1 DIFFUSION OF INFRASTRUCTURE: MOBILIZATION AND IMPROVISATION

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Abstract

The development and subsequent spread of a versatile and flexible information infrastructure in internationally oriented business organizations is readily recognized as strategically important. There is a pressing need to develop a firmer, empirically underpinned understanding of the structure and contents of such broad, socio-technical processes for control, management, or intentional shaping to be viable. We study and discuss a six year effort in an internationally oriented oil company to develop a flexible, Lotus Notes based infrastructure facilitating the company's further development toward globalization of its business processes. Drawing upon a historical reconstruction of this case, we describe key characteristics of infrastructure diffusion: the need to continuously re-appropriate it, the vital episodes of improvisation, the bundling or packaging of the infrastructure, and the alignment with the existing, installed base of information systems and work routines. Based on this, we critically assess the scope and options for managing such processes.

Keywords: Lotus Notes, information infrastructure, actor network theory, mobilization, improvisation, strategies for intervention.

Introduction

Oil and gas operations are a key industry in Norway, representing 15.5% of the GDP. Statoil is the largest producer in Norway and the second last exporter of oil world wide. Statoil—the state of Norway's oil company (Den norske stats oljeselskap A/S)—is in the midst of a metamorphosis. After years sheltered from unbiased competition guaranteed through a broad, political coalition, Statoil is changing into an internationally oriented, competitive enterprise. Statoil is learning to operate in a competitive market at the same time as it diversifies. The development of a comprehensive, versatile, well aligned, and communicative information systems—in short, establishing an information infrastructure—is identified as a key, strategic vehicle in this metamorphose of Statoil. An iconic manifestation of Statoil's ability to operate on the global scene is to develop a resilient and flexible "infrastructure that permits changes to the businesses without loss of time or quality for the customer...and be able to set up a new office site world-wide in five days" (SData strategy, 1997, Statoil home page). We describe and discuss the strategic efforts of Statoil to establish a Lotus Notes information infrastructure during the years 1992 to 1998. Our aim is two-fold. First, we try to contribute to establishing a firmer grasp of the contents and structure of infrastructure development and diffusion. We seek to identify characteristic features of the underlying, socio-technical process of negotiation. Second, grounded in this account of infrastructure diffusion, we discuss and critically assess strategies for intervening or managing.

In the espoused version, Statoil is a case of the introduction and diffusion of Lotus Notes to meet the ambitions of strategic, communicative use of IT. Statoil is seemingly an example of a highly successful introduction of Lotus Notes. With its 18,000 Lotus Notes users, Statoil is among the world's largest user organizations (Lotus Notes for the Next Millennium). The number of Notes users in Statoil has grown rapidly: 1,017 (January 1994), 4,104 (January 1995), 8,210 (October 1995), 14,209 (October 1996), 18,300 (October 1997). Scratching below the surface, however, shows a different picture. The "diffusion" is but a convenient short-hand for an ongoing socio-technical negotiation. It took hard work—and luck—to mobilize sufficient support behind the Lotus Notes decision. Challenges had to be addressed, either by enrolling and aligning them with the existing infrastructure or by co-existing with them through a technological compromise (a kind of generalized "gateway") (Hanseth and Monteiro 1998). It was an ongoing effort that constantly needed to breath to live. Establishing an information infrastructure is a long-term process; it does not simply unfold from a decision (Latour 1996).

One of our concerns is to display the various forms and strategies required to keep mobilizing support for an infrastructure. Crucial elements here are how technological solutions and visions of IT are enrolled. We pay attention to the performative role—the strong mobilizing effect—the construction, circulation, and reproduction of visions, myths, and icons have in Statoil. We are, for instance, interested in how images of orderliness are strong mobilizing vehicles for the necessary categorization underlying any information infrastructure effort. Fragmentation of the information infrastructure provokes strong, negative and common-sense reactions. Fragmentation represents "dirt" (Douglas 1966) and mess (Bowker 1994).

Our study is related to a body of previous research. In much of the MIS literature (Broadbent and Weill 1997; see Ciborra 1997 for a critique), technology strategies are

— like other plans—straightforwardly "aligned" with the business strategy. There is a tendency, however, to emphasize the planned and controlled aspect of such efforts vis a vis the more opportunistic and improvised aspects (Broadbent and Weill 1997). This down-plays to the level of nonexistence the mutual negotiation, as well as the improvisation between technology development and business strategies. Our analysis of strategic IS investments in Statoil in the 1990s is intended to shed some light on how strategic use of IT actually unfolds, how strategy development extends well beyond simplistic notions of "alignment."[1]

There exists a growing number of Lotus Notes studies in and around the field of computer supported cooperative work (Ciborra 1996; Essler 1998; Korpela 1994; Orlikowski 1992, 1996). The bulk of these, however, are focused around Lotus Notes as a fairly self-contained artefact. This misses out on one of our key concerns, namely to recognize Lotus Notes as but an element of a larger, evolving infrastructure and its relation to the business strategy. Orlikowski (1996) and Ciborra (1996) represent exceptions in the sense that they position the Lotus Notes introduction within the larger organizational and business setting.

The picture of information infrastructure development and diffusion that emerges from our account does, of course, share a number of aspects with other processes of adaption and widespread use of technology. Hence, an infrastructure tends to "drift" (Berg 1997; Ciborra 1996, 1997) and gets "improvised" (Orlikowski 1996) during "windows of opportunities" (Tyre and Orlikowski 1994). Our ambition is to extend and adjust earlier accounts to the specific case of information infrastructure in such a way that it is possible to extend advice about how to manage such processes. This implies analyzing the need for continuously nourishing (Latour 1996), the importance of episodic bundling or aligning new requirements, and the conservative influence of the installed base of information systems modules and work routines (Hanseth 1996; Monteiro 1998; Star and Ruhlender 1996).

