innovation attribute section of the survey are perceptual-based measures and that utilize a 7-point Likert scale ranging from strongly disagree (on the left) through strongly agree (on the right). The definition of relative advantage is the extent to which a potential adopting organization views the innovation as offering direct financial and operational benefits over previous ways of performing the same tasks. Relative advantage has been the most frequently tested variable in IOS diffusion models (in fact, in all innovation diffusion models (Rogers 1995) and the second most frequently found significant variable influencing diffusion of IOS technology. Examples of direct operational benefits include reduced cycle times, increased throughput capability, and increases in response times. Examples of direct financial benefits include increased inventory turnover, ROI, and enhanced payback as a direct result of implementing the standards. The compatibility variable is from three perspectives: compatibility of the innovation with the firms values and beliefs, compatibility of the innovation with the IS infrastructure and work procedure needs of the firm. Several diffusion scholars (Rogers 1995; Tornatzky 1982; Premkumar, et. al. 1994) have advocated differentiating between these types of compatibility measures. Three survey items are utilized based on definitions provided by Rogers (1995).

Shared business process attributes are characteristics associated with the underlying shared business process. Examples of these business process characteristics include transaction volume needs, timeliness of the exchange, effectiveness of the communications, accuracy and integrity needs, and collaboration levels between the participating firms. A single item with multiple characteristics is utilized on the survey instrument for this measurement variable. Due to the similarity in their meanings (and effects) the possibility of replacing (and / or combining) the relative advantage variable with the shared business process attributes will be examined. The pervasiveness of the relative advantage variable has been proven on a routine basis across multiple innovation diffusion studies. The chief complaint is the vagueness of relative advantage and its' lack of specificity towards understanding unique attributes that are driving a certain technologies adoption versus a different technology (Tornatzky 1982). Rather than setting out to prove something already known, an attempt will be made to develop a set of shared business process attributes that are 'generic' enough to span across multiple types of business processes, yet comprehensive enough to include the theoretical support for both relative advantage and shared business process attributes.

Standards Development Organization

The role of an SDO could have a profound impact on IOS diffusion. Three measurement variables are introduced in this research regarding SDO governance, SDO management practices, and attributes of the standards (architecture) from the SDO.

Management practices of the SDO seek to identify whether the organization's management is following certain activities or norms. These norms are based on critical success factors of an alliance organization as discovered by Rais (1996) and Whipple (2000). Examples of these critical alliance management practices include effective communications, a high level of trust between the alliance organization and partner firms, the ability of the alliance organization to meet performance expectations, active participation is equally encouraged from all partner organizations (no favoritism), as well as clearly stated and understood goals and objectives of the SDO. A single item with five characteristics is utilized on the survey instrument for this measurement variable. In addition, respondents are provided the opportunity to add further management practices that they anticipating to experience (or have experienced) with their participation in the consortium.

Characteristics of the SDO architecture associated include modularity levels, conduciveness to high collaboration levels, vendor neutrality of the SDO and accurate and thorough technical documentation. A single perceptual-based item with five characteristics is utilized on the survey instrument for this measurement variable.

RESULTS

The survey administration portion of this study concluded in August 2003. This section provides a summary of survey results (in entirety), including respondent demographics, results from testing the proposed hypotheses and consequence measures. The multiple logistics regression technique was chosen to test hypotheses #1 through #8. The dichotomous nature of the dependent variable(s), adoption versus non-adoption and deployment versus non-deployment, would have necessarily broken assumptions of multiple regression analysis. The benefit of logistic regression is its' flexibility and ability to accommodate dichotomous and scaled (intervals) responses. The logistic function predictor variables may be quantitative, qualitative, and may represent curvature or interaction effects (Neter 1996). Maximum likelihood estimates (MLE) was used to estimate parameters of the multiple logistic response function. Prior IOS diffusion researchers have utilized logistics regression in their innovation adoption models (Zhu, Kraemer, Xu 2002; Chau and Tam 1997). Proposition #9 will be tested based on the mix of results from hypotheses tests #1 through #8 and others qualitative findings from conducting the study.

Respondent Demographics

A cross-sectional firm level survey was conducted from May to August 2003 to empirically compare the conceptual model to a real work environment. Table #3 outlines the survey structure, item counts and hypothesized impact. The sampling frame included firms that are members of an SDO or a user of IOS SPI technology, or who are considering the possibility of either. The organizational title associated with the individual respondent from the firm has been Director of IT Standards, Assistant Director of IT Standards, CIO or a direct report to the CIO. In total, 979 firms were identified that fit the sampling profile. The candidate list was then reduced to exclude organizations that were developing SPI for intra-organizational purposes only, no longer in existence, or were individuals (as opposed to a firm). 590 surveys were distributed with a total of 102 'usable' firm-level responses and 18 rejections received. An additional 34 firms indicated their willingness to respond to the survey but only provided partially completed responses (partial responses have been excluded). Multiple responses from a single firm were averaged (and considered as a single response). The overall effective response rate is 17.3%.

TABLE #4 - RESPONDENT FIRM DEMOGRAPHICS

COUNTRY OF ORIGIN		INDUSTRY		ORGANIZATION TYPE	
UNITED STATES	59	GEO-SPATIAL	17	MANUFACTURER	33
UK	12	ELECTRONIC COMP	17	GEO-SPATIAL SERVICES	11
TAWAIN	10	PETROLEUM	15	TECHNOLOGY PROVIDER	10
GERMANY	5	HUMAN RESOURCES	11	NP INDUSTRY INTEREST GROUP	9
CANADA	3	SEMI-CONDUCTOR	11	STAFFING SERVICES	8
SWITZERLAND	2	EDUCATION	8	EDUCATION	7
JAPAN	2	AUTOMOTIVE	8	ENERGY EXPLORATION	5
BELGIUM	2	PAPER	6	GOVERNMENTAL	4
NETHERLANDS	1	CHEMICAL	5	ENERGY PRODUCTION	4
AUSTRALIA	1	MARINE	3	DISTRIBUTOR	4
FRANCE	1	OTHER	1	PRINTING / PUBLISHING	4
IRELAND	1			AUTOMOTIVE RETAIL	3
SINGAPORE	1				
FINLAND	1				
DENMARK	1				
TOTAL	102	TOTAL	102	TOTAL	102

EMPLOYEE COUNT		TRADING PARTNERS		ANNUAL BUDGET (REVENUES)	
LESS THAN 25	14	LESS THAN 25	19	LESS THAN $1 million	12
25 ~ 99	11	25 ~ 49	5	$1M ~ $9 MILLION	10
100 ~ 499	13	50 ~ 74	4	$10M ~ $49 MILLION	10
500 ~ 999	9	75 ~ 99	2	$50M ~ $99 MILLION	4
1,000 ~ 4,999	13	100 ~ 149	4	$100m ~ $499 million	12
5,000 ~ 9,999	8	150 ~ 199	4	$500M ~ $999 MILLION	7
10,000 AND GREATER	34	200 ~ 250	21	$1 BILLION OR GREATER	44
		GREATER THAN 250	43	GOVERNMENT OR N/A	3
TOTAL	102	TOTAL	102	TOTAL	102

All candidate firms were provided the option to have the survey administered via (1) a paper copy through postal mail, (2) a digital copy through e-mail, or (3) a conference call interview. Of the 102 respondents, 3 chose the paper option, 67 chose the digital option and 32 chose the interview option. All survey questions were precisely the same (regardless of the option selected by the respondent) and the same individual conducted all interviews. Collectively, the firms originate from 14 different countries, represent 10 different industrial groups, and participate in 15 different SDOs. Overall, the firms could be classified into 12 different organizational types, ranging from manufacturers, distributors, energy exploration / production, printers / publishers, and a host of service orientated firms (staffing, governmental, geo-spatial, and automotive retail). See Table #4 for a summary of respondent firm demographics. Contrary to some other studies, responses from technology providers and non-profit industry interest groups were retained for analysis purposes (Chatterjee 2002). These types of organizations fit the sampling profile for this study. In addition, most of these firms are users, implementers, or (at a minimum) significant stakeholders with respect to the adoption and diffusion of IOS standards and solutions through out an industrial group.

Potential response bias was examined from three perspectives: completed surveys as percent of SDO members, non-responses as percent of surveys distributed and rejections as percent of SDO members. For larger SDO organizations (those with 75 members or more) ratios were amazingly consistent at the industrial group level and demonstrated no potential response, non-response or rejection bias. For smaller SDO organizations, ratios did significantly vary (up to a maximum of 51% of variation) with respect to three industrial groups. These variations were attributed to a low absolute count of participating members and the short time horizon since the inception of the industrial group's SDO. Overall, these results provided no significant reasons to justify further investigation into potential response, non-response or rejection bias.

Instrument Validation

Content validity was qualitatively assessed through three preliminary studies, two pre-tests, multiple reviews with IS faculty, Ph.D. students and guidance from survey development groups within the university. Content and construct validity were further qualitatively substantiated through a literature review conducted from 21 prior IOS diffusion publications, including a comprehensive coding of 101 previously used measurement variables across 6,092 samples. This resulted in the use of the organizational - innovation - environmental framework and provided a basis for deriving seven of the proposed measurement variables under examination. Consistent with Straub's recommendations, see Appendix B for a conceptual descriptions of constructs, measurement variables, survey items and item descriptions (1989). Reliability of the survey instrument's items were also quantitatively validated through calculating Cronbach alphas for each measurement variable. The alphas range from .70 to .77 and are itemized in Table #5 - Reliability of Factors. Although the Chronbach alphas are lower than Straub's (1989) .8 rule-of-thumb, they are greater than Nunnally's .6 threshold (Chau and Tam 1997). Due to the rich mix of survey items based on prior research and the introduction of new survey items pertaining to the role of the SDO, these levels are deemed appropriate for this context.

TABLE #5 - RELIABILITY OF FACTORS

		Cronbach Alpha
TopMan	3 items	0.710
Feasibility	4 items	0.734
CompPre	3 items	0.713
SDOPart	logical combination of 4 items)	0.728
RelAdv	2 items	0.714
Compab	3 items	0.700
ShareBus	4 items	0.746
ManaPra	5 items	0.724
Archit	5 items	0.722
Govern	3 items	0.713
TechConv	1 item (logical combination of 5 items)	0.769

Convergent validity and discriminant validity were also quantitatively assessed through factor analysis. Principle Components Analysis was conducted for all nine multi-item factors. Out of the 32 item loadings, all but three of the survey items loaded high (>.50 threshold) in their factors. Thus, demonstrating a good degree of convergent validity. The three exceptions are discussed and explained below

Straub defines convergent validity as "when the correlation of the same trait and varying methods is significantly different from zero and converges enough to warrant further investigation" (Straub 1989, pg. 151). Straub then distinguishes discriminant validity to be evidenced by "higher correlations of that trait and different traits using both the same and different methods" (Straub 1989, pg. 151). Discriminant validity was further quantitatively assessed using an item correlation matrix 'counting' technique outlined by Chau and Tam (1997). Generally speaking, validity is established by counting the number of higher correlations outside of an item's factor and then comparing the result with the total possible number of correlations. The general rule of thumb is discriminant validity is established if the above ratio is less than 50%. Out of the 560 total possible correlations, 220 (or 39%) experienced higher correlations outside of their own variable. Thus, these results outperform the general rule of 50% and provide partial support of discriminant validity. Further examination of this issue, as well as the Principle Component Analysis reveals the following. First, one third of the instances of these higher item correlations are associated with the Compatibility variable. Several prior IOS researchers have separated the compatibility variable between values of the firm versus the innovation (technological) compatibility. This study started under that premise until preliminary Principle Components Analysis results indicated that one of the compatibility items should be either be combined or act as a stand-alone measure. It was decided to combine the measures and avoid a single-item measure. The other two-thirds of instances of higher item correlations are associated with two of the new variables introduced in this study (SDO Management Practices and SDO Architecture). The SDO's role has become pivotal in coordinating the development and adoption of IOS SPI. Since this study is one of the first to provide framing of an SDO's role through-out an industrial group, it was decided to error on the side of too many items (as opposed to too few), to better enable research succession and progression in future studies. That is, as more studies are conducted utilizing SDO measures item phrasing, structuring, and content will evolve and improve discriminant validity. Tables #6 includes the descriptive statistics.

Table #6 - Descriptive Statistics

Variable	N	Mean	Std Dev	Min	Max
TopMan	102	5.16	1.53	1	7
Feasibility	102	5.64	0.97	2	7
CompPre	102	5.26	1.27	1	7
SDOPart	102	4.29	1.20	0	5
RelAdv	102	5.15	1.17	2	7
Compab	102	3.90	0.93	0	5
ShareBus	102	5.83	0.83	2	7
ManaPra	102	5.22	0.91	3	7
Archit	102	5.38	0.80	2	7
Govern	102	5.94	0.72	3	7
TechConv	102	1.42	0.67	-1	3
AnnSales	102	4.99	2.27	1	7

Modeling Structure

Two objectives of this study is to understand the significant antecedent conditions leading towards the adoption of IOS SPI technology and the deployment of IOS SPI solutions throughout an industrial group. Structuring the conceptual model (and analysis) in this two-staged fashion provides the ability to isolate the effects of the measurement variables on the two dependent variables (adoption versus deployment). As discussed in Survey Development, findings from preliminary work leading to this study indicate that the adoption decision (versus the deployment decision) may have a different mix of antecedent conditions. This approach is further substantiated by the notion of assimilation gaps. Assimilation gaps (large time differences between adopting a new technology versus actual deployment of the new technology across an organization) have been found to exist when a technology is susceptible to network externalities and knowledge barriers (Fichman 1999). The nature of interorganizational system standards is such that, if a firm's trading partners fail to mutually co-adopt the IOS standards, there are few benefits to be gained. Indeed, IOS SPI solutions are susceptible to increasing returns by a firm's immediate trading partners and the extended industrial group. A third reason for structuring the conceptual model in this fashion is that it enables enhanced understanding of an industrial coordination of interorganizational system standards (Johnston 2000). Using the same data and proposed independent variables, three models are constructed (altering the categorization of the dependent variable only) to measure IOS SPI diffusion from three perspectives (1) adopters versus non-adopters, (2) deployers versus non-deployers and (3) Assimilation. Two points should be noted. First, hypothesis tests were conducted regarding (1) adopters versus non-adopters and (2) deployers versus non-deployers only. Second, from a connotative perspective the use of the term 'model' seems more appropriate than the term 'scenario' for discussion purposes. Thus, the point will be re-emphasized that all three scenarios (or 'models' if you will) are based on precisely the same data set (survey responses) and proposed independent variables (the conceptual IOS SPI diffusion model). The only difference between the three models is the categorization of respondents along the technology assimilation scale (1) adopters versus non-adopters, (2) deployers versus non-deployers and (3) assimilation that entails four categories to be defined later. The following three sections provide statistical model results, hypotheses test results, and model fit assessments.

Determinants towards IOS SPI Adoption

The distinction between adopters and non-adopters of IOS SPI technology is based on responses to the 7-point technology assimilation scale (ranging from 1-Unaware, 2-Aware, 3-Interest, 4-Evaluation / Trial, 5-Commitment, 6-Limited Deployment, 7-General Deployment). Consistent with other definitions of adoption "that a decision has been reached to begin using an innovation" (Rogers 1995) responses of five, six or seven on the assimilation scale indicated that the firm adopted IOS SPI technology. No firms indicated their unawareness, rejection or discontinuance of the IOS SPI technology grouping. Non-adopters were based on responses of four, three or two. See Table #7 for respondent assimilation levels of IOS SPI technology results and definitions. Overall, there are 80 adopters, 22 non-adopters of IOS SPI technology and no firms indicating unawareness.

Since adoption versus non-adoption is a dichotomous categorization, multiple logistic regression is used where a binomial distribution is assumed. Maximum likelihood estimates (MLE) was used to estimate parameters of the multiple logistic response function. The first three columns (model #1) in Table #8 summarize the significant variables in distinguishing between adopters and non-adopters of IOS SPI technology (including the variable coefficients, Wald statistics and significance levels) based on the multiple logistics function. In distinguishing between adopters versus non-adopters the following measurement variables were found to be significant: Top Management Support, Feasibility, Technology Conversion, Competitive Pressure, Participation Level in an SDO, and Architecture. Thus fully supporting hypotheses #1 (organizational readiness attributes) and hypothesis #3 (external environment attributes), and providing partial support of hypothesis #5 (with respect to the positive direction and significance of architecture). Hypothesis #5 was only partially supported with respect to the negative direction and lack of significance of Governance, and the negative direction of SDO Management Practices. Hypothesis #7 is not supported due to the lack of significance of all innovation related attributes and the negative direction of relative advantage and shared business process attributes. See Figure #4 for a summary of hypothesis test results.

TABLE #7 - RESPONDENT ASSIMILIATION LEVELS OF IOS SPI TECHNOLOGY

							ASSIMILATION LEVELS				
	Assimilation Level	Definition	Adopters	Non-Adopters	Deployers	Non-Deployers	Non-Adopters	Adopter & Non-Deployer	Limited Deployer	General Deployer	Total
1	Unaware.	The firm is not aware of the interorganizational system SPI technologies described.		0		0	0				0
2	Awareness.	Key decision makers in the firm are aware of interorganizational system SPI concepts and capabilities.		8		8	8				8
3	Interest.	The firm is preparing plans to investigate any interorganizational system SPIs for possible production use within the next 12 months.		8		8	8				8
4	Evaluation / Trial.	The firm has purchased 'trial' capabilities and is currently evaluating possible uses of the technology.		6		6	6				6
5	Commitment.	The firm has specific plans and made formal commitments to utilize the technology in production in the next 12 months (or the near future).	22			22		22			22
6	Limited Deployment.	The firm has implemented SPI technology in at least three interorganizational systems.	30		30				30		30
7	General Deployment.	Interorganizational system SPI technology is now integrated in the majority of mission critical systems and in new systems development initiatives (where applicable).	28		28					28	28
TOTALS			80	22	58	44	22	22	30	28	102

Significance findings are based on the final (fitted) model which gives goodness of fit, maximum likelihood estimate (MLE) coefficients, Wald statistics and test results for the significant effects only (including main effects and interactions). The non-significant findings are based on the initial model that gives initial goodness of fit, MLE coefficients, Wald statistics and test results for all twelve measurement variables. Overall, the model fit was improved between the initial and final model (from an AIC of 71.64 to a final AIC of 57.34). The final model is significant at the .1212 level on a χ^2 distribution. Utilizing techniques outlined by Menard (1995) the percentage of explained variation (R^2_L) is .596. Based on the IOS diffusion literature search, the averaged explained variation in prior IOS diffusion models is .31. Thus this model's explained variation is nearly double the average from prior IOS diffusion studies. The reason is likely two-fold. First, an extensive literature search and meta-analysis of IOS adoption and diffusion studies was conducted for this study. As a direct result, six of the measurement variables and their associated survey items were utilized in this study. In addition, this resulted in the use of the organizational-environmental-technological framework in the conceptual IOS adoption and diffusion model. Second, as described in the research methodology, several preliminary studies and two pre-tests were conducted prior to launching the present study.

Table #8 - Determinants of IOS SPI Adoption & Diffusion

CONSTRUCT	**MODEL #1 - Adopters**			**MODEL #2 - Deployers**			**MODEL #3 - Assimiliation (Volume - 4 Categories)**		
Measurement Variable	Coefficient	Wald Statistic	Significance	Coefficient	Wald Statistic	Significance	Coefficient	Wald Statistic	Significance
ORGANIZATIONAL READINESS									
Top Management Support	0.849	4.959	0.026	n.s.	n.s.	n.s.	0.401	5.373	0.021
Feasibility (Fin & Tech)	1.450	6.193	0.013	0.859	5.943	0.015	0.673	5.689	0.017
Technology Conversion**	2.037	5.885	0.015	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
EXTERNAL ENVIRONMENT									
Competitive Pressure	6.004	5.648	0.018	2.168	3.445	0.064	2.698	5.759	0.016
Participation Level in an SDO	7.670	6.313	0.012	3.298	5.273	0.022	3.812	7.960	0.005
INNOVATION ATTRIBUTES									
Relative Advantage (Direct)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Compatibility (Innovation)	n.s.	n.s.	n.s.	7.496	6.242	0.013	3.974	5.448	0.020
Shared Business Process	n.s.	n.s.	n.s.	3.764	3.934	0.047	2.141	3.138	0.077
STANDARDS DEVELOP ORG (SDO)									
Management Practices**	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Architecture**	1.674	5.652	0.017	0.957	5.096	0.024	0.657	4.235	0.040
Governance**	n.s.	n.s.	n.s.	-1.137	5.496	0.019	-1.049	7.473	0.006
CONTROL									
Size (Annual Budget)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
+ / - Industry	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*	n.a.*
NON-SIGNIFICANT FINDINGS (INITIAL MODEL)									
Top Management Support	n.a.	n.a.	n.a.	0.517	0.229	0.632	n.a.	n.a.	n.a.
Technology Conversion	n.a.	n.a.	n.a.	-0.423	1.716	0.190	-0.192	0.289	0.591
Relative Advantage (Direct)	-17.010	2.047	0.153	-4.181	1.716	0.190	-1.563	0.660	0.416
Compatibility (Innovation)	2.502	0.047	0.828	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Shared Business Process	-11.585	2.461	0.117	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Management Practices	-12.284	0.949	0.330	0.325	0.005	0.945	5.551	2.443	0.118
Governance	-3.816	0.307	0.579	0.325	0.502	0.479	n.a.	n.a.	n.a.
Size (Annual Budget)	0.122	0.106	0.745	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
MODEL FIT									
	AIC	Goodness of Fit		AIC	Goodness of Fit		AIC	Goodness of Fit	
		Dev / DF	Chi Squr / DF		Dev / DF	Chi Squr / DF		Dev / DF	Chi Squr / DF
INITIAL MODEL	71.64	0.38*	0.91	131.76	1.15	1.24	250.28	not reported	
FINAL MODEL	57.34	0.45	1.18	117.82	1.06	1.10	240.50	not reported	
FINAL MODEL SIGNIFIGANCE		df=91	0.1212 df=91		0.3195 df=92	0.2476 df=92			
R^2 L "% OF EXPLAINED VARIATION"			0.5960			0.2987			0.2361

Determinants towards IOS SPI Deployment

The distinction between deployers versus and non-deployers of IOS SPI is based on responses to the 7-point technology assimilation scale (ranging from 1-Unaware, 2-Aware, 3-Interest, 4-Evaluation / Trial, 5-Commitment, 6-Limited Deployment, 7-General Deployment). Distinguishing between deployers versus non-deployers is advocated in situations where significant assimilation gaps are likely to exist (Fichman 1999). As indicated in Table #7, deployers were respondents indicating six or seven on the assimilation scale (e.g. the respondents had actual implementations of the target technology in their firm), and non-deployers were respondents indicating five, four, three or two. Overall, there are 58 deployers, 44 non-deployers and no firms indicating unawareness of IOS SPI technology.

Similar to the adoption analysis, since deployment versus non-deployment is treated in this study as a dichotomous categorization, multiple logistic regression is used where a binomial distribution is assumed. The middle three columns (model #2) in Table #8 summarize the significant variables in distinguishing between deployers and non-deployers of IOS SPI technology (including the variable coefficients, Wald statistics and significance levels) based on the multiple logistics function. In making this distinction, feasibility, competitive pressure, participation level in an SDO, compatibility, shared business process, architecture and governance are the significant measurement variables (antecedent conditions) towards IOS SPI deployment. These findings provide limited support of hypothesis #2 (organizational readiness attributes) with respect to the positive direction and significance of feasibility, and full support of hypothesis #4 (external environment attributes). In addition, hypothesis #6 (SDO attributes) has limited support. The SDO architecture attribute is positive and significant, however governance was significant (but in a negative direction) and management practices was not significant. There is support of hypothesis #8 with two attributes of the innovation itself (compatibility and shared business process) that are significant and positive towards IOS SPI deployment. See Figure #4 for a summary of hypothesis test results.

Figure #4 Hypotheses Results

H1	Organizational Readiness attributes will have a positive (and significant) relationship with IOS SPI adoption.	Supported
H2	Organizational Readiness attributes will have a positive (and significant) relationship with IOS SPI deployment.	Partial Support (w.r.t. Feasibility)
H3	The external environment attributes will have a positive (and significant) relationship with IOS SPI adoption.	Supported
H4	The external environment attributes will have a positive relationship with the external deployment of IOS SPI. Participation levels in an SDO will have significant relationship towards IOS SPI deployment.	Supported (and Competitive Pressure is significant)
H5	SDO attributes will have a positive relationship with IOS SPI adoption. Governance and Architecture will also have a significant relationship towards IOS SPI adoption.	Partial Support (w.r.t. Architecture)
H6	SDO attributes will have a positive (and significant) relationship with IOS SPI deployment.	Partial Support (w.r.t. Architecture). Governance was significant, but negative
H7	Innovation attributes will have a positive relationship with IOS SPI adoption. Relative Advantage and / or Shared Business Process attributes will also have a significant relationship towards IOS SPI adoption.	Not Supported
H8	Innovation attributes will have a positive (and significant) relationship with IOS SPI deployment.	Partial Support (w.r.t. Compatability and SBP).
P9	A different set of significant attributes will be associated with IOS SPI adoption and IOS SPI deployment.	Supported

The significance findings are based on the final (fitted) model which gives goodness of fit, maximum likelihood estimate (MLE) coefficients, Wald statistics and test results for the significant effects only (including main effects and interactions). The non-significant findings are based on the initial model that gives initial goodness of fit, MLE coefficients, Wald statistics and test results for all twelve measurement variables. Overall, the model fit was improved between the initial and final model (from an AIC of 131.64 to a final AIC of 117.82). The final model is significant at the .2476 level on a χ^2 distribution. Utilizing techniques outlined by Menard (1995) the percentage of explained variation (R^2_L) is .2987. Based on the IOS diffusion literature search, the averaged explained variation in prior IOS diffusion models is .31. Thus the deployment versus non-deployment results are consistent with the explanatory power from prior IOS diffusion studies. The decline in explained variation, however, from model #1 to model #2 is substantial. The reason for this difference is likely two-fold. First, compared with a firm's decision to begin utilizing IOS SPI technology (adoption), most firms are merely on the brink of wide-scale diffusion of IOS SPI solutions. Thus, a richer empirical understanding of adoption determinants are available compared with deployment determinants. Second, the adoption decision is inherently more of a 'yes' or 'no' dichotomous event. Deployment, on the other hand, is more closely related to a measure of dispersion (e.g. diffusing IOS SPI solutions across trading partner and share business processes). A future research recommendation is to model IOS SPI diffusion as a continuos measure, as opposed to a dichotomous categorization.

With respect to the final proposition #9, these results demonstrate a different set of determinants can be attributed towards IOS SPI adoption versus deployment. Overall the findings indicate Organizational Readiness attributes are more important towards adoption than deployment. Specifically these attributes would include top management support and the firm's installed base of older IOS solutions (e.g. EDI or proprietary solutions). Often times the IOS SPI technology adoption decision is tightly coupled with the overall firm-level decision to join an SDO. In effect, this hightens the adoption decision to a larger issue of 'Which standards game will the firm choose to participate?' Based on these findings, once the adoption decision is made organizational attributes become less in the actual deployment of the technology. Second, the findings also indicate that innovation attributes are not important towards adoption, but are significantly related towards deployment. As will be discussed in the next section, this is an extremely insightful finding. This result contradicts most prior IOS diffusion studies where attributes of the technology itself (such as the direct operational benefits and compatibility) are important determinants of IOS diffusion. Thus, strong support of proposition #9 is demonstrated.

