Information Technology & People, Vol 11 Issue 4 Date 1998 ISSN 0959-3845

From tool to *Gestell* Agendas for managing the information infrastructure

Claudio U. Ciborra
Universities of Bologna, Gøteborg and Oslo
Ole Hanseth
Universities of Gøteborg and Oslo

The recent managerial literature on the development of corporate infrastructures to deliver sophisticated and flexible IT capabilities is based on a set of assumptions concerning the role of management in strategy formulation, planning and control; the role of IT as a tool; the linkages between infrastructure and business processes; the implementation process. This paper deconstructs such assumptions by gradually enriching the conventional management agenda with new priorities stemming from other styles of taking care of infrastructures. The original, straightforward management agenda appears to be lacking: its foundations are irremediably shaken. The paper finally evokes a philosophy-based agenda, the only one valuable in the uncharted territory where the usual foundations do not deliver any longer. Such an agenda speaks a language of weak agency: releasement; dwelling with mystery; capacity to drop the tools; valuing marginal practices. Will the last agenda play a key role in coping with the information infrastructures of the next millennium?

> Actually, *Gestell* concerns us very directly. *Gestell* is more extant (*seiender*) than all the atomic energy, all the machines, more extant than the impact of organization, information and automation (Heidegger, *Identitaet und Differenz,* 1957).

Introduction

Since the second half of the 1990s IBM has been formulating and deploying an extensive new fabric of processes and tools in order to be able to operate efficiently on a worldwide basis as a global company. Consider one of the major components of such global business processes: customer relationship management (CRM).

CRM consists of an array of processes that streamline all the activities between IBM and its customers across markets, product lines and geographies. It affects more than 120,000 employees worldwide and it is based on a variety of existing and new systems and applications that automate and link multiple business processes. The logic of CRM is quite straightforward, despite the myriad of activities it involves and people it affects. CRM is supposed to be the backbone of the successful completion of any business transaction IBM is engaged in: from the early opportunity identification to the order fulfillment and customer satisfaction evaluation. Thus, CRM prescribes what is needed to execute a full negotiation cycle around any customer transaction. In this respect, the ideas and models developed by Winograd and Flores (1987) were explicitly considered by the internal IBM team who originally developed CRM. The complex bundle of the main components of CRM, processes, roles and IT tools can be looked as a part of the corporate infrastructure of the new, global IBM. Indeed, internally CRM is nicknamed the “new plumbing” of IBM.

CRM shows many features of a corporate infrastructure (Broadbent and Weill, 1997): it is shared by a vast number of IBM members and departments; it includes various sorts of standard ways of operating embedded procedures and software; it has required the uniformization of many existing practices and systems; it links systems and people according to a precise sequence of business purposes. Finally, it is managed through a significant set of management units and practices dedicated to its strategic management and operational deployment.

Issues like efficiency, timeliness and flexibility, together with the need for strategic alignment between the redefined processes and IBM’s globalization strategy, fill the management agenda at the top and middle levels of the organization. In this sense CRM is a typical example, though of a very large size, of what attracts the attention and the efforts of a number of consultants and managers in coping with the building and implementation of vast corporate infrastructures.

Rather than being a point of focus for our study, cases like CRM are a point of departure for a journey around the very notion of infrastructure and its management. Instead of trying to identify critical success factors for developing infrastructures, (Broadbent *et al.,* 1996) we want to investigate what is taken for granted, or left out or at the margins of the typical infrastructure management agenda. The latter is based on a set of assumptions and various forms of

obviousness that seem to hide, rather than clarify, what is at stake in managing complex infrastructures. What we aim for is a gradual "releasement" of the main implicit constraints that characterise the management discourse on infrastructure to move progressively to formulating a distinct agenda. We will first use the economic perspective on infrastructure to show some crucial limitations of the conventional management approaches. Economists point out that what for managers and consultants appears as an aberration or a limiting case is in reality much more frequent: infrastructure as installed base is more often than not "out of control", and tactics to govern it are much more subtle and limited than one gets the impression of in consulting the management agenda. The recalcitrance and wide-range effects of infrastructure, if not its autonomy, are the subjects of theories such as actor network theory that can further enlarge and make evolve the infrastructure agenda. Finally, tapping Heidegger's questioning about the essence of technology, we will establish an intriguing agenda able to evoke a new "disposition" ("management" will appear by then too strong a word) *vis-à-vis* infrastructure, and find through another case of corporate networking the embodiment of such different disposition.

In this way we will come full circle. After all, it was reading Heidegger's *Being and Time* (1977) that triggered Winograd and Flores (1987) to come up with a new vision of management as a network of commitments to cope with the breakdowns of business transactions. And it was this vision that contributed to the original conception of CRM as the new backbone of the IBM way of doing business globally. This paper is an opportunity to revisit one of the intellectual sources that gave rise, though indirectly, to CRM and use it to understand the essence of modern information infrastructures, but also to come up with a deeply-reformed agenda for taking care of them.

The plan for our discussion looks as follows. First, we describe what are the key features of a corporate infrastructure according to the management perspectives in good currency. We will point to the internal limitations and dilemmas of the relevant agenda. Second, we show how the economics concerning the development and governance of large infrastructures can contribute to open up the typical managerial agenda; namely, economics points out the severe limitations social institutions may face in trying to govern large infrastructures. The latter aspect is further elaborated by various schools of thought in the area of social studies of technology. They portray infrastructure as a network of humans and non-humans having "a life of its own"; and as an underlying institutional and cognitive context that influences behavior inside and outside organizations. On the basis of this wider understanding we turn to Heidegger's notion of technology as "*Gestell*" (enframing) and try to come up with a Heideggerian understanding about "how to cope with infrastructure?". The emerging agenda is at odds with the one we started with: the managerial. The case of corporate Internet/intranet use at Hoffmann La Roche is an instance where some of the tenets of such an alternative agenda are put in practice. An open question ends the paper: which of these agendas will be the most relevant to take care of the corporate information infrastructures in the new millennium?

The management agenda: alignment and control

Corporate infrastructure as a concept emerged in the 1980s in relation to the planning of large corporate information systems. It emphasized the standardization of systems and data throughout the corporation as a way to reconcile the centralized IS department and resources on the one hand, and the distribution of systems and applications on the other. More recent developments in networking focus on the communication (of data, documents, etc.) aspect of infrastructure. Today, managing an infrastructure to deliver effective IT capability means dealing with problems such as: aligning strategy with IT architecture and key business processes information requirements (Henderson *et al.*, 1996); universal use and access of IT resources; standardization; interoperability of systems and applications through protocols and gateways; flexibility, resilience and security. Ideally, infrastructure reconciles local variety and proliferation of applications and usages of IT with centralized planning and control over IT resources and business processes.

The boundaries and contents of infrastructure are set by defining the value of variables such as reach and scope. Reach is the number of activities or processes actually touched by the infrastructure, while scope is the type and variety of applications running on it (i.e. the range of processes being partially or totally automated through the infrastructure) (Keen, 1991). Depending on these two variables, and especially the strategic intent of the firm, infrastructure can play different roles: utility, dependence, and enabling (Weill *et al.*, 1996). In the first role, infrastructure is just a utility aimed at saving costs of processing and communicating information throughout the organization. Its architecture maximizes efficiency in processing and transmission but does not interfere much with the nature of applications or business processes. In the second case the performance of key business processes depends upon the infrastructure, like the use of an ERP package in a specific area of the business. Enabling infrastructures provide architectures and platforms for new applications and new businesses (think of Internet as a platform for electronic commerce).