Our approach to the study of information infrastructure leans heavily on the work by Star and Bowker (Bowker and Star 1994; Bowker, Timmermans, and Star 1995; Star and Ruhlender 1996). In their continuing series of studies of classification schemes and infrastructures, they identify a number of issues which are highly relevant to our study. In their historic study of the evolution of the classification of diseases maintained by the World Health Organization, Bowker and Star illustrate how coding and classification—essential tasks in establishing an information infrastructure—is anything but neutral. Interests are inscribed into the material of coding schemes. Timmermans, Bowker and Star study how some aspects of work are made more visible than other by inscribing them into a classification scheme. Star and Ruhlender discuss key characteristics of infrastructure based on a study of the introduction and use of an information infrastructure.

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[1]Note that the term "alignment" will be used in two distinct ways. In the present model, it refers to the notion as developed within the MIS literature (Broadbent and Weill 1997) and discussed and critiqued in Ciborra (1997). In our subsequent description and analysis of the case, however, our use of the term refers to the much richer notion developed within actor network theory (Berg 1997; Bowker, Timmermans and Star 1995; Hanseth and Monteiro 1997; Latour 1996).

We employ a method of historical reconstruction of the process around the introduction of Lotus Notes in Statoil during the years 1992 to 1998 (Mason, McKenney and Copeland 1997). Our access has been facilitated by our relation to Statoil. One of the authors has worked for Statoil for the last seven years. The other author has been granted office space, an access badge, and a Lotus Notes account and has spent on average two days a week in Statoil over a period of five months. Statoil has traditionally been relatively protective toward outsiders. The fact that the authors were free to wander about and make appointments—symbolically gestured by the existence of a Statoil based e-mail address—has greatly facilitated our ability to select and identify interesting sources of data rather than being closely steered.

The fact that one of the authors is employed by Statoil in the organizational unit called KOT (see further explanation below) may potentially influence and bias our account. The way we have addressed this problem is partly by seeking to validate and discuss our account of the case with involved actors, and partly by relying on varied and independent sources of data allowing a certain form of triangulation. We have presented our findings in meetings with representatives of most of the organizational actors. Written reports have also been circulated and resulted in both written and oral feedback.

We have been engaged in participatory observation by taking part in project meetings, informal discussions, and coffee breaks. We have conducted 20 semi- and unstructured interviews lasting from one and a half to two and a half hours. Our informants fall into the following categories: Involved in the Notes introduction: three (coded in the text as Intro1, Intro2, etc.); Managers and decision makers: seven (coded as Manager1, Manager2, etc.); Network managers: one (coded as Network1); Users: nine (coded as User1, User2, etc.).

We have had access to a rich set of written, historical material such as reports, memos, and strategy documents from various parts of the organization as well as the corporation as a whole. In addition, we have consulted two different internal newsletters in Statoil (Status and Statoil Forum) during the period 1992 to 1998.

The Lotus Notes infrastructure we study has also provided us with a rich source of information. There is an extensive electronic achieve (Elark) which contains all official Statoil reports in addition to selected contracts, e-mail discussions, memos, and project documentation. There are also a large number of Lotus Notes discussion databases, newsletters, detailed project archives, budgets, and various forms of corporate presentations (slides, brochures, and folders).

The Era of Cost-cutting and Rationalization (Late 1980s–1993)

The post-Gulf War period led to a recession in the oil industry with falling oil prices and dollar rates. The average price of a barrel of oil in 1991 was $4 less than that of 1990. Large oil companies like Shell and BP were restructuring their business and retrenched large number of people, not only because of the recession but also because of substantial changes in the business itself due to global markets and increasing environmental pressure. In Statoil, exploration and production (E&P), the key contributor to company profits, painted a dark future prognosis in the philosophy of operations document for the 1990s. The assessment of the situation led to two reorganization projects from the fall

of 1992. They had several long term consequences as they were the first round of what turned out to be a sequence of similar projects which stressed the importance of internal customer- contractor relations as a way of streamlining business, developing internal markets and pricing mechanisms. As described in later sections, it took several years and several similar projects to make the changes. They needed to be reiterated over and over again to have an impact; they produced a gradual reorientation.

The basic principles of these large reorganization efforts were mapped fairly straightforwardly to the IT area as well. Investment into IT was largely viewed as any other source of cost generation and hence a likely candidate for rationalizing and cost-cutting because "at this time [around 1992] IT was only considered an expense" (Intro1).

The many overarching strategies and reorganizational efforts boiled down to one thing with respect to IT, namely that the way to cut cost was through standardization in the sense of uniformity. The prevailing vision of the use of IT was as a subordinate, basically individual, tool for conducting the business-oriented work. The focus was entirely on office tools; there was little attention paid to the communicative abilities. There was a wide-spread and general consensus about the need to standardize the existing jungle of office tools. The choice of Lotus was settled on price only. Lotus wanted the deal "so badly they made Statoil an offer they couldn't refuse" (Intro2). In order to make the transition from the old office tools to the Lotus suite smoother, the changes with the introduction of Lotus office tools were "packaged" and lumped together with the seemingly inevitable changes involved in upgrading to Windows 3.1; that is, the inevitable transition from a text based user interface to a graphical one.

Somewhat on the margins of the key concern for controlling and cutting IT costs, there were people trying to argue for a more strategic use of IT, trying to argue for the potential for IT-based cooperation and distribution of documents. It took time before this effort picked up speed and became more widely accepted.

At this time, the only way to communicate corporate wide was with the use of Memo, an IBM mainframe-based e-mail system. It was purely text based and offered no support for attachment of electronic documents. Memo was introduced in the 1980s and had a large community of users. Its functionality was poor but "the great thing about it was that everybody used it" (Manager3). The maturing and growing awareness of using IT to support new work practices unfolded slowly over years. It drew on several, including external, sources, and seemingly "drifted" along. On closer scrutiny, however, important elements of this implementation may be identified. We describe how the visions gain momentum by drawing upon new oil field discoveries and an international trend toward tighter cooperation within the oil industry. To really take off, however, the visions about strategic use of IT needed spokespersons or allies.

