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Information Infastructure as Organization: A Critical Realist View

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INFORMATION INFRASTRUCTURE AS ORGANIZATION: A CRITICAL REALIST VIEW

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L'infrastructure de l'information comme une organisation :
Une perspective critique et réaliste

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Abstract

The notion of information infrastructures, introduced in the 1990s and refined during the past ten years, has proven quite fruitful to the IS field. It changed the perspective from organizations to networks and from systems to infrastructures, allowing for a global and emergent perspective on information systems. However, something is missing in this theory. What is an information infrastructure, ontologically? Is it a technical structure, an organizational form, an analytical perspective or a semantic network?

This paper reviews the socio-technical origins of information infrastructures. Two propositions are described and discussed. First, that it is fruitful to regard information infrastructure as an ICT-based organizational form. Second, a critical realist view allows us to conceptualise the object of study in a simpler and more intuitive way. A case study of an airline company and a re-interpretation of Star and Ruhleder's classic paper were used to illustrate the claims.

Keywords: Information infrastructures, critical realism, socio-technical theory

Résumé

Cet article présente les origines sociotechniques des infrastructures de l'information. Deux propositions sont décrites et discutées. La première souligne l'intérêt de considérer l'infrastructure de l'information comme une forme organisationnelle basée sur les TIC. La deuxième présente une perspective réaliste et critique permettant de conceptualiser l'objet de l'étude d'une manière simple et plus intuitive.

Introduction

The notion of information infrastructure (II) was introduced in the early 1990s, first as a political initiative (Gore 1993; Bangemann 1994), later as a more specific concept in Information Systems (IS) research. For the IS research community an important inspiration was Hughes' accounts of large technical systems, analyzed as socio-technical power structures (Hughes 1983). In their seminal paper "Steps toward an ecology of infrastructure" Star and

Ruhleder's (1996) suggest that large IIs present a set of entirely new challenges regarding design and use compared to traditional information systems. Reporting on a large infrastructure case they found that "despite good user prototype feedback and participation in the system development, there were unforeseen, complex challenges to usage involving infrastructural and organizational relationships" (p. 8).

The concept has proven quite fruitful to the IS field. It changed the perspective from single organizations to organizational networks and from systems to infrastructures, allowing for a global and emergent perspective on information systems. One strand of research focused on the convergence of technologies and its implications for strategic management (Weill and Broadbent 1998), while other researchers have analyzed the growth and dynamics of scientific infrastructures (Bowker 2006; Edwards et al. 2007). Another line of research built on actor-network theory and have been more interested in such issues as the social construction of standards (Hanseth and Monteiro 1996), classification systems (Bowker and Star 1999), management control and technological drift (Ciborra 2000), complexity and risk (Hanseth and Ciborra 2007), and meta-theoretical issues (Kallinikos 2006). As defined by Hanseth an information infrastructure is "a shared, evolving, open, standardized, and heterogeneous installed base" (Hanseth 2002, p. 2).

As a theory it has been used to frame a number of extensive case studies (Star and Ruhleder 1996; Ciborra 2000; Hanseth and Ciborra 2007), and in particular to develop an alternative approach to IS design: "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" (Ciborra and Hanseth 1998, p. 315). It has later been developed into a full design theory, focusing on the growth of an installed base (Hanseth and Lyytinen 2008). Information infrastructures include the Internet, health systems and corporate systems. It is also consistent to include innovations such as FaceBook, LinkedIn and MySpace as excellent examples.

A puzzling aspect of this success is that these contributions describe in detail how IIs are evolving, but they are less specific on what they actually are, ontologically. Star and Ruhleder (1996) asserted that "infrastructure is a fundamentally relational concept. It becomes infrastructure in relation to organized practices" (p. 4), and defined information infrastructure in the following terms: It is *embedded* into other structures, *transparent* in use, has *reach and scope* beyond a single event, is *learned as part of a membership*, it links with *conventions of practice*, *embodies standards* to be able to plug into other structures, is built on an *installed base* and, finally, it becomes *visible upon breakdowns*.

