9 HUNTING FOR THE TREASURE AT THE END OF THE RAINBOW: STANDARDIZING CORPORATE IT INFRASTRUCTURE

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Abstract

This paper tells the story of the definition and implementation of a corporate information infrastructure standard within Norsk Hydro. Standards are widely considered as the most basic features of information infrastructures—public as well as corporate. This view is expressed by a high level IT manager: The infrastructure shall be 100% standardized." Such standards are considered universal in the sense that there is just one standard for each area or function, and that separate standards should fit together: no redundancy and no inconsistency. Each standard is shared by every actor within its use domain, and it is equal to everybody. Our story illustrates that reality is different. The idea of the universal standard is an illusion just like the treasure at the end of the rainbow. Each time a standard, which is believed to be complete and coherent, is defined, the discovery during implementation is that there are elements lacking or incompletely specified while others have to be changed to make the standard work. This makes various implementations different and incompatible—just like arbitrary non-standard solutions. This fact is due to essential aspects of standardization and infrastructure building. The universal aspects disappear during implementation, just as the rainbow moves away from us as we try to catch it.

Keywords: Information infrastructures, standards, universals.

The original version of this chapter was revised: The copyright line was incorrect. This has been corrected. The Erratum to this chapter is available at DOI: 10.1007/978-0-387-35566-5_20

O. Ngwenyama et al. (eds.), *New Information Technologies in Organizational Processes*

1. Introduction

Standards have usually been an issue related to phenomena being shared by large communities such as nations or even the whole world. Such standards are set by international committees and relate to issues ranging from measurement (the metric system) to telecommunications. As the number of information systems and the computing equipment grow inside organizations, the need to integrate them becomes crucial. Based on this fact, notions such as corporate IT infrastructures have gained attention (see, for instance, Weill and Broadbent 1998), and the definition and implementation of "corporate standards" have come into focus. As a company or corporation is different from a nation or the whole world, corporate standards might be seen as very different from "traditional" standards. We will show in this paper that they are not. Large organizations, through their globalization processes, are becoming too large and diversified for tight centralized control. At the same time, they are becoming increasingly embedded into different local environments because close customer contact is crucial for survival.

Corporate standards are almost non-existent as a research issue. Weill and Broadbent, for instance, simply declare that corporate infrastructures should be implemented by "defining and enforcing corporate standards." They do so without any discussion, which makes one assume that they think that it is self-evident that implementing standards is an important objective and that doing so is trivial. That is a serious misunderstanding.

With the emergence of various plans for making "National Information Infrastructures" it is widely accepted that standards are of crucial importance at the same time as existing strategies for their development and implementation are considered obsolete (Kahin and Abbate 1995). However, research to date seems not to have brought any pathbreaking results so far. No new approaches have been developed—beyond a consensus about learning from the Internet experience.

Standards are traditionally considered as purely technical and universal in the sense that there is *one* definition satisfying the needs for all users. This definition is assumed to be complete, ensuring that all correct local implementations will work in the same way. How to implement and use a standard is assumed given by the standard itself. This view is shared by engineers as well as managers, those involved in the definition of standards as well as their implementation. When implementing specific standards, it is commonly experienced that the assumptions do not hold. The problem, however, is then considered to be the specific standards themselves; they are incomplete and should be extended. For instance, when implementing standardized EDI solutions[1] between two (or more) organizations, the implementations of the standards are often found to be in conflict. This is seen as being caused by the incompleteness of the standards. One response to this has been the Open EDI standardization effort (Open EDI 1997). This effort is based on the assumption that the problems experienced will be solved by making the standards complete. "Completeness" will be achieved by standardizing not only the structure of the messages to be exchanged, but also their semantics and the

[1]EDI (Electronic Data Interchange) denotes the exchange of information between computers which traditionally are exchanged on various forms such as orders, invoices, customs declaration forms, etc.

organizational processes the messages will support. A similar approach is also chosen by the Open Distributed Processing standardization (ISO/IEC 1995).

2. Standards and Universals

This paper draws on research on issues related to standardization within the field of Science and Technology Studies (STS), trying to illustrate the fruitfulness of their findings for corporate as well as national or global information infrastructure standardization. The view on standards common among "standards designers," which we presented above, is not acknowledged in the STS field.

Communication protocols standards have not been much in focus within STS. On the other hand, standards, in a wide sense, are indeed *the* issue addressed in STS; in particular, standards in the form of universal scientific facts and theories and widely used technologies. These studies also, we believe, have something to tell us about information infrastructure standards.

Universality, actor network theorists have argued, is not a transcendent, a priori quality of a body of knowledge or a set of procedures. Rather, it is an acquired quality; it is the effect produced through binding heterogeneous elements together into a tightly coupled, widely extended network.

Perhaps the most basic finding within STS is the *local* and situated nature of all knowledge, including scientific knowledge. Latour and Woolgar (1986) describe how scientific results are obtained within specific local contexts and how the context is deleted as the results are constructed as universal. Universals in general (theories, facts, technologies) are constructed in this way: they become taken as given when the context disappears into a larger space of taken for granted assumptions. This construction process has its opposite in a deconstruction process when universals are found not to be true. In such cases, the universal is deconstructed by re-introducing its context to explain why it is not valid in the context at hand (Latour and Woolgar 1986).

In spite of the fact that the context of origin and the interests of its originators are "deleted" when universals are created, these elements are still embedded in the universals. They are shaped by their history and do not just objectively reflect some reality (scientific facts, theories) or exist as neutral tools (universal technologies). They embed social and political elements.