The first oil field found by Statoil, which was not simply overtaken from others with the help of governmental license contracts, was Norne. It was discovered in 1991. Norne was important in boosting the self-confidence of Statoil, to document Statoil's position as a capable actor also in the discovery of oil fields, not only their subsequent exploitation after somebody else had found them:

> "We have constantly had a bad conscience about the fact that we have
> not located the oil fields ourselves" (User9).

For Norne to be commercially interesting, the operations work needed to be radically restructured. At the same time, the Norwegian government introduced the NORSOK report on the future competitiveness on the Norwegian Continental shelf in

February 1994, following arguments that had been launched by its British counterpart, CRINE. Both reports concluded that development costs of new installations should be reduced by 40%–and that cutting costs was not enough. Just as important was the development of new collaborative work practices that would enable the industry to reduce development cycles of new installations. Not surprisingly, this work also stressed standardization as a key to success in the future and an ISO 9001 certification program was launched in different parts of Statoil.

In Statoil, the Norne project had started to live by these new principles, which seemed ripe at the time. A company initiative called BRU (cheaper, faster development projects) was initiated in 1994, taking up the challenges from NORSOK and following up and spreading the new practice from the Norne project.

The visions and ideas for exploiting IT more communicatively stem, as outlined above, from several sources. Within Statoil, several actors recognized the (pretty obvious) opportunities and tried to maneuver into position. In the turbulence and uncertainty around the outcomes of the many reorganizational efforts, the IT departments and staffs perceived themselves as vulnerable (User3). It was accordingly of importance to become more proactive, to maneuver IT into a more strategically focused location rather than only a place to perform cost cutting. Lotus Notes was to meet this need. The situation at this time, then, may a described as one of unfulfilled potential in the sense that there were both ideas and actors lobbying and mobilizing support for (fairly vague) conceptions about a new and different use of IT. As a result of the Lotus agreement, the head of the IT department was invited to Lotus in 1992. As part of his visit, Lotus demonstrated Lotus Notes v2.0, a product he "fell immediately for" (Intro2). He instantly wanted to try out Notes to implement his ideas. Contrary to most accounts in the literature, Statoil's initial choice of Lotus Notes was not due to careful strategic planning. It was improvised; it came as a surprise, "an amusing little side dish" (Intro3) relative to the real decision, namely the Lotus office suite.

For the diffusion of Notes to succeed, it was necessary to develop skills and competence in handling all aspects of Notes, that is, developing applications, helping users, finding ways to coexist with existing systems, and maintenance and support. In order to gain further experience with Notes, it was introduced into the whole IT department (about 200 people at that time). It was furthermore perceived as important to develop six standard applications. This was to avoid the impression that Notes was only an application framework, only "an empty shell" (Intro3). These six applications were fairly general, administrative tools dealing with meeting room reservation, individual week plans, news, sick or absent leave recording, discussion bulletin board, and an answering service for users.

Alongside, but organizationally and technologically independently, islands of Unix machines were starting to grow. The introduction of Unix, in contrast to both the introduction of the Lotus office suite and the efforts to push Notes, was a bottom-up process driven and financed by local user needs. The first Unix machines arrived around 1991 and they simply were "forced through by the users" (User1). The fragmentation due to Unix deployment was tolerated because it was made largely invisible through the institutionalizing of routines for reporting the results originating from the Unix world. The fact that the Unix users were specialists, but not in IT, made it effectively impossible for them to seize the technological opportunities to establish an alternative, Unix-based communication infrastructure.

The Construction of Trust (1993)

The streamlining of E&P led to the centralization of the old decentralized IT units (coined Statoil Data or SData) in April 1993. In this sense, centralization was the flip side of standardization. Included in these challenges was management mistrust and frustration related to IT and the need to substantiate both the IT investments and effects of IT. The real challenge was to transform SData into a business and market oriented organization, to change from a "plan economy to a market economy" (Manager2). This represented substantial changes along several dimensions: how E&P perceived SData, how SData perceived themselves, SData routines for handling customer inquires, and the internal organization of SData.

As outlined above, ideas about exploiting IT beyond the more narrow use as a vehicle for rationalizing were gradually emerging. To really make them fly, they needed allies. By themselves, these visions were unable to achieve much. Similarly, the different actors who were lobbying for communicative use of IT were also not influential enough on their own. What was required was for the actors to mobilize support by enrolling the visions. The actors together with the visions were a lot stronger than either one alone. The question, then, is who managed to maneuver into this position, and what kind of mobilization strategies were employed?

Corporate IT (KIT) were given the responsibility for the more strategic long term polices on IS/IT: IS safety, telecommunications, information management, and development of guidelines for application of IT related to database architecture, electronic work flow, and methods for systems development and activity analysis. SData were given the role of delivering IT products to the customers. A newly formed research group, KOT, had a problematic birth in the late 1980s. Under the name Applied Information Technology they came under pressure from KIT, who refused to let them use such a name. R&D management in Statoil gave Applied Information Technology half a year to prove their viability in Statoil and develop new customer relations. KOT embarked on a strategy of trying to combine IT and organizational development in their slogan "ORG+IT=Synergy" (Status, 26 June 1996). The name KOT, "coordination technology," was a buzzword that was growing in use in the United States. Mainly to create more internal Statoil credibility and improve internal skills and expertise, KOT developed a relation to the newly founded MIT Center for Coordination Science in 1991. Paying them a yearly fee literally bought KOT credibility in the internal market in Statoil. A good working relationship with MIT, an icon of outstanding research, was enrolled as an ally of KOT.

The idea that emerged was to have a number of operational networks of people that were connected via Lotus Notes and could give electronic improvement proposals related to a number of best practice documents that were shared electronically via the pull functionality in Notes. It is instructive to study how KOT moved to enroll this emphasis on experience transfer. The strategy of KOT was to quickly work out a prototype that was perceived as useful. KOT developed a close relationship with the operational environment in E&P, in the Bergen and Gullfaks installations, to study best practice in present operations and incorporate this into the design of new oil installations, Troll (Borstad et al. 1993). KOT embarked on a strategy of creating attention around their work and keeping a high profile in the internal market. While KIT and later Statoil

DATA in most cases envisioned the use of Notes as an office administrative tool, KOT's vision was to develop use within offshore operations in E&P.