Determinants towards IOS SPI Assimilation

The distinction between assimilation levels of IOS SPI is based on responses to the 7-point technology assimilation scale (ranging from 1-Unaware, 2-Aware, 3-Interest, 4-Evaluation / Trial, 5-Commitment, 6-Limited Deployment, 7-General Deployment). As depicted on Table #7 responses are grouped into four categories; (1) Non-adopters were respondents who answered two, three, or four, (2) Adopters & Non-Deployers were respondents who answered five, (3) Limited Deployers were respondents who answered six and (4) General Deployers were respondents who answered seven. Distinguishing between deployers versus non-deployers is advocated in situations where significant assimilation gaps are likely to exist (Fichman 1999). The intent of the above categorization and modeling technique is to emulate the assimilation of IOS SPI (as opposed to treating it as a dichotomous categorization of deployment versus non-deployment). This is analogous to Massetti and Zmud's recommended diffusion measure of volume, which refers to the total number of instances (implementations) of the IOS SPI solutions (1996). Overall, there are 22 non-adopters, 22 adopters but non-deployers, 30 limited deployers and 28 general deployers of IOS SPI technology.

The final three columns (model #3) in Table #8 summarize the significant variables in distinguishing between assimilation categories of IOS SPI (including the variable coefficients, Wald statistics and significance levels) based on polytomous logistic regression (Neter 1996). With one exception, all of the significant variables in distinguishing assimilation levels are the same as those with distinguishing between deployers and non-deployers. The exception is Top management support, which became significant in the assimilation model.

The significance findings are based on the final (fitted) model which gives goodness of fit, maximum likelihood estimate (MLE) coefficients, Wald statistics and test results for the significant effects only (including main effects and interactions). The non-significant findings are based on the initial model that gives initial goodness of fit, MLE coefficients, Wald statistics and test results for all twelve measurement variables. Overall, the model fit was improved between the initial and final model (from an AIC of 250.28 to a final AIC of 240.5). The final model significance was not assessed due to the polytomous logistics regression SASv8 would not provide goodness of fit results. However, since this model is based on the same data as the two prior models (where confirmatory fit results were conducted) we can assume the fit is satisfactory. Utilizing techniques outlined by Menard (1995) the percentage of explained variation (R^2_L) is .2361. Compared with the averaged explained variation in prior IOS diffusion models of .31, this model's explained variation is less.

Control Variables

The control variable size was tested in all three models from three potential perspectives (sales or annual budget, trading partner count and employee count). From all three perspectives and in all three models, the size control variable is non-significant. Firm size was found significant in six prior IOS diffusion studies (primarily based on EDI or EDI-like technology) and non-significant in five. Traditionally, a firm's size has been considered a potential significant factor in IOS diffusion due to EDI's relative large up-front expenses. This no longer appears to the case with modern-day IOS solutions.

Second, attempts were made to incorporate an industry control variable into all three final logistics regression models. SASv8 reported convergence failures in every attempt. Convergence difficulties have been known to occur in multiple logistics regression during numerical search procedures for finding maximum likelihood coefficient estimates (Neter 1996). With satisfactory principle components analysis results, one remedy sought was to categorize the 10 industries into four higher-order industrial groups. The convergence errors remained, however, and the industry control variable was dropped. Based on discussions with statisticians, the convergence errors were likely due to the high number of significant predictor variables in relation to the sample size. Descriptive industry-based analysis and findings will provided in the discussion section.

Consequences of Diffusion

The far right side of Figure #3 - A Conceptual Model of the Adoption & Diffusion of IOS Standards and Process Innovations examines consequences of IOS SPI diffusion. This study examines the direct and indirect impact of adopting and deploying IOS standards. Overall, these results provide initial insights into the potential consequences on an industrial group as a result of deploying IOS standards. The effects are cumulative in nature and are tiered into 1st, 2nd, and 3rd ordered effects based on time since deployment. Respondents provided insights into 18 different anticipated industry consequences for the short-term (immediate), medium-term (next 1 to 2 years) and longer-term (next 3 to 4 years). Due to the proprietary nature of the survey items in the Consequences section, respondents were asked to assess consequences with respect to their industrial group (as opposed to a specific firm). 16 of the measures utilized a perception-based measure on a 5-point scale (ranging from 1 - significant decrease, 2 decrease, 3 - no change, 4 - increase and 5 - significant increase) for each time period. Two additional consequence measures (anticipated longevity of IOS standards and required annual return on investment (ROI) required to justify IOS SPI related expenditures) utilized 7-point scaled responses including the option of an Other category for specific responses. Table #9 - Industrial Group Consequence Trends of IOS SPI Diffusion (all respondents) provides a summary of the consequence measures. The response values in table #9 have been normalized (to a 0 scale), averaged and are cumulative over the three time periods. Thus, anything above 0 reflects a mean cumulative anticipated consequence increase, anything below 0 reflects a mean cumulative consequence decrease.

Overall the consequence trends on an industrial group are extremely favorable with respect to the adoption and diffusion of these innovations. As a starting base line, respondents indicated that a 14% annual ROI would be necessary to justify expenditures on IOS SPI technology and anticipate the longevity of IOS SPI standards to be at least 36 months (or greater). The majority of trends have fallen where one would hope they would fall (for proponents of diffusing IOS standards). The direct financial (e.g. ROI, firm profitability, payback) consequences and direct operational (improved response times and throughput capability) consequences of diffusing IOS standards are both positive and are anticipated to grow during the three time periods (with the operational benefits increasing at a significantly greater rate). The key source of these positive trends stem from reductions in IOS standards negotiation efforts with trading partners in time periods two and three (despite anticipated increases in employee training and infrastructure capital expenditures in all three time periods). It's interesting to note that no significant difference exist in the anticipated direct financial consequences of diffusing IOS standards across new trading partner versus implementing new IOS standards across the same trading partners. Thus it is anticipated that the learning curve associated with bringing on new trading partners, is very similar to that of diffusing new standards across the same trading partners. This has not been the experience of EDI diffusion and may lend insight into the potential reasons for the significant IOS standards grow projections.

Also indicated in Table #9 are numerous indirect benefits enabled from diffusing IOS technology standards. For example, improved loyalty with trading partners (including compliance improvements with trading partner mandates), enhanced revenue opportunities (or the attraction of new customers), lead-time improvements, and modest product / service cost reductions.

Table #9 - Industrial Group Consequence Trends of IOS SPI Diffusion

EXPECTED LONGEVITY OF IOS SPI STANDARDS * 35.7 months
REQUIRED ROI TO JUSTIFY IOS SPI EXPENDITURES * 14.2% per annum

	All Respondents (n=102)		
	Short Term	Mid Term	Long Term
	Immediate	1 ~ 2 Yrs	3 ~ 4 Yrs
Maximum Cumulative Absolute Value-->	+/-2	+/-4	+/-6
CONSEQUENCE MEASURES**			
DIRECT MEASURES			
Direct Operational Benefits***	+ 0.5	+ 1.4	+ 2.5
Direct Financial Benefits***	+ 0.1	+ 0.8	+ 1.9
With new trading partners (same standards)	+ 0.5	+ 1.4	+ 2.5
With new standards (same trading partners)	+ 0.4	+ 1.3	+ 2.3
With new trading partners and new standards	+ 0.5	+ 1.3	+ 2.3
Employee training expenditures	+ 0.7	+ 0.9	+ 0.5
Standards negotiation time & expenditures	+ 0.0	- 0.3	- 0.7
IOS Development time & expenditures	+ 0.5	+ 0.4	+ 0.1
IOS Implementation time & expenditures	+ 0.3	+ 0.1	- 0.5
INDIRECT MEASURES			
Trading Partner Loyalty	+ 0.5	+ 1.2	+ 1.9
Compliance w/ trading partner mandates	+ 0.6	+ 1.3	+ 2.0
Entry Barriers in Industry	+ 0.2	+ 0.2	+ 0.1
Revenue (or the attraction of new customers)	+ 0.4	+ 1.3	+ 2.2
Infrastructure Capital Expenditures	+ 0.7	+ 1.0	+ 1.0
Manufacturing Lead Times	+ 0.0	- 0.2	- 0.6
Cost of providing the firm's services / products	+ 0.1	- 0.2	- 0.8

NOTES:
* Weighted average based on scale responses (incl. specific responses in "Other" category)

IOS Diffusion Levels (S-curve)

Respondents in the study currently report having 4,732 IOS SPI solutions implemented (volume), consisting of 286 distinct message types (diversity), across 904 different trading partners (breadth). Respondents are hopeful of experiencing substantial growth in diffusion levels over the mid-term and longer-term time periods. For example, they are projecting a 53% increase in diversity, a 216% increase in breadth, and an overall volume increase of 240% of deployed IOS SPI solutions over the next 12 months (alone). In the following 12 months, respondents are projecting an additional increase of 36% in diversity, a 118% in breadth, and an overall volume increase of an additional 175%. Thus, in the next two years, respondents are expecting the volume of implemented IOS SPI solutions to reach a staggering 44,158 consisting of 595 message types (diversity) and 6,217 trading partners (breadth). If these projections are representative of what is occurring throughout industries (overall) we are on the verge of reaching a much steeper segment of the IOS SPI deployment (S-curve). That is, if we simply assume an average start date of early to mid-1999 for the majority of SDO IOS SPI development initiatives (which based on Table # 6 and the fact that the W3C did not formally approve XML until February 1998) this is a fair assumption. It has taken approximately 3 to 3.5 years to reach 4,732 implemented solutions. In the next two years (alone), this expected to increase to 44,158 implemented solutions (representing a 833% increase in volume). Even if these projections are off by 50%, IOS standards are on the verge of significant widespread diffusion from all three perspectives (volume, diversity and breadth). It's interesting to note that faster growth is expected across trading partners (breath) than with new message types (diversity).

	Current Installed	% Increases		Projected Next 24 Months
		Next 12 Months	Following 12 Months	
Volume (count)	4,732	240%	175%	44,158
Diversity (message types)	286	53%	36%	595
Breadth (trading partners)	904	216%	118%	6,217

DISCUSSION

The discussion will begin with a brief framing and scope of the background (emerging key issues) confronting firms (and industrial groups) regarding modern day IOS SPI solutions. This will include discussions regarding IOS SPI deployment levels over the next 12 and 24 months (as projected by survey respondents), standards convergence challenges and the most critical unmet needs of firms participating in an SDO. The discussion will then turn to the specific results discovered in this study pertaining to IOS SPI adoption, deployment and assimilation. Proper perspective of these findings will be integrated into the discussion in light of the emerging issues. The section will then conclude with a discussion concerning industrial coordination of IOS SPI solutions, including profiles of firm-level assimilation and other industry analysis findings. Qualitative insights from respondents are included (where appropriate) and numerous recommendations to practitioners and researchers are provided throughout.

Background

One of the aims of this study is to develop a prescriptive set of influential measures that could assist practitioners and researchers alike in reaching this new era of interorganizational information sharing. Three critical issues confronting firms (and industrial groups) with respect to IOS SPI have emerged from this study: managing diffusion levels, horizontal convergence and resolving a voluminous pile of unmet needs of firms participating in an SDO. Briefly highlighting these issues at the outset of discussion will provide proper context and framing for the ensuing analysis and recommendations pertaining to IOS SPI diffusion and industrial coordination.

First, respondents to the survey reported as having 4,732 currently implemented IOS SPI solutions (volume). They are projecting this level to reach 44,158 implemented IOS SPI solutions (representing a 833% increase in volume) at the end of the next two years. In fact, many respondents indicated they have already begun incorporating the potential operational and financial benefits into their business plans and financial forecasts, respectively, despite the fact they do not know with whom or how they will reach these deployment levels. As one respondent indicated, "The economy is in recession, budgets are being slashed, and were looking for potential upside. We have to move on faith that we'll find <trading partners> folks willing to anti up." The second area of emerging issues is horizontal convergence of IOS standards. The core issue of convergence is how to leverage the work of industry-based SDO's (a.k.a. the verticals) into horizontal (cross-industry) sets of IOS standards. The key problem is the ability to find funding sources to support the cross-industry effort. Everyone understands the potential benefits, but technology providers are unwilling bear the cost due to the 'open-source' non-profit nature of the standards, larger organizations are slow to adopt due to their EDI installed base, leaving much of the burden on small to medium sized organizations. However, even these organizations are reluctant to fund horizontal convergence since the benefits of these cross-industry level of projects will only tangentially accrue to their operations. The third area of emerging issues is a voluminous pile of unmet needs of firms participating in an SDO. Based on an open-ended survey question regarding 'What services should be offered by your industry's SDO, but currently are not', the following are the top four responses. First, adoption and sustained diffusion assistance. That is, the SDO should provide additional services associated with convincing trading partners to adopt IOS SPI. Second, horizontal convergence assistance. That is, the SDO should insure the standards that are being developed will not ultimately have to be replaced, if a new set of IOS SPI standards emerge on a horizontal basis. Third, additional services associated with compliance and conformance testing. Fourth, the SDO should find ways to minimize the amount of standards versioning.

IOS SPI Adoption

In distinguishing between adopters versus non-adopters top management support, feasibility, technology conversion, competitive pressure, participation level in an SDO, and architecture were found to be significant determinants. The first noteworthy item is the lack of any attributes associated with the innovation itself (relative advantage, compatibility, shared business process attributes). For innovation diffusion scholars, this is a significant finding. Attributes such as relative advantage and compatibility have consistently been found to be two of the most significant determinants of adoption in prior research (Rogers 1995; Tornatzky 1982). An interpretation of this finding is as follows. The direct operational and financial benefits (e.g. cost reductions, enhanced response times) enabled by IOS SPI are not significant factors in distinguishing between adopters versus non-adopters. This finding contradicts the literature search in this study where relative advantage was the third most frequently significant variable towards IOS diffusion. This finding is not with out precedence as prior IOS diffusion studies did find a lack of significance of relative advantage (Premkumar 1997, 1994; Chau 1997; Grover 1993). Thus, in certain situations, other things must become more important in making the distinction between adopters and non-adopters. Since this study examined the use of IOS SPI technology strictly in an interorganizational system context, there are plenty of other things to consider. Such as those associated with the willingness of other organizations to adopt IOS standards (competitive pressure and participation levels in an SDO) and the role of the industry's SDO (architecture and governance). Perhaps the intrinsic benefits of IOS SPI technology innovations are mutually understood, that other things take precedence.

Second, attributes associated with Organizational Readiness (top management support, feasibility and technology conversion) were significantly related towards distinguishing between adopters versus non-adopters. Top Management Support is the second most consistently found significant variable in the literature search of IOS diffusion studies. The development of interorganizational system standards is a direct outward manifestation of the firm and their willingness to participate throughout an industrial group. This was evident by the typical level of respondents to the survey (CIOs, Director of Standards, or their immediate direct reports). Often times the IOS SPI technology adoption decision is tightly coupled with the overall firm-level decision to join an SDO. In effect, this hightens the adoption decision to a larger issue of 'Which standards game will the firm choose to participate?'. The significance of Feasibility is an extremely interesting find. Feasibility refers to the firms' technical sophistication to develop and make work flow changes to use IOS SPI technology, and their financial resources to purchase and maintain the technology. It is similar to the notion of readiness (Chwelos 2001; Iacovou 1995). The start-up costs associated with implementing an initial IOS SPI solution was around $100,000 in 2001 (Behrman 2002). The incremental cost thereafter was considered minimal and could be incurred on a piece-meal basis (e.g. an additional server or software license purchase as volumes necessitated). Firms now estimate this initial start-up cost to be less than $50,000 (and dropping). In fact, an emerging group of firms no longer associate these start-up costs with IOS SPI solutions with trading partners (per se), they are now simply considered initial investments associated with having an electronic transactional capability and presence via the public Internet and the web (a.k.a. "IT infrastructure upgrades"). The overwhelming feedback regarding feasibility from survey respondents is in respect to making work flow changes to accommodate the technology. Interorganizational system standards cut to the heart of firms' underlying shared business processes. To reap the potential benefits of modern-day IOS solutions they must comply with their industrial group's choreographed cross-company business processes and common semantics. This compliance has a cascading ripple effect throughout their backend applications and internal business processes. Technology conversion refers to the firm's installed based of older IOS solutions (e.g. EDI, semi-automated, proprietary solutions) compared to modern-day IOS SPI solutions. The interpretation of this finding is, the greater the installed based of older IOS solutions (compared with modern-day IOS solutions), greater the likelihood of IOS SPI adoption. This is the first known use of this type of variable in IOS diffusion studies.

Third, attributes associated with the external environment are significantly related towards distinguishing between adopters versus non-adopters. The external environment construct includes competitive pressure (from three respects - trading partners, the industry, and the expectations of market trends) and the firms participation level in an industry-based SDO. Although the significance of SDO participation level variable may appear to be a self-fulfilling finding (in light of this overall study), the aim of this brief discussion is to prove that it is not. In fact, this finding is consistent with findings from recent researchers (Teo 2003) and consistent with recommendations from other researchers (Reekers 1994; Grover 1994; Cavaye 1996). SDO participation levels can manifest in several ways. Some firms participate in the industrial groups' standards development process, but then fail to internally deploy the IOS standards. Some firms implement the IOS standards, but then fail to become a formal member of the SDO. Some firms choose to adopt IOS standards within the next 12 months, but then fail to participate in the SDO's standards development process. The significance of the SDO Participation Level finding is that in distinguishing between adopters versus non-adopters, the greater the levels of SDO participation (from all four respects enumerated above), the greater the levels of IOS SPI adoption. This is a clear recommendation to SDOs, to improve adoption of levels of IOS SPI technology, engage member firms involved with a rich diversity of participation alternatives (e.g. standards development efforts, membership, testing / evaluation, etc.). In fact, most respondent firms provided insights into services that their industrial groups' SDO is not currently providing, but should be. For example, respondents from the Electronics industry are seeking case studies (or white papers) regarding the business process reengineering associated with IOS SPI implementations (rather than just the technical-based case studies). Respondents in the geo-spatial industry are seeking permanent walk-in hosting labs, to allow potential IOS SPI users to 'kick the tires' at any time. Respondent firms from multiple industries are seeking improved compliance and conformance testing procedures to insure they (and their partners) are on the right track. The second highest point of feedback for additional SDO services is for SDO's to develop specific plans to for shifting their vertically focused standards to more horizontally based efforts (across multiple industrial groups). The point with these illustrations is not to further burden an SDO. Rather, a preeminent role of an SDO's management team is to manage, delegate and synchronize various standards development activities throughout the industrial group. Thus, the SDO management team should acknowledge these untapped needs, and delegate them members of the industrial group's community. The greater the number of participation touch-points, the greater the likelihood of IOS SPI adoption.

The competitive pressure variable in the external environment was also found to be significant in distinguishing between adopters and non-adopters. As evident by the fact that 75% of respondent firms are at limited deployment of IOS SPI technology assimilation (or lower), there is much hesitancy occurring in industry. Many firms are in wait-n-see mode, stuck in the "analysis paralysis" state. The competitive landscape is becoming extremely complex and the front lines of the battles are beginning to form. Technology vendors have just recently started offering price discounts to firms that implement utilizing the industries "predominant" SDO's IOS standards. SDO's must remain vendor-neutral and develop open-standards that are platform independent. Larger corporations (those that use to dominate an industrial group's technology standards) must weigh the sunk-cost of their EDI investments in proprietary IOS solutions, versus the greater diversity and larger breadth of access to trading partners across the entire industrial group that IOS SPI solutions enable. Small to medium sized organizations are perhaps in the best position. They are no longer confronted with expensive EDI investments and they have a much larger (and richer) quality of access to the entire industrial group. They can not afford, however, the time nor cost of reconfiguring back-end applications if the standards they elect to implement do not ultimately have the largest up-take.

Fourth, one attribute associated with the industry's SDO (architecture) was significantly related towards distinguishing between adopters versus non-adopters. The SDO's architecture includes items pertaining to the appropriateness of modularity levels (scope) of the IOS standards, the conduciveness of the standards towards interoperability between supply chain partners, the vendor neutrality of the SDO's standards, and the quality of the SDO's technical documentation. The fact that this variable is significant (with an extremely diverse mix of survey items) is a significant contribution from this study and to researchers. No known use of this variable could be found in the literature survey regarding IOS adoption.

IOS SPI Deployment & Diffusion (Volume)

The section's discussion will focus on differences between the determinants towards adoption versus deployment. As supported with proposition #9, the findings suggest a different mix of significant determinants is associated with each.

First, one organizational readiness attribute (feasibility) was significant in distinguishing between deployers and non-deployers of IOS SPI. All three organizational readiness attributes were significant towards adoption. The explanation is closely related to innovation attribute findings, where no innovation attributes were significant towards adoption, but two are significant towards deployment. This is consistent with earlier findings where the adoption decision is regarded as a higher order and more challenging decision. In light of the industry-focused nature of IOS SPI development, firms have a variety of SDOs to choose from. The selection of an SDO has a ripple effect throughout their entire organization (across shared business processes and trading partners). As firms progress from adoption to implementation, the types of decisions shift from "Whether the firm should adopt IOS SPI", towards "When do we implement the standards with trading partner X, for business process Y". Thus, the decisions become more finite and organizational attributes become less important and attributes associated with the technology become more important. It's interesting to note that an exception to this occurred in distinguishing between diffusion levels (model #3). Recall that model #3 classified respondents into four groups (non-adopters, adopters but non-deployers, light deployers and general deployers). Top management support was found to be significant in advancing a firm from one level to the next.

Second, shared business process attributes are significantly related towards deployment of IOS SPI. Modern-day IOS solutions are structured around shared business processes. SDOs coordinate work groups whose sole focus is to document consistent definitions, develop parameters and choreograph information flows, all of which are designed around cross company business processes. Some of these attributes include timeliness, data accuracy, communications effectiveness, data integrity, and collaboration levels. From a researcher's perspective, shared business process attributes have become pivotal in modern day IOS solutions and their role should be comprehended in future IOS diffusion studies. In the spirit of Tornatzky's criticisms regarding the generality of the relative advantage, initial objectives of this study was to ultimately combine relative advantage with the shared business process variable. With hopes of providing specificity towards the meaning of the direct operational and financial benefits enabled by the technology. However, based on the PCA results and the lack of significance of relative advantage, these two variables are distinct.

Third, two attributes associated with the industry's Standards Development Group (architecture and governance) are significant towards IOS SPI deployment. The SDO's architecture attribute was included in the adoption discussion. This variable includes items pertaining to modularity levels, the conduciveness of the standards towards interoperability, the vendor neutrality of the SDO's standards, and the quality of the SDO's technical documentation. Governance includes items related to the structure of the SDO such as its' non-profit status, its' scope and mission, and the perceived benefits provided to firms. No known use of the SDO architecture or governance variables was found in the literature survey. The survey items were constructed based on the preliminary work leading to this study, as well as critical success factors in the alliance literature survey. The implications of these findings to standards development organizations are numerous. First, architecture is significant towards adoption and deployment. Governance, on the other hand, is only significant towards deployment and the relationship is negative. Thus the interpretation, as counter intuitive as it may seem, reads the greater the governance, the less likelihood of deployment. Further examination into the qualitative feedback from the survey sheds light on this interpretation. Firms with the greatest IOS SPI assimilation levels are the same firms seeking the greatest number of services from an SDO. They often disagree with the SDO's mission and scope since they seek additional value-added services including development of innovative technologies or expanding the SDO's scope to operate as a creative "think-tank". Many of these General Deployer firms have ranked the perceived benefits of the SDO low, because of the firm's high expectations of the SDO.

Industrial Coordination

Categorization of Respondents (Profiles of Firm-Level Assimilation)

Based on an examination of assimilation levels, the industrial group trends analysis, and qualitative feedback from respondents a pattern is emerging with respect to firm-level IOS SPI technology assimilation. This pattern is briefly described here and in Tables #7 and #10. For purposes of this analysis, non-adopters of IOS SPI have been grouped into a single group referred to as Fence-Sitters. Indicating that these firms have IOS technology standards available to them (through their respective industry's SDO), and they have demonstrated awareness, interest or are conducting evaluations / trials regarding the technology, but currently have elected not to adopt (nor deploy them) in an interorganizational system context. This results in a categorization of respondents into four categories based on their technology assimilation level: (1) Fence-Sitters (Non-Adopters), (2) Commitment (Adopter, Non-Deployer),

(3) Light Users (Limited Deployment) and (4) Heavy Users (General Deployment). See Table #7 for assimilation levels of survey respondents. This categorization is similar to practices from prior IOS diffusion researchers (Grover 1993; Grover and Goslar 1993; Sabherwal and Vijayasarathy 1994 and others). In addition, this categorization is consistent with Fichman and Kemerer's recommendations where the likelihood for significant assimilation gaps exist (1999). The discussion within each group will include a summary of the group demographics, IOS SPI assimilation levels and key consequence measures. Based on results from the study and conceptual IOS SPI diffusion model, a prescriptive set of influential measures (managerial recommendations) that could be taken by the industrial groups SDO (or other members from the industrial group) to move a group further on the assimilation scale are also provided.

Fence-Sitters

The Fence-Sitters (non-adopters) are equally composed of small, medium and large sized organizations. The have the lowest expectation of ROI levels to justify IOS SPI expenditures, but also expect the greatest longevity of IOS SPI technology standards. They also have a relatively balanced installed based of older IOS solutions and more modern Internet-based IOS solutions. An analysis of the anticipated consequence results sheds light on the obstacles preventing fence-sitters from achieving greater assimilation levels. Fence-sitters have the lowest expectations regarding the direct financial and operational benefits of diffusing IOS standards. In addition, Fence-sitters have the lowest expectations regarding the indirect benefits from diffusing the IOS standards (lead times, product cost savings, and trading partner loyalty). If an industrial group wishes to encourage fence-sitters to get off the fence (a.k.a. adopt), these areas represent impressions that must be adjusted. Based on the adopter versus non-adopter conceptual model findings, the following are specific recommendations towards strategies to encourage adoption. Overall, the recommendation is to promote the SDO first, and the technology second.

- *Maximize the number of 'touch-points' between the Fence-sitter and the industry's SDO (e.g. participation levels in an SDO).* This study focused on several dimensions of this such as becoming a member in the SDO or participating in IOS SPI development activities. Developmental participation can be as simple as reviewing technical documentation, providing feedback on the industry-wide data dictionary (e.g. the use of business term and definitions) or simply attending the SDO's conferences and meetings. The point is not to burden the Fence-sitter, but rather to engage them in industry-wide cooperative initiative. Recall that the adoption decision has more to do with the industry-wide SDO initiative and less to do with the technology itself.

- *Promote the feasibility of adopting IOS SPI.* Fence-sitters may have a false impression that their organization lacks the financial or technical resources to begin utilizing IOS SPI. Manage these expectations and promote the benefits of SDO involvement; technology awareness, mutually shared R&D expenses, greater quality of access to potential suppliers and customers across their industry. Compared with developing these solutions 'in-house', SDOs offer an extremely valuable alternative. Recall the up-front expenses associated with IOS SPI are 50% of what they were two short years and are continuing to drop. Technology providers are beginning to offer discounts to firms engaged in an SDO and others are beginning to develop off the shelf solutions.

- *Engage support from the Fence-sitters top management*. Gathering support from lower level employees may provide a foot in the door, but it clearly will not close the deal. IOS SPI adoption has firm-level consequences with a breadth and scope that go well beyond lower level employees. The adoption decision has less to do with the innovation itself, and much more to do with the 'will the firm join the industry's IOS standards game'.