In the same way as other universals, infrastructure standards are in fact "local" (Bowker and Star 1994; Timmermans and Berg 1997). They are not pure technical artifacts, but complex heterogeneous actor-networks (Hanseth and Monteiro 1997; Star and Ruhleder 1996). When a classification and coding system such as the ICD (International Classification for Diseases) is used, it is embedded into local practices. The meaning of the codes "in use" depends on those practices (Bowker and Star 1994). The ICD classification system, developed and maintained by the WHO in order to enable a uniform registration of causes of death globally (to enable the generation of statistics for research and health care management), reflects its origin in the Western modern world. "Values, opinions, and rhetoric are frozen into codes" (Bowker and Star 1994, p. 187).

Berg and Timmermans argue that studies in the STS field tend to reject the whole notion of universals (Berg and Timmermans forthcoming; Timmermans and Berg 1997).

They disagree, saying that universals exist, but they are always embedded into local networks and infrastructures. They exist as *local universals*. They argue further that there are always multiplicities of universalities. Some of these will be in conflict. Each universal defines primarily an order it is meant to establish. Implicitly it defines at the same time a *dis*-order that does not match the standard. When a multiplicity of standards are involved in an area—which is always the case—one standard's order will be another's dis-order. Further, Berg and Timmermans show how a standard even contains, builds upon, and presupposes dis-order.

In parallel with showing how universals are constructed, STS studies have addressed more extensively how they are used, i.e., how they are made to work when applied in spite of the seemingly paradoxical fact that all knowledge is local. This is explained by describing how the construction of universals, the process of universalization, also has its opposite, the process of localization. The meaning of universals in specific situations, and within a specific field, is not given. It is, rather, something that has to be worked out, a problem to be solved in each situation and context. Working out the relations between the universal and the local setting is a matter of a challenging design issue. As a universal is used repeatedly within a field (a community of practice), a shared practice is established, within which the meaning and use of the universal is taken as given.

Just as the development of a universal is not a neutral activity, there are social and political issues involved in the use of universals. As their use is not given, "designing" (or "constructing") the use of universals is a social activity like any others taking place within a local context where social and political issues are involved.

We bring these theories to bear on the definition, implementation and use of corporate infrastructure standards. We will do this by first showing how the need for a universal solution—a standard—was constructed, how the decision to define and implement a corporate standard called Hydro Bridge subsequently was made, and the definition of its content. However, the main part of the article concentrates on the implementation of the standard. The most characteristic aspect of this implementation process is the repeated discovery of the incompleteness of the standard in spite of all efforts to extend it to solve this specific incompleteness problem. The process is a continuous enrolment of new actors and technological solutions to stabilize the network constituting the standard. This stabilization process never terminates due to the open nature of infrastructures, and because the standard creates disorder within exactly the domain for which it is designed and in which it is implemented in order to bring the domain into order.

The Bridge Standard in Norsk Hydro has been a success in the sense that it is widely diffused and several of its components are useful for large user groups. But it is a failure in the sense that there are still many users using products not complying to the standard and using the standard is highly problematic for larger user groups. The partial success is achieved because Hydro has been quite clever in doing all the required "real-time work" to "make the standard work." This work involves extensive efforts at adapting the standard to local environments, including developing and implementing quite a few gateways and converters and various ad hoc solutions, and accepting to live with inconsistencies and incompatibilities and managing them in a rather ad hoc fashion.

Implementing information systems has—just like standards—turned out to be nothing but a straightforward process. The problems encountered when implementing standards, seen as universals, are not just the same old problems repeated. The problems are new and different. To express it somewhat like a slogan, information systems gets implemented although they require continuous maintenance and other forms of "repair" work to keep it working, alive, on track, etc. A universal never gets implemented as such. The universal character disappears during implementation.

3. Norsk Hydro

Norsk Hydro was established in 1905. Fertilizer was the only business area until the 1950s, when Hydro started its expansion: moving into light metals and, later, oil and gas. These are the core business areas.

During the period 1972 to 1986, Hydro grew rapidly; its income raised from 1 billion to 60 billion NOK. The growth took place through acquisitions in agriculture (fertilizer) and light metals, and by building up brand new activities within oil and gas. Hydro's traditional style of management was to run the factories "hands off." This changed in 1985 when the decision was made to stop growing and concentrate on consolidating existing business.

Although a corporate IT department, called Hydro Data, existed, running the factories "hands off" implied independent IT strategies and solutions. Top corporate management acknowledged the view that IT was an important issue. Divisions had to work out IT/IS strategies, and they had to evaluate their own IT solutions' value for the company.

A central institution, called IS-Forum, was established and assumed responsibility for working out common strategies and policies concerning IT. A "Corporate Steering Group for IT" was set up as the legitimate unit for making decisions at the corporate level. Members of IS-Forum were primarily top IT managers in the divisions while the Steering Group was composed of high level managers in the divisions. The head of the Steering Group was one of the corporate vice presidents.

In 1990, a "consensus process" around common IT architecture started. Consensus was arrived at in 1991-92 about the importance of standards in general, the establishment of a shared TCP/IP based network, and the need for corporate standards concerning office automation/desktop applications. The corporate standard, defined a bit later, was named Hydro Bridge. Hydro Bridge is the standard on which we focus. During the 1990s the globalization process has gained momentum, and so has the focus on collaboration across all divisions and the development and use of a shared infrastructure.

4. The Hydro Bridge Standard: Constructing the Universal

We will now turn to the Hydro Bridge standard: its conception, definition, implementation and use. Bridge is seen within Hydro as the standard defining the infrastructure shared by the whole corporation.