To a large extent, SData was delegated the non-glamorous tasks such as the responsibility for the day to day operations, maintenance, and upgrading of the Notes servers and user community. SData appeared more and more as a slow moving, gray bureaucracy. The more eye-catching tasks was overtaken by others, primarily hired, external consultants but also KOT. This created tension between SData and KOT which took several years to stabilize into a more clear cut and productive cooperation.

The Bundling of Notes (1993–1994)

The mobilization strategies of KOT and SData described above concern the larger reorganizational picture of infighting and maneuvering, the search for attention and organizational space, for organizational units (and people) to become visible. Let us turn to the strategy of diffusion of Lotus Notes. A striking aspect, closely linked to the infrastructural character of Notes, is the way Notes was not introduced in isolation. It partly makes up an infrastructure and partly is an element of one. In short, Notes was not introduced as a more or less isolated artefact, it was "bundled," packaged or aligned with existing and new elements. The establishment of an information infrastructure always requires this kind of careful alignment for adoption and diffusion to be feasible.

The Lotus Notes infrastructure that SData attempted to establish was packaged with two other components, namely the standardized suite of office tools from Lotus and a PC-based, wide area network that allowed the PC to communicate across the geographical locations of Statoil in and outside Norway. This PC-based wide area network was called I-net. I-net represented a massive investment for SData. In combination with Notes, I-net was—and still is—the gem of SData in the sense that it is a vital corporate asset entirely under the control of SData. The control over I-net allows SData to act as a "gatekeeper." The continuous evolution of I-net is a resource consuming endeavor. I-net included name directory services allowing log-ins independent of geographical location, a feature not commonly available in PC-based networks at the time. I-net was introduced piece-meal in Statoil as an upgrading of PCs. For instance, during one weekend in December 1994, 25 SData employees managed to upgrade 650 PCs to I-net at corporate headquarters (TeamIT 161294). To upgrade all PCs to the first version of I-net took a major part of 1994.

By the end of 1994, there were 10,390 Lotus users but only about 4,000 Notes users (TeamIT 221294). It is easy to forget the novelty of allowing the PCs to communicate beyond a purely local context. This had previously belonged to the world of mainframes and Unix; it was introduced as something really new in Statoil, something that the users were supposed to identify with Notes. In this sense, the fact that Statoil had previously lagged behind in offering communicative services to their PC users gave the Notes advocates an opportunity to take advantage of this to boost Notes because "remember, before Notes there was no wide area network [for PCs]!" (Intro2).

Given such a package and the functionality of Notes, a number of more ambitious changes would have been possible. But this was not the strategy pursued by SData. Instead, the project group advocating Notes employed a more conservative approach, namely to focus on only a restricted aspect of Notes, the e-mail. Notes was presented as

Memo but with the additional feature to attach documents. In an actor network theory vocabulary, this amounts to the alignment of e-mail and word processing.

The introduction of the new e-mail service in Notes was made smoother by ensuring the coexistence with the older e-mail system, Memo as a gateway between Notes and Memo is provided (Memo: PRESINN.SAM 1993; Introduction of Lotus Notes in Statoil, pp. 10-11). Memo had a long history in Statoil. In a 24 hour log of e-mail traffic in Statoil in 1994, 12,821 out of a total of 14,977 e-mails were generated from Memo with the rest using Notes mail (TeamIT 210494). The installed base of Memo was considerable. To the extent that Lotus Notes qua e-mail was to spread, coexistence with Memo was essential as "today Memo is Statoil's main e-mail system and other systems need to be able to exchange messages with Memo" (Electronic message exchange X.400 address standard in Statoil 1995, p. 8). The establishment of a gateway between Memo and Notes mail implies that users need not "jump" to Notes—they can still communicate the way they did when they still used Memo (Hanseth and Monteiro 1998).

This strategy of alignment—first, aligning Notes with office tools (through attachment) and, second, with the simultaneous establishment of a PC-based wide area network—is a key strategy for the diffusion of an infrastructure. It takes the form that as new requirements or "incidents" occur, the Notes proponents needed to improvise in order to align these with the evolving Notes infrastructure (Tyre and Orlikowski 1994). This pattern runs through any information infrastructure establishment; it is at the core of developing infrastructure.

Diffusing Lotus Notes—or Was it E-mail? (1994–1996)

Up to 1995, E&P had been the major area for large organizational change efforts in Statoil. A project called K-2000 tried to apply the same principles that were behind the business orientation of E&P to the rest of the company. The main aim was also to increase the team-work and the exploitation of resources across the organization. New, flexible, collaborative work patterns were first developed in the Norne project and, starting in 1995, also at a new methanol plant under construction at Tjeldbergodden. K-2000 was the latest in a long sequence of reorganization efforts but finally managed to break ground for more communicative use of IT.

By using an improved e-mail (vis a vis the former Memo) as a spearhead for advocating Notes, together with the growing acceptance (expressed through K-2000) for a more communicative use of IT, the evolving Notes infrastructure was picking up speed. To feed the process, it was necessary to continuously translate and align new requirements.

This created some space around the Notes introduction; the project team pushing Notes could loosen up a bit. For instance, there was a clear policy that the users should be able to develop their own applications. The facade of Notes was undoubtedly e-mail, but in the background a more versatile use was prepared and encouraged as "we had a clear policy about allowing the users to develop their own Notes application" (Intro2).

SData was then able to turn to the vast number of minute details that were needed to glue Notes together to facilitate further spreading. They needed to fill the Notes infrastructure with a contents that "Lotus themselves had not focused on, they had emphasized network administration" (Intro2). What SData needed was support for the

management of users, that is, creating, deleting, and moving of users, changing names and administration of the mailboxes. In addition, it was necessary to translate and align the corporate database for personal information with Notes. Filling in the gaps in the infrastructure, providing the invisible but necessary parts of the infrastructure is a recurring pattern in the development of an infrastructure (Latour 1996; Monteiro 1998).