Schematically, a typical management (and consulting) agenda concerning the creation and governance of a corporate infrastructure would entail the following activities:

1. •Analysis of the firm's strategic context so as to elicit the key business drivers.
2. •A joint consideration for the need to improve or transform existing business processes and infrastructure (various combinations are possible in the sequence and significance of the change in both areas). Formulation and implementation of a relevant BPR and technical change plans.
3. •Envisioning the related changes in roles, responsibilities, incentives, skills, organizational structures required by BPR and infrastructure reforms.

Empirical studies, and insightful thinking related to the actual management of infrastructures point out some problematic aspects of the pretty straightforward agenda just set out. For example, empirical findings suggest that the more firms undergo change, the higher the need for investment in infrastructure. One may ask, however, are there decreasing returns to infrastructure? (Cordella and Simon, 1997). Or, does more investment mean more sophisticated infrastructure or just facing maintenance and adaptation costs of an existing, rigid infrastructure? Relatedly, is it better to have a highly flexible infrastructure that enables the firm to seize a wide range of future, unplanned business redesign options, or a highly consistent (i.e. aligned) infrastructure with the current strategic intent? Thus, should one aim for alignment, as repeatedly suggested by the literature, or for flexibility? Extensive review of top managers' opinions seem to lead to no clear-cut conclusions (Duncan, 1995).

More in general, the models of strategic alignment, the agendas that spell out what to do in order to extract the maximum IT capability from corporate infrastructure and the empirical studies of how corporate infrastructures are developed and used in practice all seem to include the same kind of caveats. Consistently, authors suggest that (Luftman, 1996):

1. •aligning business and technology strategies is an ongoing executive responsibility: "strategic alignment is a journey, not an event";
2. •managers must be ready to learn and adapt, no matter what is the alignment pattern selected at one point in time;
3. •there are expression barriers that prevent the clear articulation of the strategic intent of the firm, and thus hamper the effort for an explicit strategic alignment;
4. •there are barriers that due to political, cultural or economic factors impede the smooth implementation of any strategic plan concerning infrastructure.

While the management agendas are very effective in guiding the formulation of an infrastructure plan, they do not give any special advice on the implementation and adaptation side. They only provide wise words of caution: the business world out there is complex and varied and changing; any of the models on which the management agenda is based should be used with a grain of salt, and so on. In other words, all the caveats repeat the same message: of course the world out there is complicated and cannot be captured fully by a static model, but that is due to the unavoidable difference between models and real life.

However, these obvious caveats and words of caution make the management agenda largely irrelevant for action, since it does not deal with the key transition between having a nice vision and producing that vision (Argyris and Schoen, 1996). Management agendas are obvious, sound and look pragmatic. In reality, they are deceivingly persuasive. They are not actionable, being highly simplified and based on sweeping generalisations and abstractions (such as "strategy", "utility", "infrastructure"). The rest of the paper is dedicated to the getting closer to the "of course", the obvious dismissal of the intricacies of "real life" that "naturally" cannot be captured by a model, to the "experience" to which the caveats implicitly make reference. It is this long journey towards the sources of obviousness that gradually will change radically the infrastructure agenda.

The economic agenda: the tactics of cultivation

The management agenda is not only deceivingly sound, simple but highly abstract: it is also too narrow. It looks at infrastructure just as a large information system, where systems and applications may be heterogeneous, but control and resource allocation can be centralized. However, the case of large, national infrastructures reminds us that the management of infrastructure goes beyond the boundaries of centralized, hierarchical control of a resource. Economics, and especially the economics of standards and network infrastructures, (Hanseth, 1996; Hanseth *et al.*, 1996) can help us in overcoming the narrow MIS mindset that lurks in many managerial discourses about infrastructure. Though not strictly relevant in our context, the problem of pricing can be a good entry point to see how economics broadens the management agenda. The problem, schematically stated, is how to price the service given by a common, collective good such as an infrastructure. The notion of pricing a public good has several facets: how to let people who use more pay more; how to avoid free riding; what is the trade off between universal service

type of delivery versus a customized service; how to reach a critical mass of infrastructure users? Who should pay for the positive and/or negative externalities generated by infrastructure use? How to cope with the issues of installed base (infrastructure inertia) and flexibility (i.e. the costs of infrastructure change)?

Beyond their economic relevance, a correct and balanced answer to all these questions is a key factor for the take off and long-term growth of any infrastructure. But they also point to another issue: the scope for control over an infrastructure can be limited, and management have to live with a resource that they can govern only in part (pending the issue of transaction costs (Coase, 1960)) Relatedly, the governance of infrastructure is a problem, not a given, since there can be multiple stakeholders with conflicting interests. The outcome is that the infrastructure can expand and grow in directions and to an extent that is largely outside the control of any individual stakeholder.

Second, building large infrastructures takes time. All elements are connected. As time passes, new requirements appear which the infrastructure has to adapt to. A whole infrastructure cannot be changed instantly - the new has to be connected to the old. The new version must be designed in a way making the old and the new linked together and "interoperable" in one way or another. Hence, the old - the installed base - heavily influences how the new can be designed. Infrastructures develop through extending and improving the installed base (Hanseth, 1996).

The focus on infrastructure as "installed base" implies that infrastructures are considered as always already existing, they are never developed from scratch. When "designing" a "new" infrastructure, it will always be integrated into and thereby extending others, or it will replace one part of another infrastructure. This has been the case in the building of all transport infrastructures. Every single road - even the first one if it makes sense to speak about such - has been built in this way; when air traffic infrastructures have been built, they have been tightly interwoven with road and railway networks - one needed these other infrastructures to travel between airports and the end points of the travels. Air traffic infrastructures can only be used for one part of a travel, and without infrastructures supporting the rest, isolated air traffic infrastructures would be useless.

A large information infrastructure is not just hard to change. It might also be a powerful actor influencing its own future life - its extension and size as well as its form. Consider the issue of "standards" as a part of a more general phenomenon labelled "self-reinforcing mechanisms" (Arthur, 1988; 1996) and "network externalities" (Katz and Shapiro, 1986). Self-reinforcing mechanisms appear when the value of a particular product or technology for individual adopters increases as the number of adopters grows. A standard which builds up an installed base ahead of its competitors becomes cumulatively more attractive, making the choice of standards "path dependent" and highly influenced by a small advantage gained in the early stages. Thus, the development and diffusion of infrastructural technologies are determined by "the overriding importance of standards and the installed base compared to conventional strategies concentrating on programme quality and other promotional efforts" (Grindley, 1995).

Self-reinforcing mechanisms are, according to Arthur (1996), outside the scope of traditional, neo-classical economy, focusing on diminishing return on investment (utilization of natural resources being the paradigm example). Schematically, there are four sources of self-reinforcing processes (Arthur, 1988): large set-up or fixed costs; learning effects (improvement through experience); coordination effects (advantages in going along with others); and adaptive expectations. Key effects of self-reinforcing mechanisms are:

1. •*Path-dependence:* i.e. passed events will have large impacts on future development and in principle irrelevant events may turn out to have tremendous effects.
2. •*Lock-in:* i.e. when a technology has been adopted it will be impossible to develop competing technologies. "Once random economic events select a particular path, the choice become locked-in regardless of the advantages of alternatives" (Arthur, 1996).
3. •*Possible inefficiency:* i.e. the best solution may not necessarily win (David, 1987).