The first PCs arrived at Hydro in 1983. PCs were introduced based on local initiatives. The oil community, being "allergic against mainframes" because they had to "turn around fast," was the first adopter. New PC technology was acquired as it appeared in the market: file servers and PC LANs, network operating systems, etc. The first Novell server was bought in 1987. The variety of products, applications, and configurations exploded, and the need for standardization was acknowledged. Standards for document templates, partition of disks, backup facilities and routines were defined and enforced. The pendulum moved back and forth between standardization and diversification for each new major "generation" of PC technology. The definition of the Bridge standard can be seen as a step in this process. It was now due time for standardizing PC desktop applications.

In 1992, poor integration among the IT mangers in IS-Forum was becoming widely acknowledged as a major obstacle for smooth operation of the company. There was a lack of integration and communication across divisions and between the divisions and the corporate headquarter, costs were too high, resource use was sub-optimal, etc. The most obvious answer to this problem was, for those concerned, standardization.

IS-Forum agreed with developing one corporate standard for desktop applications. As they knew others had a different view, the Hydro Bridge project was set up in November 1992 to look a bit deeper into the issue: analyzing costs and benefits, important obstacles, possible solutions, etc. The project was staffed by IT personnel. The leader was the IT manager in the oil refining and distribution division. The project soon proposed to the Corporate Steering Group was that a corporate standard should be defined and implemented.

Having decided that a standard should be settled, the next step was to define its content. It seemed obvious for all involved that this was a choice between Microsoft and Lotus products. Most saw Microsoft products as the clear winner. The Bridge project, however, decided, mainly due to costs, to go for the Lotus SmartSuite applications. The project members knew that this decision would be difficult to sell. To make that easier, they translated the issue about which producers' software to buy into a strategic one. To succeed in that effort, they allied with Lotus Notes: Lotus was chosen because Notes was a strategic tool!

Having decided on the content of the standard, there were still more issues to take care of. Among these were the scope, the reach and range, in Keen's (1991) terms, of the standard. Who should use it and in which functions or use areas? Initially, those advocating the Bridge standard meant that there should be no other systems used by anybody inside Hydro for functions which Lotus SmartSuite products covered. However, to obtain required acceptance for the decision, the Bridge project group had to agree to using Microsoft products in some areas. These included areas where large software applications were developed in Excel; for instance, applications for interpretation of data from lab equipment and for currency transformations in some budgeting support systems. Word was also accepted as the preferred word processor in several joint projects with other oil companies where the others required Word (or other Microsoft products) to be used as a shared platform.

Bridge as a corporate standard was formally approved by the Steering Group for Information Systems on April 29, 1994. But even in the very first version of the Bridge standard as defined at this moment, the ideal of having just one corporate standard was in fact already abandoned.

5. Product Development: Opening Pandora's Box

The step following the formal approval of the (first version of the) standard was its implementation into a "product." As the standard specified only a set of commercial products to be used, this might seem unnecessary. That was far from being the case. Products such as those involved here may be installed and configured in many different ways. To obtain the benefits in terms of less costly installation, maintenance and support of these products, they had to be installed coherently on all computers. Such a coherent installation is also crucial for establishing a transparent infrastructure where information may be exchanged smoothly between all users. Reaching these objectives, a considerable development task had to be carried out. The task included primarily bundling work in the form of developing scripts installing the applications in the same way "automatically." Developing these scripts was quite a challenge. Many unforeseen problems popped up, but the implementation of the first Bridge version of the desktop applications package was declared finished by January 1, 1995. When the product was launched, it was, however, far from being free of errors.

Until the product implementation project started, Bridge had been seen (or at least treated) as a self-contained package. During the product development, it was "discovered" that this was definitely not the case. To work as a shared infrastructure, this infrastructure itself required an extensive underlying and supporting infrastructure. However, the infrastructure underlying Bridge was far from standardized within the company. The major problems during the product development project were seen as caused by the lack of standardization of the underlying infrastructure. The implementation project tried solving the problems by standardizing each layer as they were uncovered.

The first and immediately underlying layer "discovered" was the operating system. Virtually all PCs were running DOS or Windows, so agreeing on Windows as the OS standard was not controversial.

A large number of PCs were running in local area networks running LAN software and possibly a networking operating system. This "layer" also had to be standardized for several reasons: most Bridge applications would be installed on a file server and not on each individual PC, the applications (users) were storing their files on such servers and using other shared resources such as printers, etc. On this level, a standard based on Novell's LAN products was specified. This included a design of a specific LAN topology to be implemented everywhere.

Dealing with the PC hardware layer was certainly the most demanding implementation challenge. PCs were discovered to differ significantly with respect to external device adapters (LAN, screen, keyboard, mouse, etc.) and their drivers, BIOS, memory, etc. This was so in spite of the fact that they were all "IBM standard" PCs. Later on, when laptops were included in the platform to be supported, PCMCIA cards created severe problems. Standardizing this layer would imply changing most of Hydro's PCs. This was obviously an impossible short term solution because of its costs. But it was considered a necessary long term solution—i.e., to be phased in over time.

The efforts aiming at strict standardization of PCs have been given up. It is simply beyond reach. The specification of the latest version of Bridge says that it will support any "standard" PC from any "major" manufacturers selling PCs "globally."

In parallel with the implementation of the Bridge infrastructure, communication generally has become more important. This implied that the global IP based network being built, Hydro InterLAN, also be included in Bridge. The underlying layers are indeed heterogeneous: two MBits leased lines, telephone services, broadband networks (ATM), radio and satellite communication (to oil platforms, for instance), etc. However, this heterogeneity has not caused any trouble since TCP/IP runs smoothly on top of all of them.