- *Adjust IOS SPI ROI and longevity expectations*. Ironically, Fence-sitters have the lowest ROI expectations of benefits enabled by the technology and also the greatest expected longevity of IOS SPI standards. Both of these impressions need to be managed and educated. The failure of many SDO's is to simply offer volumes of white-papers and case studies justifying IOS SPI implementations. Rather, they should supplement these case studies with the value that the SDO offers (e.g. mutually shared R&D expenses, greater quality of access to potential suppliers and customers in the industrial group, technology awareness). Again, when the issue is related to adoption, promote the SDO first and the IOS SPI second.

Table #10 - Profiles of Firm-Level Assimilation

	Fence-Sitters	Commitment	Light Users	Heavy Users
n=	22	22	30	28
DESCRIPTION	Demonstrated Interest in IOS SPI, but are non-adopters	Adopters, but Non-Users	Deployed IOS SPI technology in three or less IOS	Deploy IOS SPI in all major new systems development (where
FIRM SIZE	Balanced between Small, Med, Large Firms	Balanced between Small, Med, Large Firms	Large to Medium Sized Firms	Small to Medium Sized Firms
EXPECTED LONGEVITY OF IOS SPI STANDARDS *	45 or greater	27 or greater	36 or greater	33 or greater
REQUIRED ROI TO JUSTIFY IOS SPI EXPENDITURES *	8.9%	17.8%	14.2%	17.4%
EXISTING IOS SOLUTIONS INSTALLED BASE **				
Manual Solutions	Low	High	Moderate	Moderate
Semi-Automated	Low	Moderate	High	Moderate
EDI orEDI-Like	Moderate	High	High	Low
Other / Proprietary	Low	Moderate	Low	Low
Internet-Based	Moderate	Moderate	Low	High
OBSTACLES TOWARDS ADOPTION / DIFFUSION	Unaware of the industry-wide nature and benefits of the SDO Lowest expectations of Direct Operational Benefits Lowest expectations of Direct Financial Benefits	Lowest expected longevity of IOS standards Lowest expectations of indirect revenue growth / opportunities Greatest expected increases in IOS development & expenditures. Greatest expected increases in new infrastructure expenditures	Overcoming large EDI installed base The largest sized firms, Internal ripple effect of IOS standards cascades thru the organizaton. Avoidance of re-work. Reluctant to deploy new IOS standards, if uptake is not likely on a cross-industry (horizontal basis). Lack of resolutions to overcome horizontal convergence.	Very few obstacles. These small to medium sized firms are the market leaders of this technology.
PRESCRIPTIVE INFLUENTIAL MEASURES TOWARDS DIFFUSION	Promote the SDO first, and the technology second. Maximize the number of 'touch points' with the SDO. Promote the technical and financial 'feasibility' of utilzing IOS SPI Engage support from the fence-sitter's top management Adjust ROI and longevity expectations.	Promote the technology first, and the SDO second. Demonstrate the indirect benefits of deploying IOS SPI SDO outreach is crucial. Demonstrate infrastructure investments are associated w/ establishing a transactional presence via the Internet. Demonstrate the compatibility of the technology.	Demonstrate IOS SPI benefits on business process by business process basis. Emphasis the industry-wide benefits and network externalities. Engage the horizontal convergence issue. Manage the SDO governance issues (manage and meet expectations, stay focused, satisfy unmet demands).	Manage the SDO governance issues (manage and meet expectations, stay focused, satisfy unmet demands). Engage the Heavy users with outreach activities. Engage the horizontal convergence issue.

Commitment Group

The Commitment Group (Adopters but Non-Users) are equally composed of small, medium and large sized organizations. They also have a relatively balanced installed based of older IOS solutions and more modern Internet-based IOS solutions. Ironically, the commitment group has the highest ROI expectations to justify IOS SPI related expenditures, but also have the lowest longevity expectations regarding the IOS SPI technology standards. [It is noteworthy to point out that these measures are the opposite of the Fence-sitters.] This is challenging to explain since they also have the lowest expectations regarding increased revenue opportunities and the greatest anticipated expenditure increases associated with new IOS systems development, implementation and infrastructure expenditures. Based on the qualitative survey feedback, firms in the Commitment Group have experienced significant pressure from industry and trading partners to adopt. They have made the adoption decision, but just beginning to ramp-up their internal capabilities to accommodate the upcoming implementations. For the most part, they appear to be reluctant adopters, but are willing to give the innovations a chance. Firms in the commitment group do expect cost reductions through in IOS standards negotiation and product cost. Based on the deployment versus non-deployment conceptual model findings, the following are specific recommendations towards strategies to encourage deployment. Overall, the recommendation is to promote the technology first, and the SDO second. SDO outreach (and from fellow trading partners in the industrial group) is crucial throughout.

- *SDO outreach is crucial*. The Commitment group is experiencing the height of pressure (both internally and externally) with respect to their recent adoption decision. They have responded to industry pressures to 'play in their industry's standards game', but now must deliver the financial and operational benefits internally to their management. Support from their industry's SDO is crucial. This will maximize the touch-points, in addition to assisting new adopters through the pressures.

- *Promote the indirect benefits of deploying IOS SPI.* To supplement these internal pressures, the indirect benefits must be demonstrated. Indirect consequence measures include improved trading partner loyalty, enhanced revenue opportunities and greater quality of access to suppliers and potential customers.

- *Demonstrate their investments associated with becoming IOS SPI ready are broader than just their industry's SDO*. Based on qualitative feedback from the study, many high-end IOS SPI users are no longer associating the IT investments with a particular SDO or trading partner, but rather with their firms need to develop an overall on-line transactional presence over the Internet.

- *Demonstrate the compatibility of the technology.* Notions of compatibility stem from multiple perspectives, consistency with the firms future vision / needs of their IT infrastructure, values and beliefs, and workflows. In addition, the benefits associated with enhanced business process attributes such as timeliness, accuracy, data communications reliability and integrity need to be emphasized.

Light Users

The Light Users (Limited Deployment) represent the largest sized firms with the largest existing installed based of semi-automated and EDI-based IOS solutions. The Light Users may also be considered moderately coerced into IOS SPI adoption. They have the greatest expectations regarding increases in trading partner loyalty and compliance with trading partner mandates. Although these firms may not be the leaders in "pushing" IOS SPI solutions through out an industrial group, their size and bargaining power always makes them forces to contend with. They have huge sunk-cost investments in EDI and will be reluctant to sustain diffusion of IOS standards unless the benefits can be demonstrated directly to them. More importantly however, is the ripple effect of adopting new IOS standards throughout their backend applications and internal business processes. Based on survey feedback, these larger firms are willing to make the necessary work flow changes to accommodate IOS standards, but they will only do it once. Their chief concern is the ability for the vertically orientated IOS standards to gain momentum and uptake on a cross-industry (horizontal) basis. Clearly, large up-take reduces the likelihood of massive rework in the future. Although these larger organizations could hold the key towards wide-spread diffusion among an industrial group, most have currently avoided making widespread mandates. They have chosen rather, the "develop a little, implement a little" approach. Based on the diffusion conceptual model findings, and the qualitative feedback from the study, the following are specific recommendations towards strategies to encourage further diffusion.

- *Demonstrate IOS SPI benefits on process by process basis*. The large EDI installed base of Light Users is a significant hurdle to overcome. Many firms have developed techniques to utilize their existing IT infrastructure to accommodate EDI and IOS SPI. The key is to demonstrate IOS SPI on a business process by business process basis. Emphasize the improved compatibility and enhanced business process attributes (timeliness, through-put capability, and capacity).

- *Emphasize Industry-wide (scope and breadth) benefits*. Large firms will have the entire industrial group's perspective and interest as forefront. IOS SPI could enable the shift from a supply-chain versus a supply-chain perspective, to an entire industrial group versus industrial group. Highlight the network externalities and other indirect benefits. These benefits include substantial improvements indirect consequences (employee morale, trading partner loyalty). In addition to significant gains in collaboration levels, richer quality of access to small to medium sized organizations (including industry action groups, research centers, down-stream distributors and up-stream suppliers).

- *Engage the horizontal convergence issue.* The horizontal convergence issue has already been defined to be one of the largest hurdles to overcome with IOS SPI. This issue is paramount with larger firms. The ripple effect (and re-work) of modifying back-end work procedures and systems due to modifications in IOS standards could be devastating. SDO's must demonstrate their willingness to engage this issue at the shared business process (message) level. Keep abreast of solutions developed by other industrial groups and the higher order SDOs (if applicable). If a message is significantly different from another SDO's, then halt development. Investigate the differences, apply best practices and identify the risks of proceeding with development. Compare, contrast and communicate the differences. Encourage all voting members to make informed decisions. Absent the funding and resources to institutionalize cross-industry coordination, these techniques must be incorporated to avoid re-work and encourage sustained diffusion.

- *Manage the SDO governance issues*. The light users represent the largest size firms in the industry. Most SDO governance structures (non-profit, voluntary consensus, vendor neutrality) represent the antithesis of how larger organizations are accustomed to operating their business. With equal voting rights established in most SDO by-laws, Light Users may view their traditional 'size' power to be diminished. SDO's must keep these large firms engaged. Be responsive to the unmet needs (as discussed earlier), manage expectations and deliver when commitments are made.

Heavy Users

The General Deployment (Heavy Users) is the most experienced group of Firms with IOS SPI technology. These are small to medium-sized organizations with minimal EDI installations and already operate the majority of their IOS solutions over the web. Heavy Users have the greatest expectations of the direct operational and financial benefits enabled by IOS SPI technology. Heavy users are the drivers of this technology throughout their industrial groups. Sustaining diffusion from this group of firms will most likely not be a substantial problem. They are enjoying the benefits of being the most experienced and knowledgeable with respect to this technology. Based on the diffusion conceptual model findings, and the qualitative feedback from the study, the following are specific recommendations towards strategies to encourage further diffusion.

- *Manage the SDO governance issues.* An interesting finding from this research was the negative (and significant) correlation between IOS SPI diffusion and SDO governance.

Recall, SDO governance includes items such as the SDO's mission and objectives, non-profit status, and the perceived benefits of participating in the SDO. Thus, be responsive to the unmet needs (as discussed earlier), manage expectations and deliver when commitments are made.

- *Engage Heavy End Users for with SDO Outreach.* Several prior recommendations involved reaching out to firms lower on the technology assimilation scale. Enlisting the assistance of high end firms to assist with this outreach would be an excellent approach towards maximizing firm participation levels in an SDO and further engaging the high-end user base.
- *Engage the horizontal convergence issue.* Similar to the discussion with the Light Users, SDO engagement of the horizontal convergence issue will encourage sustained diffusion with the Heavy User group.

CONCLUSIONS

The landscape for a new era in interorganizational information sharing is firmly within our grasp. Cross-industrial coordination is important, but the adoption and diffusion of interorganizational system standards and process innovations is tantamount. A conceptual IOS SPI adoption and diffusion model was defined, supported and eight hypotheses and one proposition were tested. Based on a cross-sectional survey of 102 firms from 10 industrial groups representing 15 SDOs, the hypotheses were tested and results provided. The following conclusions have been reached.

First, Interorganizational system technology has been overhauled since the mid-90's. IOS solutions are now collaboratively developed, structured around discretely defined cross-company business process standards and able to be distributed via the web. Compared with EDI technology from the past, the notions of open standards code, modularity, scalability, and interorganizational business process reengineering have become embedded in modern-day IOS development. Second, these modern day IOS solutions can be referred to as interorganizational system standards and process innovations. IOS SPI are the enablers towards reaching a new era in interorganizational information sharing; the scope, depth and breadth of which have rarely been experienced at an industrial group level. Third, the role of an industry-based standards development organization has emerged as pivotal in coordinating the development and managing the adoption and diffusion of IOS SPI. An industry-based SDO's minimalists approach towards standards development enables them to be extremely responsive to market demands. Their non-profit, voluntary-consensus, vendor neutral structure places them in a unique and challenging position with their industrial group. Fourth, the determinants of IOS SPI diffusion change from adoption to deployment. The significant determinants of IOS SPI adoption are top management support, feasibility, technology conversion, competitive pressure, SDO participation level, and SDO architecture. The significant determinants of IOS SPI deployment are feasibility, competitive pressure, SDO participation level, compatibility, shared business processes, SDO architecture and SDO governance. Only two of these variables (competitive pressure and top management support) are consistent with the synthesized findings from prior IOS diffusion studies. Fifth, IOS SPI solutions deployment across industrial groups is merely on the brink of widespread diffusion. Respondents from this study anticipate astronomical growth projections (nearly 833%) over the next 24 months. Sixth, horizontal convergence is regarded as one of the primary inhibitors of IOS SPI adoption and diffusion. The underlying issues revolve around funding and coordination. Similar to the OASIS-RosettaNet-UCC model, industry based SDO's are positioned well to brake the stalemate. Seventh, the consequences of IOS SPI diffusion are extremely favorable. Respondents indicated an annual 14% ROI with longevity estimated at 36 months (or greater). The direct financial and operational consequences are positive and anticipated to grow during the three time periods (with operational benefits increasing at a significantly greater rate). The key source of these positive trends stem from reductions in standards negotiation efforts (in outer periods) and improved trading partner loyalty, enhanced revenue opportunities, the attraction of new customers, lead-time improvements, and modest product / service cost reductions. Finally, four profiles of firm-level IOS SPI assimilation were provided (fence-sitters, commitment, light users and heavy users). This categorization enabled the development of several prescriptive influential measures that could be taken my practitioners towards encouraging IOS SPI adoption and deployment.

Academic Contributions / Future Research Considerations

This study has provided several contributions and recommendations to the research community. First, a conceptual IOS SPI adoption and diffusion model was developed, hypothesized antecedent conditions were proposed and empirically tested based on a cross-sectional survey. The significant antecedent conditions leading towards adoption and deployment of IOS SPI were identified. Second, this study introduced, defined and tested four new measurement variables associated with IOS SPI diffusion (SDO governance, architecture, SDO management practices and Technology Conversion). Three of these variables (SDO governance, architecture and Technology Conversion) resulted in significant determinants towards IOS SPI diffusion.

Several recommendations to researchers for future considerations in the critical and emerging research frontier have been made throughout the discussion. First, begin lines of inquiry and analysis regarding horizontal convergence. This area presents a unique opportunity for researchers to provide specific recommendations or possibly to act in coordination roles. At a minimum, future IOS diffusion researchers should assess the SDO's (and their member firms) perceptions towards horizontal convergence. Are specific plans in place to manage horizontal convergence? Have they driven the plans down to a business process level? Second, future IOS diffusion studies should comprehend the role of the SDO and shared business process attributes. As was concluded in the study, both of these aspects are important in modern-day IOS standards development, adoption and deployment. Third, further examine the four new measurement variables introduced in this study (SDO governance, architecture, SDO management practices and Technology Conversion). Fourth, future IOS diffusion studies should comprehend standards versioning into their research design (potentially as a technology attribute). Based on the qualitative feedback from the study, versioning is an emerging issue in IOS standards development. Frequent versioning causes re-work to early adopters and carries a cascading re-work effect throughout backend applications and business processes.

Limitations

The limitations of this study are summarized as follows. First, the sampling frame was limited to industrial groups where an SDO existed. Efforts were made to identify an industry where an SDO did not exist, but the attempts failed. The sampling profile, however, did include a rich mix of industrial groups where the SDO was recently formed (less than six months) to several years since the SDO's inception. Second, consequence measures are descriptive only and respondents assessed consequence measures at the industry-effects level (as opposed to the respondent's firm). Based on pre-test results, respondents expressed concerns of sharing firm-level consequence measures (due to confidentiality clauses in work agreements) even on a confidential basis. Third, the organizational - environmental - innovation - SDO framework of the research design. Although a significant amount of up-front rigor and content validity activities were conducted to minimize this limitation, there could be more specific (firm level and industrial group level) contextual factors influencing IOS SPI adoption and deployment.

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APPENDIX A

IOS ADOPTION AND DIFFUSION LITERATURE SURVEY PUBLICATIONS					
Code#	**Reference**	**Year of Publication**	**Journal**	**Article Title**	**Type of Technology**
1.0	Saunders and Clark	Winter 1992	*Information Resources Management Journal*	EDI Adoption and Implementation: A Focus on Interorganizational Linkages	EDI
2.0	Grover and Goslar	Summer 1993	*JMIS*	The Initiation, Adoption and Implementation of Telecommunications Technologies in U.S. Organizations	15 Distinct Telecommunication Technologies
3.0	Varun Grover	1993	*Decision Sciences*	An Empircally Derived Model for the Adoption of Customer-based Interorganizational Systems	Proprietary IOS systems with customer interfacing connectivity (inherently supplier dominant, since suppliers are developing systems for their customer connectivity)
4.0	Zaheer and Venkatraman	May-94	*Management Science*	Determinants of Electronic Integration in the Insurance Industry: An Empirical Test	Proprietary IOS systems based on ACORD - IVANS standards (insurance industry specific standards group).
5.0	Prekumar, Ramamurthy, Nilakanta	Fall 1994	*JMIS*	Implementation of Electronic Data Interchange: An Innovation Diffusion Perspective	Interorganizational Systems (EDI)
6.0	Reekers and Smithson	1994	*European Journal of Information Systems*	EDI In Germany and the UK: strategic and operational use	EDI
7.0	Sabherwal and Vijayasarathy	1994	*European Journal of Information Systems*	An Empirical investigation of the antecedents of telecommunication-based IOS	Telecommunication-based IOS (across 11 technologies: Mobile phones, ISDN, LAN, WAN, e-Mail, Fax, VideoConferencing, PBXs, Computer to computer)
8.0	Iacovou, Benbasat, and Dexter	Dec 1995	*MIS Quarterly*	Electronic Data Interchange and Small Organizations: Adoption and Impact of Technology	EDI in Small Business
9.0	Premkumar and Ramamurthy	1995 (26:3)	*Decision Sciences*	The Role of Interorganizational and Organizational Factors on the Decision Mode for Adoption of IOS	Interorganizational Systems (EDI)
10.0	Alm Cavaye	1996	*European Journal of Information Systems*	The Implementation of Customer Oriented Inter-Organizational Systems: an investigation from the sponsor's perspective	Customer Oriented IOS (e.g. ATM Networks, POS Systems, HHD)
11.0	Massetti and Zmud	Sep 1996	*MIS Quarterly*	Measuring the Extent of EDI Usage in Complex Organizations: Strategies and Illustrative Examples	EDI Usage in Complex Organizations
12.0	Prekumar, Ramamurthy, Crum	1997	*European Journal of Information Systems*	Determinants of EDI Adoption in the transportation industry	EDI IOS in Trucking Industry
13.0	Chau and Tam	1997	*MIS Quarterly*	Factors Affecting the Adoption of Open Systems: An Exploratory Study	Open Systems
14.0	Kettinger and Grover	1997	*Decision Sciences*	The Use of Computer-Mediated Communication in an Interorganizational Context	e-mail used for interorganizational settings
15.0	Crook and Kumar	1998	*Information & Management*	Electronic Data Interchange: A multi-industry investigation using grounded theory	EDI
16.0	Hart and Saunders	1998	*JMIS*	Emerging Electronic Partnerships: Antecedents and Dimensions of EDI Use from the Supplier's Perspective	EDI
17.0	Chwelos, Benbasat, Dexter	Sep 2001	*ISR*	Research Report: Empirical Test of an EDI Adoption Model	EDI
18.0	Sanjay Gosain	Dec 2001	*DIGIT Workshop 2001*	Web Technology Diffusion - Initial Adoption, Assimiliation and Network Prominence	Web Technologies
19.0	Chatterjee, Grewal, Sambamurthy	2002	*MIS Quarterly*	Shaping Up for E-Commerce: Institutional Enablers of the Organizational Assimiliation of Web Technologies	Web Technologies (e-Commerce Activities and Strategies)
20.0	Zhu, Kraemer, Xu	Dec 2002	*23rd ICIS Conference*	A Cross-Country Study of E-Business Adoption Using the Technology-Organization-Environment Framework	e-Commerce Technologies
21.0	Teo, Wei and Benbasat	March-03	*MIS Quarterly*	Predicting Intention to Adopt Interorganizational Linkages: An Institutional Perspective	Interorganizational Linkages (IOL), more specifically FEDI (Financial EDI)

APPENDIX B

Constructs, Measurement Variables, Survey Items, Item Descriptions

Construct	Measurement Variable	MV Code	Survey Items	Item Measure Description	Scale
ORGANIZATIONAL READINESS	Top Management Support	TopMan	4(a)	- Actively participate	7-point Likert (SD~SA)
			4(b)	- Assigned project champion	7-point Likert (SD~SA)
			4(c)	- Effectively communicates support	7-point Likert (SD~SA)
	Feasibility (Financial & Technical)	Feasibility	5(a)	- Technical sophistication to implement & maintain	7-point Likert (SD~SA)
			5(b)	- Technical sophistication to make work flow changes	7-point Likert (SD~SA)
			6(a)	- Financial resources to implement & maintain	7-point Likert (SD~SA)
			6(b)	- Financial resources to make work flow changes	7-point Likert (SD~SA)
	Technology Conversion Type	TechConv	Sum of D14(a~d)	- Extent of IOS solutions use (EDI, manual proprietary)	5-point (None to Extens)
			minus D14(e)	- Extent of IOS solutions use (Internet-based)	5-point (None to Extens)
INNOVATION ATTRIBUTES	Relative Advantage	RelAdv	11	- Direct operational benefits	7-point Likert (SD~SA)
			12	- Direct financial benefits	7-point Likert (SD~SA)
	Compatibility	Compab	3	- Required work procedure changes are consistent	7-point Likert (SD~SA)
			13	- Consistent w/ future vision of IS infrastructure	7-point Likert (SD~SA)
			14	- Compatible with existing IS infrastructure	7-point Likert (SD~SA)
	Shared Business Process Needs	ShareBus	15(b)	- Enhances timeliness	7-point Likert (SD~SA)
			15(c)	- Provide reliable data communications	7-point Likert (SD~SA)
			15(e)	- Improve data integrity	7-point Likert (SD~SA)
			15(f)	- Improve collaboration levels	7-point Likert (SD~SA)
EXTERNAL ENVIRONMENT	Competitive Pressure	CompPre	7	- Meet trading partner requirements	7-point Likert (SD~SA)
			8	- Industrial group pressure	7-point Likert (SD~SA)
			9	- Firm will loose competitive edge	7-point Likert (SD~SA)
	Participation Level in an SDO	SDOPart	17 + 18 + 19	- SDO member status, user status, development status	Dichotomous 'yes' / 'no'
			+ (2 * #24)	- Committed to implement IOS SPI next 12 months	7-point Likert (SD~SA)
STANDARDS DEVELOPMENT ORGANIZATION	Management Practices	ManaPra	28	- Open & honest communications	7-point Likert (SD~SA)
			29	- SDO meets performance expectations	7-point Likert (SD~SA)
			30	- Responsibilities are appropriately delegated	7-point Likert (SD~SA)
			31	- SDO's goals are well communicated	7-point Likert (SD~SA)
			32	- SDO is neutral w.r.t. to all member firms	7-point Likert (SD~SA)
	Architecture	Archit	34	- Modularity levels are appropriate	7-point Likert (SD~SA)
			35	- Technical standards are conducive to interoperability	7-point Likert (SD~SA)
			36	- Vendor neutral technical standards	7-point Likert (SD~SA)
			37	- Require minimal changes to business processes	7-point Likert (SD~SA)
			38	- Accurate and useful standards documentation	7-point Likert (SD~SA)
	Governance	Govern	21	- SDO's mission and objectives	7-point Likert (SD~SA)
			23	- An SDO should be a non-profit entity	7-point Likert (SD~SA)
			25	- SDO benefits are well understood	7-point Likert (SD~SA)

THE ROLE OF STANDARDS IN THE INFORMATION INFRASTRUCTURE DEVELOPMENT, REVISITED

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ABSTRACT

Development of national Information and Communication Technology (ICT) infrastructure is a kind of activity that government engage to in order to create a rubric of progress and to promote diffusion of information technology (IT) revolution. ICT infrastructure is perplexing because we do not have a good model to use to analyze its development. Besides, the modernist style of regulation in the countries promoting diffusion of IT revolution does not require the technology developers to consider the impacts of technology systematically, which creates substantial uncertainty in regard to possible trajectory of technological development. To improve the construction of effective policy planning for large information infrastructures, the conceptual link between the abstract enabling structures and concrete technologies – the building blocks of infrastructure – must be established.

This paper presents a work in progress on a conceptual model which should help us to do the analytical work necessary to improve the policymaking for ICT.

Keywords: standard, information infrastructure, policy, actor-network theory, modernity, micro-macro divide.

INTRODUCTION

> *“eEurope is a political initiative to ensure the European Union fully benefits for generations to come from the changes the Information Society is bringing. These changes, the most significant since the Industrial Revolution, are far-reaching and global. They are not just about technology. They will affect everyone, everywhere. Bringing communities, both rural and urban, closer together, creating wealth, sharing knowledge, they have huge potential to enrich everyone’s lives.”*
>
> *(Council of the European Union 1999, p.2)*

The first, focused statement of national policy for information infrastructure development was the Clinton Administration’s policy initiative on National Information Infrastructure (NII), published as *The National Information Infrastructure: Agenda for Action* of September 15, 1993 (The White House 1993). It encompassed everything that produces, contains, processes, or uses information, in whatever form, or whatever media, as well as the people who develop the information, applications, and services, etc (Kahin 1997, p.163). Six years after the publication of NII's *Agenda for Action*, the European Commission (EC) presented a program *eEurope* aimed at accelerating the process of exploiting the potential of the *new economy* which "has tremendous potential for growth, employment and inclusion" (Council of the European Union 1999, p.4). Japan has seen initiation of a similar initiative in its Information Policy in 1997[1].

Development of national information infrastructure is a kind of activity that governments must engage to in order to create a rubric of progress, but also to promote the diffusion of information technology revolution (Castells 1996. p.219) in all spheres of social and economic activity and thus contribute to providing the infrastructure for the formation of a global economy, where informational production, knowledge generation and technological capacity are key tools for competition not only between firms and organizations of all kind, but also between countries (Castells 1996, p.124).

Indeed, the information technology revolution (Castells 1996, p.30) and what governments of nation-states refer to as Information Society, both refer to *technologies of information processing and communication* and are about building *pervasive* national information infrastructure (II), which must penetrate all domains of human activity (Castells 1996, p.29).

The kind of large-scale initiatives like building *e*Europe, is subject to mobilization of resources, creation of laws, formulation of political will, and legitimating of ideas. The common knowledge, however, goes that these programs usually don't work out exactly as envisioned. For example, The U.S. NII initiative was aimed at creating an advanced information infrastructure and an "information superhighway" (Kahin 1998, p.339) to be delivered to the public by private sector with encouragement from government. But the only visible achievement of the NII initiative was that it succeeded as a shared vision of transformative potential of ICT[2] and was instrumental in accelerating embrace of the Internet within the government (Kahin 1998, p.346). "Instead of a bigger and faster "highway" there was a paradigm shift from circuits to tiny packets of information as the organizing unit of telecommunications" (Kahin 1998, p.339). Do we have any confident reasons to believe that *e*Europe will be any bigger success than NII?

There are at least two reasons for separation between the policy (rhetoric) and reality in large-scale information infrastructures development. First, there is a problem in the complexity of the object of analysis – the infrastructure as a complex network of social, institutional, and technological actors. Second, the subject of policymaking, i.e., strategic planning, is a problematic procedure, too.

These two problems are well known to the scholars of social constructivism – the theories have been criticized for maintaining separation between structure and subject, or structure and agency (Marshall 2003, p.116). More specifically, there is a problem of non-integration, or incongruence, of different levels of analysis: local action and individual agency on the one hand, and longer-lived and more disperse social structures on the other (Marshall 2003, p.116).

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[1] http://www.miti.go.jp/intro-e/a228100e.html (Access: May 27, 2003).
[2] Information and Communication Technologies.

