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.

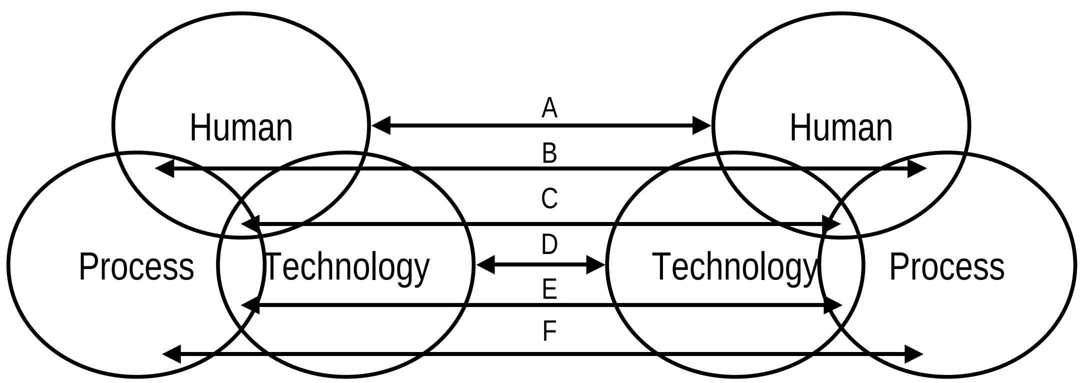

Figure 1. Identification of different kinds of communication between organizational systems

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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