Other definitions of IIs include:

"*The set of organizational practices, technical infrastructure and social norms that collectively provide for the smooth operation of scientific work at a distance* (Edwards et al. 2007, p. 6).

"A shared, evolving, heterogeneous installed base of IT capabilities developed on open and standardized interfaces" (Hanseth and Lyytinen 2008, p. 1).

"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 (..) necessity. Infrastructure becomes an essential factor shaping the taken-for-grantedness of organizational practices" (Ciborra and Hanseth 1998, p. 321-322).

"The technological and human components, networks, systems, and processes that contribute to the functioning of the health information system" (Braa et al. 2007, p. 3).

This is not very clear. Is it a technical structure, an organizational form, an analytical perspective or a semantic network? Does it matter? One may argue that life is too short to involve oneself into ontological speculation. There is, however, something deeply disturbing in dealing with a sophisticated theory on an undecided object of study.

To explore this matter I will start with a brief discussion of the socio-technical origins of II, which I conclude by suggesting to view II as an organizational form. To analyse this in more depth, I will introduce the lens of critical realism. Then the attributes and mechanisms of II as an organizational form are discussed in detail, and the benefits of the approach are demonstrated by a case study. Lastly, I offer a re-interpretation of Star and Ruhleder's paper.

The Socio-Technical Object of Study

The definitions cited above suggest that an II is a socio-technical object in some sense; it consists of both social and technical elements which interact in complex ways. This object has been researched extensively the past 50 years by workplace researchers (Emery and Trist 1960), system theorists (Bateson 1972), sociologists (Latour 1987; Castells 1996) and many IS researchers (Bostrom and Heinen 1977; Kling and Scacchi 1982; Mumford 1983; Orlikowski 1992; Alter 1999; Avgerou 2002; Avison and Fitzgerald 2003; Orlikowski and Scott 2008). The basic insight is that the object of study is not a thing, but a network of heterogeneous elements, including technology. The caricature of this insight is the useless and mock statement that "everything is connected to everything."

Defining the socio-technical object of study in ontological terms has proved to be difficult, to say the least. Is the object something real, or is it only an analytical tool? Does it have a structure? Does it act? The socio-technical founders at Tavistock Institute (Emery and Trist 1960) struggled with their ontological and epistemological foundation for a generation – starting with a realist and materialist view, and ending (perhaps) at a moderate constructivist position (Van Eijnatten 1993). In IS research it has re-emerged as a core topic the past years (Orlikowski and Iacono 2001). Some researchers have asked for a return to the IT artefact as the object of study (Benbasat et al. 1987) while others have stressed the need for the socio-technical perspective (Alter 2004). An increasing number of highly theoretical contributions have made it clear that the character of socio-technical networks are not easily analyzed, proposing concepts such as *assemblages* (Kallinikos 2006) and *entanglements* (Orlikowski and Scott 2008). They also warn us, however, that we are not only in need of more theory but of simpler and more intuitive conceptualisations.

I will propose the following: *The root of the perceived complexity of the socio-technical object lies in the fact that we are trying to do two things in one breath, namely to describe structure and action as one object.* This is an unreasonable and counter-intuitive conceptualization. Let us briefly consider some historical examples of networks of people and technology, illustrated in Table 1.

Table 1. Networks of people and technology

Socio-technical network	**Name of structure**	**Name(s) of action**
Man and wife, plow, soil	Farm	Plowing, harvesting
Priest, sacred building, worshippers, sacraments	Temple	Mass, ceremony
Officers, soldiers, weapons	Army	War
Production equipment, materials, managers, workers, energy	Factory	Production
Accounts, clerks, customers, money, arithmetic machines	Bank	Financial transactions

As this simple table illustrates, networks of people and technology are not new. Rather, most of human history the past 6000 years has revolved around these networks. It is notable, and perhaps worrying, that while the objects in Table 1 are easily associated with the real world, the terms of most current socio-technical research (*assemblages*, *entanglements*) are mainly associated with books.