As a result of these processes of alignment, the "diffusion" of Notes unfolded. The use of Notes largely came down to the use of e-mail, despite the six standard applications. In response to the more popular and "free" use of Notes, SData started focusing on the institutionalizing of patterns of use. A campaign late in 1995 illustrates this.

The campaign was dubbed "The search for the paper clip" (Norwegian: Bindersjakten). The name made reference to what was initially the key argument for Notes, namely the ability to attach various documents to e-mail. This is graphically depicted as a paper clip on the screen. The proliferation of e-mail with attachments was perceived as a growing problem. The ease of mass distribution and forwarding resulted in a growing number of e-mail with extensive attachments. Throughout the campaign in 1995, SData attempted to institutionalize a more disciplined use of attachments (and e-mail) by "searching" for paper clips. The campaign was highly profiled internally through electronic and paper newsletters.

An often reiterated theme and ambition with establishing a working, corporate-wide infrastructure is to finally make the world fit together, to integrate the various applications, platforms, and information systems that exist. The rhetorical thrust of the vision tidying up—sweeping the old mess aside—in order to avoid fragmentation and chaos is strong (Douglas 1966). It is one of the driving ideas of the notion of a comprehensive and versatile infrastructure. Despite the practically unanimous acceptance of the need to avoid fragmentation, important user groups still have to learn to cope with the mess. The fragmentation, of course, exists for good reasons and will not simply be swept away. The most important sources for the all too common situation of a fragmented infrastructure are, first, that the users requirements vary too much and, second, that new information systems extend and superimpose older ones rather than straightforwardly substituting them. Focusing on the users in Statoil primarily engaged in the early phases of production illustrate this point, what it means to compensate for a fragmented infrastructure.

The people involved in the early phases of oil production are largely engineers and people with technical skills. The work consists of a variety of tasks including drilling, seismic exploration, analyzing and visualizing drilling data, simulations and modeling of the reservoir. As pointed out above, the tools and applications needed to support this work have, throughout the 1990s, been Unix-based, prompting a user-driven, bottom-up introduction of Unix work stations from early in the 1990s (User1). The tools for producing reports, slide presentations, and archives are not Unix-based but PC-based, implying that everything has to move across the two platforms using file transfer services. This moving around of data is not always as smooth as it is supposed to be: "It is a lot of fuss with Postscript files, they cannot be read on a PC when exported from Unix" (User4). This prompts an extensive repertoire of work-arounds to cope with these problems. As a result of stripping all staff functions, this kind of work becomes invisible and unaccountable (Bowker and Star 1994). Having a staff or a support would be visible in accounting. Now all work is accounted for on the projects creating the impression that all overhead, that is, work not directly connected to the value chain, has been eliminated

(User2). When reporting upward, the accounting routines for work accordingly inscribe the invisibility of these work-arounds. They simply disappear from sight, an effect which is necessary to not make the fragmentation of the infrastructure bothersome and evident.

Web technology could in many ways be considered an alternative to much of the actual use of Notes in Statoil: distribution, circulation, and archiving of documents. Web technology in Statoil spread bottom up via the Unix islands. The first Web servers and Web clients (browsers) were only accessible via Unix. It did not occur to the engineers that the Web could be enrolled as a proponent of Unix. They were already so accustomed to and socialized into living in a technologically fragmented world that they "did not reflect on the fact that the Web was only a Unix thing—some things are PC-based, some are Unix-based, that's the way things are" (User1).

As outlined earlier, the first "real" Norwegian oil field was Norne. It accordingly acquired an iconic or symbolic status extending beyond its immediate commercial significance. In this situation, the fact that Lotus Notes was enrolled in Norne gave Notes an important impetus. In late 1995, Norne had started their preparations for operations and were willing to try out new collaborative technologies in their operational phase. KOT knew key Norne people and developed strong relations inside the Norne organization and embarked on a project in January 1996 as an operative pilot for the collaborative work space research project. Starting with Lotus Notes release 3, it became evident that Norne wanted to take advantage of more Web-like functionality, like clickable graphical interfaces. Together with KOT, Norne asked Statoil Data to come up with a technical solution that would match Norne's future operational requirements. By then Lotus Notes release 4 had the possibility of developing navigators that employed graphical hypertext/media functionality and Web access via a product named Inter Notes, an ability that was quickly aligned with the Norne efforts. This official company pilot status enabled Norne to get access to release 4 of Notes. Even though KOT and Norne were in charge of running the development pro- cess of an integrated organizational and IT development process, Statoil Data did most of the basic coding and delivered the necessary Notes release 4 infrastructure. In this project, KOT and Statoil Data cooperated together successfully, filling complementary roles helping Norne in their preparations for operations from April 1996 (Hepsø 1997).

Strengthening Through Alignment: Upgrading to Notes v4 (March 1996)

By early 1996, the Notes infrastructure had acquired a certain robustness, a certain level of irreversibility. This, as we have illustrated above, did not unfold automatically as a result of the "diffusion" of Notes. Rather, it was the pay-off of the continuous process of appropriating or "improvising" the incidents that "drifted" along. In short, it was a continuous process of alignment.

March 1996 marks a point in this process of alignment, this process of building up robustness and strength of the Notes infrastructure. SData had decided to upgrade Notes from version 3 to 4. The diffusion strategy of SData, as it has been all along, was one of alignment. More specifically, they framed this upgrading as one aimed at strengthening the position of Notes by making as few changes as possible. This strategy did not take advantage of the new, technical potential of the new version of Notes. The mechanisms

to design clickable, graphical user interfaces mimicking the functionality of the Web were especially interesting. By completely bypassing this possibility, SData created space and opportunity for their more proactive and fast-moving competitor, KOT. In this way, the impression of SData as passive and KOT as more active was further entrenched.