All major difficulties during product development were related to the desktop applications, not Notes. The desktop applications were brought into focus basically due to the fact that there was already an infrastructure—although a fragmented one—in place. The implementation of the Bridge standard implied that the existing infrastructure should be turned into a new one. In this process, several users (divisions) had to stop using their existing applications and switch to others. Concerning Notes, however, the infrastructure was designed from scratch. There was no infrastructure to be replaced: no *installed base* to fight (Arthur 1987; Hanseth forthcoming). Replacing one infrastructure with another is the most challenging issue, technologically as well as politically. Technologically because the transition will take some time, and during this period both the old and the new have to work and maybe even interoperate. Politically, simply because most users prefer the products and applications they are experienced in using.

The lack of standardization of an infrastructure's underlying layers will often be visible to those using and maintaining the infrastructure. This may imply that the infrastructure does not appear as unified and coherent, but rather as several separate and different ones. The Hydro Bridge standard was initially defined to save the expenditures on maintenance and support work. These expenditures were certainly lowered, but not as much as planned because several different Bridge implementations had to be maintained and supported on different platforms.

6. Diffusion, Adoption and Use: Meeting the Local

The common view seeing standards as universals means that the standard is just one thing equal for all. That is not how Bridge appeared as the adoption process unfolded. It was seen very differently by the different units due to differences concerning existing computing environment, available resources in terms of money and competence, cultures concerning management styles as well as use of technology, felt need for improved infrastructure, etc. The adoption speed and style also depended on the distance from the main office of Hydro Data. For those already using Lotus products, adopting Bridge meant doing almost nothing. Others had to change considerably. Bridge soon came to encompass several different systems. This implies that some implemented the whole package, others just a few components. In the latter group, you would find smaller offices in Africa, for instance, typically having just a few standalone PCs.

Strategies adopted for implementing Notes on the one hand and the rest of Bridge on the other have been very different. The desktop applications have been intensively pushed from the top. Notes, however, was initially not pushed at all. Later on, it was pushed as an e-mail system. Differences in strategies among the different units have implied that the Bridge is not implemented as one coherent universal package, but rather as many different ones which need to be integrated and linked together to make the overall infrastructure work.

The desktop part of Bridge diffused pretty fast. In April 1998, there were about 18,000 users, which means that it has diffused throughout most of the Hydro corporation. However, the diffusion speed and patterns have varied a lot among the divisions.

The Oil & Gas division is always the first to adopt any new technology, as it was with Bridge. However, Oil & Gas was a heavy user of Microsoft products, so the adoption of Lotus SmartSuite products has been somewhat mixed. The Lotus package is installed and used to some extent. Microsoft products were, however, still used heavily. This is partly due to local resistance among experienced Microsoft users, but, more importantly, the close collaboration with other oil companies using Microsoft products. The general rule established within this collaboration is that the company being the operator of an oil field to be developed determines what tools to use. That means that Lotus products are used in the projects where Hydro is the operator. In cases where a company using Microsoft products is the operator, Hydro has to use these products as well.

Within the oil sector, it has always been important to be advanced in using new technology to stay competitive. The actors in this sector have significant resources and most employees are highly educated engineers, always focused on finding better tools.

The large fertilizer divisions also adopted Bridge rather fast. The adoption was fairly smooth and easy as they already used Lotus applications, except the word processor. For them, adoption of Bridge basically meant switching from WordPerfect to AmiPro. They also used Novell's LAN technology already. Their existing network topology, however, was different from what Bridge specified. So, they had to restructure their network. This implied hard work for the technical personnel.

Other divisions were more reluctant because they had an installed base of solutions significantly different from what Bridge specified. In particular, adoption of Novell was challenging and expensive for those having large Banyan Vines installations. The transition to the Novell-based Bridge standard took time, and happened stepwise. Throughout this process, many different network structures were in operation. This required local customizations of other parts of the Bridge standard to make them run on top of the local networks.

The light metal (aluminum and magnesium) divisions have been slow in adopting Bridge. The aluminum divisions were fusioned into the company latest, having their own systems, which differed considerably from those found in most other divisions. In addition, they have a culture stressing local independence. For these reasons, they were negative toward Bridge and resistant to adoption. The magnesium division has also been slow in adopting Bridge. For them, the basic problem has been the costs. They are continually struggling with low income and have had problems finding space for Bridge investments in their budgets. This is in strong contrast to the Oil & Gas division.

There is also variation in diffusion speed within divisions. All new products and versions are first installed in Hydro Data, being the permanent pilot site. The next units are those physically located at Vækerø in Oslo, which is the largest Hydro Data site and the largest office in Norway housing major parts of the Oil & Gas and Technology & Projects divisions.

To make this heterogeneous infrastructure work, filters and converters for word processing formats still had to be used. In addition, different viewers are included in Bridge to let users easily get access to documents produced by tools they are not using themselves.

One of the desktop applications was more difficult to implement coherently in the organization than any other: e-mail. Companies always communicate with externals. With the diffusion of the Internet, supporting such communication by computers has gained much attention. Hydro has also adopted the Internet and integrated it with Bridge (discussed in a later section). However, they are already using several other computer networks for various purposes. They are developing a considerable network together with other oil producers and engineering companies working within the oil sector in Norway. They are using an X.400[2] based network as carrier for EDIFACT messages.

In finance and trading activities, they have been using Telex for a long period and they are, for instance, using a proprietary system delivered by Digital for communication with the aluminum exchange in London. They have even purchased a new computer-based Telex system, running on a PC under the CP/M operating system! These various e-mail and messaging systems are partly used separately, implying that quite a few users are using several of these systems. Others are integrated and interconnected through gateways. The new Telex system, for instance, is integrated into the overall message handling infrastructure. Telex messages can be sent and received as Notes e-mails through an X.400 system.