If we take a closer look at the organizations in Table 1 we notice that there is no need for a complex conceptualisation. A factory is a structure of machines, raw materials and energy. The structuring principle of the factory is a routine that is partly mechanical or electronic and partly human, such as for example the outlay of an assembly line. To work it needs people, such as managers and workers. Conversely, the managers and workers need this structure to accomplish their, indeed, very complex task; the production of goods. Thus, there are *two* socio-technical objects of study; the factory as structure and the production as agency. They are dynamically linked, in complex ways, but a factory is not the same as production and an army is not the same as war.

When describing structure we use terms of technology and routines (such as, in the case of a bank), *accounts, drawing rights* and *digital certificate*. When we describe action we use terms of technology-in-use-by-people such as a *withdrawal* or a *transfer*. These terms, in the same way as *plowing* or *bicycling*, always include the use of technology in an integrated way, as part of the action. The examples also illustrate that action usually does not require a deep knowledge of structure. In a small farm, the farmer couple would perhaps know both the structural

elements and the action to the same degree, while a bank customer remains happily unaware of the complexities of financial systems. Indeed, this division of knowledge and work is the key to industrial productivity.

Conceptualising structure and action as two different socio-technical objects is congruent with recent studies in organization research (Van de Ven and Poole 2005), which view organizations as both structures and processes. An organization as structure is usually described in terms of social entities and things (nouns), while organizations as processes are described by verbs. In the structural view the processes are important, but are secondary terms in relation to the things. In the process view it is opposite; the things are reifications of the processes. This dual view of organizations has a parallel in a long-standing debate in sociology on the relationship between agency and structure. One of the major contributions of sociology during the past twenty-five years is an almost general agreement that this relationship is dynamic and recursive; structure is the result of human action, and action is enabled and constrained by structure (Giddens 1979; Latour 1987; Archer 1995). Of course, it should be added that these approaches do not form a common research stream, nor do they share a common ontology. Rather, while structuration theory and actor-network theory conflate structure and action into one object (Archer 1995), critical realism holds that they are two distinct objects.

In my opinion, the key to a simpler conceptualization of the socio-technical object is to accept the critical realist view that we deal with two different objects; one structural and one actionable. Thus, in our further discussion, I have two propositions:

- It is fruitful to view information infrastructure as an ICT-based organizational form
- A critical realist view allows us to conceptualise the object of study in a simpler and more intuitive way

Structure and Action in Critical Realism

Critical realism has been established the past few years as an alternative to positivist and interpretive IS research (Dobson 2002; Mingers 2004; Longshore Smith 2006; Volkoff et al. 2007). The basic assumption of critical realism is the existence of a real world independent of our knowledge of it. Reality is conceived as being stratified in three domains. The *real* domain consists of objects, both physical and social, with capacities for behaviour called mechanisms. These mechanisms may (or may not) trigger events in the domain of the *actual*. In the third layer these events may be (or not) observed, in the *empirical* domain. Thus, structures are not deterministic; they enable and constrain events (Archer 1995; Sayer 2004).

Critical realism combines a realist ontology with an interpretive epistemology (Archer 1995; Archer et al. 1998); although a real world exists, our knowledge of it is socially constructed and fallible. This does not imply an epistemological relativism; since a real world does exist critical realism holds that some theories *approximate* reality better than others. This process of approximization is seen as a key part of scientific enquiry. It follows from this that critical realism does not aim to uncover general laws, but to understand and explain the underlying mechanisms. This is done through *retroduction*; we take an empirical observation and hypothesize a mechanism that might explain that particular outcome. These mechanisms are associated with the *nature* of the object of study, not to the regularities of events (Sayer 2004).

The relationship between agency and structure in critical realism was developed in Bhaskar's *transformational model of social action* (illustrated in figure 1) and later in Archer's (1995) *morphogenetic model*. They share with Giddens' structuration theory the assumption that action and structure are mutually constituted. In the critical realist view, however, social structure exists independently of current human activity. This implies that although structure exists only through human activity, it is not reducible to such activity. Structure enables and constrains action. Human action reproduces or transforms structure, although this is not usually the intention of the activity (Lawson 2007).