In this work, we propose a way to overcome the micro-macro separation that has plagued studies of social constructivist theories (Latour 1996; Marshall 2003; Russel et al. 1988; Winner 1993), economics (Rosenberg 1982), history of technology (Calhoun 1998), and other. In the following sections we elaborate on problems associated with policymaking for large-scale IIs and propose an analytical technique to deal with micro-macro divide. This novel analytical approach is necessary to improve the construction of effective policy planning for large information infrastructure initiatives, such as *e*Europe.

POLICYMAKING FOR LARGE-SCALE ICT DEVELOPMENT

Complexity of structure: re-opening the black-box of technology

The modernist[3] style of regulation adopted by governments of leading industrialized countries does not require technology developers to consider impacts of technology systematically, let alone at an early stage, while technologies are undergoing development and taking on their durable forms (Schot 2003, p.258). This might come as a surprise, since the common knowledge is that technologies interact deeply with society and culture, and these interactions involve mutual influence, “substantial uncertainty, and historical ambiguity, eliciting resistance, accommodation, acceptance, and even enthusiasm” (Misa 2003, p.3). Although technology promoters devote substantial resources to persuading the public to adopt a “better understanding” (acceptance and enthusiasm) of the issue at stake (Schot 2003, p.258), uncertainty, resistance and even failure have equal roles in the history (Latour 1996).

Unexpected turns in the technology developments can be to a large extent attributed to the popular discourse that technologies are “black boxes”, fixed entities that irresistibly change society and culture (Misa 2003, p.2). Technology policymakers and promoters often seem to be ignorant of the fact that stabilization of a technology implies the embedding of the technology in a stable network consisting of humans and other technologies, and the acceptance of a dominant view on how to interpret and use technology (Brey 2003, p.52). Treating technology as a black-box, as “a “technology-with-a-capital-T” leads to vagueness, obscures differences between technologies, and fails to distinguish the varied ingredients that make up technology (knowledge, artifacts, systems, actions) and the way these relate to their context” (Brey 2003, p.56). These kind of generalizations about technology development on behalf of policymakers and alike go against many key ideas of technology studies (Brey 2003, p.58; Latour 1996).

To avoid over-generalization, promoters of technology must open the black-box of technology. This issue has been addressed before in regard to a technology in general (Rosenberg 1982; Russel et al. 1988; Star 1992; Winner 1993). In this work we seek to understand how to make better policy for building national information infrastructures by opening the black box in yet another way.

Complexity of subject: policymaking for infrastructure development

Ciborra (2001, p.2) described corporate information infrastructures and the design and implementation processes that lead to their construction and operation as *puzzles*, or *collages*, which are embedded in larger, contextual puzzles and collages (Ciborra 2001,

[3] The concept of modernizations (and hence the modernist regulation) refers to “a new mode of social organization, a new social order, and a discontinuity in history” Schot, J. "The Contested Rise of a Modernist Technology Politics," in: *Modernity and Technology*, T.J. Misa, P. Brey and A. Feenberg (eds.), MIT Press, Cambridge, MA, 2003, pp. 257- 278.

p.2). “Inter-dependence, intricacy, and interweaving of people, systems, and processes are the culture bed of infrastructure” (Ciborra 2001, p.2). If ICT infrastructure is perplexing, because we don’t have a good model to apply to its analysis (Brey 2003; Ciborra et al. 2001; Edwards 2003), then how policy makers can develop an appropriate policy given the complexity of the problem?

Axelrod and Cohen (1999), propose a way to deal with the difficulty of policy making, a solution to the Ciborra’s puzzle. According to Axelrod and Cohen (1999, p.12), a standard procedure of design and policy making for complex organizations is to develop expectations of how the future will unfold and to define actions that would lead to more desirable predicted futures. This approach requires an expert knowledge from similar past developments. The problem is, creation of a *new economy* is a novel undertaking. Many large-scale developments of the industrial age saw fiasco and, according to Ciborra, “those very principles that were supposed to govern the emergence of the industrial society are even less applicable to the information society” (2001, p.5).

An alternative approach to cope with difficulty of national policymaking is a generation of various forms of scenario derived from identification of the driving forces of the system (Axelrod et al. 1999, p.12). This approach requires a comprehensive understanding of the system and forces that operate within it. Moreover, understanding of processes that bring the elements together into a complex network is also required. Thus, it is our intention to remind the policymakers and modernists alike, that if a technology development policy is to generate positive results, the black box of technology must be reopened. And since success of creation of Information Society is critically dependant on *technologies of information processing and communication* and *pervasive* national information infrastructure (Castells 1996, p.29), the system under analysis is information infrastructure.

The micro-macro divide

The problem of analysis of large-scale ICT developments is that the promoters of technology often visualize it as a “technology-with-a-capital-T” (Brey 2003, p52), thus being unable to foresee many possible trajectories that the development can take. The problem of myopic understanding of the nature of and forces operating within information infrastructures is in “analyzing macrolevel phenomena... in terms of other macrolevel phenomena” (Brey 2003, p.62), and inability to see the actors and forces that operate at the micro level.

The problem of bridging the gap between micro and macro perspectives has received considerable attention in studies of management, policy, economics, and social organization (Callon et al. 1981; Fomin et al. 2000a). In spite of the attention, there is still no error-prone method on how to connect macrolevel and microlevel analyses. This comes as no surprise, since, according to Brey (2003), considerable confusion exists over what makes a phenomenon studied in the social sciences a macro or micro: one view is that macrolevel phenomena and the concepts that refer to them are abstract and general, whereas microlevel phenomena tend to be concrete and specific; the other view is the size of the object (small size is associated with micro, large size – with macro) (Brey 2003, p.63). To bridge the micro- and macrolevels, analysts have to work at level building, engaging in what Brey (2003, p.69) called decomposition, suibsumption, deduction, and specification.

Arriving at an adequate integration of levels of analysis represents a substantial problem for information infrastructure development policymaking: how do you get from a discussion of globalization, information society, and national information infrastructure to the development and use of specific technologies (Brey 2003, p.66)? This kind of bridging is possible trough the understanding of the nature of infrastructures and their building blocks: if the divide can be overcome at the level of the building blocks, than, perhaps, an adequate way to integrate micro and macro levels can be found, too.

In the following sections we argue that standards are the building blocks of infrastructure. We see the critical role of standards as the missing link between the micro and macro, the structure and agency, the function and activity. The dual nature of the standards – the activity of standardization and the boundary object – allows for linking practice of infrastructural development (microlevel) to its function and structure (macrolevel). Thus, the conceptual bridging of large, diffuse, and abstract infrastructures and concrete, small (in terms of part-whole relationship to the infrastructure), and singular standards becomes possible – the black box of technology can be reopened.

THE NATURE OF INFRASTRUCTURES AND THE ROLE OF STANDARDS

Standards as building blocks of infrastructures

Before different technologies are meshed into a single infrastructure, they evolve relatively independent from each other. To become integrated into II, they must be harmonized in technological and socio-institutional terms, meaning that relationships between the elements have to be reinforced and transformed. In this, not only “the whole is more than the parts” (Anderson 1972), but a novel socio-technical configuration linking regulatory framework, communications infrastructure, user practices, maintenance networks, etc. (Geels 2002, p.1257) have to be formed. Standardization (either *de jure* or *de facto*) becomes a crucial element in such harmonization process, because of its ability to coordinate activities between and within diverse social groups to reconcile their varying interests while still working towards a single outcome (Fomin et al. 2000b; Lyytinen et al. 2002). If infrastructures are the connecting tissue of modernity (Edwards 2003), then standards are the building blocks of infrastructures. Standards play a crucial role at the point when technology acquires a momentum, when competing or complementary components are being added to what is becoming information infrastructure (Edwards 2003; Hughes 1993).

From a technological standpoint, without standards, information infrastructure is merely a collection of separate independent connections and cannot function as integrated whole (Hanseth et al. 1998). It is through aggregation of elements by the means of standards that results in formation of large and complex systems bringing about entirely new properties at each level of complexity (Anderson 1972, p.393). Standardized technology enables large-scale integration and is the basis for a division of labor (Hanseth et al. 1998, p.56), which in turn is a necessary condition for the creation of societal benefits. Thus, the socio-institutional and the technological roles of standards are intertwined and inseparable.

Thus, one can define several important roles that standards play in the process of building information infrastructures (Table 1). On the technical level, information infrastructures demand standards that enable interconnectivity of multiple technologies, or “gateways” (Hanseth et al. 1997). Creating “gateways” is a highly complex socio-technological task which includes designing communication and technical interface standards, testing and adapting these to a wide range of different use situations, and ensuring that the standards are developed according to the procedures of recognized standardization bodies, if such exist (Hanseth et al. 1997, p.183; Lyytinen et al. 2002).

From organizational viewpoint, standards align diverse interests of participating groups (Fomin et al. 2000b; Hanseth et al. 1997). In fact, interests of these social groups (government organizations, engineers, entrepreneurs, consumers, etc.) *must* be aligned if the development of the technological system is to proceed (Latour 1999). Standards provide a means for system builders and entrepreneurs to share their perspectives, and to gain understanding how the technological potential can be made to meet diverse ends. By doing so participating groups can better negotiate the desired technical and economic properties of the technology (Bekkers et al. 1999). Hence, standards inscribe and embed large socio-technical networks of developers, users, and government institutions, and provide a powerful means to analyze relational aspects of infrastructures.

From economic viewpoint, competition between system standards leads often to a situations where “a winner takes all” due to strong positive network externalities and resulting increased returns. A body or a firm, which successfully establishes a technical standard in a new technical regime, receives normally large returns, whereas its competitors may be effectively locked out or provided only with residual market niches (Schilling 1998).[4]

Finally, technologies with a high momentum normally spawn a number of competing suggestions for the correct “technical solution”. In such situations standards are both necessary and helpful in that they early on limit the technical design space and help obtain a sufficiently fast implementation of a working design with a large enough user base.[5] This is critical for the emerging markets, where chaotic competition needs to be organized relatively quickly around a relatively stable set of system concepts (Edwards 2003), otherwise the technology may lose its momentum. Standards thus help reduce the risk of entrepreneurs as well as consumers thereby increasing the momentum behind the dominant system solution (Edwards 2003).

[4] Sometimes this “battle of the systems” can culminate with the invention of devices that make possible the interconnection between incompatible systems Hughes, T.P. "The Evolution of Large Technological Systems," in: *The social construction of technological systems: New directions in the sociology and history of technology,* W.E. Bijker, T.P. Hughes and T.J. Pinch (eds.), MIT Press, Cambridge, 1993, pp.51-82.

[5] Currently we can see similar chaotic behavior in the area of pervasive computing where all major vendors are suggesting their own protocols for service discovery and integration including Sun, HP, and Microsoft.

Table 1. Different scalar views on standards in the developing of IIs

View	Organizational	Technical	Economic
Scale	Micro	Meso	Macro
Function	*Boundary object*	*Gateway*	*Technological fix/ solution*
Example	Linking individuals, organizations, and technologies. Accommodating /inscribing different views and interests.	Allowing different technologies to interact. Interface standards, etc.	Access to market. Limiting design space to allow technology gaining momentum

Understanding infrastructures

Edwards (2003) provides an excellent analysis of the nature of infrastructures. According to Edwards (2003, p.186), infrastructures simultaneously shape and are shaped by the conditions of modernity; they are ubiquitous and critical in that their failures can affect lives of millions; they have persistence and longevity due to the large installed base; and they have become community dependent thus involving participation from a large number of constituencies from manufacturers, service providers, users, regulators, and so on (Edwards 2003, p.186; Hanseth et al. 1997; Star et al. 1996). Finally, infrastructures form the stable foundation of modern social worlds by *linking* micro, meso, and macro scales of time, space, and social organization (Edwards 2003).

If infrastructures are linking different scales of time, space, and social organization, they can also be studied on different levels (Table 2), each producing different pictures of how they develop, as well as their constraining and enabling effects on social and individual life (Edwards 2003, p.220). Different scalar views lead to different understanding of the “modernist settlement” (Latour 1999, p.14) that brings together nature, society, and technology (Edwards 2003, p.221).

Microlevel analyses illustrate how individuals and small, spontaneously organized social groups shape and alter infrastructures, creating their own version of modernity (Edwards 2003, p.221). Relational concept of infrastructure is appropriate for micro-scale analysis. As Star (1999) points out, an infrastructure is “fundamentally a relational concept, becoming a real infrastructure in relation to organized practices.” In consequence, an infrastructure must be studied as a set of relationships: how do specific actors relate to it, and what is the significance and impact of the given infrastructure for a given actor, and how this relationship evolves over time. Thus, micro scales provide a constructivist view on infrastructure development.

On *mesolevel*, infrastructures follow a development pattern visible only on a historical time scales. Infrastructures consist not only of technological, but of legal, corporate, and political elements (Edwards 2003, p.199). Because of these properties, building regional infrastructure, similar to *e*Europe, requires large institutions with long lifespan, and sufficient political and social powers, and huge private investments (Edwards 2003, p.200).

Macro-scale perspective reveals entire societies and economic systems as functional and systemic, rather than constructivist infrastructures (Edwards 2003, p.186; Misa 1994) and in contrasting light: as technologies, infrastructures on macro scale die (they become obsolete and phase out); seen as function, on the other hand, infrastructures grow (the obsolete technology is replaced by a newer and superior one) (Edwards 2003). On macrolevel infrastructures can be studied mainly through their technological trajectories and expansion as indicated by functionality, diffusion rates, traffic volume, or coverage, and their possible decay (Lyytinen et al. 2002), and thus similar to analysis performed on mesolevel are seen as ecological systems. Infrastructures are best studied on macrolevel, but they mediate among the actors that are studied in microlevel analysis (Brey 2003, p.60).

Table 2. Different scalar views on infrastructures. Adopted from (Edwards 2003)

View	Relational	Ecological	
Scale	Micro	Meso	Macro
Function	*Organized practices*	*Force amplification*	*Solution to systemic problem (technological fix)*
Example	Defines a set of dependencies between technological artifacts, actors, and sites.	Not under control of any individual actor	Adapts to demands of environment.

STANDARD – THE MISSING LINK IN MICRO-MACRO DEBATE

Infrastructures-as-technologies phase out and die, but as functions – live and develop (Edwards 2003). This contradiction points at interesting phenomenon – a sort of gradual regeneration process typical for biological organisms – there is an ongoing process of aging and renewal, in which infrastructures are seen as macrolevel ecological systems, which constantly adapt to the demands of various environments including technology push, market pull, and regulatory intervention.

To understand how the activity (the ongoing process of renewal) is related to the structure (the function that infrastructure is carrying) is but one way to overcome the micro-macro and concrete-abstract divide. In the following, we deploy actor-network approach to propose an analytical technique to develop a functional connection model linking infrastructures to standards by way of functions through specific dyads – social practices and boundary objects, technology and gateways, institutional arrangements and technological fixes.

When we deploy what Bowker and Star (1999) called “infrastructural inversion” and look at the micro level of social practices, an infrastructure – the object of analysis – can be seen as an actor-network (AN) (Geels 2002; Latour 1999) consisting of both technological elements and social practices. At any point of time of infrastructural evolution, [ecological] adaptation of the infrastructure to environmental demands (of any nature) is possible if and only if translation (Latour 1999) of associations that infrastructure holds together is permitted by the AN constituting it. Translation generates ordering effects, which in turn can result in durability of the infrastructure in time (Law 1992, p.9) holding together the structure and the activity (Suchman 2000, p.316) – the social practice of actor networks and technology-as-a-function.

An information infrastructure dictates rules through which new components and/or services are connected to it by imposing a set of *de facto* or *de jure* standards (Monteiro et al. 1995). Standards, although not seen as readily available from the shelf, are integrated into the infrastructure according to their functional purpose: gateways for [data] interconnection with existing modules/systems; technological fix for technological solution to economic, social, or organizational demands; or boundary object for aligning interests between different [groups of] actors. The process and outcomes of infrastructure formation vary depending on how the actors interacted, who had the initiative, how the entrepreneurs could build their visions of the technology or service, and how it affected the actual design. The institutional and industrial context plays also a role here (Table 3).

Table 3. Dyadic connection model linking infrastructures and standards

Infrastructure: Dyadic connection model linking infrastructures and standards

Function (Structure)		
Social practices	Technology	Institutional arrangements
	Development and integration activity	
Boundary object	Gateway	Technological fix
Function		

Standard: concrete miclolevel object

Standard commands a central role in the network as a boundary object that other actors can relate to (Fomin et al. 2000b). As an actant in the network it constrains actions of other actors, and inscribes certain behaviors. Standard is never separated from the activity, actors, or structures (Fomin et al. 2003), and thus bridges the micro- and the macro. Such links between activity and structure have already been established in recent empirical technology development studies (Carlson et al. 1990; Gorman et al. 1990), but have not been applied to standards.

The duality of standards opens the way to dealing with micro-macro divides in analysis of infrastructure development, and, consequently, provides a solution to more effective policy planning for large information infrastructures, such as the U.S. NII, European *e*Europe, and Japanese Information Policy.

CONCLUSIONS

Information infrastructures development is not easily explained by any of the classical theories. Moreover, institutional actors assigned key roles in the process often have either a myopic views on the problem, their scope being limited to the immediate tasks of their institutions.

Given these inhibitors to analysis and formulation of policies for very large-scale socio-technical initiatives, our goal was to present an analytical framework to harnessing complexity of the system by means of providing better understanding of the system itself, its constituents, and forces that operate within it.

One of the major problems associated with policymaking for diffusion of information technology revolution, creation of information society, or any other large-scale ICT development, is the separation between the micro- and macro- in problem definition: marcolevel accounts typically adopted by policymakers can not adequately represent the microlevel processes taking place in the actornetworks (Brey 2003, p.59). As a result, the technology development and implementation for establishing/ sustaining the needed structures and functions can take on different trajectories, often unanticipated and unwanted.

Although substantial amount of literature has previously addressed the problem of micro-macro divide in technology and management studies, looking at the same problem as a structure-activity divide is a novel contribution. The analytical technique deployed in this paper should help us to do the analytical work necessary to improve the construction of effective policymaking for information infrastructures development initiatives.

Through exploration of the nature of infrastructures, their formation, and forces that operate within them, we concluded that the notion of standard becomes a cornerstone in the analysis – it connects technological artifacts and social networks, activities of actors and environment in which these actors operate. Standards allow for bridging the views of policymakers and technology developers, “harnessing complexity” by narrowing uncertainties associated with technological development.

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THE ROLE OF STANDARDS IN THE CREATION AND USE OF INFORMATION SYSTEMS

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ABSTRACT

Technical interoperability standards play an important role in the creation and use of information systems. However, that role has been understudied in the MIS field, much as previous researchers have concluded that the role of technology has been understudied by the field.

This paper reviews various definitions of “standard”, but concentrates on the role of *de facto* product compatibility standards in the organizational adoption of information systems. It then considers the role of interorganizational standards upon the management of information systems. such as through the network effects and switching costs created by the supply of specialized complementary assets.. It concludes with suggestions for future research.

Keywords: standards, IS adoption, computer architecture, network effects, switching costs.

INTRODUCTION

A large portion of MIS research is directly or indirectly about standards. IT standards are front and center in research on product creation and competition in IT industries (e.g. Mendelson & Kraemer 1998; Dedrick & West 2000; Gallaugher & Wang 2002). But they are also a salient attribute of most information systems adoption decisions: sometimes the role of standards is explicitly considered (Kaufman et al 2000; Damsgaard & Truax 2000; Tam & Hui 2001), but usually the standards themselves are an implicit and unexamined aspect of the information systems artifact (e.g. Chau & Tam, 1997).

The disconnect between MIS and standards research has two deleterious consequences. First, in explaining MIS outcomes, researchers are largely overlooking a rich body of work about how such technologies are created and adopted. Information systems require compatibility standards to assure interoperability between disparate components, a major concern of those that must administer such systems on a daily basis. Researchers in economics, telecommunications and strategic management have studied the creation and selection of such standards, providing a theoretical framework for explaining the product choices faced by the MIS buyer.

The MIS community is also missing an opportunity for impact on other fields of social science research. The organizational adoption of information technologies is at the center of the field’s domain, and yet by ignoring the role of standards in IT production and use, the work of MIS researchers will tend to be overlooked by others considering such phenomena.

The gap between MIS and standards research is consonant with larger challenges facing the field. Orlikowski & Iacono (2001) have bemoaned the lack of technology in information technology research, while Benbasat & Zmud (2003) argue that to be relevant, MIS research must include either the IT artifact or its immediate precursors or consequences.

This article reviews the existing body of research related to IT standards, both inside and external to the MIS field. A review of peer-reviewed research on technology standards suggests that such research can be classified into four areas:

- **technical content:** details of specific new standards, which are well covered by professional journals such as *Communications of the ACM* and the various *IEEE Transactions*.
- **standards creation,** including standardization institutions, single- and multi-firm standardization initiatives and the process of standardization; such standardization in telecommunications is often found in *Telecommunications Policy.*
- **standards selection,** including standards adoption and competition between standards; such work has typically reported in economics and (rarely) MIS journals.
- **using standards,** measuring the economic value or impact of standards, which has rarely been measured if at all.

The first of these areas is well covered in engineering and computer science, while the remaining three areas correspond to the concerns of social science research. As such, the paper focuses on these latter areas and their potential applicability to MIS phenomena. The paper concludes with suggestions for future research.

DEFINING STANDARDS

In considering the impact of standards upon MIS, one first must agree upon a standard definition of the term. In one of the earliest typologies Hemenway (1975) subdivided standards along two dimensions: purpose (quality or uniformity) and degree of coercion (voluntary vs. mandatory). Antonelli (1994) terms these two dimensions as “reference” vs. “compatibility” and *de jure* vs. *de facto* standards. These dimensions are fully orthogonal, i.e. all four possible combinations can be found in practice (Table 1).

	Reference	Compatibility
De jure	Kilogram	NTSC, PAL
De facto	UL/CSA approval	Microsoft Windows

Table 1: Examples in the 2x2 typology of standards

These dimensions have been widely employed (either implicitly or explicitly) in the study of standards in I.T., and they will be considered in turn.

Reference vs. Compatibility Standards

Formal reference standards have an impact upon business practices, most notably through process quality standards such as ISO-9000. In systems analysis and design, the structured methodologies reported by Fichmann and Kemerer (1993) would fall into this category, even if they lack the formal ISO enforcement.

Reference standards have also been incorporated in *intraorganizational* standardization of MIS practices. For example, an MIS procurement policy might specify the approval process and decision authority, product compatibility standards (e.g. POSIX compliant), product reference standards (e.g. FCC Type B emissions certification), and policies for deployment and use. To the degree to which MIS research defines and improves “best practice”, it contributes to the *interorganizational* standardization of such practices. For example, Osmundson and colleagues (2003) developed quality metrics for the management of software development programs.

However, it is the technical role of compatibility standards makes such standards fundamental to IT products. Researchers and managers often use a simple unidimensional, bifurcated typology, terming any product as "compatible" or "incompatible" with a given standard. Beyond this, Gabel (1987) classifies compatibility as a multi-dimensional product attribute, with each attribute assuming one of several (discrete) levels. His dimensions (updated with contemporary examples) are:

- **multivendor compatibility,** such as the compatibility of PCs made by HP and Dell;
- **multivintage compatibility,** such as the compatibility of Dell 486-series PCs with subsequent Pentium-based models;
- **product-line compatibility,** as when desktop PCs (using Windows XP) from HP share a file format with its handheld (Windows CE) computers.

All three types of compatibility make it easier to reuse key complementary assets, and thus are germane to the study of MIS adoption decisions and producer strategies in information industries.

Nonetheless, in their study of EDI adoption Damsgaard and Truex (2000) concluded that the isotropic assumption of such *industrywide* standards was only one of three standardization patterns in EDI use. They listed two other approaches to standardization — standards negotiated by each pair of exchange partners, and hub-and-spoke rules imposed by a few large players on their smaller (usually supplier) partners. The latter concept could also be applied to multiple interpretations of Unix or HTML standards by proprietary vendors during the 1990s.

Systems of Related Compatibility Standards

A subset of compatibility standards can be classified as providing for interoperability between complementary components. Such interoperability standards are important because they allow for the design of modular systems, and, in particular, provide incentive for the development of cospecialized complementary assets (Teece 1986; Langlois & Robertson 1992).

Realistically, there are both economic and statutory limits as to the degree of vertical integration that is possible in promulgating a family of products that require such complementary assets. For example, while a computer company such as IBM, Apple or Sun may be capable of building a computer with an integrated operating system, it typically lacks the necessary resources to provide the additional software, hardware, training and documentation expected by customers. Even in cases where a firm has the ability to produce complementary assets, firms have an incentive to attract competitors to increase the supply of assets, as Sony did when it sought additional music companies to produce recorded music on compact disc (Grindley 1995: 101-124).[1]

By providing a series of interfaces for the required complementary products, the manufacturer can induce other firms to produce such products. This is particularly important if the complements must be "cospecialized", as, for example, when software is provided for a Macintosh rather than an IBM-compatible PC. The developer of the standard then can choose to concentrate on those components of the system that provide the greatest barriers to entry and opportunities for profit, and use intellectual property protections in an attempt to realize those profits (Teece 1986).

A series of related standards often allow for the modular construction of complete systems, in which a group of products are combined using standardized interfaces. Among the best known examples are modular audio components and personal computers. This modularity allows for (and, in fact, encourages) producers to specialize in one particular component (such as

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1 In 1987, Sony paid a 60% market premium to purchase CBS Records (Grindley 1995: 121). This was widely interpreted as a reaction by Sony to the failure of its Beta video tape format, a failure many attributed to a lack of pre-recorded movies.

speakers or software); the capability of the system is increased by multiple independent innovations by competing producers (Langlois & Robertson 1992). In a such a system of multiple standards, the control of the interface standard for the key complementary asset determines both the evolution of the system and which firms will profit from it (West and Dedrick, 2000).

A proprietary platform consists of an architecture of related standards, controlled by one or more sponsoring firms. For a computer system, the architectural standards typically encompass a processor, operating system (OS), and associated peripherals. Some have also extended the concept of a "platform" to include multiple layers of software, such as applications that rely on a "middle ware" tool such as Java or a database (Morris and Ferguson, 1993; Bresnahan and Greenstein, 1999; West and Dedrick, 2000).

A platform is but a specific example of the general class of technological innovations studied by Teece (1986), who links the ability of firms to profit from their technological innovations to the appropriability regime for intellectual property rights (IPR) — either through formal *de jure* protection (e.g. patents) or through *de facto* protection such as tacit knowledge or trade secrets. Absent such IPR protection, firms selling a given technology can be expected to adopt marginal cost pricing and drive profit margins to zero (Katz and Shapiro, 1986; Beggs and Klemperer, 1992). Without appropriability, Teece (1986) suggests that firms must use some combination of speed, timing and luck if they hope to appropriate returns generated by their innovation.

De Facto vs. De Jure Standardization

The classification dimensions for standards are often presented as dichotomous, assuming that each standard is, for example, either *de facto* or *de jure.* As with most typologies, in practice the classification of standards along a dimension is more a matter of degree than bifurcation.

Both Microsoft's Windows and Apple's MacOS are *de facto*, proprietary, partially restricted standards for personal computer operating systems. Both owned standards provide profits to their owners, and both allow (and encourage) the provisioning of a particular class of complementary assets, software applications. But the standards differ in their restrictions on PC hardware, with entry of new PC makers encouraged for Windows (like MS-DOS before it), while Apple forbade (except during a brief window) rival hardware makers for the Mac OS.

In the absence of a legal mandate, *de facto* standards creation tends to attract multiple competing implementations, thus forcing the IT adopter to choose from among the competing standards (or defer technology adoption until the outcome of the competition is more clear).