The way SData translated the upgrading as one of strengthening the position of Notes was basically one of making their own Notes administration more efficient. By March 1996, there existed about 3,500 Notes databases in Statoil which generated a considerable amount of administration for SData. These applications were poorly aligned with work practices. Aligned with the upgrading to version 4 of Notes, SData trimmed this jungle of databases by forcing the owners to identify the ones they wanted to migrate to the new version of Notes. SData simultaneously tightened the requirements connected to Notes applications by ensuring that all applications had an owner and a brief description of functionality (Intro1). This cleansing paid off. The number of Notes databases shrank from 3,500 to about 1,200. Still, the proliferation of these independently developed Notes applications represent an important learning process that neither the use of Notes as e-mail nor the six standard applications captured.

In addition to this move toward rationalizing their administration of Notes, the changes related to the upgrading were bundled or packaged together with another and seemingly bigger change—the upgrading of Windows 3.1 to Windows' 95. In this way, the Notes upgrading was made less visible by being only a (small?) part of what was perceived as an inevitable upgrading to Windows 95. In much the same way as the original bundling of Notes with I-net in 1993/1994, the upgrading to Notes v4 was packaged into a more invisible and "inevitable" upgrading of I-net to Windows 95.

As pointed out earlier, a key strategy in constructing the robustness of an infrastructure is the continuous process of alignment. The upgrading to Notes version 4 was no exception. To illustrate, we list a few of these to get a feeling for the kind of ongoing reconfirmation that is required. They are always small, grey, and non-glamorous but are the life blood of a working infrastructure. Without the constant work, the infrastructure simply would not "diffuse."

An alignment of Notes e-mail and services for electronic archiving that was fueled by the pressure for ISO 9001 was attempted to meet with the new version. Specifically, the e-mail window was equipped with an additional button (besides the ones for "send," "reply," "print," and so forth) for "archiving" (e-mail archived in Elark 200396). In this way, e-mail was aligned with archiving and quality standards. Similarly, in response to a growing concern with facilitating communication with the outside world, the address book that already was aligned with e-mail was extended to incorporate external addresses and X.400 addresses. A final example is the way the color codes of e-mail was changed to make it easier to differentiate between e-mail where you appear in the "To:" header from those where you only appear in the "Cc:" part (TeamIT newsletter 280796).

Enrolling the Outside World (April 1996–1997)

Establishing the Notes infrastructure in Statoil was never automatic. In the previous sections, we illustrated how the momentum or irreversibility of an infrastructure—disguised by the potentially misleading term "diffusion"—is the product of the hard work of continuous alignment.

We now turn to more serious threats to an evolving infrastructure, threats that not obviously are possible to translate and align into the existing infrastructure. If you cannot employ a strategy of alignment, then what do you do? Before returning to this question, let us first have a quick look at the sources of these threats.

In a number of ways, the pressure for opening up, orienting Statoil more toward the outside world was building up. Some of this thrust was of a fairly general nature. The rapid folklorization of the Internet and the Web by the media was especially influential in Statoil. Additionally, the oil industry underwent important restructuring during this period. There was a growing awareness about the need to communicate with external partners and subcontractors. The development and introduction of NORSOK, in response to a British initiative (called CRINE), was a decisive move in focusing on external communication in the whole of the oil industry. Up to now, Statoil had been (and probable still is) characterized by a kind of self-centeredness that is related to its remarkable achievements during its 26 years of existence as "we are proud of what we have achieved. But we have probably been a bit self-centered, a bit reluctant to orient toward the external world" (Network1). Similarly, there was a growing focus on supporting industry communication, for instance, by establishing Oilnet (www.oilnet. com). The NORSOK work was supplemented with a standardization effort for facilitating a more efficient communication about technical components (pipes, platforms, ships, rigs, and so forth).

With regard to the evolving Notes infrastructure, the over-arching trends were translated into a simple question: Is Notes an appropriate infrastructure to meet these challenges? There was at this time no obvious way to align these new requirements with the existing Notes infrastructure.

The strategy used by SData was one of marginalization. The proponents and arguments behind, for instance, the Internet and the Web were side-lined by presenting them as misguided. Hence, the proponents of Notes tend to downplay the significance and substance of the objections toward Notes because "the advocates of Internet are those who do not know how good Notes is with regard to the Internet" (Intro1). The heart of the problem, the accusation that Notes is a closed system and hence inappropriate when Statoil is to open up to the world, is defined as a misunderstanding as "Notes has tools for SQL queries together with the new Domino servers" (Intro1). And as a consequence, "the controversy has died out" (Intro2). Later we study more closely how the introduction of a new version of Notes (version 4.5, called Domino) has been framed as a compromise between the existing Notes infrastructure and the pressure from the outside world signaled through access to the Web. This is not an instance of alignment but rather of a kind of socio-technical compromise, a generalized "gateway," preserving the two competing infrastructures.

Statoil has traditionally been fairly closed to the outside world. Unix users have had access to e-mail communication with external partners from the early 1990s. Memo, the corporate wide e- mail system introduced in Statoil in the 1980s, was only for internal communication. With the establishment of an X.400 gateway, Memo and Notes mail were able to be used for external communication from 1995. In 1996, a Notes based SMTP server made Internet mail directly available from Notes. Non-e-mail communication with the outside world, however, arrived rather late in Statoil, that is, for PC users. Unix users had access to a broad range of services such as archie, ftp, telnet, and the Web. As described earlier, the Web was for this reason merely shrugged off as a Unix

"thing." A PC-based Web browser was allowed only from late 1995, and only in response to a formal application. Only in January of this year was browsing from a PC without special permission allowed.

The Current Situation (1998)

As a result of successfully aligning a rich set of elements, the Notes infrastructure has acquired a certain robustness, a certain level of irreversibility. Is it, then, finally "introduced," is it a stable, working infrastructure?

It is certainly the case that it is considered obligatory, that other decisions presuppose the existence of Notes: "We have to relate to fact that Notes is pervasive, to the already existing installed base of Notes" (Network1). This observation, that the installed base of Notes is heavy, gets reiterated in strategy documents of various kinds. Still, how sure is Statoil that they are not flogging a dying horse, that the future lies in Web? The fact that Norsk Hydro is also a large Notes user organization is used in Statoil to legitimize their own commitment: "[Norsk] Hydro is also using Notes, so we cannot be completely off target" (Manager1).