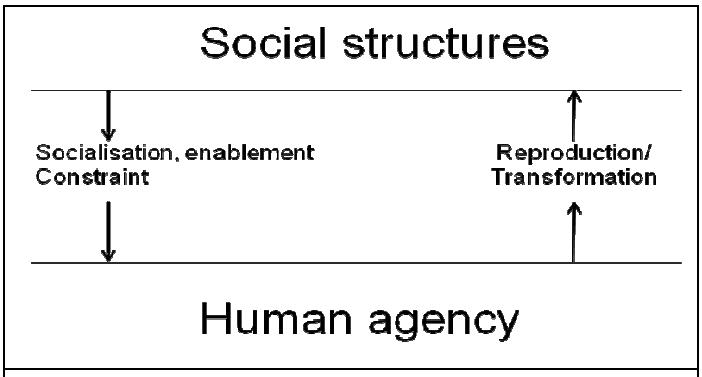

Figure 1. The Transformational Model of Social Action. (After Lawson, 2007).

Recently, Volkoff et al. (2007) have suggested that the transformational model enables us to be more specific in our understanding of technology as a mediator of organizational change. The founders of socio-technical organization theory described our object of study as consisting of two separate systems, one human and one technical (Bostrom and Heinen 1977; Emery and Trist 1960). Socio-technical IS research has later shown that this clean-cut division does not make sense, for two simple reasons: Structure is not only material and action is not only social.

Building on Archer (1995) Volkoff et al. (2007) offer a solution to this problem. First, they argue that it is easier to conceptualise the socio-technical object if we accept that while social action is continuous, social actors relate to an organizational structure they have not created. This was illustrated also in Table 1. In critical realist terms the structure is the result of human activities, but it is distinct from the ongoing activity. This basic distinction between agency and structure does not mean that structure is independent of action, but that it has emergent structural properties.

Further, building on Pentland and Feldman's concept of organizational routines (Pentland and Feldman 2005), they find that such routines may be described both as structure and as action. Using Latour's terms, they describe the structural aspect of a routine as consisting of *ostentive* elements; this describes the routine in theory. The actionable aspect of a routine is called *performative;* it refers to the actual actions taking place in time. From their study Volkoff et al. observed that routines have a material aspect that is *embedded* in the routines, and also in roles and data. In their case of an Enterprise System the structure consists of ostensive (steps to be performed) and material (programs to be executed as parts of the same steps) elements. The actionable aspect of the routine consists of the performative (the actual use of the system) and the material (the execution of transactions) elements.

The strength of this conceptualisation is that it allows us to describe structure and action as separate socio-technical entities at a level of necessary detail, but at the same time understanding their recursive relationship: the ostensive and material aspects enable and restrain the performative, while the performative reproduces and changes the ostensive and material. Based on Archer's basic model and on these assumptions Volkoff et al. proposes that we should analyse socio-technical change in three phases:

1. Structural conditioning; the design of a structure consisting of both material and ostensive objects. IT is an integral ("embedded") part of the routine. IT affects not only the routine, but also the distribution of roles and data. This is done when a solution is designed and configured.
2. Social interaction; the actual use of the structure. Action is always situated, in the sense that the performative aspect is dependent on the individual's interpretation of how the task should be solved (and on the tools at hand), although this may differ from how the routine was designed. However, the material and ostentive aspects of the routine will enable and constrain the actor.
3. Structural elaboration/reproduction; through use the material and ostensive elements are reproduced or changed. If the routine was performed as designed, this will reproduce the structure. If not, the performative aspect may serve as an input (among many) to transform the structure.

I will now use this framework to describe information structure as an organizational form in more detail.

Information Infrastructure as an ICT-based Organizational Form

As illustrated in Table 1 there are both historical and analytical reasons for this claim. Historically, organizations have always used technology as an integral part, although this aspect – with the possible exception of Marx - is not addressed in much depth in the classical works of organization theory. The factory originated in China in the first millennium BC, the first bank in Genoa in the fifteenth century and the London stock exchange was founded in 1801(Kindleberger 1993). Analytically, it is certainly possible to interpret these organizations in socio-technical terms, but it is more logical and simple to regard socio-technical networks (including information infrastructures) as organizational innovations in a long tradition.