Information infrastructures are paradigmatic examples of phenomena where "network externalities" and positive feedback (increasing return on adoption) are crucial, and accordingly technologies easily being "locked-in" and turning irreversible. All factors mentioned above apply. The positive feedback from new adopters (users) is strong. The usefulness is not only dependent on the number of users, in case of e-mail for instance, the usefulness is to a large extent its number of users. Technology becomes hard to change as successful changes need to be compatible with the installed base. As the number of users grows, reaching agreement about new features as well as coordinating transitions becomes increasingly difficult. Vendors develop products implementing a standard, new technologies are built on top of it. As the installed base grows, institutions like standardization bodies are established, and the interests vested in the technology expand.

It follows that designing and governing an infrastructure differs from designing an MIS, due to the far-reaching influence of the installed base and the self-reinforcing mechanisms pointed out by the economists. The very scope of the management agenda should change. Infrastructure is not just a complex, shared tool that management are free to align according to their strategy. The economic perspective highlights a much more limited and opportunistic

agenda involving trade-offs and dilemmas, and a number of tactics. David (1987) points out three dilemmas and corresponding tactics one usually faces when developing networking technologies:

1. *Narrow policy window.* There may be only brief and uncertain "windows in time", during which effective interventions can be made at moderate resource costs.
2. *Blind giants.* Decision makers are likely to have greatest power to influence the future trajectories of network technologies, just when a suitable informational basis on which to make system-wide optimal choices among alternatives is most lacking. These actors, then, resemble "blind giants" - whose vision we would wish to improve before their power dissipates.
3. *Angry orphans.* Some groups of users will be left "orphaned"; they will have sunk investments in systems whose maintenance and further development are going to be discontinued. Building gateway devices linking otherwise incompatible systems can help to minimize the static economic losses incurred by orphans.

One tactic David (1987) finds worth considering is that of "counter-action" - i.e. to prevent the "policy window" from slamming shut, before the policy makers are better able to perceive the shape of their relevant future options. This requires positive action to maintain leverage over the "systems rivalry", preventing any of the presently available variants from becoming too deeply entrenched as a standard, and so gathering more information about technological opportunities even at the cost of immediate losses in operations efficiency.

Possibly, the most important remedy to help overcome the negative effects of positive feedback and network externalities, i.e. lock-in and inefficiency, is the construction of gateways and adapters (Braa and Sandahl, 1998; David and Bunn, 1988; Hanseth and Monteiro, 1998; Katz and Shapiro, 1986). Gateways may connect heterogeneous networks, being built independently or based on different versions of the same standards. David and Bunn (1988) argue that " in addition to short-run resource saving effects, the evolution of a network technology can be strongly influenced by the availability of a gateway innovation".

Relying on all these, and other tactics, changes deeply the scope of the management agenda. While from a technical and strictly managerial perspective the business is to design, build, align and control an infrastructure, the thrust of the economic understanding of the dynamics of infrastructures would point out that "cultivating" (Dahlbom and Janlert, 1996) an installed base is a wiser and sounder strategy. The concept of cultivation focuses on the limits of rational, human control. Technological systems are regarded as "organisms with a life of their own" and cultivating means developing tactics of interference with such an organism. "Cultivation is a conservative belief in the power of natural systems to withstand our effort at design, either by disarming them or by ruining them by breakdown" (Dahlbom and Janlert, 1996).

Social studies of technology: who sets the agenda for whom?

Considering technological systems as organisms "with a life of their own" implies, possibly to the extreme, that one can look at existing technology itself as an actor. Infrastructures are then socio-technical networks where components, usually considered as social or technological, are linked together into networks. The "development organization" as well as the "product" being developed are considered unified socio-technical networks (Callon, 1991; Latour, 1991). Acknowledging the importance of the installed base implies that traditional notions of design as performed by humans only have to be rejected. The idea of cultivation as the outcome of design carried out by multiple agents (one of which is for example the installed base or the infrastructure standards) captures quite effectively the role of both humans and technology. The installed base is a powerful actor. Its future cannot be consciously designed, but designers do have influence - they might cultivate it. But what is the actual level of agency one can attribute to infrastructure? The installed base acts in two ways. It can be regarded as an actor involved in each single development activity, but perhaps more importantly, it plays a crucial role as a mediator and coordinator between the independent non-technological actors and development activities. If humans strive for control, i.e. making the world appropriate for engineering tasks, strategies for cultivating infrastructures should be considered strategies for fighting against the power of the installed base (Monteiro and Hanseth, 1995).

To enrich the infrastructure management agenda along this line of reasoning we tap in what follows various streams of research stemming from the area that can be broadly labelled social studies of science and technology.

Actor network theory sees technological, human and social elements as linked together into networks, based on the assumption that technologies are always defined to work in an environment including non-technological elements - without which the technology would be meaningless and would not work. In the same way, humans use non-human objects (technologies and other artifacts) in all their dealings - our existence in the world is based on the existence of these very objects. Neither humans nor technological artifacts should be considered as pure, isolated elements, but as heterogeneous networks. Elements in such a network are not initially defined as human, social or technological, they

are referred to by a common term - “actant”. These assumptions do not deny any differences - or borders - between what is social or human and what is technological. However, these borders are seen as negotiated, not as given.
Two concepts from actor network theory are of particular relevance for enlarging our infrastructure agenda: inscription (Akrich, 1992; Akrich and Latour, 1992) and translation (Callon, 1991; 1994; Latour, 1987).
The notion of inscription refers to the way technical artifacts embody patterns of use. During the design, the designer works out a scenario for how the infrastructure will be used. This scenario is inscribed into it. The inscription includes programs of action for the users, and it defines roles to be played by users and the infrastructure. By inscribing programs of action into a piece of technology, for example through BPR, technology becomes an “actant” imposing its inscribed program of action on its users. To have any effect, programs of action should not only be inscribed into isolated technological components, but rather aligned networks of technologies, humans and social institutions.
The inscribed patterns of use may not succeed because the actual use deviates from it. Rather than following its assigned program of action, a user may use the system in an unanticipated way, he/she may follow an anti-program (Latour, 1991). When studying the use of technical artifacts one necessarily shifts back and forth “between the designer’s projected user and the real user” in order to describe this dynamic negotiation process of design (Akrich, 1992, p. 209).
The strength of inscriptions, whether they must be followed or can be avoided, depends on the irreversibility of the actor-network they are inscribed into. It is never possible to know beforehand, but by studying the sequence of attempted inscriptions one can learn more about exactly how and which inscriptions were needed to achieve a given aim.
A different style of managing alignment emerges. Stability and social order, according to actor network theory, are continually negotiated as a social process of aligning interests. As actors from the outset have a diverse set of interests, stability rests crucially on the ability to translate, that is, re-interpret, re-present or appropriate, others’ interests to one’s own.
Design is translation - “users’” and others’ interests may, according to typical ideal models, be translated into specific “needs”, the specific needs are further translated into more general and unified needs so that these might be translated into one and the same solution.
Designing technology is more than the design of pure, isolated technological artifacts. These are designed together with non-technological elements like documents, work practices, organizational rules and structures, training programs, etc. When a solution is working, all these elements constitute an aligned heterogeneous network. When making these aligned networks, existing technology will also be re-interpreted, inventing new ways of using it.
As in economics, also the social studies of technology indicate that a key feature of infrastructure is the difficulty of changing them as they are growing. Callon’s concept of the (possible) irreversibility of an aligned network captures the accumulated resistance against change quite nicely (Callon, 1991; 1994; Hanseth and Monteiro, 1997). It describes how translations between actor-networks are made durable, how they can resist assaults from competing translations. The degree of irreversibility depends on the extent to which it is subsequently impossible to go back to a point where that translation was only one amongst others, and the extent to which it shapes and determines subsequent translations.
The crucial issue in design of infrastructures, as seen by the designers and managers as well from the economic perspective presented above, is the settlement of standards[1]. 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.
This view is not acknowledged in the STS field. The maybe 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 (theories, facts, technologies) are constructed as the context is deleted, basically by being taken as given, in the same way as other universals are infrastructure standards in fact “local” (Bowker and Star, 1994; Timmermans and Berg, 1997). They are not pure technical artifacts, but rather complex heterogeneous actor-networks (Hanseth and Monteiro, 1997; Star and Ruhleder, 1996). When a classification and coding system like ICD[2] is used, it is embedded into local practices. The meaning of the codes depends on that practice (Bowker and Star, 1994).
All universals are shaped by their history and context of origin and the interests of its originators. They are not objectively reflecting some reality (in case of scientific facts of theories) or neutral tools (in case of universal technologies). They embed social and political elements.

