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 $(K_1-c_{12}) < A < (c_{21}-K_2)$:

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

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

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

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

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.

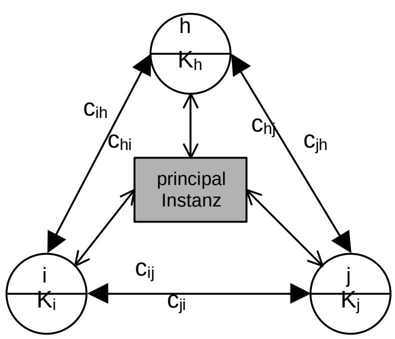

Figure 1: Network with three agents and a principal

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).

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

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.

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

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.

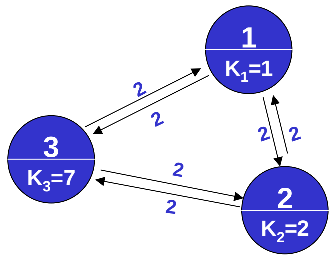

Figure 2: Example of discrepancy between maximum ROI and centralized solution (edges show c_{ij}, i.e. efficiency potential if both adjacent nodes standardize)

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	$\frac{88}{0.015 \times 11500} \approx 0.51$	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	1,185,96 7	**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.

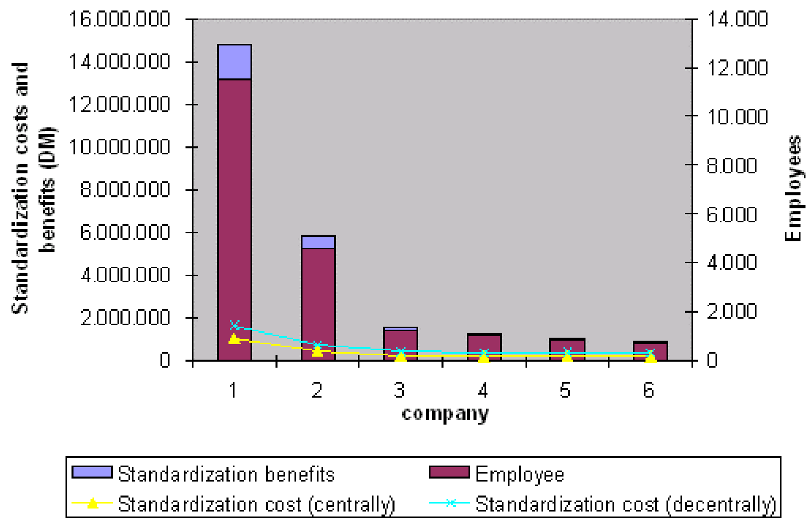

Figure 3: Costs and benefits of X.500 standard implementation

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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