There is, of course, something new. The relationship between organizational forms and ICT has been studied extensively the past two decades (Beniger 1986; Fulk and DeSanctis 1999; Groth 1999), and researchers have suggested terms such as *network* organization (Fulk and DeSanctis, 1999), *virtual* organization (Markus et al. 2000) and *horizontal* organization (Castells 1996). Organizational form is loosely defined as the structural features shared by a number of organizations. Beniger (1986) viewed technology and organizational form as "homologous," viewing the design of technology and organization as an integrated task. Fulk and DeSanctis (1999) showed that there is a causal and reciprocal relationship between ICT and new organizational forms, in four dimensions:

- Changes in size, scope and products: A trend toward flexible specialization and information intensive products
- Vertical control: Flatter organizations, reduced middle management
- Horizontal control: Electronic workflow, concurrent engineering and cross-functional teams
- Changes in connections: Networks and strategic alliances.

If we assess IIs in these four dimensions, IIs combine them. IIs are specialized and information intensive, with little vertical control, horizontal control fully electronic, and structured on a network topology. Traditional organizations have an ownership, well defined borders, a stated purpose and hierarchical control. The same applies, to a certain extent, to the most important organizational innovation in the second half of the 20th century, namely the project. In contrast, information infrastructures are open and decentralized structures, built on standards, not ownership. Groth (1999) analysed such phenomena as stock exchanges and airline reservation systems as *computer mediated organizational forms* (Groth 1999). He found that they do have some similarities with traditional organizations (such as a basic structure, coordination mechanisms and a shared purpose) and many differences (no clear ownership, no real division of labour, no specific location). Groth proposed to name these phenomena "organized clouds," held together by the gravity of a common database.

I believe that the analysis is valid, but that the suggested term is misleading. There is nothing "cloudy" or "virtual" in this organizational form of information infrastructures; it is only new. We may now extend Hanseth's (2002) definition: *An information infrastructure is an organizational form which is characterized by a shared, evolving, open, standardized, and heterogeneous installed base.* As an organization it is both structure and agency, as two distinct socio-technical entities: The structure as a network of technical and ostensive objects ("structure-as-form"), and agency as a network of performative and material objects ("technology-in-use"). The interplay between structure and agency is, in the case of II, particularly dynamic. An emergent property is the potential to become self-reinforcing, in the sense that a new user will increase the value of the structure, as described by Hanseth (2002). The causal mechanism for this is that the usefulness of the structure increases with size, provided that the network is not clogged.

Some attributes of an II, seen as an organizational form, are:

- It is a permanent initiative, in contrast to projects or events
- It is enacted, reproduced and changed through daily use
- ICT has (to some extent) supplanted hierarchy as the coordination mechanism
- It has borders, although very open, enabled by standards
- Often, it does not have one specific purpose, but the members share some common objectives
- Transaction costs are very low, and decreasing with size

It is a permanent initiative, consisting of both material and ostensive elements.

The most important attribute of an II is that it is a permanent initiative, designed to have a long life (Hanseth 2002). It consists of both technical and social elements, which together often represent large investments. The technical elements are mainly physical infrastructure, business infrastructure and applications. The ostensive (social) elements are the designed business or behavioural processes that potential users are supported and constrained by.

It is enacted, reproduced and changed through daily use

This structure has no value without actual use. Through the daily use individual actors solve problems and satisfy needs, such as ordering an airplane ticket or connecting to a new friend on FaceBook. It goes without saying that most users have no idea of the complexities and underlying mechanisms of the II. However, through the use they reproduce the structure (Volkoff et al. 2007). Sometimes, their behaviour contributes to changes. For example, they may choose to use the solution in new ways, thus influencing on the ostensive structures. They may also choose not to use certain parts of the solution, thus making it obsolete.