Based on this perspective, infrastructures should rather be built by establishing working local solutions supporting local practices which subsequently are linked together rather than by defining universal standards and subsequently implementing them.

A very famous study of infrastructure is Thomas P. Hughes' (1983) work on the development of electricity networks. His work can be read as an actor-network theory study, and accordingly seen as an actor-network theory based theory about infrastructure[3]. Hughes defines a "technological system" as a heterogeneous collection of technical components, humans and institutions which includes the pure "technical" system, its designers and support organization, regulating bodies, etc. Such systems are both socially constructed and society shaping. They are actor-networks.

Large technological systems seem to evolve in accordance with a loosely defined pattern. According to Hughes, they tend to acquire what he calls style and momentum as they mature. Technological systems have a mass of technical and organizational components; they possess direction, or goals; and they display a rate of growth suggesting velocity. The large mass of a technological system arises especially from the organizations and people committed by various interests to the system. Manufacturing corporations, public and private utilities, industrial and government research laboratories, investment and banking houses, sections of technical and scientific societies, departments in educational institutions, and regulatory bodies add greatly to the momentum of modern electric light and power systems. Inventors, engineers, scientists, managers, owners, investors, financiers, civil servants, and politicians often have interests in the growth and durability of a system. And as a system grows, it becomes more attractive for others to adapt to it. This makes Hughes' concept of momentum closely related to the self-reinforcing processes at the center of the economics of standards. The development of the Internet, including all its designers, standardization bodies and local network operators, is a good example of a technological system with considerable momentum.

In the development of infrastructures and infrastructure technologies, a phenomenon Hughes (1983; 1987) calls "reverse salients" (corresponding to the phenomenon Rosenberg (1994) calls "technical imbalance") plays important roles. Reverse salients denote those elements that are "lagging behind" and for that reason causing major problems for the further development of the whole technological system. When a reverse salient cannot be corrected within the context of an existing system, the problem becomes a radical one, the solution of which may bring a new and competing system.

In the early 1880s, direct current was turned into such a reverse salient, as the voltage could not be transformed across long distances. A "battle of the systems" then ensued between alternating and direct current, culminating in the 1890s, not with victor and vanquished, but with the invention of devices, i.e. gateways, making possible the interconnection of the two systems.

Exploiting the momentum of existing installed bases as underlying infrastructures, i.e. translating them into allies, will always be important when establishing new infrastructures. To make an infrastructure "grow", it needs to be planted in "fertile soil". The potential success of this strategy is illustrated by the way World Wide Web has been designed to build on the existing Internet. To escape the reverse salients of an installed base that seems unwilling to adapt to new requirements, moving its users to a new one connected through gateways is the maybe most important strategy.

Adaptation is a response to different environments and adaptation to environments culminates in style. There are countless examples in this century of variation in technological style. A 1920 map of electricity supply in London, Paris, Berlin, and Chicago reveals, to Hughes, remarkable variation from city to city in the size, number, and location of the power plants. The striking variation was not in the amount of light and power generated, but in the way in which it was generated, transmitted, and distributed. The differences were primarily due to variation in regulatory legislation that expressed fundamental political values. Natural geography and regional and national historical experiences are also factors Hughes found to shape technological styles.

By having "style" infrastructures embody a representation of the functioning of the organizations they support, especially when they are deployed with joint efforts of BPR (Broadbent *et al.*, 1995). In other words, infrastructures are not just made of networks, data flows and work procedures, but also are embodiments, or "vehicles", of emerging modes of work organization, of new cognitive imageries and institutional arrangements. More specifically, they interact with both the structural and institutional arrangements associated to a given division of labour, and the assumptions, frames and mental images people hold while routinely enacting and practicing that specific division of labour: infrastructures are immersed and nurture "cognitive ecologies".

Infrastructures can then be regarded as "formative contexts", i.e. sets of the pre-existing institutional arrangements, cognitive frames and imageries that actors bring and routinely enact in a situation of action (Ciborra and Lanzara, 1994). As such, they constitute the background condition for action, enforcing constraints, giving direction and meaning, and setting the range of opportunities for undertaking action. Infrastructure as a formative context can

shape both the organization of work and the set of social scripts which govern the invention of alternative forms of work, the future ways of problem-solving and conflict resolution, the revision of the existing institutional arrangements and the plans for their further transformation.
Infrastructures as formative contexts show a pasted-up nature, and a makeshift one, where old and new systems, artifacts and practices (automated and manual) are tested, discarded, retrieved, collated and combined over time. Typically infrastructures are subject to "shift and drift" phenomena (Berg, 1997; Ciborra, 1996). The ways they are implemented and used never fully correspond to the original plans and visions, and design processes more often than not take paths unthought of at the start, almost beyond the actors' will. Thus infrastructures possess an open nature and are subject to continuous reinvention, i.e. to an innovative adoption process carried out by the users themselves. In part, they are characterized by formalized components, such as hardware, software, rules, functions etc., but these do not completely dispose of how infrastructures behave in everyday life. Surrounding these stylized components, usually laid down as a result of *ex ante* design, there are routines and interventions carried out by users who may take unplanned courses of action or by designers who happen to be temporarily with the project, introduce quirky or irreversible design choices, and then leave. All these routines and interventions are continuously developed, tried out, retained or discarded, retrieved and combined, on a local, often tacit basis, outside or at the margins of the master plans and designs, in an endless process of *bricolage* (Ciborra, 1994). In sum, infrastructure as formative context possesses a double nature. On the one hand, it appears to be highly stable and inescapable, given its pervasiveness; on the other it is the culture bed for experiments in organizational restructuring and innovation, within certain economic and technical constraints. A regimen of permanent, ineliminable fluctuations characterizes infrastructures in use.