There is a considerable installed base in terms of applications, routines, and delegation of roles. In addition to this, and a lot less visible over the years, a set of institutionalized structures and arenas that contribute strongly to keeping Lotus Notes in place has developed. Statoil and Hydro, the two largest user organization of Lotus Notes in Norway, have established about 10 different forums were representatives from the two companies meet on a regularly basis to discuss and evaluate each other's experience. From a slow start, these forums have turned into working institutions, not empty shells. Similarly, Notes user forums both in Scandinavia and internationally meet regularly in formalized cooperation and experience exchange. In conjunction with the technical side of Lotus Notes, this adds significantly to the installed base of Notes in Statoil. The current level of confidence about Notes is a direct result of a successful definition of the Notes version 4.5, the Domino servers, as an acceptable compromise. Let us see in more detail how this took place.

The threat to the Notes infrastructure from Web was quite real. What would the outcome have been had not Statoil been saved by the bell through the introduction of the Domino servers? The outcome would be uncertain:

> "Had not Lotus introduced their Domino servers, I think it would have been difficult to defend Notes [against Web proponents]" (Manager1).

The Internet had been of marginal importance to the company up to now. Unix-based specialists and a few people at KOT or SData had used it regularly since 1993. But the general potential of this new phenomenon was first realized via the media from in 1995, increasing steadily in 1996, with the folklorization of the Internet. With this, a general change of spirit occurred focusing on IT as an enabler.

The mobilization of the Web as an alternative to Notes was not merely in the form of "pure" technology. Also organizational actors started to move in order to enroll the Web as an ally. Especially the media and information unit (INF) was active here. As they were delegated the new responsibility of Web editing, they felt a special need to become visible. As is the case in many places, the most enthusiastic proponents of the Web are

initially found outside the traditional IT department. In a recent memo outlining a new project, a project leader in INF describes the situation as follows: "Information sharing in Statoil will gradually shift from the basically Notes based reality of today to a Web based system" ("Information sharing in Statoil" 121297, p. 5).

There are distinct and conflicting views—still—about whether Domino represents s a sufficient strategy to address the requirements on openness as "many are still very skeptical to whether Domino is sufficient" (Manager1).

The compromise in the form of Domino has since been substantiated by using it in several projects. KOT started using Notes release 4, with which they had experience from the Norne case, to develop the concepts from Norne further. Faros, a new project initiated from the STI standardization department, launched a similar concept in operations partly based on Norne functionality and embedding a new concept of computer based training. After Norne, KOT had plans for reorienting their focus from operations to exploration within Statoil. A new pilot, VISOK, was launched in the fall of 1996 together with Statoil Data, who had several people in the project from the start. Both Faros and VISOK started to use Lotus Domino when this was made available in Statoil in early 1997. INF also established, in 1996, a new department for editing WWW information with Statoil's official homepage (www.statoil.com). INF increasingly developed a role as the key supporter of a new Web-based intranet. INF was given the prestigious task of creating Statoil's official 25 year jubilee CD-ROM, early in 1997, made with Internet technology.

Discussion and Conclusion

Having described Statoil's effort in some detail, we attempt to contribute to a conceptual platform for making sense of infrastructure diffusion by characterizing the structure of such processes in light of our case. We discuss four characteristic aspects: (1) the non-automatic nature of diffusion, (2) the need for continuous re-appropriation, (3) the way episodic opportunities are improvised and bundled to align them with the installed base, and (4) the way gateways are used to forge compromises or side-step confrontations. We elaborate on these in turn.

The term "diffusion" of infrastructure is potentially misleading. It may easily encourage a view where the infrastructure unfolds more or less by itself, that it suffices to set it in motion and await its gradual momentum and critical mass. The field of social studies of science and technology contains numerous accounts of how any technical design, like Lotus Notes in Statoil, is molded into a stable solution through complex socio-technical negotiations processes (Bijker and Law 1992; Latour 1996; Law 1991). Nothing gets done by itself, nothing unfolds "automatically." In our study, Notes would never have spread had not SData and later KOT lobbied so intensely for it. The bulk of this literature, however, is devoted to the development from scratch of fairly self-contained artefacts. Less attention has so far been paid to describing how large, infrastructural technologies are evolutionary, developed over time as historical sediments, overlapping, substituting, or extending the existing installed base. The study of large technical systems contains some relevant material (Hughes 1983; Summerton 1994). Hughes, for instance, coins the terms "reverse salient" to describe obstacles or problem areas which need to be overcome to facilitate further spread of the infrastructure.

Second, we have described and argued that it takes hard, continuous Latour to keep a decision like Lotus Notes in Statoil alive. Without continuous reconfirmation, the commitment fades away. In his study of the Aramis project, Latour (1996, p. 86) similarly emphasizes how a decision continuously needs to be kept alive to avoid dying because "there is no autonomy to keep them alive....For technologies, every day is a working day." In our case, the sequence of gray, minutiæ and invisible work (such as providing an address book or additional push buttons to archive e-mail; see earlier sections for details) represents vital but neglected work required to re-appropriate the infrastructure.

This constant re-appropriation, this stream of micro-events tends to make the infrastructure "drift" (Ciborra 1996, 1997; see also Berg 1997). Still, to hold that it is "almost outside anybody's control" (Ciborra 1997, p. 76) is, as we see it, to down-play the structure of this re-appropriation too much. The stream of micro-events should be represented as an ongoing effort to keep the (gradually metamorphosed) infrastructure on track (Monteiro 1998). A key observation, in the vocabulary of actor network theory, is to recognize that an infrastructure is a well aligned actor network. This amounts simply to the fact that Lotus Notes in Statoil is not an isolated tool. It fits into and presupposes a rich and dynamically expanding set of other information systems, work routines, work manuals, and organizational hierarchies. In so doing, it is more the essence than the specifics of the plans that are preserved. To illustrate, including an address book (see above) counts as an (unforeseen, nonspecified) alignment to reconfirm any user that might otherwise jump off the Notes effort. An important source for this sequence of micro-events is the ongoing discovery of how to take care of the installed base, e.g., exploiting the existing electronic archive by providing a push button to archive e-mail.