ICT has (to some extent) supplanted hierarchy as the coordination mechanism

Information infrastructures are relatively flat structures, albeit very large ones. This is an impossible combination in traditional organizations, and is only possible because they are not only using ICT, but are constituted through an ICT-enabled network. Successful infrastructures are often *scale-free* (Barabasi 2002), i.e. they have a topology that allows for strong growth without becoming clogged. The main coordination mechanisms are entities and links in databases (Groth 1999), together with search engines.

It has borders, although very open, enabled by standards

Traditional organizations have clear borders, IIs does not. Most of them are quite open, such as the World Wide Web and FaceBook, while others require a membership in another organization, such as business exchanges or intranets. The openness is possible by the use of standards; the World Wide Web is based on the TCP/IP and http protocols, and international air reservation systems are based on format standards of Amadeus and payment standards of the world financial system. The borders of IIs are not very visible, but they usually appear when entering the II, in the form of user IDs, passwords, and with the acceptance of the regulations and code of conduct of the II.

Often, it does not have one specific purpose, but the members share some common objectives

Tradition organizations (and projects) have stated aims and objectives. In contrast, IIs are enabling structures. Users gravitate to IIs not because of the mission or aim of it, but because they share some common objectives between themselves, which may be solved by the use of the II. Thus, the mechanisms for the reproduction of IIs are different than for traditional organizations, because the users do not necessarily identify with the II. Rather, they use it for their own purposes. It is habit, not loyalty that makes the II into a permanent structure. The flip side of this, of course, is that the owner of the II is much less in control of it compared to a traditional organization, which is well documented in earlier II research (Ciborra 2000).

Transaction costs are very low, and decreasing with size

This leads us to a last attribute. Compared to traditional organizations transaction costs are amazingly low. In an organization theory perspective this is an important aspect, because organizations are often seen as being structured by transaction costs (Williamson 1975). The main reason for this is that the coordinating mechanism of IIs is not management; rather the structure is self-coordinating. This is made possible through the embedded combination of technology (database, applications) and ostensive structure (business and behavioural rules). As shown by Hanseth there is a self-reinforcing mechanism in IIs; a useful structure leads to more use, while more use leads to higher value and lower transaction costs (Hanseth 2000).

There are many examples of new IIs the past fifteen years. Using the categories of Hanseth and Lyytinen (2004) some illustrating IIs are:

- General: FaceBook, LinkedIn
- Industry: Exchanges, airline reservation systems
- Corporate: Intranets, knowledge management systems

There is an important historical perspective on this discourse. It is easy to forget that the *project* was a central organizational innovation in the 20th century. The project is an organization form that was introduced to compensate for the shortcomings of the functionally divided corporation. This organizational form enabled us to go to the moon and to organise most IS projects in a sensible way. In parallel with the project form, an information infrastructure is (usually) not a separate legal entity; rather IIs span both organizations and countries.

Shifting the perspective to an ICT-based organizational form allows us to analyse IIs more specifically. The analysis above shows that the power of IIs is not in the similarities with traditional organization, but because of the differences. As the project work form was a central organizational innovation in the 20th century, the information infrastructure may play a similar role in the 21st. I will illustrate this claim with two examples.

An Example: The "Norwegian" Company

Norwegian is an airline carrier based in Norway. It was founded in 1993, but its strong growth started in 2002, when it established a national network, helped by the government deregulation of the airline industry. Today the company has 1.300 employees, 85 destinations in Europe and carried 6.4 mill passengers in 2007. More than 85 % of ticket sales are accomplished on the web (Norwegian.no). The company has pioneered the Scandinavian low price airline market, and has been quite innovative. Some important events were:

2002 : Introducing low cost airline in Norway, with print-out tickets with bar-code identification

2004 : Introducing the low-price calendar (this was internationally patented)

2005 : Dialogue with 85% of customers is electronic

2007 : Bank Norwegian is introduced

2008 : Call Norwegian (mobile telephone operator) is introduced

In 2007 the company decided to enter the banking market with Bank Norwegian. Said the CEO Bjørn Kjos at the start: "Today we have one of the most visited web pages in Norway, with 2-3 million visitors each month. We aim at coupling this traffic towards bank services." (E24, 4th May 2007). The initiative has been quite successful; in fact so successful that Norwegian will offer a mobile service Call Norwegian, based on the same thinking.