Hydro's policy, saying that they should use only Notes (and cc:mail up to now) for message based communication implies that these systems should be replaced. That has not happened, and there is no indication that it will, either. The use of most of these systems has deeply penetrated the work practices within which they are used, as most infrastructures do (Joerges 1988). And because Hydro is only one of many organizations included into these practices and networks, it is far beyond Hydro's power to replace Telex technology by other systems.

7. Applications Integration: Including the Environment

7.1 The Problem

We illustrated in section 5 how a smooth implementation of a standardized infrastructure on one level recursively requires a standardized infrastructure on the level below. A similar problem is found along the border between an infrastructure and its environment. When using the term context we are here referring only to *applications* which are not a part of the Bridge standard but related, in one form or another, to the applications included in Bridge. An application becomes a part of Bridge's environment when it is used within the same or related tasks.

There is an important difference concerning the relations between the Bridge standard/ infrastructure and its underlying infrastructure on the one hand and Bridge and other applications in its environment on the other. Bridge *requires* an underlying infrastructure, otherwise it will not work. Which applications populate its environment, however, is accidental. These are applications that the Bridge users decide to use in a

[2] X.400 is the ISO and ITU standard for e-mail.

way making them related or linked to each other. How these links are addressed and managed are accordingly different.

The applications that are included in another's environment can to some extent be specified at the same time as one is deciding to adopt an application. But the collection of applications used varies over time and so does how each application is used. Further, the way a user really uses her tools is to a large extent tacit. This means that an application's environment will be disclosed as the users go along using it.

Dealing with borders is also closely related to learning. As an infrastructure is used, one discovers new ways of using it, it drifts and "meets" other infrastructures. And this happened with the Bridge applications. One strategy for dealing with evolving use and drift is to include an application in the environment into the standard. We have mentioned above the inclusion of Microsoft applications and various "viewers." As the Internet was growing in popularity, its relationships to the Bridge applications became closer, leading to the situation where it was included in Bridge. Among others, a package of administrative applications (for smaller offices), called SUN, was included.

Some applications are linked together in a way making them interdependent. This leads to a need for standardizing the interfaces between them and how to use of them. Other applications are included because of relationships on a more abstract level. For instance, applications already included and some outside may be seen as "really of the same kind." So if one is included, then the others should be included as well.

The strategy followed in the examples above—i.e., when a relationship between one application inside the standard and one outside is discovered, the latter is included—might in some cases be the best one. But it does not work as a general strategy. Each component in a standard has its environment, and different components have different environments. Do the environments of different components need to be aligned? This means that environments are indefinite. Trying to solve this problem by extending the standard to cover what is linked to it will lead to indefinite regress. This means that one cannot solve this "border" problem. Further, borders cannot be drawn once and for all. They continuously have to be renegotiated and maintained through more or less ad hoc links and various forms of gateways.

We will illustrate in more detail the relationships between the inside and the outside and how changes on one side interfere with and affect what is on the other by looking at the integration and links between the Bridge infrastructure and SAP[3] implementations in Hydro.

7.1 SAP

The Bridge infrastructure has been built in parallel with a considerable SAP infrastructure.[4] These infrastructures were initially considered completely separate, but they have become increasingly intertwined as they have grown. The first SAP applications were

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[3]AP is the leading product within the market for so-called Enterprise Resource Packages (ERP), which integrates applications for accounting, logistics, production control, etc.

[4]For a presentation and analysis of this SAP infrastructure, see Hanseth and Braa (1998).

installed in the agriculture division in France in 1990, and SAP was settled as the corporate standard in 1994. At that time, SAP implementation projects were going on in parallel projects in several divisions. As Bridge and SAP have been implemented in Hydro, they have also been closely tied together as illustrated by Figure 1. However, Hydro has never considered including SAP in Bridge. SAP is outside the scope of Bridge and it is a too big and complex an issue to be seen as just a part of Bridge. The relationships between SAP and Bridge have to be managed without being part of the same standard.

During the SAP implementation process, a wide range of links between SAP and Bridge were uncovered. Some of these were in fact "known" in advance and taken care of in the design process. This covers the part of Bridge that implemented infrastructural services required by SAP such as PCs, operating system, data communication network, etc. Other links emerged during the process. This includes services such as maintenance and support. Some important links still seem to be invisible to those involved. And the links do not always cause trouble. In some instances, SAP and Bridge are mutually dependent and are mutually enhancing each others' development and use.

Some divisions, for instance, discovered that the SAP applications have rather complex user interfaces. For infrequent users, this constitutes a big problem. Some divisions have tried to solve this problem by developing Notes interfaces to their SAP applications as well as others. This turned out to be quite a challenge, not the least because of SAP's policy in relation to allowing their customers to integrate SAP and other applications.

For some needs, data from SAP applications are extracted and made available through the Web-based intranet. Data are exchanged between SAP applications and others, in particular spreadsheet (1-2-3) and other Bridge applications. In some cases, data are transferred manually by means of cut and paste operations. In others, scripts and programs are developed to transfer data more or less automatically.