Infrastructure as *Gestell*

In describing the general features of CRM, IBM's initiative to set up a global new infrastructure made of redesigned processes supported by an array of IT tools, we found two sides of the phenomenon. The apparent one is that CRM has been developed and managed according to the "classical" tenets of the managerial literature on BPR. The not so explicit, or actually hidden side is that the basic "philosophy" of CRM was influenced by the vision of management as networks of commitments developed by Winograd and Flores (1987): the task of management is to cope with breakdowns of business transactions by completing all the necessary negotiation and coordination loops needed to executing a transaction. Such vision of what management, information and decision making is all about is based on the attempt to bringing Heidegger's philosophy to bear on to the field of business organizations and information systems. Specifically, notions such as "being thrown into the world", engagement, breakdowns and ready-to-hand tools are picked up by Winograd and Flores and harnessed to deliver both a new perspective of the management of business processes and the design of IT tools (of which the software coordinator was the concrete implementation). After the broader endeavour by Dreyfus (1982) to bring phenomenology to bear into the field of IT and in particular artificial intelligence, the one of Winograd and Flores has been perhaps the most influential attempt in this direction. They were followed by further contributions. Specifically, Ehn (1989) has focused on the key metaphor of IT as a tool ready to use, in order to develop ideas about the design of user interfaces that can render information systems less conspicuous in the work flow. More recently, Kallinikos (1995) carries out a brilliant study of the "*vorstellen*" (representing) property of technology. Introna (1997) revisits the world of management, information and power in light of Heidegger's work in a comprehensive way, though he does not focus on the specific role of technology. Today the latter seems to be still the domain of interest of the philosophers (Feenberg, 1998), who try to go beyond the more strictly exegetical study of Heidegger's writings on technology and see whether a new radicalizing philosophy of technology can be put forward.
In what follows, our focus will be on the question of technology as discussed by Heidegger and the notion of infrastructure and its relevant management agenda, while we leave to another occasion the analysis of the management of business transactions as networks of commitments, how they are implemented in CRM and other instances (Ciborra, 1999).
We submit that the works of Winograd and Flores (1987) and Ehn (1989) need to be overcome. Namely, they convey, especially the latter, the idea that Heidegger's conception of technology can be found in the notion of "tool". This is misleading. Heidegger in his major work "*Sein und Zeit*" (1977) focuses on the notion of tool to describe phenomenologically how we encounter the world. We do not encounter it as an assemblage of objects we can describe geometrically or physically, but as "in order to" devices endowed with functions. As such we "use" the objects before describing them. Description is only a very peculiar and selective instance of taking care of the world: the measuring and scientific one. The relevance and modernity of those pages of Heidegger's major work for the field of user-interface design of computer systems could not go unnoticed. However, this is *not* what Heidegger had to say about modern technology, the latter being in its essence anything *but* a tool.

For Heidegger (1978) the essence of modern technology is denoted by the German word "*Gestell*". *Gestell* means in German "skeleton", frame or shelf. Note, in passing, that the word "*Untergestell*" means chassis and infrastructure (again meant as a light physical support).
But Heidegger uses the word *Gestell* in a new sense stemming from the two parts composing the word in German: the prefix "*Ge*" and the word "*Stelle"* derived from the verb "*stellen*". "*Ge*" in German is the prefix that denotes reunion, gathering, or collecting and reassembling (think of *Ge-sellschaft* = society; or *Ge-meinschaft* = community; or, the example introduced by Heidegger himself, *Gebirge* = mountain (*Bergen*) chain). *Stelle* and *stellen* have a variety of meanings. The noun means place, spot, location. The verb means generically put, place, stand, set, arrange, regulate, provide, order, etc.
Thus, *Gestell* means literally the reunion of the placing, arranging, regulating, ordering. Of what, and how? And what has such a reunion to do with technology? First, Heidegger suggests that the essence of technology is not something technical, i.e. linked to the more or less fascinating technical aspects of highly sophisticated tools for production, transport, communication, or power generation.
The essence of technology as a phenomenon lies beyond the appearances. Specifically, Heidegger (1977) approaches what lies behind the captivating appearances of modern technology from two slightly different angles.
In his 1949 Bremer lectures, Heidegger (1994) starts by remarking that despite the power of modern technology of shortening distances, things remain for us still far. "All the mastering of farness does not deliver any proximity", rather we experience the world as an undifferentiated "without distance". But such a "without distance" has definitely a place: it constitutes the stock or standing reserve (*Bestand*) of all what is available (present-at-hand).
What supplies this stock of undifferentiated resources that represent the world as experienced by the modern man? It is the supplying itself (*bestellen*) that is, the infinite chain of actions of ordering, requiring, demand and supply.
"The forester who measures the felled timber in the woods is today ordered by the industry that produces commercial woods, whether he knows it or not. He is made subordinate to the orderability of cellulose, which for its part is challenged forth by the need for paper, which is then delivered to newspapers and illustrated magazines. The latter, in their turn, set public opinion to swallowing what is printed, so that a set configuration of opinion becomes available on demand" (Heidegger, 1994).
Man far from being the master of this enchaining process is, under various forms, as a worker, a manager, or a citizen who reads the newspapers, "employed" (i.e. ordered and organized) by this process, thus becoming himself part of that standing-reserve. This circulation process is self-feeding and leads to nothing else than its perpetuation. The process becomes so universal to embrace the world, nature, history and the destiny of mankind.
The gathering of the multiple actions of ordering and their enchainment is called *Gestell*[4]. The *Gestell* captures all that is extant and makes it available through a stock to be put in circulation. Machines are built and applied, science generates new solutions that get converted into new systems and applications because of the *Gestell*, not the other way around. Nature itself loses the property of being an object (*Gegen-stand*) and becomes *Be-stand*, i.e. standing reserve of available resources to be exploited in the process of circulation.
It is because of this "distortion" in what we encounter as real, things, people, the world, that "machines created by the technology can only shorten distances, but at the same time do not bring about any proximity, precisely because the essence of the technology does not give access to proximity and farness", but just undifferentiated, average availability (Heidegger, 1994).
The second approach to the definition of *Gestell* is employed by Heidegger (1978) in his later Munich conference on "The question concerning technology". There, Heidegger starts directly from the instrumental definition of technology (a tool, a means to an end) and inquires into the notion of instrumentality, i.e. causality. Causality as a way "bringing-forth", presenting. The essence of technology lies in its capacity to bring forth, to reveal.
"The revealing that rules in modern technology is a challenging", setting on resources, putting nature and man to demand to yield. It is a way of expediting, of driving on to the maximum yield. "Such challenging happens in that the energy concealed in nature is unlocked, what is unlocked is transformed, what is transformed is stored up, what is stored up is in turn distributed, and what is distributed is switched about ever anew. Unlocking, transforming, storing distributing, and switching about are ways of revealing" (Heidegger, 1978). Again, *Gestell* refers to the ways through which the ordering and setting up unveils what is extant as standing reserve of resources (including human) made available for future deployment.
We are now in the position of looking at the links between *Gestell*, or the essence of modern technology as arrived at by Heidegger, and some key aspects of the modern corporate information highways.
First, the emphasis put by Heidegger on the enchained processes of ordering highlights a paramount aspect of how infrastructure is conceived today by the management literature. Networks are not only there to facilitate communication, but to reduce costs of transacting, in supporting the alignment, disintermediation and interlocking of business processes within and between organizations. This is precisely the phenomenon of the intertwining of