If we look closer at the company (the author conducted a case study in 2008), parts of the success may be explained by a particular IT architecture (Bygstad and Aanby, 2008). It is illustrated and simplified in figure 2. The key elements are the web page for each service, the customer database and "the bus." Each service constitutes an information infrastructure, with a number of registered customers. For the airline this is currently ca. 1 million, for the bank around 80.000, while the mobile company is starting up in the autumn 2008.

The "bus" is conceptualized as a bus in computer hardware architecture. It connects the customer services with the databases and technical services. Technically, it is a Java application, and the only software that the company technicians programmed themselves. The rest is bought components or services, such as Amadeus bookings, bank systems and revenue systems. Thus, in technical terms we might describe the function of the bus as bridging two different standards; the standards of World Wide Web with the standards of international booking (Amadeus) and banking systems.

The architecture allows the company to innovate on an existing infrastructure, in much the same way as Virgin and Amazon have done. The traffic on the airline website may be routed to other services at very low marketing costs. Accordingly, new infrastructure services, such as bank system and mobile system (from external providers) may be linked to the "bus" at low costs and in time windows of opportunity. It is essential that all communication with the customers is electronic, as a combination of web pages and e-mail. Of course, this lowers transaction costs, but more importantly, it makes it much easier to enroll new customers into the infrastructure.