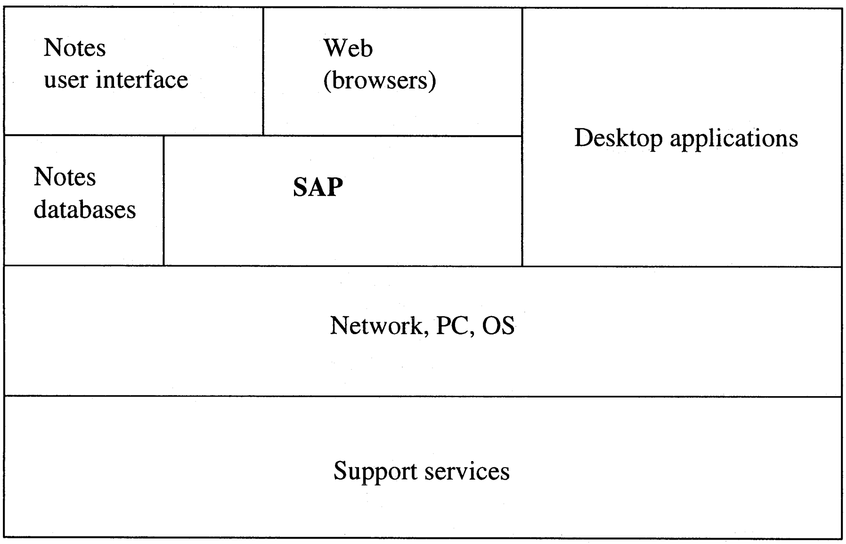

Figure 1. SAP's Embeddedness in the Bridge Infrastructure

When the Bridge standard was extended to included PCs, operating systems, and network protocols, this part of the standard was defined with a focus on the requirements of the Bridge applications. However, it was obvious that this part of Bridge also had to support other applications used by Bridge users, and accordingly it defined the infrastructure underlying SAP as well. Further, in some cases, SAP and Bridge had to rely on shared underlying services, for instance, user support. We will now look at a case from the European fertilizer division (called HAE) where SAP and Bridge required different kinds of services (as seen by those responsible for them).

The European fertilizer division has, since 1995, been developing a considerable SAP implementation to support a new organizational structure integrating all units in Europe. The SAP solution runs on top of the Hydro Bridge infrastructure as the SAP applications require, of course, PCs, operating systems, communication networks, etc. This part of Bridge turned out to fit SAP very well.

The implementation of Bridge in HAE turned out to be strongly influenced by SAP. Shortly after the decision to go for SAP, the IT manager concluded that Hydro itself did not have the resources and competence to take responsibility for the required data processing and operations services. HAE then decided to outsource these functions to a major global company offering such services.

The SAP transaction processing would run on computers physically located at a large processing center in the United Kingdom. When the decision about outsourcing SAP processing was taken, the IT management in the division thought that it would be an advantage if the same service provider also delivered the required network services connecting the client software on local PCs to the servers, so they decided to outsource that as well. Moreover, they also believed it would be beneficial to have just one provider responsible for the whole chain from the servers running the SAP databases through the network to the hardware equipment and software applications used locally. Accordingly, a contract was signed covering three areas, called processing, network, and (local) site management respectively. At this time, Bridge had been extended to include Hydro's global network. This contract meant than that the design and operation of the Bridge network was handed over to the service provider, as was the responsibility for installation and support of all elements of Bridge locally (PCs, operating system, desktop applications, the Notes infrastructure and applications, Internet software and access, etc.).

So far the outsourcing has been a mixed blessing. The network and processing services are fine, but site management (i.e., local support) has been problematic. The major problems seem to be related to the fact that the actual global service provider has organized its business in independent national subsidiaries, and is not able to carry out the required coordination across national borders. In addition, some problems are related to the fact that the site management contract specifies that users should call the help desk in the United Kingdom when they need support. The threshold for doing this is quite high for large user groups not speaking English, although the help desk should have people speaking all major European languages. When getting in contact with the help desk, problem solving is experienced to be much more difficult than when getting assistance from local support personnel. In this way, SAP has made the support of Bridge far more complex than desired. The site management contract was cancelled toward the end of 1998.

To make the SAP project succeed, people from all sites had to be involved to provide the project with the required knowledge about how tasks were performed and business was conducted at different sites. For a project of this size and distributed nature, smooth communication is mandatory. Notes applications have been used as the e-mail system, project document archives, and discussion databases. As such, Notes has been a crucial infrastructure, making possible the required cooperation between those involved all over Europe.

Notes has been widely used by virtually all SAP projects in Hydro, and SAP projects have in many divisions been the first users of Notes. In that way, SAP has been an important agent for making Notes diffuse. The initiatives for using Notes have been taken by IT personnel familiar with the technology and optimistic about its potential contributions to Hydro's overall productivity and efficiency. As all SAP projects are large and involve numbers of different user groups, knowledge about and practical experience with the technology become widely spread. SAP projects seem to be the most intensive users of Notes, and accordingly SAP one of the most important actors in making Notes diffuse in Hydro.

7.3 Notes and the Internet

There is often an overlap in functionality between components of an infrastructure and components in the environment. This raises the issue about which components should be used when and for which purpose. The relations between the Internet/Web and Notes are very much of this kind. Where to draw the border between the areas where each of them should be used is hard to specify. In almost any case, when the development of a Notes application is considered, one could just as well use Internet/Web technology. This means that where the border should be drawn has to be defined in every single case. Over time, an organization changes and technology evolves, implying that the border can drift (Ciorra 1996) significantly.

To avoid making the definition of the border a time consuming effort full of conflicts, a smooth interface is required. Inside Hydro, Internet technology is used for developing an "intranet." The Web technology overlaps a lot with Notes, so the Web-based intranet and the Notes infrastructure are integrated. In many cases, it has been considered a fairly open question whether to use Notes or Web technology. A Web interface to all Notes databases (through Domino) has been provided. The divisions developing Notes interfaces to their applications do the same for the Web.

As the integration between Notes applications and Internet (technology) was growing rapidly, Internet technology has also been put into the Bridge standard.

The close links between solutions based on Internet technology and Notes applications also include positive interference by causing a spill-over (Steinmueller 1995) in the sense that solutions available in the Internet world are also developed for Notes. For example, Hydro has also developed a search engine similar to those found on the Internet for searching across all Notes databases.