networks and computers as a layer on which enterprise packages can run to implement the linking of business processes (ERP) and the management of the workflow, for example as prescribed by methodologies like BPR. Second the self-feeding nature of such a process, and its reliance on planning and standards emerged as central themes of the economics literature, are also included in the *Gestell.* Standards, network externalities, imitation are all factors that contribute to the momentum of the self-feeding process of infrastructure development and diffusion. Furthermore, note how the way in which Heidegger defines *Gestell* as a reunion of ordering process, or even literally as "a frame that sets up", overcomes in a felicitous way the dichotomy between the "structural", i.e. static, aspects of infrastructure and their dynamics. In *Gestell* both dimensions are hosted, while the term infrastructure seems to privilege the structural aspects only.
More uncertain remains the role of characteristics such as installed base and irreversibility. They could be linked to the notion of standing reserve, but in our modern vision of infrastructure it is the inertia of the successive accumulation of systems and applications the outstanding feature of such a reserve. Heidegger, instead, seems to pinpoint the process of accumulation of "resources" made available as future input to the relentless ordering process. Of the dynamics aspects of the technology, *Gestell* seems to give a priority to its accelerating, self-feeding aspects, while the study of infrastructures puts at least an equal emphasis on the inertial effects, eventually as the key determining factor of the quasi-autonomous nature of sophisticated system technologies in modern organizations. In this respect Feenberg (1998) argues that the unilateral way of looking at the implications of *Gestell,* are due to the "unhistorical understanding of essence (in this case of the technology) to which most philosophers are committed". In order to capture the phenomena of resistance to and diversion of the *Gestell*, one should focus on the "socially concrete stages of development that itself has an essential logic we need to uncover" (Feenberg, 1998). A first attempt in this direction has been done by studying the unfolding of infrastructures in a number of large corporations (including IBM - see above) (Ciborra, 1999). This study provides also material to consider a final aspect of our essay: is there scope for an "Heideggerian agenda" in dealing with information infrastructures?

Towards an Heideggerian agenda? The case of Hoffmann La Roche

Heidegger's ideas about "what to do" are developed in a successive step of his inquiry into the essence of technology, namely around the notion of danger (*Gefahr*) (Heidegger, 1994).
Gestell does not deliver the nearness to things. It does not deliver "the world" (that is the "there" where man's existence unfolds). Everything instead is just undifferentiated standing reserve of resources ready to be deployed. *Gestell* becomes the world, but a world of a special kind, that can subsist only thanks to the oblivion of the authentic one. Through oblivion *Gestell* chases away "the world". This chasing represents, according to Heidegger, the essence of the *Gestell:* it is the danger. With a play of words, the danger is the essence of the essence of technology. However, Heidegger does not commit himself to a favourable or negative stance towards technology. He states that such stances belong to the technical discourse on technology, and do not deal with its essence. They implicitly assume technology as a set of tools, that can be good or bad, be deployed in a positive or negative way. These stances address only the "instrumental" dimension of technology, i.e. they adhere to the technical discourse on technology missing that which is non-technical (non-instrumental) in the essence of technology.
What is the essence of the danger, then? It is that *Gestell* comes to represent what "is" and what "is not". The danger lies in the fact that *Gestell* delivers "representations" of all that subsists, and these become the "real world". If one can talk about the domination of technology, one should speak of "the domination of the essence of the technology that orders in its appropriating even and precisely the representations man makes about it The essence of technology, the *Gestell,* carries out its own simulation" (Heidegger, 1994). The outcome of such representing and simulation is the essence of the danger, able to encompass any discourse pro or con the technology and its effects (see on all these aspects the thorough analysis of Kallinikos, 1995).
More radically, technology works outside the sphere of means and ends. It is not an object, or a tool among many. Rather, it is the hidden trait of all that today is "real". In sum, "Heidegger's concern is the human distress caused by the technological understanding of being, rather than the destruction caused by specific technologies The danger, then, is not the destruction of nature or culture but certain totalizing kinds of practices - a levelling of our understanding of being" (Dreyfus, 1993).
Recall what we discussed in relation to the social studies of technology, i.e. the contextual, i.e. at the same time cognitive and institutional, role of infrastructure. We can, then, appreciate the relevance of Heidegger's thought. Information infrastructures can, as formative contexts, shape not only the work routines, but also the ways people look at practices, consider them "natural" and give them their overarching character of (false - see Unger (1987)) necessity. Infrastructure becomes an essential factor shaping the taken-for-grantedness of organizational practices. Imagining, world views and reform initiatives, or new designs are moulded by the subtle and hidden influence of infrastructures.

How to deal with “the danger”? Again, Heidegger avoids falling into the “easy” role of being a romantic and reactionary critic of technology (as a mistaken and superficial reading of his works on the subject has led some to conclude). His argument, as Dreyfus (1993) has aptly noted, is much more open, subtle and complex.
Gestell having the power to enact a world in which everything is a resource available to yield would seem to leave little hope for any change, since any change or even debate about change would be somehow “supervised” and governed by the *Gestell* itself (precisely as a formative context). Recalling Hölderlin’s verses, Heidegger (1978) does not agree with such a conclusion, and submits that where the greatest danger lies, also lies the opportunity for rescue. “Although a technological understanding of being is our destiny, it is not our fate Although the technological understanding of being governs the way things have to show up for us, we can be open to a transformation of our current cultural clearing” (Dreyfus, 1993). It is in the nature of destiny that in a sudden, unpredictable moment the destiny of being can lead itself onto other unexpected, and different directions. These other directions will not put aside the technology, the essence of which still delivers the world through the *Gestell*, but such an essence will be able “to heal itself, by finding its hidden truth” (Heidegger, 1994). This shift of gears cannot have anything to do with a destiny that can be planned in a logical and historical way, nor as “the outcome of a process of history that can be constructed”, or “managed” we may add. Heidegger indicates a few ways in which such a sudden transformation can concern man:

1. •*Releasement*, that is a comportment toward technology which expresses a “yes” and a “no” simultaneously. “We let technical devices enter our daily life, and at the same time leave them outside” (Heidegger, 1992).
2. •*Openness to the mystery*, in order to remain open to the meaning hidden in technology, and the rehabilitation of astonishment at that which is.
3. •*A new sense of responsibility.* The traditional notion of responsibility means to be in control of what comes from us. Releasement, instead, implies responsibility in accepting what is largely beyond our control, the unforeseen.
4. •*Shifting fluctuations to the center stage.* “Take up practices that are now at the margins of our culture and make them central, while de-emphasising practices now central to our cultural self-understanding” (Dreyfus, 1993).

Surprisingly, in our investigation on the present practices of infrastructure deployment and management, we encountered at least one significant case where the relationship between organization and technology is enacted according to a “releasement” approach. With this example, that runs against our initial one of a radical, centralized and global process redesign (CRM), we conclude outlining the practical implications of the four main points above, which might denote as steps towards a Heideggerian agenda concerning modern technology, and information infrastructures in particular.
The case in question is the one of the use of Intranet and Internet technology as the backbone of strategic marketing at Hoffmann La Roche (hence Roche), the number six pharmaceutical company in the world.
The strategic marketing function at Roche’s headquarters in Basel comprises a couple of hundred people. This function was created in the 1980s to centralize and globalize Roche marketing worldwide. At the same time, the headquarters must operate with national companies (affiliates) that still have a strong power and autonomy in the local markets. So far, there is no new process re-engineering aimed at streamlining and unifying marketing worldwide. Adaptation to local markets, and especially national regulations, has still a paramount importance that impedes the enactment of fully global processes (the pharmaceutical industry belongs to the class of heavily regulated industries).
Marketing a pharmaceutical product is as “knowledge intensive” as many other activities in a pharmaceutical company. Knowledge is created in developing a new product; knowledge emerges from the clinical trials and is consolidated in the new drug application; further knowledge is acquired and processed once the product is in use. Knowledge comes from various sources, inside and outside the company, and is continually gathered, processed and communicated throughout the product life cycle. Strategic marketing sifts, filters, accumulates and distributes the knowledge necessary to market a product worldwide. Strategic marketing can only intervene in and influence indirectly the local marketing activities, namely by providing the background knowledge that is essential to carry out marketing in each country. Such knowledge has many forms and supports: training on the product features; clinical test information, both before the launch of the product and after; prescription strategies etc. Most of the knowledge is a “template” that has to be locally adapted, enriched and modified.
In the second half of the 1980s strategic marketing championed a major technological innovation: the establishment of the first corporate network, supporting a variety of applications. The purpose of the network and its applications, that went under the name of MedNet, was to further increase the levels of globalization and integration through standardization. MedNet had many of the properties of a *Gestell* (Ciborra, 1996).