Some *de jure* standards are legally enforced by the government, as in the regulations of the U.S. Federal Communications Commission. In other cases, they are enforced by non-profit organizations with semi-official powers delegated by the government, such as the American National Standards Institute or the Japan Industrial Standards Committee (Hemenway 1975; McIntyre 1997). Damsgaard and Truex (2000) note the emergence of two major EDI standards, UN/EDIFACT and ANSI X.12, which were widely adopted by international shippers for the exchange of invoices.

In still other cases, private standards bodies have no official role, but non-compliance is so costly that adherence is nearly universal — as with the insistence of insurance companies on approval by Underwriters' Laboratories or the Canadian Standards Association. Finally, multi-vendor standards consortia often attract such a critical mass of vendor support that any competing standard is suppressed and market (rather than political) institutions impose a single standard upon buyers and sellers.

The assumption of MIS adopters is that such *de jure* and quasi-*de jure* standards are exogenous to the firm, and immutable. But many of the *de jure* and consortia standards process identify a formal role for user-buyers in the standards creation. And the standardization process itself can make a large difference in the utility and adoption rate of the standardized technology, as Lyytinen and Fomin (2002) found for first-generation cellular telephone systems.

“Open” vs. “Proprietary”

The concept of an “open” standard has been juxtaposed against less desirable “proprietary” standards. Originally an “open” standard corresponded to “multivendor compatibility” of Gabel (1987) and the corresponding shift of negotiating power from I.T. providers to I.T. buyers. Meanwhile proprietary (or owned) standards provided sponsors with the economic returns and incentives to keep a technology up-to-date to attract buyers afraid of vendor lock-in (Morris & Ferguson, 1993).

As buyers expressed greater interest in “open” standards, the term’s technical definition has been redefined by marketers eager to position their standards to prospective adopters. Various firms pursued a so-called “open systems” strategy (Garud & Kumaraswamy, 1993), which involved proprietary extensions to Unix-like operating systems to increase switching costs and relative advantage beyond a pure multivendor standard. Even an interest in standards conformance and interoperability does not accurately predict actual adoption of such “open systems” (Chau & Tam, 1997).

One of the problems of such dichotomies is that actual standards manifest different degrees of openness, ratable on an ordinal if not interval scale. West (2003) proposed a multi-attribute scale of operating systems standards openness, measuring factors such as multiple hardware vendors, multiple implementations and the availability of source code. He concluded that the most open standards were those which included unrestricted source code implementations, such as provided by a BSD-style or Apache-style open source license.

STANDARDS SELECTION AND ADOPTION

In some cases, I.T. standards are mandated by a national government agency or industry association. But more often, they are selected in the marketplace, through the adoption decisions of organizations or individuals.

Research on the economics of standards and organizational adoption of information systems both are concerned with adoption decisions for standardized I.T. products. The economics theories makes predictions about winning and losing standards, predictions that are tested in the aggregate across a national (or global) market; such theories have recently been used by MIS standards researchers (Table 2). MIS adoption theories such as TOE and TAM focus more specifically on organizations, and treat all technology as equivalent without regards to standards. The two literatures have rarely been joined, perhaps due to the different units of analysis.

De Facto Market Competition

Economics research on standards considers two ways in which standards affect the utility of a new technology: asymmetric switching costs and positive network effects. The two effects are mediated by the supply of co-specialized complementary products (such as software and peripherals) or other co-specialized complementary assets (such as IT worker skills).

Asymmetric Switching Costs

The presence of asymmetric switching costs mean that a buyer's previous adoption choices will change the relative attractiveness of future adoption choices, making some options more expensive than others. Among theoretical studies of switching costs, von Weizsäcker (1984) provides a model in which buyers discount future investments. In his economic model, Klemperer (1987) classified switching costs into three categories:

- transaction costs (e.g., the cost of uninstalling equipment from one supplier and installing equipment from a new supplier);
- learning costs (e.g. PC usage skills);
- contractual costs, or costs deliberately introduced by suppliers (e.g. frequent flyer programs).

Article	Phenomenon	Methodology	Theoretical Framework
Au & Kauffman 2001	Online billing	Theoretical model	Network effects
Brynjolfsson & Kemerer 1996	Spreadsheet product competition	Hedonic price regression	Network effects
Chau & Tam 1997	Open systems adoption	Logistic regression	Technology-organization-environment
Damsgaard & Truex 2000	EDI adoption	Multiple case studies	Linguistic grammars
Gallaugher & Wang 2002	Web server product competition	Hedonic price regression	Network effects, diffusion of innovations
Kauffman, McAndrews & Wang 2000	Bank ATM networks	Hazard model	Network effects
Tam & Hui 2001	Mainframe vendor competition	Regression	Network effects, Bass diffusion model
West & Dedrick 2000	PC standards competition	Case study	Network effects, product architectures

Sampling frame: Standards-related articles published in *MIS Quarterly, Information Systems Research, Journal of Management Information Systems, European Journal of Information Systems,* plus those in *Management Science* by MIS authors.
Search terms: standards, network externalities

Table 2: Standards-related research in MIS

"In all these markets, rational consumers display brand loyalty faced with a choice between functionally identical products. Products that are ex ante homogeneous become, after the purchase of one of them, ex post heterogeneous" (Klemperer 1987: 376).

Such product-specific switching costs give the incumbent vendor "some monopoly power" and weaken competition between firms (Farrell and Saloner 1988: 123). In a multi-period model of competition between two producers, Farrell & Saloner (1988) showed that an incumbent protected by switching costs has an incentive to exploit existing customers rather than aggressively seeking out new ones.

Other switching costs are specific to compatibility standards. Such standards provide a benefit that it is easy to mix and match products within the same standard (Langlois and Robertson 1992). Switching costs for computer owners typically fall into one of three categories:

- cospecialized complementary assets (e.g., software or peripherals), which becomes worthless with the new standard;
- user data, which requires conversion for use with new standard;
- user skills and training, often referred to as "psychic" switching costs.

Because of these switching costs, a standards-related re-adoption decision (such as for a computer) is fundamentally different than, say, a decision regarding an automobile or a copy machine.[2]

Perhaps the clearest empirical test of switching costs s Greenstein's (1993) examination of U.S. federal government procurement of mainframe computers from 1971-1983. Using a multinomial logit model and controlling for likely confounds, he showed that government agencies did prefer compatibility in their subsequent computer purchases. Heide and Weiss (1995) found similar switching costs for commercial purchases of computer workstations, which they attribute to the uncertainty faced by organizational buyers in using a new technology.

Network Effects

Perhaps the most influential economic theory of standards adoption and competition is that of positive network effects, also referred to as positive network externalities.[3] The theory was originally developed for telecommunication technologies such as telephone or fax, where as Rohlfs (1974: 16) describes it, "the utility that a subscriber derives from a communications service increases as others join the system." Such direct network effects also apply to the adoption of other bilateral communication technologies such as e-mail, videoconferencing or EDI (e.g., Riggins & Mukhopadhyay 1999).

But more broadly applicable are the category of indirect network effects identified by Katz & Shapiro (1985), in which the utility of a "hardware" innovation is mediated by the provision of specialized "software":

> For example, an agent purchasing a personal computer will be concerned with the number of other agents purchasing similar hardware because the amount and variety of software that will be supplied for use with a given computer will be an increasing function of the number of hardware units that have been sold. This hardware-software paradigm also applies to video games, video players and recorders, and phonograph equipment (Katz & Shapiro, 1985: 424).

Such software is a specific category of what Teece (1986) categorizes as "cospecialized assets." For some products (such as computers) most companies lack either the capital or the capabilities to produce all the complementary assets ("software") necessary to make their products successful: instead, they must rely on third parties to provide this software. For standardized "hardware" such as personal computers and videocassette records, this software must be cospecialized by the software producer, and thus hardware producers must provide incentives to the software producer to make such investment (Teece 1986).

Because one of the most attractive incentives to a software producer is a large possible market, when there are competing hardware standards, the most widely adopt will theoretically attract

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2 Both the automobile and copy machine decisions may entail some psychic switching costs. However, these are probably less than for, say, switching word processors; also, there is little evidence to suggest that vendors of these products seek to provide multivintage or product-line compatibility of user skills, the way that a PC operating system or application standard inherently does.

3 There is some question as to whether the positive-feedback benefits of a network of adopters fit the economic definition of an "externality" (Liebowitz & Margolis 1994) . Subsequent economic researchers have used the term "network effects" to avoid making such claims (e.g. Shapiro & Varian 1999).

the largest supply of software, which in turn would make it even more attractive to potential adopters. This positive feedback loop results in “demand side economies of scale” (Katz & Shapiro 1986), or will contribute to “increasing returns to scale” (Arthur 1989), widening the lead of the dominant standard indefinitely.

Such theoretical models have been directly extended to the MIS field. In considering competition between electronic bill payments standards, Au & Kauffman (2001) showed the conditions under which the guarantee of upward compatibility would induce firms to wait for a later but “better” standard.

Among empirical studies of information systems, network effects have been used to explain the uncontested adoption of new technologies, such as automated teller machines (Saloner and Shepard, 1995; Kauffman, McAndrews and Wang, 2000).

Another possible test was presented by the many competing MS-DOS spreadsheet applications in the late 1980s. Hypothesizing that compatibility with the market leader (then Lotus 1-2-3) would allow a given applications to enjoy benefits from Lotus’ complementary assets, both Gandal (1994) and Brynjolfsson and Kemerer (1996) showed that such compatibility accounted for the gap between actual and hedonic price. However, the analyses did not distinguish between two possible benefits accruing to the Lotus “clones”: access to the network of Lotus-compatible assets, or reduced switching costs for existing Lotus users.

The empirical evidence on contested adoption of information systems (as predicted by Katz & Shapiro and others) is more equivocal. Tam & Hui (2001) studied U.S. sales of large computer systems from 1965-1993 and found that installed base did not predict market share for new sales of three product categories. In a study of Japanese PC standards, West & Dedrick (2000) concluded that the network effects of a large installed base and software library could be rendered obsolete through architectural reconfiguration.

The spreadsheet hedonic pricing test was extended to competing standards adoption by Gallaugher & Wang (2002), who also provided a more direct test of network effects model using the early phase of the web server market. Adjusted for relevant controls, they found that server market share (or the highly correlated browser market share) helped predict price, along with support for emerging standards and trialability.

Combining Networks and Switching Costs

In a real adoption decision, firms are likely to consider both network effects and switching costs. When one standard holds a majority share, then the combination of network advantages and installed base switching cost will tend enable the leading standard to get even further ahead (Arthur 1996). However, in a rapidly growing market, the effect of the installed base switching costs is dwarfed by the decisions of the larger population of new and potential adopters (Liebowitz & Margolis 1990; West & Dedrick 2000).

One way for a new MIS standard to become adopted in competition existing standards is through the provision of gateways or converters. Despite a promising theoretical literature (David & Bunn 1988; Farrell and Saloner 1992) and occasional use in industry practice (e.g. word processor import filters), this area has received little in the way of empirical study.

Adoption of IS Standards

The MIS field is, not surprisingly, interested in the adoption of information technologies by organizations. While such technologies often incorporate product compatibility standards, the study of such adoption has customarily been based on the diffusion of innovations framework.

Many researchers cite the sociological model of Rogers (1983, 2003) with its framework for the adoption and diffusion of technological innovations. MIS research has focused more on his enumeration of key innovation attributes (relative advantage, compatibility, complexity, trialability and observability) than his better known categorization of individual adopter personalities such as early adopters and laggards.

More specifically to MIS, the technology acceptance model (TAM) operationalizes an individual's adoption propensity in terms of two IS attributes: perceived usefulness and perceived ease of use (Davis 1989). The technology-organization-environment (TOE) model of Tornatzky and Fleischer (1990) has been use to explain intra- and inter-organizational factors that influence MIS adoption.

While these frameworks explain the adoption of an innovation, rarely do MIS researchers incorporate the salient characteristics of standards in their adoption studies. For example, in their study of open systems adoption, Chau & Tam (1997) treat the Unix-compatible operating systems standard (aka "open systems") as an innovation in the context of Rogers (1983) and Tornastky and Fleischer (1990). They do not, for example, measure network effects or switching costs as a predictor of switching propensity.[4]

In contrast, various MIS researchers have studied MIS adoption using standards theories but not TAM, TOE or similar MIS theories (e.g. Brynjolfsson & Kemerer 1996; Kauffman et al 2000; Gallaugher and Wang, 2002).

One of the few to integrate both perspectives is the early work of Fichmann & Kemerer (1993), who studied the adoption of three software process innovations using both the diffusion of innovations (of Rogers, Tornatzky and Fleischer) and network effects (of Katz, Shapiro and others) models. Although not studying standards *per se,* their use of the two competing theories provides an exemplar for how both MIS and economics theories could be employed to explain organizational adoption of standards.

It is anticipated that the recent call by *MIS Quarterly* for papers on standards in information systems will increase the supply of such work that crosses such boundaries.

CONCLUSIONS

The role of product compatibility standards has been under-studied in the MIS field. With key theories developed in economics and tested in management, economics and (rarely) in MIS, there is an accepted body of theory that could be used to explain the evolving technological environment facing MIS executives.

It is possible that the field might choose to turn away from such external standards theories in search of its own core discipline. The larger field of business research (MIS, finance, organizational studies, strategy, marketing) is rife with "paradigm envy" due to heavy borrowing from reference disciplines of economics, psychology and sociology. The concerns of Weber (2003) that borrowing external theories threatens the IS identify may represent an extreme position, but such concerns would tend to discourage extending on prior theories from other disciplines.

[4] They also appear unaware of the earlier work of Gabel (1987) on open systems standards adoption, which is often cited among standards researchers.

Below are a few possible areas for future research on the adoption of information systems standards by organizations:

Integrating Standards and Innovation Research. As noted earlier, the MIS field has a rich and established body of research on innovation adoption, while economics offers theories of standards adoption. The two distinct constructs could be combined into a separate study, with each construct measured and tested separately. For example, the relational database of Fichmann & Kemerer (1993) is an organizational innovation (consistent with Tornatzky & Fleischer 1990), enjoying economic "bandwagon effects" (Rohlfs, 2001) as it achieved critical mass, while the competition among commercial database products (such as Oracle, Informix, Ingres, etc.) would be marked by network effects and switching costs (Katz & Shapiro, 1986; Greenstein, 1993).

Similarly, the perceived usefulness of a standardized technology (per Davis 1989) might include both attributes characteristics of standards adoption (availability of application software) and other attributes appropriate for any technology (price, reliability).

Impact of Standards. As Tornatzky & Fleischer (1990: 22) noted more than a decade ago, the adoption of an innovation is not the end of the story — there is also the question of whether it delivers the payoff expected by the adopter. The same question could (and should) be asked of standards. Do they in the abstract deliver the benefits of compatibility, modularity and interoperability as promised? Are MIS managers accurate in their ability *ex ante* to estimate the relative availability of complementary products for a prospective standards adoption, or the utility such products will provide?

Incorporating Technology. Standards research inside and outside MIS tend to conceptualize the actual technology in a nominal sense in the formulation of Orlikowski and Iacono (2001). But standards have an inherent technical role of allowing engineers to achieve interoperability between products and across organizations, and such motivations remain prominent in many formal standardization efforts such as those of the IEEE. So unanswered questions remain. Does the technical content matter, as when designers must trade off competing imperatives?[5] Is the quality of the standard (or the quality of the technology delivered by the standard) germane to an adoption decision? Is this an objective or subjective construct?

Changing Forms of Standards Competition. The importance of *de jure* standards seems to be declining as firms and multi-firm consortia ship products (such as 56K modems and 802.11g wireless network equipment) prior to formal standardization. How does this uncertainty affect adoption decisions? Absent a formal imprimatur, what guarantees of interoperability are important in standards adoption? Is the claim of "open"-ness of a standard have any impact, or is it only the reality of openness that increases adoption likelihood?

Effects of Open Source Software. Open source software has already had a major impact upon the development of information systems, particularly for applications that support Internet-related standards (Stewart & Gosain, 2001; West & Dedrick, 2001). How are MIS buyers' attitudes towards open source standards different from more customary "open" or "proprietary" standards? How can we measure the success of "free" software: for example, a hedonic pricing model of web server market share (Gallaugher & Wang, 2002) could not be used with current industry data, because the free open source server Apache has held a 60% market share since mid-2000.

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5 As an example, Liebowitz & Margolis (1994) noted that the initial design choices for videocassette formats provided two hours per VHS cassette, but limited smaller Beta cassettes to one hour each.

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DEFENDING THE SPIRIT OF THE WEB: CONFLICTS IN THE INTERNET STANDARDS PROCESS

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ABSTRACT

The creation and adoption of standards is often modeled as a game between large corporate players. Alternatively, the standards process can be modeled as the actions of a set of actors in a network. A third perspective is also possible – standards can be seen as the outgrowth of the technical ideas of the participants and the technical community they consider themselves part of. This work focuses on applying all three perspectives on the development of web services choreography standards. A model is developed, and the three methods are applied. All three are shown to be intertwined, in the sense that ideas from one method can feed another. Evidence is presented which suggests that the technical culture of the participants is a strong driver of standards development – and of migration between standards groups. The role of standards bodies are analyzed – given the fast movement of technical architects between companies and standards groups, the bylaws of the groups themselves may be important in encouraging or frustrating the creation of successful standards.

Keywords: standards development, standards adoption, decision making, web services, workflow, choreography, software architecture, aesthetics.

INTRODUCTION

The creation and adoption of a technical standard has a large effect on our society – economically, a standard can impact the rate at which new products can be developed, and socially, it can determine who can produce and control these products. So understanding the process of standards creation and adoption is important to our overall understanding of our society. Such an understanding can ideally help us facilitate the development of effective standards. In the rapidly growing literature on standards research, there are a number of cases oriented toward particular standards, as well as research into horizontal similarities across different efforts.

This paper is the outgrowth of a case study the authors recently completed on the development of web services choreography standards. In the paper related to the case, we detail the history and explain in depth the technological arguments surrounding the standards (zur Muehlen, Nickerson and Swenson). We went into the study expecting to explain a technical battleground. What we found was that the battles were not purely technical. For example, for all the debate on one solution versus another in 11 different groups, no one suggested actually testing the proposed technologies to verify claims and counter-claims.

Here, we build a model for standardization, and look at our previous case from three perspectives. The first perspective is social – we follow the people involved in the standards process, an approximation of more complex approaches such as actor-network theory (Latour 1987). The second is cultural – we look at the ideas of the participants, particularly ideas about technology. Our approach is a simple form of text analysis as practiced in cultural anthropology (Bernard 2002). The third approach is economic, utilizing decision theory (Keeney and Raiffa 1993).

These three approaches are intertwined. In general, economic theories are helpful in understanding how individuals with a given set of utilities will interact. It has been observed before that economic theories are not good at determining where the utility comes from; social theories are better for understanding how an individual's utility gets formed (Kling, Kraemer, Allen, Bakos, Gurbaxani and King 1992). Consistent with their work, this study can be seen as providing more evidence that standards study calls for multi-method approaches. More specifically, this study focuses on technological culture as a determining factor in standards creation.

The economic approach is well-understood by all standards participants – often one will impute game-playing motives on another. But the imputation itself is connected to beliefs of the participants, as a careful reading of running newsgroups surrounding standards will show. And, in analyzing the decisions to be made in a standards committee, a look at the social networks revealed that the decision to quit and reform a standards group is an important option in the game. So, depending on one's perspective, one can say that the social research allows us to build and calibrate a better decision model, or the decision research helps us probe backward into the ideas that form an individual's utility function. Fomin and Keil (2000) have applied a multi-method approach to standards before, utilizing 8 different approaches – while their study focused on the political aspects of their cases, ours focuses on the cultural aspect.

First, before examining each perspective in turn, we present a diagram in figure 1.

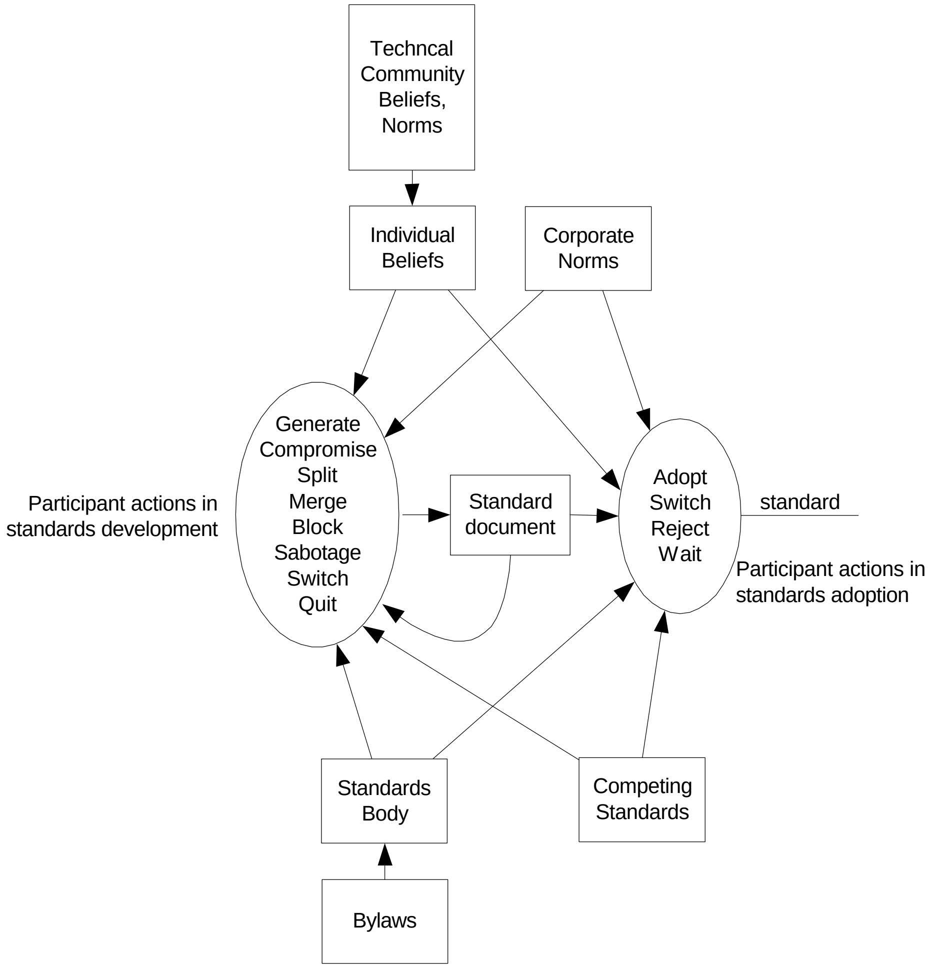

Figure 1: Standards Process

The diagram describes the standards process as consisting of two decision processes, development and adoption. In the development process, the participants in a standards body create and debate the standard. Notice the number of different actions that take place in the development stage. Originally, we assumed that the generation and compromise would be the major moves, but in analyzing what happens we came to realize that many more options besides compromise are possible. Part of the pressure on a standards group is an external factor – there are often other competing standards. So, in true game playing fashion, a player who favors an outside standard may either suggest merging with that standard, or block or sabotage a standard, much the same way a congressional committee can block or sabotage a bill. Unlike a congressional committee, those who object to such moves can switch to another standards group without incurring large switching cost. If the standards development goes well, they produce a standard document, which is often refined until it is presented to a wider community for acceptance.

The wider community considers both the standard and other competing standards, and may adopt the standard, reject it, switch to another one (a different form of rejection), or simply refuse to make a decision. This latter process has been the subject of much economic analysis (Farrell and Saloner 1985; Besen and Farrell 1994). It has been observed that the game-theoretic techniques employed are more suited to the adoption than the development process (Fomin and Keil 2000).

Having presented the model, we give some detail on the domain we will use as an example throughout this study.

Web services choreography describes the coordination of long-running transaction between business partners using standard Internet protocols, such as HTTP, SOAP, and WSDL (all acronyms are defined in a glossary at the end of this paper). It can be applied in a variety of domains, ranging from supply chain management to media content solicitation. The origins of web services choreography can be found in workflow management technology, which has been commercially available since the middle of the 1980s.

In the early 1990s large workflow users became aware of the possibility that they would be confronted with the existence of several workflow solutions from different vendors. These users chartered workflow vendors with the definition of interoperability standards for workflow technology. These standards were first created within the scope of the Workflow Management Coalition (Hollingsworth 1995; WfMC 1999), but they are increasingly being defined by competing standardization groups, such as BPMI, OASIS, and W3C. In parallel to this development, the use of Internet technology for application integration became feasible through the introduction of value-added standards on top of the basic HTTP protocol used for the World Wide Web. These standards, WSDL for the description of externally accessible operations and SOAP for messaging using XML, allow application designers to open their applications for access over the Internet. However, SOAP and WSDL only provide support for simple request-response message exchanges. More powerful mechanisms are required for the coordination of long-running transactions, such as the subsequent exchange of Quotes, Purchase Orders, and Delivery Notes.

THE SOCIAL PERSPECTIVE: FOLLOWING THE PEOPLE

Latour (1987) writes that we should "follow all the actors whoever they may be and wherever they may go". First we start with the institutions, and then look at the people.

The goal of creating a web services choreography standard has already generated 11 different standards, and is not yet concluded. Figure 2 shows the complex interweaving of standards groups just around the formation of choreography standards – groups form, argue, splinter, and create new standards. In this particular case, we can identify a repeated pattern – enthusiasm over a standard turns into conflict over architectural issues, a group espouses a purer, simpler architecture, breaks off the main standards stream and forms another standard in a different standardization organization. In this process the rogue group merges with another group. Then the cycle repeats. Most of the standards backed, discussed, and even completed are never implemented, but instead dead end as their champions jump onto a new one.