7.4 The Order's Dis-order

Standards and infrastructures interfere with each other. Sometimes a simple interface can easily be specified while the infrastructures stay rather independent. In other cases, they interfere in a way actively supporting each other so that each makes the other more useful. However, in some cases, they cause trouble for each other in a way that requires careful attention. The site management problems prove that what seemed to be a wise decision from a SAP point of view was at the same time a bad decision from the Bridge perspective. Standards are settled in order to create order. A smooth interaction between standards requires a global order. But such a global order is beyond reach in our complex world. We define local standards creating local order. Each local order interacts with others. And as long as there is no global order, one local order, however, well it is designed - will create disorder in its environment. SAP's order was Bridge's dis-order.

8. Maintenance, Support and User Training: Designing the Non-technological Elements of the Infrastructure

The Bridge infrastructure requires more supporting layers than operating systems, network services, etc. It also requires non-technical services: user training, maintenance and support (see Figure 2). Such services are equally as important as the technical layers such as operating systems and networks. The non-technical supporting infrastructure required by Bridge has been hard to establish. In fact, these are the required underlying infrastructures that Hydro has managed less successfully to implement. We will here mentioned three reasons for this.

First, these infrastructures are beyond the control of the Bridge team. This is illustrated by the SAP project presented above. For most divisions, the support services required by Bridge are seen as just a part of the overall IT support services within a division. How these services are set up, for instance, whether they are provided by an internal IT department, bought from Hydro Data, or outsourced to another organization, is—as in the SAP case—mainly based on what is believed to serve the "mission critical" applications best.

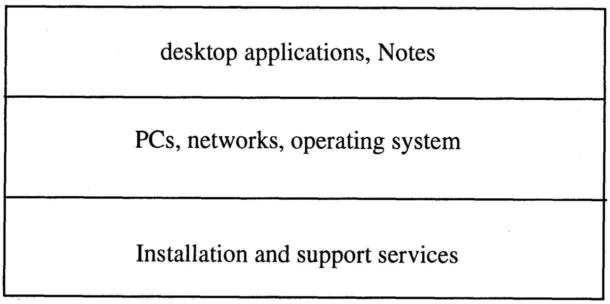

Figure 2. Applications and Required Underlying Services

Second, the problem is partly due to the fact that most of those involved in the design of the Bridge standard are technicians being blind to non-technical elements in the infrastructure. The problems related to lack of user support and training have only been addressed as far as they can see technological components as proper solutions. Advanced tools for IT infrastructure management, systems for "automatic" downlowding of applications, a CD-ROM based training program, etc., have been developed and included in the Bridge package. However, very little seems to have been done to identify the needs for support and training, and how services satisfying these needs could be established.

The blindness to the non-technological elements is related to the third issue we will mention. There is huge local variation in the kinds of services needed as well as the bases upon which they can rely. The needs depend upon factors such as what kind of work is done, what kind of applications are used, which parts of Bridge are used, the general competence of the users, and, not the least, their knowledge about IT. How to establish support and training services depend, among other things, on what kind of resources—human and technical—are available. The kind of support services Hydro can offer its users in, say Africa, is rather different from what is easily available to those having an office in the same building as most Hydro Data people.

Hydro Data serves as the permanent site for pilot testing. As an IT department, the staff is very knowledgeable about how to use the Bridge tools. Further, the computing equipment and competence of the support staff are the best in Hydro. This is certainly far beyond what is found at smaller offices at remote locations. The competence level and services provided are taken for granted. The technicians do not see the role the support personnel are playing and how Vækerø differs form other sites in this respect. This fact is reflected in a statement expressed by users working in Hydro: "Bridge is the world as seen from Vækerø."

The technical and non-technical components of the supporting services are interdependent. Which non-technical (human, organizational) services are required depends on the design of the technical services. For instance, the need for user training will decrease if a carefully designed, computer-based user training package is provided. Further, the need for support also depends on how the technology is designed. Hydro Data has experienced, for instance, that equipment running at remote locations with limited support needs to be set up in a way that makes it more robust than otherwise. Disk drives are duplicated, more processing and storage capacity is provided, etc.

9. Standards Evolution: A Changing World

From its initial conception, the Hydro Bridge standard has changed considerable. Several new versions have been defined. Doing so is partly a result of learning and of Bridge's own success, and partly a result of the needs to adapt to a continuously changing world (also illustrated by the Internet example above).

Previous sections have mentioned many components being included in Bridge since its initial definition. We will mention some more: A second version of the Notes infrastructure was operational in May 1997. It introduced a new service providing high speed replication of databases following the established structure of hubs and spokes, a service providing replication directly between servers bypassing the hierarchical structure of hubs and spokes. Hydro templates for standard documents such as letters, memos, fax front pages, summons to meetings, minutes of meetings, etc., were defined, and a central directory service for resources across Hydro's different technologies is under development. The components included in Bridge are split into two categories.

Changing from one Bridge version to the next is a challenging task. Migrating to Bridge 97 means moving from Windows 3.1 to Windows 95 or NT. This implies that all applications had to be ported. This did not cause much trouble for most commercial products. But Hydro is using a wide range PC software developed in-house. Porting this software has been a major task.

The Bridge standard has been growing considerably since its initial conception, as illustrated in Figure 3 and Table 1. The character of the Bridge standard and infrastructure has also changed similarly. While it was clean and well structured at the time of conception, its evolution has caused an increasing number of parts which are overlapping and linked together in an increasingly more complex lattice, as illustrated in Figure 4.

Bridge has been growing along several dimensions: users and use areas, the number of applications, degree of duplication, and inclusion of the required underlying services.