Third, the "drifting" of the infrastructure is punctuated by episodes that need to be "improvised" (Orlikowski 1996) and that create "windows of opportunities" (Tyre and Orlikowski 1994). Metaphors of drama vs. improvisation (Orlikowski 1996) provide different solutions. The development of an information infrastructure cannot only be seen as a drama staged by deliberate actors with predefined scripts and choreographed moves or technological logic. The case of Lotus Notes in Statoil shows that it is to a large degree an ongoing improvisation enacted by social actors making sense of and acting in an organizational setting. Again, our study suggests that these episodes have a structure. They provide valuable, unforeseen opportunities to translate and align the new circumstances into a reconfirmation of the infrastructure. To illustrate, during the period from 1994, after the decision in E&P to spread Lotus Notes, there was a growing concern to streamline business and improve quality. As a result, requirements for ISO 9001 certification "drifted" along. This opportunity was immediately seized. It provided a valuable, unforeseen opportunity that was important to exploit, similar to the episodic "windows of opportunities" that Tyre and Orlikowski report. The pressure for ISO certification was translated into the use of a Lotus Notes application for electronic archiving (Elark). In this way, the further diffusion of Lotus Notes was secured by aligning ISO 9001 with the existing Notes infrastructure:

> "The Notes introduction went smooth in our department. Notes was grabbed immediately because it was introduced together with a routine that met with the new ISO 9001 requirements" (User4).

Also, the way the upgrading to Notes v4 was bundled with the upgrading to Windows 95 (see earlier section) illustrates these opportunities for packaging or alignment.

Fourth, the episodes or challenges that come "drifting" are sometimes too big for any kind of small-step alignment to be feasible. More drastic measure are called for, especially the use of gateways to forge compromises. This may be the case because there already existed something which the new infrastructure had to challenge. The presence of the Memo e-mail system provides an illustration as does the strategy to ease the entry of Notes by devising a Memo/Notes e-mail gateway. But challenges may drift along at a later stage as well, as the Web illustrates. With the accelerating, bottom-up spread of the Web from 1994, the Lotus Notes proponents were facing a serious challenge. Even though SData for a long time attempted to marginalize Web proponents, the threat was real enough. Notes proponents argued for defending the investments into the installed base of Notes:

> "Statoil needs to harvest the expected pay-off from our resources spent on Louts Notes....so that we can keep on exploiting our investments into our Notes infrastructure and competence" (SData K/RD21, IT Challenges and Trends 1996–1999, April 1996).

Still, the confrontation was hard. Had not Domino servers been launched by Lotus, with their gateway function between Notes and the Web, "it would have been increasingly difficult to defend Notes" (Manager1). The infrastructure strategy at play here is not alignment of the kind illustrated by the alignment of micro-events such as address books, push buttons, or ISO 9001. It is a "gateway" solution that preserve the two competing actor networks around Notes and the Web; they are allowed to coexist. Such generalized "gateways" act as political compromises where neither actor network needs to yield and represent a vital kind of response when defending an infrastructure (Hanseth and Monteiro 1998).

In terms of providing normative advice about how to organize processes of infrastructure diffusion, let us try to identify a few lessons drawing upon the characterization sketched above. The first lesson—and probably the most difficult to acknowledge—is that the "drifting" implies that one needs to focus less on the objectives and more on the process. There accordingly needs to be some space for learning and reflection. This is, of course, a lot easier to prescribe than to realize. The problem being, as Latour instructs us, exactly to work against the urge to simplify, the belief in clear-cut plans. New organizational patterns can be developed in dedicated arenas that do not necessarily originate from one life world through reflection in action (Schön 1983). A mutation can emerge through joint efforts that can develop new ideas about information infrastructures and enable a shift from organizational closure and hence develop new possibilities. Arenas for reflection vary in form: some are closely aligned and interwoven with the ongoing practice, others are more established only later; some are formal, others less so.

Second, as the aim of an infrastructure necessarily is unclear, measures have to be taken to involve a variety of actors, perspectives, and interests. When a strong objective reality (in terms of dominating organizational routines, closed technological platforms, installed base, etc.) dominates infrastructure diffusion, the lifeworlds of local groups and their experiences might not be taken seriously enough. As a consequence, the ability to incorporate situated opportunities and emerging changes become threatened. The

internal Sdata discussion on the Lotus Notes/Web controversy in Statoil Data from 1996 into early 1997 is an example of this. The lack of other perspectives reproduced the same objective reality of the information infrastructure: continuing diffusion efforts in Lotus Notes and marginalizing the development of the Web. A number of scholars claim that reflection in action must be institutionalized in organizations (Nonaka 1994; Schön 1983). Nonaka (1994, p. 28) calls this reflection in action a "creative chaos." It increases the internal tensions in the organization and focuses on the development of problems and solutions. If handled proactively, these arenas of reflection develop a space of possibility, a discursive domain where organizations can develop a number of actions to choose from (Gjersvik and Hepsø 1998). These possibilities materialize in the constructive interplay between actors and groups that have different perspectives on infrastructure diffusion in the company. Organizations that are more able to accept and use this differentiation for positive outcomes have a larger space of possibilities than those that do not, because the many perspectives of different life worlds in large companies make more than one interpretation of infrastructure developments possible.

Third, the importance of seizing the opportunities that drift along clearly suggests the need for some slack. Being alert and seizing these opportunities require work and resources. The relative passive and responsive role SData was delegated from about 1994 was to a large extent due to neglecting to seize the opportunities that were presented. The challenge represented by the Web also points to the need to be open to compromises in the shape of gateways and not worry too much about entailing "dirt" and mess (Douglas 1966).

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