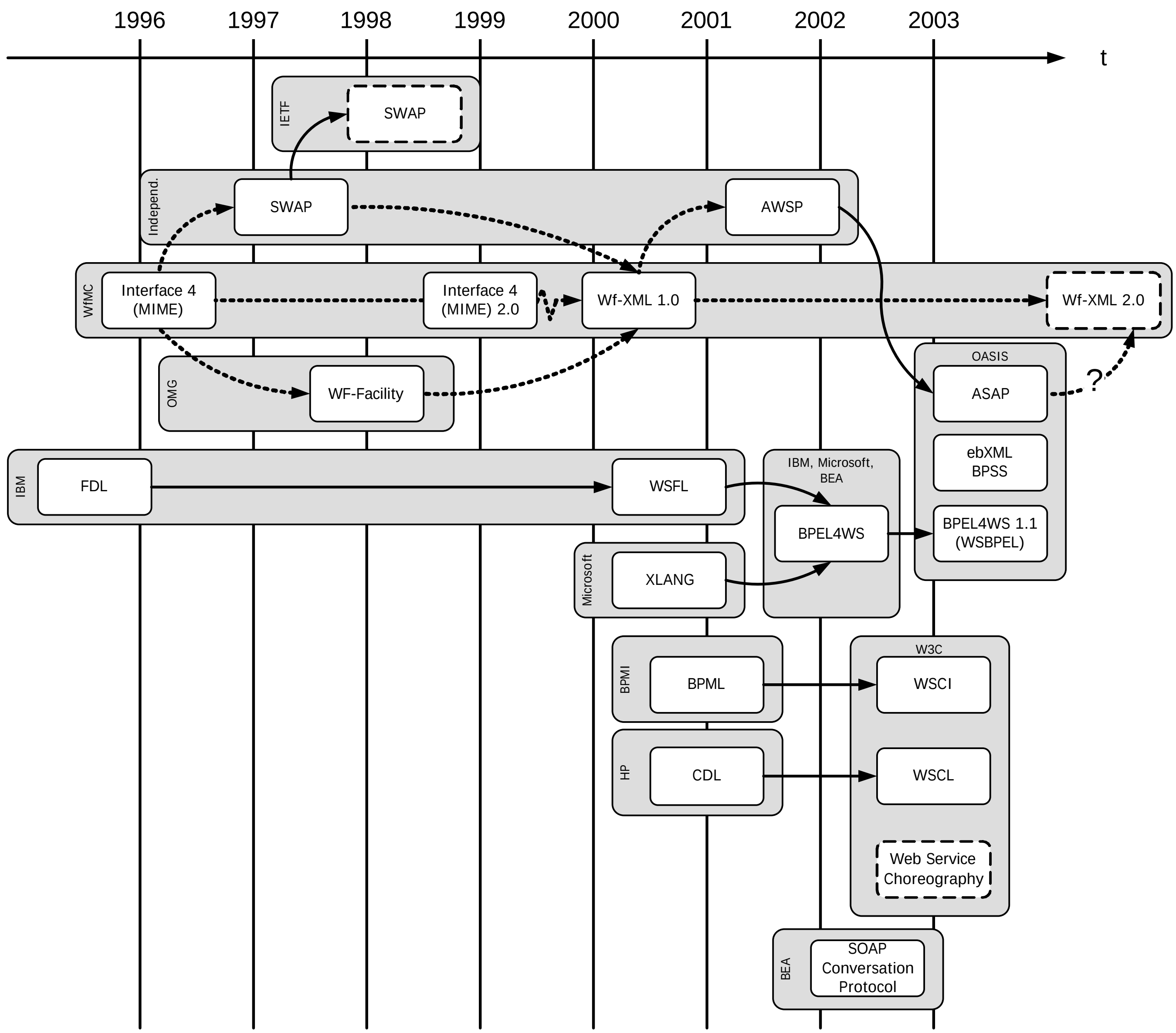

Figure 2: Timeline of Workflow and Web Service Standards

In looking at this diagram, one is struck by the migratory nature it implies. For it not really the standards themselves that are moving – it is the participants in the standards process who are packing up, leaving, and reassembling with a different standards organization. In our case, we traced several of the participants through their hops across different standards bodies. To help conceptualize what is happening, we present a set of diagrams which show the process taking place.

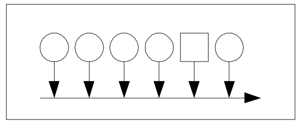

Figure 3.

In figure 3, a group forms, with slightly different beliefs (circles and squares).

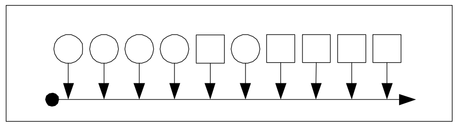

Figure 4.

The group expands, and the initial group ends up in conflict over the direction of the standards with newcomers with different beliefs.

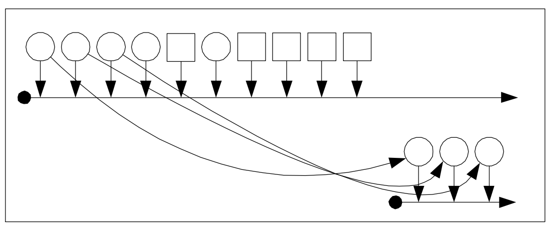

Figure 5.

Several members of the founding group break off, and form a new standards group in a different venue (the second parallel line).

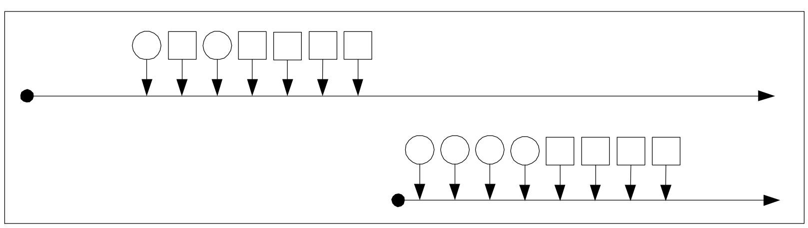

Figure 6.

More members join this new group – they happen to have a different set of beliefs.

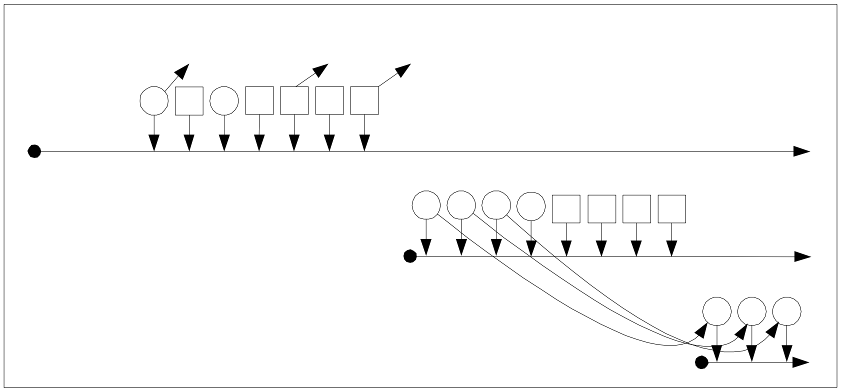

Figure 7.

The initial group finds the direction of the new standards committee is not to their liking, and they quit and form a third standards group. Note that some of the members of the first group start to move elsewhere. There are a finite number of people active in the standards process, and as a group loses momentum, some of the members will inevitably move to a livelier group.

The participants in the standards process in the case we looked at were truly searching for a venue in which they could offer a standard that was technically excellent. When they felt like the group they were in was foundering, they simply jumped to another group. From following the people, we gained insight into a movement pattern. But it leaves us wondering exactly why a group would leave. For that, we need to look at the ideas.

THE CULTURAL PERSPECTIVE: FOLLOWING THE IDEAS

In following the movements of the standards participants, we noted that the primary reason for moving to another group was disenchantment with how the work was going in the group. And this disenchantment can be described as a growing sense that the actual standard was becoming too complex.

Someone quitting a standards process because the standard is too complex doesn't appear to fit into a game-theoretic model, where players are usually described as seeking to dominate each other in order to fulfill the interests of their sponsoring corporation. Instead, the participants in this case are engaged in something that looks a lot like a process of aesthetic evaluation of the standard.

The participants in technical standards committees often consider themselves architects. They design systems. And as with the members of many design communities, they as designers have a certain aesthetic sense which has been built up over years of formal education, informal understudy, and personal experience. This aesthetic sense can in many ways stand in for more thorough technical testing – an architect in a corporate environment may claim to know that a certain messy design will result in a poorly performing system, without needing to build a prototype.

Aesthetic judgments can be part of a strong value system. For example, building architects are taught to understand when a design feels appropriate for its setting, and when it doesn't. Graphic designers of the modern school are taught to avoid that which does not contribute to the meaning of a page. And programmers are likewise taught about clean vs. kludgy code.

There is a remarkable comment in the specification of the newest version of SOAP:

> *"The use of a SOAP body to carry the request for the state, with an element of the body representing the object in question, is seen as counter to the spirit of the Web because the resource is not identified by the Request-URI of the HTTP GET." (Mitra 2003)*

The standard is explicitly disapproving of a potential use of SOAP because it is counter to the spirit of the Web. It is not that the potential use will not work – it will work. But it purportedly violates the design aesthetic of those who have built the web protocols.

The phrase "the spirit of the Web" is interesting from two perspectives. First, the phrase is understandable to anyone who has studied the protocols – there does appear to be a certain style in the way TCP/IP, FTP, and HTTP are designed. This style is closer to an aesthetic than a rule, for there are myriad different ways to define a protocol and myriad different ways to build on top of them. Fielding (2000) has attempted to articulate what is built into the spirit of the web – but it takes his full Ph.D. dissertation to explain the differences between the web architecture and other alternate architectures.

Second, it suggests that the Web has a spirit – in the same way we speak of a city having a spirit – and that this spirit is to be defended. In contrast, it is hard to imagine someone defending the spirit of EDI in the same way.

The way most of the standards have grown is through an RFC process; it is officially described in the following way:

> "The goals of the Internet Standards Process are:
> - technical excellence;
> - prior implementation and testing;
> - clear, concise, and easily understood documentation;
> - openness and fairness; and
> - timeliness." (Bradner 1996)

What is interesting is the emphasis – on technical excellence, conciseness, openness. There is no mention of the ability to fulfill a user requirement.

This general issue of design aesthetics was discussed by Richard Gabriel in an article on LISP, in which he differentiates between strategies which seek completeness, and strategies in which "simplicity is the most important consideration in a design" (1989). Gabriel argues that those who choose simplicity of implementation usually win the market battle against more complete and complex systems. A similar argument is made by Guy Steele, who argues that "The Java programming language has done as well as it has up to now because it started small. It was not hard to learn and it was not hard to port. It has grown quite a bit since then. If the design of the Java programming language as it is now had been put forth three years ago it would have failed - of that I am sure" (1998).

Table 1: Length of Standards

Group	Standard	Year	Version	Pages
W3C	WSCL	2002	1.0	22
DAMLSC	DAML-S	2002	0.9	26
W3C	WSDL	2002	1.2	30
NIST	PSL	1998	0.98	32
OASIS	ASAP	2003	0.1	34
WfMC	Wf-XML	2002	1.1	57
W3C	XML	2000	1.0	59
IETF	HTTP	1996	1.0	60
IETF	FTP	1980	1.0	70
IETF	HTML	1995	2.0	70
WfMC	XPDL	2003	1.0	87
OMG	Wf-Facility	1997	1.0	95
BPMI	BPML	2002	1.0	103
IBM	WSFL	2001	1.0	108
W3C	SOAP	2003	1.2	128
OASIS	BPEL	2003	1.1	136
OASIS	BPSS	2001	1.01	136
RosettaNet	RN Implementation Framework	2002	2.00.01	143
ISO	SGML	1986	1.0	155
IETF	HTTP	1999	1.1	176
OASIS	BTP	2002	1.0	188
OMG	UML	2003	1.5	736

In table 1, we show the length of various standards documents. While brevity may not correspond to simplicity, there is a probably a correlation. We observe two things. First, standards tend to be getting longer – notice that HTTP grew from 60 to 176 pages between versions. Second, the standards body itself may be a determining factor – the vendor-driven and user-driven standards are longer than the research-driven ones. We will return to this observation in the section on economics.

Simplicity is not the only principle that gets discussed. Feeling can become heated in online discussion groups:

> *“SOAP-based services are called "Web Services" because their proponents wish to partake of the Web's success -- yet they don't build on its core technologies, URIs and HTTP...What we need to do is gather together a fellowship of like-minded Hobbits, Dwarves, Elves and men and go on a quest to educate the world about the limitations of SOAP-RPC interfaces.” (Prescod 2003).*

The quest of Hobbits, Dwarves, Elves, and men in Tolkien is to defeat the forces of darkness. In the discussion boards, there are multiple examples of how the debate between two architectures, say REST and SOAP, becomes much larger. Here is a table of polarities that are often intertwined in discussions:

Table 2: Polarizations

One side	The other side	Notes
SOAP (Web Services)	REST	(Fielding 2000)
Functional	Object Oriented	(Swenson (in press))
Hard and Crunchy	Soft and Stringy	(Barr 2003)
Corporation	Developer	(Dumbill 2002)
[Forces of Darkness]	Hobbits, Elves, Dwarfs, Men	(Prescod 2003)
Complete	Simple	(Gabriel 1989)
Closed source	Open source	(Raymond 1999)
Hierarchy	Market	(Raymond 1999)
Strongly typed	Weakly typed	(Barr 2003)

It is as if participants in conversations either unconsciously confuse cues, or confuse them on purpose for rhetorical effect, much as politicians paint their rivals with the most extreme labels. For there are valid technical arguments for web services, and all of the advocates of web services are not corporate forces of darkness.

In figure one, we show that the participants in the development of web services are influenced by both the norms of the corporations they serve, and the beliefs of the technical community they consider themselves part of. For insight into this, we look at open source developers. Our use of open source analysis makes a certain amount of sense – Fielding not only coined the term REST but was also responsible for the development of several open source projects, including Apache.

Open source developers often develop source while working on the job, sometimes without the employer knowing. Perhaps most telling, 41% of the time, they define their identity in terms of their membership in a hacker community (Lakhani and Wolf 2003). It may be the case that standard participants are similar – that their allegiance to a community of like-minded architects is greater than their allegiance to their sponsoring institution.

THE ECONOMIC PERSPECTIVE: FOLLOWING THE MONEY

While we have been looking at standards in terms of people and ideas, it is clear we can learn a lot about standards by evaluating the potential benefits to the players involved in making the decisions. A host of economic theories have been applied, and the results are interesting. In light of our conversation about culture, it is especially interesting to look at developer's attitudes about economic analysis.

> *"SOAP is something completely different; lots of additional complexity, but very few additional benefits. Some people love complexity (especially if they see a chance to make a living out of it...). But I don't." (Lundh 2003)*

The imputation is that vendors want to make money on standards, and by making the standard more complex, they increase the chance of selling products. Another example:

> *"This is why the decision to pursue or reject the SOAP route is so critical, and why developers should be very careful. The choice is between open and established technology on which the Web is built, and the direction proposed by*

> *large corporations, whose existence depends on making money from their strategies.” (Dumbill 2002)*

In a similar vein, the open source community literature contains similar comments:

> *"The utility function' Linux hackers are maximizing is not classically economic, but is the intangible of their own ego satisfaction and reputation among other hackers." (Raymond 1999).*

The last comment is interesting, because it hints that we actually can evaluate a programmer’s utility, as long as we look at a different criterion than money. The development stage can be described as a stage of collective invention (Meyer 2003), and as part of this invention, new ideas are continually evaluated.

In academic literature, architectures are commonly evaluated with some variation of multi-objective decision making. These techniques involve eliciting values and preferences (Keeney and Raiffa 1993). Illustrative of this kind of approach applied to systems is a technique called the Cost Benefit Analysis Method (Kazman, Asundi and Klein 2001). The benefit of an architectural alternative becomes

$$Benefit(AS_i) = \sum_j (Cont_{ij} \times QA_j)$$

where *AS* represents architectural strategy, *Cont* represents contribution, and *QA* represents a quality attribute score. The quality attributes are often criteria such as reliability and scalability.

Standards groups do not explicitly use such models, but the dialogues captured in their discussions often concern the weighting of different attributes. So in a fight between REST and SOAP advocates, one might predict that the different groups will have different weights in mind for a similar set of attributes. It is easy to see how this can lead to an impasse. As we have pointed out, in many political situations, impasses are followed by compromise. But in standards groups, labor is voluntary, and switching costs are low, so quitting one standards body and reforming in another is a viable option.

There are two points to be made here – in modeling the standards creation process, one possible result of an impasse may be migration to a different standards committee. The second point is methodological – the social perspective, in this case study, helped inform the economic perspective.

In considering the game further, if one wished to model standards generation, one would need to model the nature of the different standards committees. In our case, one of the jumps was explained in the following way:

> *“OASIS has a very liberal policy about starting a TC [Technical Committee] ... anyone can start one. W3C on the other hand has a lengthy review process before you are allowed to start one. Simply put: it was easier to start an OASIS group.” (Swenson 2003b)*

The bylaws of the groups may determine the allowable jumps, so that the movement between groups may be less random than it appears.

Adoption in general, and more specifically the adoption of standards, has been studied extensively from an economic perspective (Katz 1994, Farrell 1985). And the actual strategies of high-tech companies have been studied (West 2003). In our case, two theories provide a possible explanation for the current state of web choreography standards. The first is research on network externality – a simulation shows that latecomers to a market area will have to buy their way in (Buxmann 2001). But until we near a tipping point we won't see bandwagoning effects (Oliva 1994). Work on EDI diffusion provides empirical evidence that the herd instinct is a factor in adoption (Damsgaard and Lyytinen 1998). These ideas together suggest that vendors will want to serve on multiple standards committees so they don't come late if one takes off. But they also suggest that users may have little motivation to adopt any of these standards if the herd hasn't started moving. Options theory as it relates to IT investment can be invoked to suggest that, in conditions of high uncertainty, waiting may be the best strategy (Sullivan, Chalasani, Jha and Sazawal 1999).

What we do see in the case of web services choreography is an absence of user adoption – and participation by vendors on multiple committees, as shown in table 3.

In looking at different standards and their participants, one can categorize standards as being driven by three different groups. The first two groups are self-evident. Some standards are clearly driven by vendors. And some standards are clearly driven by users – for example, RosettaNet is driven by a set of companies in the manufacturing industry. But there is a third set of specifications such as TCP/IP and HTTP where representatives of corporations are involved, but the standard does not appear to be driven by corporations. We refer to these standards as research-driven. Often, those engaged in their creation are financed by government research funding organizations such as DARPA, NSF, and CERN. The representatives of corporations involved in these standards are often individuals who maintain a strong link with the research community. And these standards are sometimes created in standards groups that are strongly identified with the research community, such as the IETF and W3C.

In understanding the economics of standards development, it may be important to look at the funding sources – and also the sympathies – of those on the committees.

Table 3: Relationship between Standards and Contributors
(● = submitter or contributor)

	ASAP	BPML	BPEL	BPSS	RosettaNet	SOAP	SWAP	Wf-XML	WSCI	WSCL	WSDL
	OASIS	BPMI	OASIS	ebXML	RosettaNet	W3C	IETF	WfMC	W3C	W3C	W3C
BEA									●		
CSC		●						●			
Chevron				●							
Cisco					●						
CommerceOne				●							
DHL					●						
E2Open				●	●						
FedEx					●						
Fujitsu	●				●			●			
HP					●					●	
IBM			●		●	●		●			●
Intalio		●							●		
Intel					●						
iWay	●										
Izar, Inc.	●										
Lucent				●							
Microsoft			●		●	●					●
Netscape							●				
Netfish				●	●						
Oracle					●		●				
SAP		●	●		●			●	●		
SeeBeyond		●									
Siebel			●								
Staffware								●			
SUN		●		●	●				●		
Telcordia				●							
UPS					●						
Versata		●									

The quotes that began this section bemoaned the vendor push into this area of standardization. And there are other case studies that show that vendors sometimes win. In the browser wars, Microsoft pushed for the adoption of its particular browser product (Shapiro and Varian 1999). To draw a parallel, most software vendors are pushing for SOAP-based coordination standards. In contrast, the dispute between different standards for railroad track widths was resolved through the wishes of an important customer, the federal government. So in some cases customers can overcome the wishes of vendors (Shapiro and Varian 1999). For REST advocates, or the advocates of any standard facing off against powerful vendors, the case would suggest they should lobby a large customer – such as the government – to adopt their standard first.

In a case related to workflow standards, we observe an example of a fight between research-oriented and vendor oriented standards. In 1996 the Object Management

Group decided to adopt existing WfMC standards, and initiated an RFC process. But a research-oriented member of the group objected (Schulze, Böhm and Meyer-Wegener 1996), forcing OMG into a longer request for proposal process (OMG 1997). The process resulted in a competition between a proposal backed by 19 vendors, and a proposal backed by Nortel and the University of Newcastle. The vendor proposal won – against the recommendation of the research-oriented group member (OMG 2000). Interestingly, in the OMG, vendors who propose a standard are required to implement it within a year after the adoption of their proposal (OMG 1998). But in this case they did not implement their own standard. One participant in the process remarked that the vendors actually did not want interoperability, and the three-year effort was doomed from the start, since the vendors controlled the entire standardization process.

It has been noted that vendors will often use the standardization process toward their own ends (West 2003) – and, in game-theoretic terms, that is what they should do. Accusations against vendors for conspiring to sabotage standards may be correct – or they may be an example of paranoia. What is clear is that there is often a tension between the proposals of research-oriented participants and those who more conscientiously represent the interest of their sponsoring firms. From a global perspective, the research-oriented standards often do well – TCP/IP and HTTP being strong examples. With increased participation from vendors on standards committees, we wonder if the tide might someday turn against the research-backed standards. It may also be the case that the user, vendor, and research community balance each other throughout the standards process in a way that is not immediately obvious.

CONCLUSIONS AND FUTURE WORK

The standards process is complex, and multiple perspectives, applying both social and economic techniques are more likely to yield insights than single techniques. This general conclusion has also been reached by others (Fomin and Keil 2000).

More specifically, we have pointed out that there is ample evidence in the texts associated with Internet standards developments that the decision making of the participants in standards development is very much influenced by the technical culture the participants identify with, perhaps more so than the culture of the corporations sponsoring the participants. The technical culture may manifest in the aesthetic evaluations of design made during the course of standard development. These evaluations are often used as heuristics for examining the technical effectiveness of the standards. Clashes over these evaluations may provoke participants to jump to a new standards body, rather than compromise.

Our observations have been qualitative, and on a small sample size. In anticipation of future research, we have provided a model. It might be used to evaluate the effects of different variables on the development and adoption of standards. Such an effort would face obstacles – the number of standards processes that have been analyzed in depth is low, and the standards processes and the participants change over time. Some studies may be easier than others. In order to gain more insight into the aesthetic heuristics of standards developers, the relative complexity of adopted versus abandoned standards might be examined. The standards process definitely affects the standard, and the standard itself, along with the public commentary from the surrounding technical community, may give us further insights into the process.

An implication of our observations about the movement of participants for standards bodies is that their bylaws may either encourage or frustrate such jumping. Future research might analyze how the field of standards bodies functions. It could be the bodies are functioning as competitors. Or it could be that different bodies are fulfilling functional niches. Either way, the research might suggest ways of preserving or improving the overall functional landscape of standards bodies.

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GLOSSARY

ASAP	Asynchronous Service Access Protocol
BPMI	Business Process Management Initiative
BPML	Business Process Modeling Language
BPEL(4WS)	Business Process Execution Language (for Web Services)
BPSS	Business Process Schema Specification
BTP	Business Transaction Protocol
CDL	Conversation Definition Language
DAML	DARPA Agent Markup Language
DARPA	Defense Advanced Research Projects Agency
EbXML	Electronic Business XML
EDI	Electronic Data Interchange
FDL	Flowmark Definition Language
FTP	File Transfer Protocol
HTTP	Hypertext Transport Protocol
IETF	Internet Engineering Task Force
NSF	National Science Foundation
OASIS	Organization for the Advancement of Structured Information Standards
OMG	Object Management Group
REST	Representational State Transfer
RFC	Request for Comment
RFP	Request for Proposal
RosettaNet	Named after the Rosetta Stone, which led to the understanding of hieroglyphics
SGML	Structured Generalized Markup Language
SOAP	Simple Object Access Protocol
SWAP	Simple Workflow Access Protocol
TC	Technical Committee
TCP/IP	Transmission Control Protocol/Internet Protocol
WfMC	Workflow Management Coalition
Wf-XML	Workflow XML
W3C	World Wide Web Consortium
WSCI	Web Services Choreography Interface
WSCL	Web Services Conversation Language
WSDL	Web Services Description Language
XML	eXtensible Markup Language

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ENABLING AN OPERATOR-INDEPENDENT TRANSACTION MODEL FOR MOBILE PHONE CONTENT SERVICE PROVISION THROUGH THE OPEN CPA STANDARD

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ABSTRACT

Content services for mobile phone subscribers compose a new business area based on the constellation of and symbiotic relationship between mobile telecommunication operators and content providers. In this paper we discuss the development and internationalization of the CPA (Content Provider Access) business model and platform by the Norwegian telecommunication operator Telenor. CPA is firmly grounded on and driven by common interests and incentives among operators and content providers. Through a discussion of relevant actors, we identify different factors supporting and hampering the success of CPA in different national markets. We further discuss how CPA relates and challenges traditional and institutionalized standardization approaches within the telecommunication industry.

Keywords: Mobile phone content service, CPA, open platform, standardization, internationalization.

INTRODUCTION

Predictions of convergence between information technologies and communication technologies describe a future environment of new mobile devices, content services, business opportunities and usages. In this paper, we describe in details the complex process of the coming together of mobile telecommunication operators (MTO) and content providers. Together, they enable economically sustainable provision of content services to mobile phones. We discuss how these different actors manage to develop a relationship with common incentives and drivers, enabling an open service environment with the CPA (Content Provider Access) business model. In particular we focus on how this process has unfolded in the context of different countries and cultures, as well as how one MTO has pursued to expand CPA to their international portfolio of MTOs.

By offering their expertise and experience in the creation of a transparent business model, MTOs are currently not simply trying to get a free ride on reselling content, but also to create a common and open market for content providers. The MTOs' implementations of the CPA business model enable all content providers to deliver content to any mobile phone subscribers in their national market. At the same time, the MTOs provide the content providers the billing services need for the content services. The MTOs make their value chain accessible to content providers through this arrangement based on a revenue sharing transaction model in return. Enabled by CPA, content providers reach economies of scale through easy access to the market, a viable billing solution as well as a possibility to brand through the use of short-codes (phone numbers with only four digits). At the same time, the content providers are able to what the MTOs are not: provide innovative services related to entertainment and impulse more than utility. At the same time they have easy and economical viable access to marketing channels.

From the point of view of content service provision, there is a need for a certain “centralization” of the telecommunication market. In particular, this is motivated by the need for easy user-access to services. This is enabled by CPA providing common service access points and pricing policies independently of to which operator the user subscribes. Providing content services for mobile phones also separates the content services and service provision. This separation is manifested in a need for non-technical standards to enable technology-based services. We conceptualize this distinction by exploring the composite transaction and coordination layers of the CPA business model. Only one of these layers is composed of technical standards related to the CPA-platforms, while the rest concerns the non-technical standardization requirements of the CPA business model.

In Norway, the CPA business model has emerged trough small-scale efforts within and between different telecommunication operators, in tight cooperation with entrepreneur-spirited content providers. The CPA business model is thus not a result of technical standardization prior to the implementation of the platforms, but a result of coordination of common interests, creation of a common open service environment (opening walled gardens). In parallel, dynamic technical development of the CPA-platforms has followed according to the development of new content services and concepts as well as the market. This process unfolds outside both the scope and the abilities (related to for example speed and flexibility) of the traditional telecommunication standardization institutions, and therefore requires new institutions for coordination of activities and standardization of technologies. In addition, there is also a need for different kinds of standards.

For some time now, the Norwegian telecommunication operator Telenor Mobile has pursued an expansion of the CPA business model to their international portfolio of MTOs located in Bangladesh, Denmark, Hungary, Malaysia, Russia, Sweden, Thailand and Ukraine. Based on data from different national markets on the CPA business models’ implementation, we describe how regulatory, business and cultural issues are hampering and supporting the process. We also discuss the appropriateness of the expansion and standardization approach followed by Telenor Mobile.

Methodologically, this paper primarily draws on interviews with central actors regarding the development of the CPA business model, the implementation of CPA-platforms and the market in Norway. During 2003, several interviews were conducted with the two Norwegian MTOs, content providers as well as involved authorities. While following the current development of the CPA-market and its new applications, a reconstruction of the historical development since 1999 was provided by Telenor. The data from the different national markets and implementation efforts are primarily based on secondary sources, in particular as interviews with Telenor Mobile employees engaged in the implementation efforts in the different companies. As research is in progress, we are planning to visit several of the companies early 2004.

This research approach is grounded in an understanding of processes of innovation and standard making as being open. Innovations and standards are not coming by them selves or emerge as a bi-product of convergence. They develop through a process unfolding within a context where a multiple of stakeholders cultivate their different strategies and agendas. In our analysis, we include a broad context of influent factors, on the levels of culture, institutions and organizations. Cultural factors are ranging from strong presence of entrepreneurship to acceptance of adult entertainment. Institutions are in particular the innovation regime of telecommunication, their related standard setting approach as well as the institutionalized practices of cooperation between operators. Organizations are primarily mobile telecommunication operators and content providers.