In addition to the growth of Bridge from one version to another, the different speed of adoption and version updates among the divisions make the Bridge infrastructure a tremendous chaos.

Some divisions move fast to new versions, others are very slow. The file formats of desktop products change from one version to the next. The products are usually backward compatible so that newer versions can read files produced by older ones. The opposite is not the case. Accordingly, new product versions mean incompatibilities between tools used in different divisions. Bridge is growing from one version to the next, but a new version is only partially replacing the old. The old ones are still in use, which means that the new versions are introduced *in addition* to the old ones. All this means that the complexity, heterogeneity, and incompatibility of the infrastructure have been growing very fast.

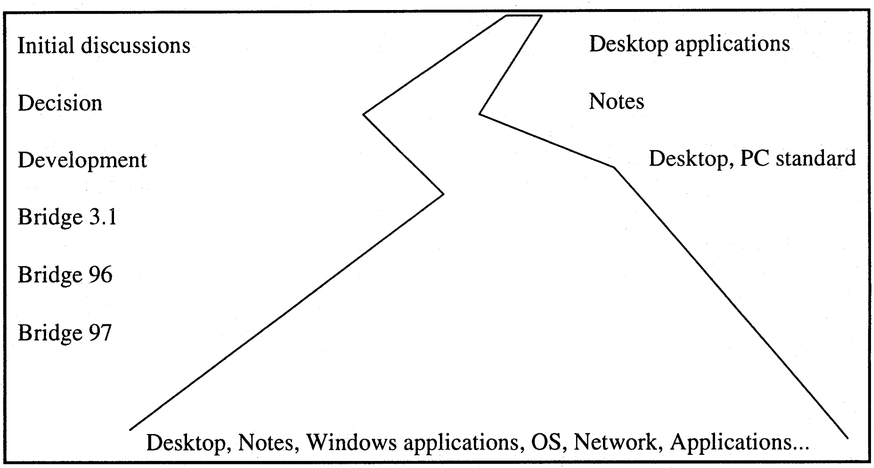

Figure 3. The Evolution of Bridge

Table 1. Bridge 97

Area	Products			
Information sharing	Notes	Web		
Desktop applications	Lotus	Windows		
E-mail	Notes	cc:mail	X.400	Telex
OS	Novell	Win95	WinNT	
PC	all major vendors			
Network	TCP/IP	Novell		
Telecom	Telephone	ATM	Radio	2MB
Support	Local	Hydro Data	Outsourced	
Versions	Bridge 3.1	Bridge 96	Bridge 97	

10. Conclusion

Standards are not universal—in the way usually assumed. They are only universal as abstract constructions. When they are implemented, they are linked to and integrated with local systems and practices, whether the applications are in the oil sector or telecommunication services (or rather the lack of) in Africa. The universality and homogeneity disappear as standards get implemented. They are locally embedded, in a sense making them part of the local, i.e., unique and non-universal. And they are continuously changing—in different directions in different localities.

Standards never creates order—in the way usually assumed. Order can only be created locally or as seen from one perspective. Dis-order is parasitic on order in the sense that creating order from one perspective means creating dis-order from another (Berg and Timmermans forthcoming). Managing dis-order—as dis-order—is just as important as creating order. One can never solve the dis-order problem by creating order. Doing that is just like trying to catch the treasure at the end of the rainbow. However, standards matter. The fact that standards are not universal does not mean that they are not important. They certainly are. Although infrastructures and standards get a local character as they are implemented and used, they do indeed also have some universals aspects. They are local and universal at the same time, i.e., they are *local universals* (Timmermans and Berg 1997). Standards are reducing the dis-order, but there will always be dis-order in terms of incompatibilities and redundancy. These issues have to be taken care of in terms of gateways, ad hoc patches, duplications, accepting to live with inconsistencies, etc. Successful implementations of infrastructures require skills in dealing with this just as much as skills in setting standards.

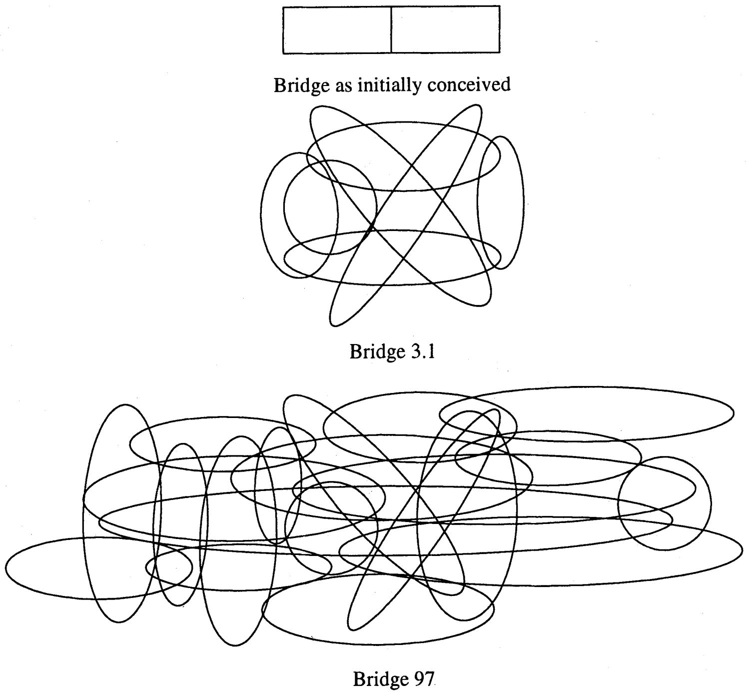

Figure 4. The Evolution of Bridge

Acknowledgments

We are most grateful to Judith Gregory, Eric Monteiro, and Sundeep Sahay for their help in improving this paper.

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