But after eight years of development the use of the applications running on the network, - consulting literature, accessing clinical trials data, office automation applications, etc. - was very low, with some affiliates developing competing systems of their own, like Roche France adopting an alternative platform: the Minitel (MedTel), or others using Internet.
Despite repeated attempts at "internal marketing" MedNet, it was eventually discontinued in the mid 1990s. Its negative aspects, especially the costs affiliates had to bear, compared to the low level of use dictated its end. The purely technical infrastructure remained in place, while the application portfolio was phased out. Since a couple of years ago a new array of Intranet and Internet applications have taken the place of MedNet.
Intranet/Internet in Roche do not only represent an infrastructure, but also a new style of networking and IT use. In contrast with the headquarters-based formative context hidden in the MedNet concept, the one of a centralizing bureaucracy wanting to harness IT to standardize local behaviour, Internet/Intranet provide an emerging formative context, the one of decentralization, autonomy and loose coupling. Headquarters use a "releasing" attitude to accompany, and so far not impede or slow down, the unfolding of this context both in the product areas and in the affiliates.
No big plan is guiding the deployment of the new infrastructure. Actually, the no plan/ no strategy attitude seems to be most favourable to let the directions and issues of Web use emerge: the process is not mature enough to be managed; it is still in a "discovering" stage; and as such is nurtured and "cultivated". The fact that Internet/Intranet cost less, or at least much less than MedNet favours the hands off, releasing attitude of top management. In the new practice, while possibly a new context for doing business is emerging, terms like alignment or BPR simply have no meaning: they lack a relevant management context. Words like drifting, *bricolage* and cultivation seem to better capture what is going on today, not only in the affiliates, but in the very headquarters among the various product areas.
One can thus find in the Roche case an alternative model of infrastructure development and diffusion from the one of top down, strategic alignment. There is no strong top down direction, but releasement; no alignment *by fiat*, but loosely coupling between local context and technology initiatives. Thus, the infrastructure expands by the decentralized linking of local initiatives that are born as spin-offs of headquarters' initiatives. The latter constitute a reference model for imitation, and provide the content allowing the local Web sites to be built already with a minimal (critical mass) content. The "grassroots" initiatives enjoy two key features: they are local (and sometimes expressed in the local language - while MedNet was always at fault in this respect), and they retain a link with the headquarters' content.
The power of the periphery is harnessed to reinforce the diffusion of the infrastructure, and not as a source of resistance. Affiliates, or product areas can refuse to adopt other products', or countries' or headquarters' templates, when developing their own sites, or, they can simply say no to building a site or accessing an existing one.
What is striking is that all this seems to fit nicely with the way knowledge is managed in Roche marketing activities: key knowledge is centrally created around the development of the product, but a lot of complementary knowledge is generated and resident close to local markets. The intranet/Internet as a technical infrastructure, and the present management approach, a mixture of releasement and cultivating strategies, seem to fit the loosely coupled nature of knowledge distribution within and across the business. In a managerial perspective, it is a case of a surprising "alignment and fit" through the decoupling of tools, processes, local and central practices, in the aftermath of the hard and costly lesson learned from the MedNet failure: the impossibility of enforced, top down alignment. From a philosophical perspective, it highlights that even in current business practices of large multinationals, possibly for those which are highly knowledge intensive, an authentic Heideggerian agenda, not the one centered on the notions of tool and breakdown fixing, but the one of releasement in front of the *Gestell*, may be still highly relevant.

Notes

1. Standards are found everywhere, and as such they have been much in focus STS. Standards is indeed *the* issue addressed in STS. Not primarily technological standards, but rather standards in form of universal scientific facts and theories. These studies also have something to tell about information infrastructure standards.
2. ICD, International Classification of Diseases, has been defined under the authority of WHO, and is used in health care institutions in most of the world.
3. The similarity between Hughes' work and ANT is pointed to both by Hughes (1987, p. 77; 1994, p. 102) and Michel Callon (1987, p. 101). The system concept presupposes usually that a distinction can be made between the system itself and its environment. The actor-network concept has the advantage of avoiding this type of problem and the many difficult questions concerning methodology it raises. According to Callon (1987) Hughes avoids this pitfall by using the systems concept in a pragmatic way. By continuously stressing all the connections linking the "inside" and the "outside" of the system, he comes close to the actor-network concept.

4. The most frequent English translation of *Gestell* is “enframing”. Alternative translations are “the compositing” or simply “composite”: both suggestions aim at retaining the original meaning of “*stellen*” in English, although they seem, alas!, to lack the “enframing” effect.