CPA AS BUSINESS MODEL AND PLATFORM

In 1997, the mobile division of the Norwegian MTO Telenor, Telenor Mobil (TM) introduced a collection of content and utility-based short message services (SMS) for their (and only their) mobile phone subscribers, branded as Mobilinfo (the second MTO in Norway branded SMSinfo). The content services were aggregated by TM, based on information from content providers, primarily news, stock quotes, weather forecasts and phone directories. The content services were priced regardless of content, and simply per transaction (NOK 3[1]). Even if less utility-based contents (in particular jokes) were introduced over time, the market stagnated.

The cost of marketing and advertising for a telecommunication operator, concerns about relating the brand of TM to non-utility services (services with great market potential), the pricing policy, a walled garden approach as well as stagnation in the market made Mobilinfo a costly and not very successful endeavor. In 1999, TM took an initiative to meet these challenges, finally resulting in the CPA business model. While the decision to change approach was clear, the management efforts and the investment in further implementation of the platform were limited. On a day-to-day basis a few key people within the TM organization still managed by initiative and a spirit of entrepreneurship. Through identification and negotiation with the other key actors in the market, they created the business model, in parallel implementing the minor technical changes the CPA platform initially required within TM. Fortunately, content providers were currently seeking new outlets and cost-effective transaction cost models for their relatively inexpensive content services. They were also concerned with getting access to the whole Norwegian market of mobile subscribers. Luckily, TM found a lead user in a small content provider Mobilnet, already engaged with content services available through premium-rate voice services.

In spring 2000, Mobilnet became available on the CPA-platform, without TM doing any real technical changes in the Mobilinfo platform. However, Mobilnet got a more open access to the network, as well as the responsibility to decide which services to provide, how to market as well as price them. When May had passed, a range of smaller as well as strong international content providers as Finnish based “Jippi” had entered the market and the traffic boosted and was ten-folded in one month. Coordination with the second Norwegian MTO NetCom, common short-codes and price categories provided the required functionality to make services easy to market and easy to use.

From providing relatively simple services as logos and stock quote subscriptions, the CPA-platform is today also providing more advanced services, in particular integrated with interactive services as voting and discussions in TV-shows and off broadcast time shows (the hours where a TV channel does not normally broadcast programming). By providing the only common available return channel, the mobile phone enables interactivity. The CPA-platform does also provide billing support for content services delivered by MMS, WAP, WEB, and POS (positioning).

The CPA business model requires only some simple steps for the mobile phone subscriber to access content services. For example, if a subscriber would like to have the song “9 to 5” by Dolly Parton as new ring tone on his mobile phone, he first locate the required information for ordering the service (for example on the web, e.g. www.inpoc.no). The information needed for ordering the service are typically a short-code identifying the content provider from where to order and the content item name. As a request for the content, the consumer sends an SMS

[1] € 0.4, respectively 0.2 for request and 0.2 for delivery

containing “9to5” to the number 1985 (that is easy to remember). As the subscriber is already registered with the MTO and the billing solution is available, there is no need for a cumbersome registration of personal data, credit card number etc and further time-consuming credit checks. The MTO receives the SMS, recognizes the number 1985 and forwards the request as well as the customer’ phone number to the content provider over a simple TCP/IP connection. The content provider receives the request, recognizes 9to5 as the item, and produces and returns the proper content back to the operator by TCP/IP together with the contents’ rating class. The MTO requests their invoice system to bill the service according to the rating class, and if successful, the content is delivered to the customer. Finally, when the customer pays his regular mobile phone bill including the cost of the content, the revenue is split between the operator and the content provider.

The business model as layers of transactions/coordination

The CPA business model and its approach to meet the challenges of providing services to customers in the mobile phone market can be conceptualized as layers of transactions and coordination. These layers together provide what is necessary to enable the CPA business model to be successful in a market (summarized in Table 1).

Related to the layers, various actors have different needs, interests and incentives. The primary actors related to the business model are MTOs and content providers. Content providers are either lean and flexible “greenfielders” (as for example Mobilinfo) or “media windows” (as for example TV broadcasters and media houses) with strong marketing channels and brands. The “greenfielders” provides innovative business ideas while the “media windows” mobilize and make own content interactive and offering market space to other content providers. Some content providers operate only in their national market, while other internationally. MTOs in advanced mobile phone-markets face saturation in relation to traditional services. Positioning them selves in relation to content providers is one approach to create increased traffic in their networks. At the same time, their competence and installed base of customers and billing systems are valued as an asset by the content providers. MTOs in advanced but saturated markets, as for example in Norway, also seek new opportunities in less developed markets by expanding their operations through international operations.

The coordination of short-codes and ease of use of the services are close related to intervention from authorities. Regulatory authorities can take a role as supporting cooperation between MTOs to enable competition and open garden access to services, hampering ease of use by complicating advertisement (supposedly on behalf of the users) or taking no role at all. Also other actors have a stake in the CPA business model, as integrators giving one single access point for content providers to the various CPA-platforms, content aggregators, content owners etc.

Table 1. Layers of transactions/coordination

Transaction/Coordination	Stakeholders	Interests and incentives
- Transparent access to services - Billing services	- MTOs - Content providers	- Need for economies of scale billing services - Revenue sharing in exchange of billing services - Increased traffic in network - Access to and by any subscriber - Return channel for interactive TV-shows
- Marketing and branding	- Content providers - MTOs	- MTOs can not brand non-utility services and adult entertainment - "Media windows" have strong brands and cheap and easy access to advertising and marketing
- One market - Ease of marketing and branding - Ease of use	- Content providers - MTOs - Customers - Regulators	- Need for transparent access for content providers and customers - A small piece of a big cake is better than a big piece of a small cake
- Service innovation	- Content providers - MTOs	- Lean and flexible content providers creates innovative services - Convergence - Strong marketing - Content providers spur market growth and initiate cooperation between MTOs

The technical challenge with the CPA-platform is to provide seamless connections between subscribers and content providers, in addition to provide open billing services to the content providers. The interfaces to the CPA-platforms implemented by the two Norwegian MTOs are not coordinated, but provide approximately the same services. As a third MTO currently enters the CPA market, there is at the same time a certain entrance and maintenance cost, especially for international content providers. This is however not addressed by the MTOs.

Plain access to subscribers for the content providers only requires interconnection between the mobile networks. However, implementing, operating and managing a billing system is for the content providers not sensible, because the content is cheap (between NOK 1 and 30[2]). Such implementations also require the user to register with each content provider and thus impede impulsive content acquisition. The content providers do have alternative payment solutions available, from companies (as for example MTOs) providing electronic purses related to a credit card or a bank account. These alternatives do also require a time consuming registration process.

By opening up their value chain, letting content providers bill their transaction on the pone bill in exchange for increased network traffic and a revenue sharing model (where the MTOs get from 30-60 percent of the revenue), the MTOs introduce a common driver for them selves and the content providers. Utilizing their already existing customer base and billing system, billing additional services has a marginal cost for the MTOs. However, in relation to concepts like interactive voting in TV-events, the MTOs have to introduce extra queuing mechanisms to handle traffic peaks.

[2] € 0,1 – 3,5

On the business layers, the MTOs face the challenge of marketing and branding. For MTOs, the cost of advertising is high and they do not have strong brands related to content, at least compared with “media windows”. The MTOs are also not willing to brand non-utility services and important services as adult entertainment (for example XXX jokes). Trading the responsibility of marketing, advertising and branding with the content providers, the operators meet this challenge.

Coordination and standardization between the mobile operators (in the national market) is another layer needed to enable success of the CPA business model. This enables on the one hand the content providers to have access to the whole market and on the other the customers to access services independent of to which operator they subscribe. This requires every MTO in the market to appreciate that the CPA business model will give higher revenue as on open garden, rather than a multiple of walled gardens (as for example Mobilinfo and SMSinfo). The primary argument supporting this approach is that coordinating common short-codes and price-categories are mechanisms which make services easy to brand, market and use, a market is more easily developed, and users more easily educated. Regulators can facilitate this process by providing and coordinating series of short-codes, or hamper it by e.g. as in the case of Denmark where customers are required to acknowledge the cost of the content in the requests for content.

The content is not created based on explicit needs from the users. Content is rather ringtones and logos, or close related to an ongoing TV-show. Service acquisition is thus primarily done on impulse. Service innovation within such an environment will necessarily be close related to the strength of marketing. In addition, new concepts can also act as an outset for content providers to initiate cooperation between the MTOs. In Thailand, where there is a lack of cooperation between the MTOs, TV-stations have made the operators coordinate in relation to special TV-events.

In the Norwegian market, all these layers are present and coordinated. At the same time, the business model shows some weaknesses. Content sold with CPA is not big business for the content providers, as a TV-station may not earn more than 20 percent revenue on the services they provide. In particular, where content providers use integrators to ease the burden of adhering to the interfaces provided by the different MTOs, there is not much left. In the Norwegian market, there is also only standard (and non-negotiable) agreements between the content provides and the MTOs, with fixed revenue sharing. This approach can on the one hand slow down content innovation, but on the other also spur initiatives to seek alternative and more attractive business models for billing. At the same time, a range of mediators as content aggregators and integrators sees an opportunity as service providers in between MTOs and content providers. Norwegian actors with the aim to expand into the international market are however not supported, as the coordination does not cross national borders.

INTERNATIONAL EXPANSION OF CPA

Restructuring their business strategy, Telenor is turning from being a primarily financial investor to an industrial investor in their international operations. The coordination of these efforts is centralized in two synergy areas: Products and Markets and Operations and Technology within the *Telenor Mobile* organization. Together with Group Support and Top management, the Synergy areas compose Telenor Mobile, facilitating cooperation among the companies. TM has the same relation to Telenor Mobile as the other companies, even if co-located with Telenor Mobile in Oslo.

Synergies between the companies have shown easy to achieve through economies of scale in procurement projects, related to network infrastructure and handsets. Telenor Mobile has also developed knowledge networks and synergy workshops, trying to facilitate introduction of new profitable services faster in the markets of the companies, as well as reduce the resources necessary to implement services. This has however shown to be more challenging.

Our further discussion of the expansion of the CPA business model and platform through internationalization is not related to economies of scale in procurement internationally, but focuses on the process driven by Telenor Mobile related to the internationalization of CPA, and how the business model have been received in the market of the companies.

Internationalization of the CPA-platform and business model

In 2001, Telenor Mobile identified the CPA business model as interesting for expansion into their portfolio of companies. During fall 2001, representatives from Telenor Mobile traveled the companies introducing the concept. CPA-platforms are now implemented in all but one of the companies[3]. The standard brought to the companies is only a description CPA business model along with consultancy support from Telenor Mobile. The business model is described briefly in "12 guidelines for best practice", mainly as how to best build the market, the need for symbiotic relationship between operators and content providers and the required ease of use.

The status of CPA in the different companies reveals variations in market success and implementation approach. These differences can be attributed both to differences in the context of the companies (as maturity of market, culture etc.) as well as the nature of the internationalization process driven centrally from Telenor Mobile. In the following, we describe several contextual issues: Choice of MT/MO-billing, presence of entrepreneur spirited content providers, maturity of the market and regulatory issues.

Most MTOs provides mobile originating billing (MT-billing), billing the subscriber on the receipt of content. Some of the companies do however understand it more appropriate to base their billing on the subscribers' request of content (MO-billing). The former is enabling different models of billing, in particular subscriptions to for example daily weather forecasts or alerts when a stock quote passes certain values. This is not possible with MO-billing, and thus limits the innovative space for the content providers and the potential for CPA success. One of the companies has implemented MO-billing which they see as the only possibility in relation to the underlying billing system. On the other hand, the real reason might as well be that the technical responsible only appreciate MO-billing as more elegant.

Some sort of proactive-ness from the MTOs towards the content providers and an entrepreneurship-spirited approach by the content providers are required to create a good CPA market. Companies based in countries were content providers are not flourishing are suffering from lack of services and a growing market, as Hungary and Russia. This is in sharp contrast with Malaysia, where a range of small entrepreneur spirited content providers are active in the market, both before and after the CPA business model was introduced.

The maturity of the mobile phone content market both relates to the MTOs and the subscribers. Some of the companies operate in markets where the operators have a long and fruitful history of cooperation (as in Norway and Malaysia), while other operates in markets with "walled gardens" and further strong mistrust (as in Thailand). In Thailand, cooperation has been spurred by the content providers in relation to CPA, but no agreements to create permanent open

[3] CPA is supposed to be implemented in Bangladesh by the end of 2003

gardens have been made. However, cooperation through CPA could at least be one step in the direction of further cooperation. In some markets, there are strong cultures of using SMS, and thus it comes easy to consume services with a well-known tool. In other countries, there is no SMS-culture, for example due to the recent introduction of SMS. As the content are primarily directed toward impulse consumption related to the “fashion” of sending SMS, the maturity of the market can change fast with strong marketing and branding.

The regulatory issues related to CPA are primarily related to what role the national telecommunication regulator takes. In some countries they have taken none. In other, they are enabling and supporting coordination of short-codes between the operators. However, in Hungary, it is required that the rating class is reflected in the short-codes and branding of the short-code and ease of use is hampered. In Denmark, the consumer must confirm the price of content in the service request also hampering ease of use, and requiring advertises to be more like user manuals.

The success factors of the CPA and where they are missing are presented in Table 2 related to the five main actors: Operators, content providers, authorities, local culture and Telenor Mobile.

Table 2. Success factors for the CPA business model

Actors	Success factors	Factors missing in
Operators	- Coordination between operators, open garden - Market and content provider oriented	Thailand, Ukraine, Russia, Bangladesh Hungary, Denmark
Content providers	- Multiple of entrepreneurs - “Greenfielders” and “media windows”	Ukraine, Bangladesh
Authorities	- Support from regulators in coordination - No interference related to ease of use	 Hungary, Denmark
Local culture	- Entrepreneurship - Low risk of fraud - Language - SMS-culture	Hungary Hungary Bangladesh
Telenor Mobile	- Commitment from Telenor - Appreciation of assistance from Telenor	Thailand

STANDARDIZING AND EXPANDING THE CPA-PLATFORM AND THE BUSINESS MODEL

The implementation of the CPA-platforms in the different companies has not followed any particular standard. The “12 guidelines for best practice” are only describing the principles of the CPA business model, even if technical issues are supposed to be derived. In retrospect, the team in Telenor Mobile responsible for the implementation of CPA-platforms in the companies suggests that a stronger approach to standardization would have given some benefits, at least as more common technical implementations. In addition, the lack of standards has also turned against the principles of the CPA business model, in particular implementation of MO-billing.

The idea of one global technical standard for CPA interfaces and functionality should be appreciated both from the perspective of global content providers, as well as giving economies of scale if one of the companies could develop a reusable technical solution. This is however not an issue for Telenor Mobile, and the few content providers with a global scope have not explicitly requested such initiatives.

The various implementations of the CPA-platform are in line with the companies understanding of what is the best technical approach, as well as close related to their already existing technical infrastructure, primarily the billing system. As the CPA-markets and the technical requirements develop over time, a common standard must be highly flexible to accommodate the changes in every market.

Globalizing the business model

On the national level, the CPA business model obliges standards. These standards are however not technical and internal for one MTO, but related to coordination with other actors to enable an open market. Primarily these actors are other MTOs, content providers and regulatory authorities.

The standardization of the market through the business model and the common implementation of CPA-platforms by MTOs are out of the scope of institutionalized standardization organizations, as for example ETSI (the European Telecommunications Standards Institute). The actors currently coordinate ad-hoc, but will probably over time create new institutions. In countries where the history of cooperation between MTOs is weak, this becomes a challenge. MTOs have a general approach of walled gardens, and a very strong belief in differentiation as market approach towards mobile subscribers. Thus, they are not primarily interested in cooperation and coordination with other MTOs, even if they find CPA as one exception. At the same time, content providers can take the role of being the driver or the mediator to make the MTOs cooperate.

The case of CPA shows that there is a need for standards in largely the same way as in other areas of telecommunication technology. At the same time, there are strong reasons to believe that CPA based content services increasingly will get an international character. This fact in addition to the increasingly international character of mobile phone operators generates a need for international standards. On the other had, the variety of services, the unpredictability of what kind of services users will adopt implies that the traditional hierarchical specification driven model followed within telecommunication standardization will very unlikely be feasible in this area. Other approaches accounting for the required flexibility in the technology will be required (Hanseth et al. 1996).

CONCLUSION

As a result of convergence, the telecommunication industry is facing new challenges and opportunities. The case of the CPA business model and platforms in particular illustrates the need for standardization, but standardization making happens outside the scope of institutionalized standardization bodies. At the same time, even if services and platforms globalizes, there is a need to accommodate local national and cultural issues. In particular, the history of cooperation between MTOs, their relation to content providers and their recognition of the open garden approach of the CPA business model as appropriate is decisive for the success of the business model. At the same time, regulators may hamper the business model by introducing requirements reducing the ease of use and advertising. The implementation process followed by Telenor Mobile has been soft and has resulted in different technical implementations, some of them also in conflict with the business model. At the same time, this approach does not favor international operations of content providers. However, an effective standardization of the platform will necessitate more than a stronger standardization approach from Telenor Mobile towards its companies, as it is closer related to the MTOs and the content providers in the local national markets.

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IS DIGITAL MEDICINE A STANDARDS NIGHTMARE?

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ABSTRACT
As technology has increased, one industry that has been slow in implementing technology is the healthcare industry. Doctors, with handheld devices, going room to room with real time information on each patient is not a reality in most hospitals today. Implementation has been slowed by multiple standards for healthcare data, and the HIPAA act that has brought up security issues for patient data. Also, research is being done in two non-convergent fields. This paper describes the standards and the problems with developing healthcare information systems.

Keywords: Healthcare MIS, Health Level 7, Medical Information Bus, Digital Imaging Communications in Medicine, Data Communication Standards, Digital Medicine.

INTRODUCTION
Healthcare management information systems are some of the most complex systems developed today. Healthcare providers, from individual doctors to hospital HMOs, want more technology integration into the system providing real time data analysis and the possibility of enhancing medical knowledge. Sharing that knowledge can lead to what many describe as “digital medicine” where stored clinical data can generate medical knowledge which can be widely distributed, incorporated into decision support systems, and lead to more effective medical practices (Shaffer, Kigin, Kaput, Gazelle 2002).

In order to achieve digital medicine, the collection of medical information to be retrieved and analyzed is necessary in real time. The equipment that monitors patients, the information recorded by nurses and even the images created in x-rays and MRIs must be stored in the system so that doctors can review all the data relevant to a patient to determine the proper treatment. Three standards specific to the healthcare field exist that healthcare information system developers must incorporate into any project so that data can be collected and stored. Any healthcare system developed incorporates these standards, which are still being developed and improved, plus standard networking protocols, and government induced standards for personal information security due to the recent Health Insurance Portability and Accountability Act (HIPAA). Medical Informatics is a new discipline which is directly influencing the development of information system in healthcare. Traditional MIS must recognize the problems in development of healthcare information systems, and the joint research possibilities with Medical Informatics researchers in solving many of the yet to be resolved issues of data collection and analysis in helping make digital medicine a reality.

This paper will examine three aspects related to the problems in developing healthcare information systems. The first aspect will be the security and privacy issues associated with digital medicine. The second aspect will be the standards for data collection that have been developed, specifically the Health Level Seven (HL7) data model standard, the Medical

Information Bus (MIB) standard for portable medical devices, and the Digital Imaging and Communications in Medicine (DICOM) standard for medical images. Finally, the last aspect will be the need for more joint research into the system architecture and need for a complete architecture of a medical information system that can lead to digital medicine.

PRIVACY AND OTHER RESTRICTIONS ON HEALTHCARE INFORMATION SYSTEMS

The communication standards developed for healthcare equipment and information, specifically the clinical and administrative data generated in hospitals are still developing and, now with the HIPPA requirements, can be the major success or failure factor of any installed healthcare information system. HIPAA has created an urgent need for common standards in the data exchange within hospitals and to external insurance suppliers. HIPAA requirements for security requires all involved with administering patient information to implement basic safeguards to protect electronically stored health information from unauthorized access, alteration, deletion, and transmission. With wireless technology being implemented in hospitals, the security of information on those wireless networks is necessary for HIPAA compliance. In order to make digital medicine a reality, access to patient information from other healthcare workers is necessary without revealing private information.

To create decision support systems and medical knowledge bases will require careful consideration on the uses of patient data which are restricted under HIPAA. Anyone who has visited a doctor recently has signed waiver forms on the privacy of their medical records. Individual privacy concerns could hamper development or implementation of a real time knowledge base.

HEALTHCARE INFORMATION SYSTEM DATA MODEL AND COLLECTION STANDARDS

In health care, specifically hospitals, the different electronic systems that have to connect to a real time information system that can provide doctors with timely information on patients poses an almost overwhelming communications problem. Each piece of equipment that monitors a patient should be capable of electronic data interchange within the hospital's network. Standards have been developed for the equipment that allows electronic data interchange. These standards are capable of providing a software developer the necessary tools that could allow for a fully integrated health care system that not only dealt with the patient records, but with the real time information on the patient's status while in the hospital. Doctors could use this information to provide better medical care.

Three standards are available for the system developer. The Health Level Seven (HL7), the Medical Information Bus (MIB or IEEE P1073), and Digital Imaging and Communications in Medicine (DICOM) all have had an enormous impact on health care information systems and patient care. Each of these standards impacts the data gathering and exchange of information within a health care information system. Wireless communications also presents a new security threat for the network systems, and also HIPAA compliance. So far, a new security standard for healthcare MIS has not been developed.

These three standards encompass data standards (HL7), communication standards (MIB) and digital imaging standards (DICOM). Software vendors must rely on all three of the standards to get a complete medical system useful for hospitals. These real-time systems are available, but with old equipment, hospitals can't switch directly to the new systems. That is why most healthcare software developers work with the equipment manufacturers to develop drivers for the older equipment. With each custom 'driver', the software vendor must expand the system and the potential of incompatibility increases. Each standard is described below focusing on the problems of each in terms of security, incompatibility and implementation.

Although these standards are widely known in the Medical Informatics field, they are not commonplace terminology in the MIS field. Networking protocols, such as TCP/IP and Ethernet are used in healthcare systems, but are only the transport protocols, not the implementation (MIB) or the data standards (HL7 and DICOM). Since healthcare information systems must integrate with other systems, such as insurance companies and government agencies, the standards for data models and data access become more important to the success of a healthcare information system. Since most MIS researchers do not understand these standards, a short description of each standard is given.

Health Level 7 (HL7)

The HL7 committee was founded in 1987 in an attempt to develop standards for the storage and exchange of clinical, financial and administrative information generated by such hospital areas as laboratory, pharmacy, admissions, etc. It was designated as an accredited standards developer by ANSI (American National Standards Institute) in June of 1994. HL7 has grown from its modest beginnings to become "*the*" standard for vendors and most prominent hospitals the world over. It essentially is a protocol for electronic data exchange, defining transmission transactions for patient registration, insurance, billing, orders and results of laboratory and physiologic tests, imaging studies, observations, nurses' notes, diet and pharmacy orders and inventory/supply orders. In 2002, the National Committee on Vital and Health Statistics (NCVHS) recommended HL7 as the primary Patient Medical Records Information (PMRI) message format standard. That same committee adopted DICOM, NCPDP SCRIPT (from the National Council for Prescription Drug Programs) and IEEE 1073 (MIB) be recognized as standards for specific PMRI market segments.

HL7 is very flexible, being an "open system," which has led to some confusion and vendor "sales pitch stretch" as far as the issues of connectivity and "HL7 compliance" are concerned. In relation to the seven layer OSI model, HL7 is a seventh layer, application standard. It defines the data to be exchanged, sets timing of such exchanges and manages error messages between applications. It assumes compatible protocols for layers 1-6 and herein lies one of the difficulties of "HL7 compatibility" insofar as different I.T. routes may be taken in those layers to reach the application layer. Different systems from different vendors for aspects of the information system for a hospital could be incompatible in the other layers, especially the network layer.

The flexibility of the HL7 standard-which gives rise to this compatibility issue- is important because the level of care, demographic patient base, payer mix, content of physician versus respiratory therapy orders, etc. differs from institution to institution. Data fields differ widely from hospital to outpatient surgical center to multi-speciality clinic office. In its latest version (HL7 3.0), the issue of flexibility has received considerable attention and indeed is being scaled back as the problems of compatibility abound. ("The reduced optionality will greatly help HL7 to approach plug and play specificity. The slogan for Version 3 is, "optionality is a four-letter word."") (Health Level Seven Organization, 2001) Thus, an ongoing attempt to streamline the collection and retrieval of "static data," which HL7 represents, promises even more in the way of "plug and play" which the medical as well as general public has come to expect. Indeed, HLV3 as it is known represents a complete "rethinking" of the delivery of clinical information, as it is built around the concept of a single object model, the HL7 Reference Information Model (RIM.) The HL7 Board of Directors has proposed this as the solution to :

> "*The most intractable barrier to the application of information technology in healthcare has been the lack of standards for exchanging fine-grained, highly*

> *heterogeneous, structured clinical data among information systems. The strength of Version 3 messaging is the exchange of fine-grained data without bilateral negotiations."* (Health Level Seven Organization, 2001)

It is felt that the adoption of HL7 V3 with its RIM which allows for the use of 96 hierarchical message descriptors (HMDs) that delineate specific message types which can be “implemented as a unique, but compatible XML schema” will advance the cause of a single, integrated suite of standards for health care informatics around the world. So far, the only evidence that this may come true is the adoption of HL7 by the NCVHS as the message standard.

Medical Information Bus (MIB)

> *MIB’s scope: “To provide for open systems communications in health care applications, primarily between bedside medical devices and patient care information systems, optimized for the acute care setting.”*
> *MIB’s purpose: “To allow hospitals and other health care providers to interface medical instrumentation to host computer systems in a manner that is compatible with the patient care environment.” (IEEE MIB Website, 2002)*

The critical care areas of a hospital represent a formidable challenge from an information systems standpoint (and from a health care standpoint too, I might add.) This is an area where the requirements for data generation, interpretation, status changes, alarms, safety and reliability, are far beyond those required of typical and “standard issue” computer hardware and software. The number of “device riders” on the “bus” can easily go from one to 7-8-10 within a matter of moments as a patient’s status changes rapidly. It is not uncommon for patient monitors to suddenly and quickly increase their displays from simple EKG and temperature to 5-6-7 lines of waveform data, accompanied by a profusion of IMED (intravenous) pumps, a ventilator and cardiac support pumps within minutes. This is the environment where “plug and play” is not a desirable, comfortable, lazy man’s feature but a matter of life and death. And indeed this was recognized very early on, in 1984, when the IEEE (Institute of Electrical and Electronic Engineers) founded the committee charged with writing the “Standard for Medical Device Communications.” This committee, which produced the family of standards known as IEEE P1073 (MIB) has continued working to this day and needless to say has rewritten the standards several times in a continuing effort to reach a true plug and play environment where the manufacturer, model number, vintage (within reason) of a needed piece of equipment is of no consequence in the overall care/information picture except in so far as it performs its clinically designated task.

MIB is a model that focuses on object orientation- that is entities defined as objects by the MIB model, be they pumps, monitors, ventilators, etc. They may also include patients, doctors, nurses, therapists- in short all the “Virtual Medical Objects” in play at and around the bedside, as defined by MIB, using the Medical Device Data Language (MDDL). Since the objects, information, access to the information and usage /display of the information all are addressed by MIB, it is- in contradistinction to HL7- a full seven layer protocol stack in the OSI model. The lower layers cover the equivalent of what in an office would be covered by Ethernet and TCP/IP- that is the physical connections, topology and transmission protocols. Considerable effort was expended in the area of connections, grounding and safety, given the sometimes less than ideal environment in which these devices must function. Star topology- specified by MIB- can also be viewed as a safety device in so far as it prevents a single cable failure from bringing down the entire local device network (i.e. attached to one patient). MIB also specifies a once per second device polling to ensure prompt failure recognition.