References

Akrich, M. (1992), “The description of technical objects”, in Bijker, W.E. and Law, J. (Eds), *Shaping Technology/Building Society*, MIT Press, Cambridge, MA, pp. 205-24.
Akrich, M and Latour, B. (1992), “A summary of a convenient vocabulary for the semiotics of human and nonhuman assemblies”, in Bijker, W.E. and Law, J. (Eds), *Shaping Technology/ Building Society*, MIT Press, Cambridge, MA, pp. 259-64.
Argyris, C. and Schoen, D. (1996), *Organizational Learning II*, Addison Wesley, Reading, MA.
Arthur, B. (1988), “Self-reinforcing mechanisms in economics”, in Anderson, P.W.*et al*.(Eds), The Economy as an Evolving Complex System, Perseus Press, New York, NY.
Arthur, B. (1996), “Increasing returns and the two worlds of business”, *Harvard Business Review*, July-August.
Berg, M. (1997), “On forms, containers, and the electronic medical record: some tools for a sociology of the formal”, *Science, Technology and Human Values*, Vol. 22 No. 4, pp. 403-31.
Bowker, G. and Star, S.L. (1994), “Knowledge and infrastructure in international information management. Problems of classification and coding”, in Bud-Frierman, L. (Ed.), *Information Acumen. The Understanding and Use of Knowledge in Modern Business*, Routledge, New York, NY, pp. 187-213.
Braa, K. and Sandahl, T. (1998), “Documents in infrastructures - challenges for design”, in Baets, W.R.J. (Ed.), *Proceedings from 6th European Conference on Information Systems*, Euro-Arab Management School, Granada, Spain, pp. 1025-40.
Broadbent, M. and Weill, P. (1997), “Management by maxim: how business and IT managers can create IT infrastructures”, *Sloan Management Review*, Spring.
Broadbent, M., Weill, P. and St Clair, D. (1995), “The role of IT infrastructure in business process redesign”, *CISR WP278*, Sloan School of Management, May.
Broadbent, M., Weill, P., O’Brien, T. and Neo, B.S. (1996), “Firm context and patterns of IT infrastructure capability”, *International Conference on Information Systems Proceedings*, Cleveland, OH.
Callon, M. (1987), “Society in the making: the study of technology as a tool for sociological analysis”, in Bijker, W.E., Hughes, T.P. and Pinch, T. (Eds), *The Social Construction of Technological Systems*, MIT Press, Cambridge, MA, pp. 83-106.
Callon, M. (1991), “Techno-economic networks and irreversibility”, in Law J. (Ed.), *A Sociology of Monsters. Essays on Power, Technology and Domination*, Routledge, New York, NY, pp. 132-61.
Callon, M. (1994), “Is science a public good?”, *Science, Technology & Human Values*, Vol. 19 No. 4, pp. 395-424.
Ciborra, C.U. (1994), “From thinking to tinkering”, in Ciborra, C.U. and Jelassi, T. (Eds), *Strategic Information Systems*, John Wiley & Sons, Chichester.
Ciborra, C.U. (1996), “Introduction: what does groupware mean for the organizations hosting it?”, in Ciborra, C. (Ed.), *Groupware and Teamwork. Invisible Aid or Technical Hindrance?*, John Wiley & Sons, Chichester.
Ciborra, C.U. (1999), *Corporate Networking - The Dynamics of Infrastructure in Large Multinationals*(in press).
Ciborra, C.U. and Lanzara, G.F. (1994), “Formative contexts and information technology”, *Journal of Accounting, Management and Information Technology*, Vol. 4 No. 2.
Coase, R. (1960), “The problem of social cost”, *Journal of Law and Economics*, Vol. 3.
Cordella, A. and Simon, K. (1997), “Decreasing returns to infrastructure”, *IRIS Proceedings*, Oslo..
Dahlbom, B. and Janlert, S. (1996), *Computer Future*, University of Gøteborg.
David, P.A. (1987), “Some new standards for the economics in the information age”, in Dasgupta, P. and Stoneman, P. (Eds), *Economic Policy and Technological Performance*, Cambridge University Press, Cambridge, pp. 206-39.
David, P.A. and Bunn, J.A. (1988), “The economics of gateways technologies”, *Information Economics and Policy*, Vol. 3.
Dreyfus, H. (1982), *What Computers Can’t Do: The Limits of Artificial Intelligence*, Harper & Row, New York, NY.
Dreyfus, H.L. (1993), “Heidegger in the connection between nihilm, art, technology and politics”, in Guignon, C. (Ed.)*Heidegger*, Cambridge University Press, Cambridge.
Duncan, N.B. (1995), “Capturing flexibility of IT infrastructure”, *Journal of Management Information Systems*, Autumn, Vol. 12 No. 2
Ehn, P. (1989), *Work-Oriented Design of Computer Artifacts*, Arbetslivscentrum, Stockholm.

Feenberg, A. (1998), *Radicalizing Philosophy of Technology, Radical Philosophy Review*, forthcoming.
Grindley, P. (1995), *Standards, Strategy and Policy Costs*, Oxford University Press, Oxford.
Hanseth, O. (1996), "Information technology as infrastructure", PhD thesis, University of Gøteborg.
Hanseth, O. and Monteiro, E. (1997), "Inscribing behavior in information infrastructure standards", *Accounting, Management and Information Technologies*, Vol. 7 No. 4, pp. 183-211.
Hanseth, O. and Monteiro, E. (1998), "Changing irreversible networks", in Baets, W.R.J. (Ed.), *Proceedings from 6th European Conference on Information Systems*, Euro-Arab Management School, Granada, Spain, pp. 1123-39.
Hanseth, O., Monteiro, E. and Hatling, M. (1996), "Developing information infrastructure standards: the tension between standardisation and flexibility", *Science Technology and Human Values*, Vol. 21 No. 4, Autumn, pp. 407-26.
Heidegger, M. (1957), *Identitaet und Differenz*, Neske, Stuttgart.
Heidegger, M. (1977), *Sein und Zeit*, Klostermann, Frankfurt.
Heidegger, M. (1978), *Basic Writings*, Routledge, London.
Heidegger, M. (1992), *Gelassenheit*, Neske, Stuttgart.
Heidegger, M. (1994), *Bremer und Freiburger Fortraege (1949)*, Klostermann, Frankfurt.
Henderson, J.C., Venkatraman, N. and Oldach, S. (1996), "Aligning business and IT strategies", in Luftman, J. (Ed.), *Strategic Alignment*, Oxford University Press, Oxford.
Hughes, T.P. (1983), *Networks of Power: Electrification in Western Society, 1880-1930*, John Hopkins University Press, Baltimore, MA.
Hughes, T.P. (1987), "The evolution of large technical systems", in Bijker, W.E., Hughes, T.P. and Pinch, T.*The Social Construction of Technological Systems*, MIT Press, Cambridge, MA, pp. 51-82.
Hughes, T.P. (1994), "Technological momentum", in Smith, M.R. and Marx, L. (Eds), *Does Technology Drive History? The Dilemma of Technological Determinism*, MIT Press, Cambridge, MA, pp. 101-14.
Introna, L. (1997), *Information, Management and Power*, Macmillan, London.
Kallinikos, J. (1995), "The architecture of the invisible: technology as representation", *Organizations*, Vol. 2 No. 1.
Katz, M. and Shapiro, C. (1986), "Technology adoption in the presence of network externalities", *Journal of Political Economy*, Vol. 94.
Keen, P.W. (1991), *Shaping the Future*, Harvard Business School Press, Boston, MA.
Latour, B. (1987), *Science in Action*, Open University Press, Buckingham.
Latour, B. (1991), "Technology is society made durable", in Law, J. (Ed.), *A Sociology of Monsters. Essays on Power, Technology and Domination*, pp. 103-31. Routledge, New York, NY.
Latour, B. and Woolgar, S. (1986), *Laboratory Life: The Construction of Scientific Facts*, Princeton University Press, Princeton, NJ (first edition 1979).
Luftman, J. (Ed.) (1996), *Strategic Alignment*, Oxford University Press, Oxford.
Monteiro, E. and Hanseth, O. (1995), "Social shaping of information infrastructure: on being specific about the technology", in Orlikowski, W., Walsham, G., Jones, M.R. and DeGross, J.I. (Eds), *Information Technology and Changes in Organisational Work*, Chapman & Hall, London, pp. 325-43.
Rosenberg, N. (1994), *Explaining the Black Box*, Cambridge University Press, Cambridge.
Star, S.L. and Ruhleder, K. (1996), "Steps towards an ecology of infrastructure: design and access for large information spaces", *Information Systems Research*, Vol. 7 No. 1, pp. 111-34.
Timmermans, S. and Berg, M. (1997), "Standardization in action: achieving universalism and localization in medical protocols", *Social Studies of Science*, Vol. 27, pp. 273-305.
Unger, R.M. (1987), *False Necessity*, Cambridge University Press, Cambridge.
Weill, P., Broadbent, M. and St Clair, D. (1996), "IT value and the role of IT infrastructure", in Luftman, J. (Ed.), *Strategic Alignment*, Oxford University Press, Oxford.
Winograd, T. and Flores, F. (1987), *Understanding Computers and Cognition*, Addison Wesley, Reading, MA.