The upper layers of the MIB OSI protocol stack define content, format, structure and syntax of the message in question. This area is of crucial importance for- unlike HL7 which is designed for PC and workstation type equipment, where significant computing power is available and where upper layers are loaded into the machine via the applications- MIB deals with micro controller and micro processor based equipment with little processing power and little if any programmability. In addition, these devices are mobile, and must be connected and disconnected several times daily by non IT trained clinicians who neither know, nor care to learn, the finer points of network programming.

The upper layer protocol work has progressed slower than the lower. The IEEE has purposely attempted to standardize device classes, such as infusion pumps (the first to be standardized - IEEE 1073.1.3.1) in order to define parameters, attributes and services in a logical fashion. In addition, the Andover Working Group, a consortium of IT and healthcare companies under the direction of HP, has also continued work in this area and indeed has been one of the champions of standards based networks in this area. Finally, it cannot be ignored that MIB devices are by definition FDA regulated, which adds additional engineering, clinical and clerical “hoops to jump through” and which impacts the speed of advance of this work.

Digital Imaging and Communications in Medicine (DICOM)

Soon after the advent of CT (computerized tomography) scanners in the late 1980's, it became apparent that a method of storage and transmission of radiographic and other images more efficient than the traditional X-ray file room was needed. The American College of Radiology and the National Electrical Manufacturers Association formed a joint committee in 1983 to develop interfaces and standards relating to imaging equipment and other medical electronic equipment. The first version of DICOM was published in 1985 and has undergone several revisions. (DICOM Standard Website at National Emergency Management Agency, 2001)

In its present form, DICOM 3.0 is a full 7 layer OSI protocol stack. This is indeed necessary given the bewilderingly different pieces of equipment from an impressive array of vendors that make up even a relatively unsophisticated radiological department. DICOM 3.0 addresses interoperability and such questions as: commands, information objects (CT scan, barium enema etc.) and their attributes, data element tagging, naming and semantics (interpretation),encoding rules for data stream construction, message exchange, all of which allow applications to establish sessions, transfer messages (data) and terminate sessions. DICOM 3 allows support of numerous OSI protocol stacks, to include Ethernet, FDDI, ISDN, X.25, TCP/IP and other LAN and WAN technologies. However, DICOM physical layer protocols specify a 50 pin cable to accommodate the large data transfer requirements inherent in medical imaging.

As in the previous discussion on MIB, the environment of DICOM devices can be less than ideal. More importantly, the crucial aspect of virtual every byte of information in the reconstruction of images cannot be overestimated. The presence of errors in, or the failure of transmission of but a few bytes out of millions can render an image unreadable as understood in the clinical sense of the word. Indeed, recognizing that digital radiological images vary from 0.064 Mbytes per exam image(nuclear medicine scan) to 32 Mb per exam image(computerized radiography) and bearing in mind that transmission rates via a DS-0 would vary from 59 sec to 76 minutes gives the reader some idea of the magnitude of data accumulation, transmission and the extraordinarily low tolerance for error in this area of medical information technology.

Work continues on the DICOM standard, in particular on interface with HL7, crucial to enable demographic and other data needed for radiological examination to flow smoothly from the “static” to the “imaging” portions of hospital care. Once again, however, the term “DICOM compliant" needs to be taken with a grain of salt when emanating from a vendor, for the sheer complexity and size of DICOM standards is such that no products currently implement it totally. Thus, careful consideration of the "non compliant" areas is in order and adequate planning for interfacing at those points is mandatory.

RESEARCH POSSIBILITIES IN HEALTHCARE INFORMATION SYSTEMS

Even though these standard organizations are starting to work toward integration of the standards, there are still no interface standards between them. With many hospitals integrating wireless technology, each standard organization must come up with security aspects of the standards that can ensure encryption of the data that meets or exceeds the necessary security requirements for securing the data over wireless networks. Compatibility issues of interfaces for portable equipment within the hospital setting is forcing software vendors and manufacturers to write special 'drivers' for all the possible equipment from all the different equipment manufacturers. Even though the Medical Information Bus (MIB) standard is for the portable equipment, older equipment used in hospitals don't have the MIB interface yet are still used in most hospitals today. Recent research suggesting that medical errors can be reduced with more technology integration also points out the problems with dealing with complex standards, government regulation and policies, and even physicians that are not technically savvy (Chung, Choi and Moon 2003).

Joint research efforts between MIS and Medical Informatics can lead to solutions for building healthcare information systems which encompass the complexity of multiple standards, provide real time/life saving access to information, and still satisfy the business processes of a hospital. Add to the complexity the legacy systems most hospitals have and the complexity of installation without data loss or service interruption multiplies.

Medical informatics has defined the two technology areas that need to converge as information processing methodology (IPM) and information and communication technology (ICT). Convergence and clearly defining the technology areas involved in successful design of healthcare information systems are research areas. Potential research areas have been defined for informatics in the areas of the electronic patient records (which relates to the HL7 standard), system architectures for medical information systems, and medical knowledge bases (Haux, 2002).

As vendors integrate the standards into the systems they sell to hospitals, the complexity of the task to fully automate and digitize all the information that any one patient can generate at one time, and all the data gathering equipment to be tied to the system, along with any image data that is needed in real time by primary and surgical care providers is also compounded by the legacy systems that most hospitals have with patient data that they can't afford not to tie into a new system.

Other areas for future research are defined by research that suggests managed care has limited the technology development and adoption in the healthcare area. A review finds limited literature on technology adoption affected by managed care (Baker, 2002). Integration of wireless technology, for instance, increases complexity of systems by requiring compliance to HIPAA, and requiring data collection and access security problems. Some researchers already recognize problems with wireless technology that they say will hinder the availability in hospitals due to interference with existing medical devices, and no immediate communication of urgent messages (Helsop, Howard, Fernando, Rothfield and Wallace 2003). Technological influence on patient treatments and treatment trajectories can lead to digital medicine. Social medicine researchers are already researching the socio-cultural influence of technology in health care

(Mechanic, 2002). Training in technology is necessary for healthcare workers, especially physicians, to use the technologies most efficiently and effectively. Defining the role of the physician in digital medicine, and therefore the training necessary for the physician has also been an area of research (Howell, 1999).

Most research in this area is from the medical side, while the amount of research in healthcare information systems in MIS is minimal in comparison. The value add from joint research to establish system architecture standards, knowledge base development research techniques, communication standards, system integration with legacy systems, and the potential of developing digital medicine can lead to great advances and rapid solutions to many of the problems outlined in this paper.

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THE NEED FOR A STRATEGIC ONTOLOGY

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ABSTRACT

Although it is often not obvious or intuitive, advances in technology have historically driven organizational strategy that incorporates technical components. This has not proven to be successful. We advocate that advances in technology should be driven by strategy, and that one way of accomplishing this is to have strategic ontologies that serve as foundations for strategic patterns, than arbitrary technological patterns. This paper describes ontologies and how they have been used, somewhat loosely, in the definition of technological patters for software development. It discusses the implementation of enterprise resource planning (ERP) systems, and how they could have been more successful had they been introduced with strategic patterns based on a social ontology. In conclusion, this paper encourages the MIS community to lead strategic IT initiatives, rather than follow the opportunities created by technology.

Keywords: Ontology, Strategy, Architecture, Patterns, Business processes.

INTRODUCTION

As technology increases at a rapid rate, it presents organizations with new and varied opportunities. Unfortunately, these new technical opportunities often drive strategic positioning by organizations, rather than having technology use being driven by the organizational strategy. ERPs are an example of this phenomenon. While organizations often thought they were strategically changing their processes for competitive advantage, they were, in effect, having their strategy implicitly driven by the processes embedded in the software – the technological imperative at work.

MIS professionals and academics, versus computer scientists, have both an opportunity and an obligation to mitigate technology from driving strategy. While MIS has successfully impacted the standardized operation of computing through the creation and support of standards such as SEI/CMM, our discipline has failed to keep senior non-MIS managers from being at the mercy of technology projects that have up to a seventy percent failure rate (Hildebrand, 1998). This treatise proposes that one way to significantly shift the balance of technological power from the technologists that create the technology to the managerial organizations that use technology can be accomplished by creating ontologies for emerging technologies that are written in a language that business decision makers understand and control. By articulating business technology needs through understandable and consistent ontologies, business will proactively drive competitive needs down to the technologists to configure, rather than attempting to "mate" with what the technologists present to them. Business executives are not going to learn to speak "techie," and the time has come for the MIS community to create technological solutions in the language of business.

ERPs are an example where a lack of understandable standards and ontology has contributed to massive failures (Sumner, 2000). Since technical terms are often unclear, non-standard, and not described in the language of business, many managers are at a disadvantage when negotiating with technical firms who have essentially created the rules and ontology of outsourcing whether they are implicit or explicit. These examples demonstrate the need for the MIS discipline to become actively involved in standard setting and ontology development expressed in the language of business.

As a discipline, we are uniquely positioned to be the gatekeepers between business executives and basic technical scientists. We can accomplish this by setting standards of semantic consistency that are understandable to the people who make technology ultimately useful, high level executives. While the CIO often plays this translation role, it is virtually impossible to keep track of every new technology becoming available. MIS academicians need to get involved as new technologies develop, helping define and develop standard semantics and ontologies. By doing so, we can significantly increase the success of technology projects which will be driven by strategic needs rather than being fit to technology. This should also increase the speed by which non-IT executives understand the implications and opportunities presented by new technologies and improve the quality of their IT investment decisions.

The purpose of this paper is not to create a specific standard but to send a challenge to the MIS community to use our unique position between business and computer science to set IT standards using consistent, business-based semantic ontologies. The next section of this paper discusses ontologies from the technologist's perspective, highlighting the inconsistencies inherent even within one discipline. The following sections discuss ontology as a social phenomenon, arguing that it is possible to create ontologies for IT that business can understand and use. Next, we discuss patterns and how they also vary by author and lack consistency. This leads to a discussion of how our discipline failed to predict and prevent many ERP failures – failures that may have been reduced by a more fundamental understanding of the technology by the business executives making these large investments.

In conclusion, we call the MIS community to action to take the lead in creating semantically consistent ontologies for technology opportunities, in the language of business rather than past ontologies such as UML, CORBA, or XML. We need to insure that MIS investments are made wisely, and standard setting for language and patterns is one way to address this issue, with MIS academicians and practitioners leading in a collaborative manner.

ONTOLOGIES

There many definitions for the term *ontology*. Guarino and Giaretta (1995) identify seven different interpretations. Many of the definitions for ontology tend to be technical, as the art and practice of constructing ontologies has moved from a relatively obscure philosophical area of study to an important area of software engineering and knowledge management. Some sample definitions can be seen below:

> *Ontologies aim at capturing static domain knowledge in a generic way and provide a commonly agreed upon understanding of that domain, which may be reused and shared across applications and groups. (Pinto & Martins, 2001)*

> *An ontology can be thought of as a sharable representation of knowledge that: (1) provides a shared terminology that various applications can jointly understand and use; (2) defines the meaning of each term (a.k.a. semantics) in a precise and unambiguous*

> *manner; and (3) implements the semantics in a set of axioms that allows one to automatically deduce the answer to many "common sense" questions. (Gruninger, Schlenoff, Knutilla, & Ray, 1997)*
>
> *In our work, an ontology serves as a partial specification of the knowledge representation to be built in a later stage. The specification is partial because it supplies concepts in which states of affairs can be expressed but does not actually specify states of affairs. (van der Vet & Mars, 1998)*
>
> *An ontology is a representation vocabulary specialized in some domain or subject matter. … Ontologies are quintessentially content theories, because their main contribution is to identify specific classes of objects and relations that exist in some domain. (Falbo et al., 2002)*
>
> *In the simplest case, an ontology describes a hierarchy of concepts related by subsumption relationships; in more sophisticated cases, appropriate axioms are added to express other relationships between concepts and to constrain their intended interpretations. (Wang, Chan, & Hamilton, 2002)*

One of the most concise and most often cited definitions for ontology is: "An ontology is an explicit specification of a conceptualization" (Gruber, 1993b), or more specifically, a systematic account of Existence (Gruber, 1993a). A conceptualization is an abstracted, simplified view of the world containing the things, the concepts, and the other entities of interest along with the relationships that hold between them (Genesereth & Nilsson, 1987). An ontology can be thought of as a vocabulary (a set of words), a grammar (the set of rules for combining words into larger structures), and semantics (the meanings of the words and the larger structures) all defined within a specific domain.

An ontology begins with a particular view of a domain, for example: the interaction of subatomic particles (physics), how the human body moves (biomechanics), the definition and manipulation of data (various programming languages and databases), and areas of business such as strategy, finance, management, accounting, marketing, information systems, and so on. This view, typically a shared view among practitioners within the domain, contains the foundational theories and axioms of the things and "how the things work" within the domain. The ontological foundation allows the practitioners to reason about and understand their domain (Gruninger et al., 1997).

An ontology is a formalization of this domain-view foundation. The ontology identifies the objects of interest within the domain and assigns various symbols to represent them in a declarative formalism. This set of objects becomes the universe of discourse. For example, an ontology based in technical language that formally describes processes (a "data flow diagram") may include objects such as *external entities*, *processes*, *data stores*, and *data flows*. Further, there is a set of rules that defines when a process description is "correct," such as how data flows stand between processes, data stores, and external entities, and so on.

There are several design criteria for formal ontologies (Gruber, 1993a). An ontology must be clear and effectively communicate their intended meaning through objective, complete, and correct definitions. It must be coherent so that it supports inferences consistent with its definitions. It must be extendable so that it anticipates new uses of the shared vocabulary without changing the existing definitions. It must have minimal encoding bias so that the meanings in the world are preserved without making representation choices merely for the convenience of the representation. Finally, it must have a minimal ontological commitment, allowing the practitioners in the domain the freedom to specialize and instantiate the ontology as needed.

Ontologies are useful because they encourage the standardization of the terms used to represent knowledge about a domain (Jurisica, Mylopoulos, & Yu, 1999). It is very difficult to describe phenomena using a natural language even with a shared domain view. An ontology gives a formal, common language for representing, sharing, reasoning about, and making inferences from knowledge. This formalization of a domain of knowledge allows the formation of industry-wide standards (McGuinness, 2002). For example, NIST (the National Institute of Standards and Technology) is encouraging the development of controlled vocabularies and ontologies. RosettaNet (http://www.rosettanet.org) is a consortium of organizations in information technology, electronic technology, electronic components, and semiconductor manufacturing that is using ontologies to develop e-business standards and a language for business processes. Unfortunately, all of these ontologies are written in technical languages.

SOCIAL ONTOLOGY

A social, semantically consistent approach to strategic technology ontologies has the potential to capture a more complete description of the realities of using technology for strategic business purposes. Unfortunately, we (as a discipline) have failed to make this a standard method in describing strategic business needs to implementers. Project managers do not get to use their knowledge of social issues to influence technical architecture (Cockburn, 1996). Similarly, social and transactional knowledge of executives is not communicated to the project level managers, making the problem more dire. Technologists see architectures as “blueprints” for managing the construction and operation of the computing and telecommunications operations of the organization. However, architectures should also be representations of the social reality of the organization (Cockburn, 1996).

Habermas (1990) describes three separate “worlds”: the object world, the social world, and the subject world (Weigand, De Moor, & Heuvel, 2000). While the ontologies and patterns created by technologists do a good job of representing the object world (and a sometimes adequate job of describing the social world), the subject world is represented from their perspective of computer codes, technical objects, and technical transactions. A key to creating ontologies that lead to patterns that truly represent the social and subject world of the strategic business is to have the MIS community act as advocates for the non-MIS executive to insure that a semantically consistent ontology exists as a foundation for strategic patterns. Although some work has been done in this area with a focus on business communication semantics (Kimbrough & Moore, 1997; Winograd & Flores, 1986), the results are quasi-ontologies that are incomprehensible to non-technologists.

Semantically consistent patterns and ontologies have lifted the level of the design discourse (May & Taylor, 2003) and contributed to improved understanding and faster translation of knowledge and requirements between technologists. Since most large IT projects fail between the interpretation of the strategic business need and the technological implementation (Luftman & Brier, 1999; Luftman, 1996), the use of social ontologies and patterns at the strategic level will make a substantial contribution to standards led by the MIS community, plus may potentially save organizations millions of dollars in misunderstood requirements and technology capabilities.

PATTERNS

An organization encounters many problems in its day-to-day operations and in its strategic positioning against other organizations. These problems occur over and over in slightly different forms but with the same fundamental characteristics. A pattern is a "core of the solution" to these common problems (Alexander et al., 1977). Recognizing that a problem is one that has been seen before, and applying a semi-customized solution pattern to it, allows faster reaction times, and it "enables efficiency in both the communication and the implementation of software design, based on a common vocabulary and reference" (Adams, Koushik, Vasudeva, & Galambos, 2001, p. 11). However, the common vocabulary and reference may not be so common. The business side of the organization has the task of recognizing and communicating about the problem. However, the language of the solution pattern is often derived from technology rather than communicated in the language of business. In other words, from a technological ontology rather than a strategic ontology. We use patterns in this paper as an example of where a social, business semantic ontology would make the approach more successful.

For example, Schmidt and Buschmann (2003) provide an overview of patterns and describe three main types of patterns. Design patterns refine the elements and the communication structure of a software system. Architectural patterns express the overall structural organization of a software system by defining subsystems, subsystem responsibilities, and subsystem interrelationships. Pattern languages are a set of patterns that define a vocabulary for talking about software development.

Perhaps the most technical, earliest of the pattern works was written by Gamma, Helm, Johnson, and Vlissides (1995), well known as the "gang of four." This book describes design patterns, which describes solutions to problems in object oriented design. This is a very low-level, implementation oriented approach where software design problems are matched with object oriented solutions that describe the objects, relationships, responsibilities, and collaborations. The authors provide a catalog of twenty-three design patterns to help software developers create more efficient, easier to maintain object oriented code. Despite this very technical beginning, the concept of design patterns has been stretched from a technological solution set to be called upon at implementation time to a driver of organization strategy.

For example, organizations are trying to understand the external strategic and the internal tactical problems of e-commerce and e-business. In their book, Adams, Koushik, Vasudeva, and Galambos (AKV&G) (2001) discuss patterns for e-business. "These patterns help us understand and analyze complex business problems and break them down into smaller, more manageable functions that can then be implemented using lower-level design patterns" (Adams et al., 2001, p. 13). They "extend the domain of software patterns to earlier phases of the application development life cycle" by introducing four major types of patterns for e-business: Business, Integration, Application, and Runtime patterns.

Business patterns and Integration patterns are the highest level patterns, with Application and Runtime patterns representing successively more implementation-oriented solutions. Business patterns are closest to the strategic problems of the organization. They describe the high-level components of the solution as well as the interactions between these components. The components of the solution are: the solution users (customers, investors, etc.), the environment in which the users interact (company, organization, system, etc.), and the organizational data. AKV&G describe four examples of Business patterns: self service (user to business, collaboration (user to user), information aggregation (user to data), and extended enterprise (business to business).

Although the Business pattern is supposed to be closest to the organizational view of problems, it is described primarily in technical terms. The self-service Business pattern, for example, is described as typically consisting of three things: users, a network, and enterprise systems as shown below in Table 1. The other three sample Business patterns are described in similar technical terms.

Table 1. Self-service Business pattern.

Users	• In the enterprise, in partner organizations, or any other location. • Accessing the solution using a Web browser.
Network	• Based on TCP/IP and other Internet technologies. • Can be a dedicated LAN, broadband, or dial-up connection
Enterprise systems	• Custom systems • ERP systems such as SAP, BAAN, and PeopleSoft • Databases

Integration patterns are similar to Business patterns in that they are close to the organizational view of problems. They are also similar to business patterns as they are described in technical terms as shown below in Table 2. The other two types of pattern, application and runtime patterns, are very technical and represent the patterns used to implement the business and the integration patterns.

Table 2. Access integration pattern.

Users	• In the enterprise, in partner organizations, or any other location. • Accessing the solution using a Web browser.
Network	• Based on TCP/IP and other Internet technologies. • Can be a dedicated LAN, broadband, or dial-up connection
Business applications and data	• Custom developed systems (old and new) • ERP systems • Databases
Access integration services	• Device support • Presentation • Personalization • Security and administration

Table 2 makes a great deal of sense to a technologist, but does not give the non-IT business executive a conceptualization of what this pattern contributes to the business.

These patterns are useful for solving many problems that occur as organizations try to tackle e-business. They are indeed the “core of the solution” to these business problems. However, there is a disconnect between recognizing the problem and applying the pattern. An organization’s executives may recognize a strategic e-business problem but need to find and implement a strategic, rather than jump into a patterned technical, solution. This solution may eventually be realized as business, integration, application, and runtime patterns, but the patterns described by AKV&G are more useful for technicians who need to implement the solution than for executives who need to recognize and solve a problem at the strategic level.

AKV&G note that there is a business problem that needs to be matched to the pattern, which leads to a technical solution. They begin with the business problem (but disconnected from the business strategy) to define their patterns. Other authors note the business problem, but design their patterns around very technical concepts, missing the step of decomposing the business problem into business patterns and moving directly from business problem to technical pattern. For example, Fowler (2003) discusses enterprise applications and the patterns that can be used to support them. In his introduction, Fowler describes several business problems: a business-to-consumer online retailing, processing leasing agreements, and tracking expenses. Each of these problems has a different enterprise architecture solution. However, the patterns composing the architectures are highly technical. Patterns such as a *Remote Façade*, a *Data Transfer Object*, a *Transform View*, or a *Front Controller* are very useful for defining and implementing enterprise application software, but are little help in identifying and/or describing the overarching business problem. Again, there is a gap between the technical language of the pattern and the business language of the organization, making pattern technology of limited use to executive decision-makers.

Robertson and Sribar (R&S) (2002) note that there is a "clear misalignment" between the business organization and the IT organization. Executives work with consultants to determine the strategic direction for the organization, but this strategic direction reaches the infrastructure planners only through rumors and hearsay (Robertson & Sribar, 2002). However, R&S's patterns are also technical. They are derived from the application infrastructure consisting of transact patterns, publish patterns, and collaborate patterns. The disconnect between the language of the business and the technical language still exists.

There is no doubt that patterns have had a positive impact on the way that software solutions are found, are designed, and are implemented. Patterns have altered the way that developers speak and think about software design (May and Taylor, 2003). When properly applied, patterns aid the capture, transfer, and management of software design knowledge. These patterns begin and end with the technical side of software development. Unfortunately, little progress has been made in a top-down approach to pattern definition, beginning with strategic patterns, moving to business problem patterns, and then into software patterns, all with consistent business-oriented specifications and conceptualization and language. This is where MIS professionals need to step in and define standards through a strategic pattern ontology.

THE LESSON FROM ENTERPRISE RESOURCE PLANNING

The evolution of Enterprise Resource Planning (ERP) in organizations illustrates the need for business-based ontologies that are semantically consistent and can be understood by executives who hold the purse strings. Less than 30% of ERP installations are considered successful (Brown, 2001). This has been attributed to many causes, such as: CEOs who do not understand the strategic implications of ERP, consultants, users, lack of fit between requirements and product capabilities, and so on (Al-Mashari, 2001; Willcocks & Sykes, 2000). Nowhere in the literature has it been suggested that a lack of standardized language about these products caused this great deal of confusion and led to many poor investments. ERPs were sold as strategic enterprise solutions, even though at their core is a set of integrated, somewhat standardized business processes (Lee, Siau, & Hong, 2003). This approach to product development had virtually no strategic intent, and therefore ERPs, while sometimes solving process level problems, often create more strategic problems than they solve (Davenport, 2000; Ezingeard & Chandler-Wilde, 1999). Although advertised as flexible, recent articles have identified the need for far move flexibility in ERPs (Al-Mashari, 2001; Willcocks & Sykes, 2000).

The MIS academic community was "asleep at the wheel" with the advent of ERPs. This is clear since most of the extant literature on the subject reports on practice, rather than proactively prescribing solutions and standards for what has been one of the biggest IT investments in the last decade. We had a minimal role in ERP development or implementations, and we did nothing to help business managers avoid multi-million dollar mistakes. We did not translate the vendor or technical jargon to decision-makers in language they could understand and we did not identify the potential pitfalls of these monolithic systems. Had MIS academicians and professionals presented ERPs to senior management in an ontology based on business language, the results of these installations may have been much improved or the installations may not have been viewed as viable investments.

There is support from the MIS research community for the creation of standards for ERP and other technologies. Willcocks and Sykes (2000) suggest that MIS leadership devise strategy and structures to ensue that technology delivers value. We propose that standardized patterns based on business-based ontologies are a critical element of doing this. Interestingly, in the same article, Willcocks and Sykes argue for architectural planning but do not link it to strategy and structures. This represents the disconnect that is rampant in the MIS literature. Sprott (2000) suggests that ERPs need to be adaptable to the complexities of today's business, but again, fail to suggest deriving this adaptability from the strategic level. Without intervention and a mind shift on the part of MIS academics, we will continue to report on failures resulting from the disconnect between technology and strategy, and we will miss the opportunity to be the leaders in making technology truly ubiquitous by presenting it in business ontology form and making technology decisions as easily accessible to senior executives as other strategic decisions.

CONCLUSION

Technology project successes and failures have shown that greater structure, standards, and understanding at higher levels greatly improves the chances for a successful and useful implementation (Schmidt, 1996). Structured software development techniques organizes "spaghetti code" into more easily understood blocks. Object oriented software development techniques organize code and data. Software development patterns further organize object oriented code into "chunks" that match generally recognizable development problems. All this is good, but it begins with the very technical and stretches toward (but is still far from reaching) organizational strategic problems. This is starting from the wrong direction if technology is to lead to business value and competitive advantage. This disconnect between organizational strategy and technology is one of the causes for the enormous amounts of money wasted on failed technology projects (Luftman & Brier, 1999; Luftman, 1996).

We propose that MIS academics, professionals and non-IT executives begin the investigation of standardized strategically-oriented ontologies as the basis for strategic pattern development. Organizations such as the Society for Information Management (SIM) can play a key role in both developing and certifying these standards. These strategic patterns can, in turn, drive the development and fit of technology patterns so that a seamless path from organization strategy to implemented technology may be forged with business driving technology, rather than the reverse that often happened with ERP implementations. We have a responsibility not to repeat the costly mistakes of the ERP era.

This paper defines a problem and describes an approach rather than prescribing standards. This must be done as a community of academics and practitioners. It is a "call to action" for MIS academicians to begin leading practice, instead of merely reporting on its "state of the art." There is a true need for a greater chance of success and return of IT investments. A strategic ontology linked to technology implementation may be one solution that will lead to these greater returns.

We believe that an ontology based on strategic business language that describes strategic technical needs can lead to true strategic business patterns that can then be used as requirements that link to technical patterns. This approach builds on a promising new technology method – patterns. As MIS professionals, we have the unique opportunity to develop standards that help the people that fund technology investments understand more clearly what they are paying for. At the same time, we are enabling technologists to extend the pattern concept in a way that will lead to more successful IT projects and more satisfied users and executive stakeholders.

We are currently engaged in an empirical proof of concept study in a major insurance company. The CTO (an expert in patterns, and who is referenced in this paper), with the cooperation of the CIO, is giving us access to all levels of the organization from strategic planning through IT pattern implementation. This study will develop a strategic ontology that can then be tested and improved in future research.

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