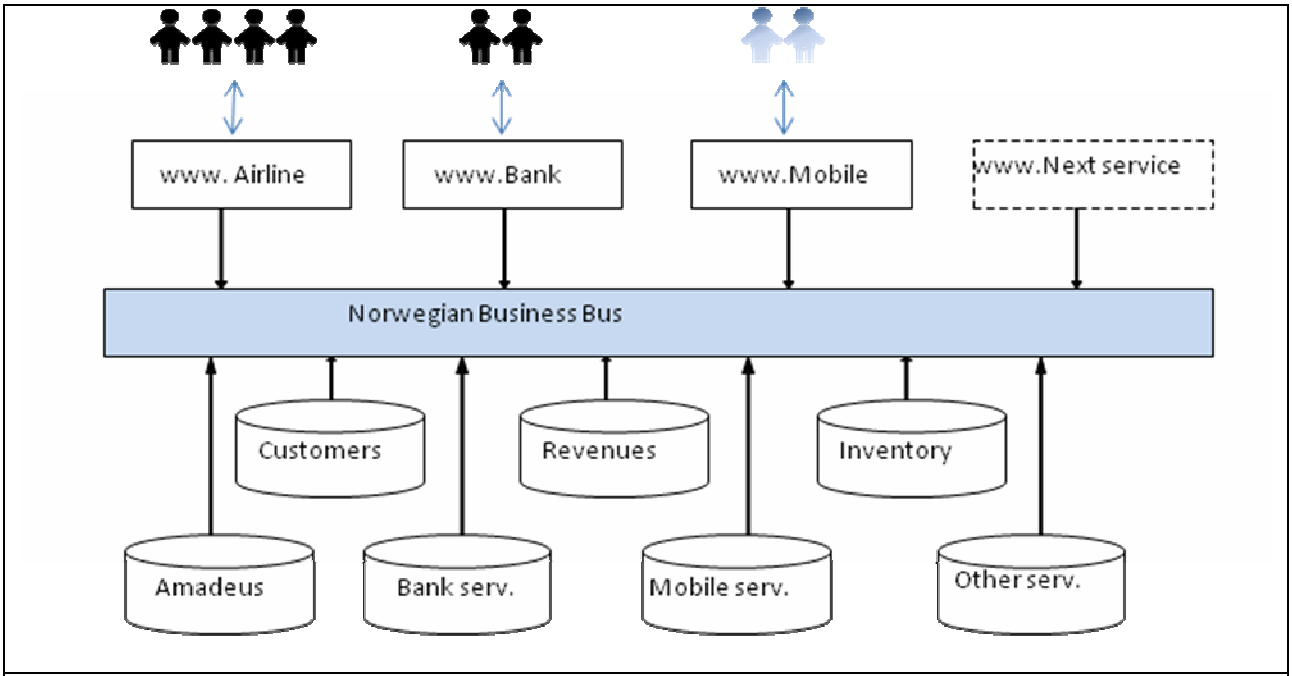

Figure 2. Information Infrastructures at Norwegian

Of course, the different services of Norwegian are organized in a company structure. To understand the dynamics of this innovation process, however, I suggest that it is more useful to regard them as interrelated information infrastructures. The success of the first, the airline service, was very much the result of IT-based service innovations, such as the bar-code ticket and the low-price calendar. They served as *boot-straps* (Hanseth, 2002) to enable the establishment of a critical mass of users. It is important to understand that the simplified booking and embarking procedures enabled Norwegian to keep their prices below their main competitor SAS, and thus expanding their market share.

The establishment of Bank Norwegian is an extension of an existing information infrastructure. Mr. Kjos, cited above, identified the two basic resources for expanding his information infrastructure: a technical infrastructure (mainly business infrastructure) and a large base of customers. This represents a powerful generative capability for infrastructure innovation. In critical realist terms, bulding on Volkoff et al. 2007, we may very briefly analyze this case in the following steps.

First, the structural conditioning phase, an existing infrastructure (the airline reservation system) is extended into a new structure. It utilizes the technical structure (database structure, security mechanisms, payment and revenue systems etc) and structures the new ostensive structure, i.e. the business process steps of marketing, the routine for assessing and registering of users, the allocation of accounts etc. Drawing on the resources of the existing infrastructure represents an immense advantage compared to establishing a new structure from scratch.

Second, the actual use of the new structure is mainly dependent on the users' behavior. The material and ostensive structure is not determining the use, it only enables it. The performative aspects depend to a large degree on whether the installed user base may be transferred from the airline services. To analyze this, we must understand the formation of a new socio-technical network; the 80.000 users that become bank customers, the volume of financial transactions and the type of transactions.

Two mechanisms may be identified here, which we might call the *bridge* and the *self-reinforcement* mechanisms. The bridge mechanism makes it easy for the user to join the new II, because existing (airline) structure and the new (banking) structure share many ostensive (routine for joining, steps to perform bank transactions) and technical (web page, transactions) elements, making the bridge to the new infrastructure simple to cross. In critical realist terms; this moved the performative aspect closer to the ostensive. The *self-reinforcement* mechanism is described by Hanseth (2002), and works like this: The value of an installed base increases with use, because new users will lead

to more services, which will increase the credibility of II, which in turn will attract more users. This mechanism will also lower transaction costs.

Third, the actual use of the Bank Norwegian will influence on the information structure. Patterns of behavior may influence of the technical capacities of the services, or on the ostensive aspects. One illustrating example is how the web pages are changed through the use of them. Patterns of use are monitored on a daily basis during business hours For example, if a significant part of users check the details of a service, but decide not to engage with this, the marketing people may decide to change the price. However, they may also decide to change the web page, making it more easy to use, or even taking it out of production. Over time, this practice will change the structure significantly over time.

Second Example: A Re-interpretation of Star and Ruhleder's Paper

The classic paper of Star and Ruhleder (1996) analyzed the findings from a longitudinal case study in an international community of 1400 biologists, aiming to identify and document the gene structure of a small nematode. The project in casu developed and implemented an information infrastructure, the Worm Community System (WCS), designed to create a collaborative environment for the scientists. Moreover, it was designed to support an "ideal community" of rich communication and seamless information access for all members.

Unfortunately, the project was not very successful. The WCS was designed with prototyping, user participation and expert technicians, but a number of problems arose. Building on Bateson (1972) Star and Ruhleder classified these problems in three levels. *First order* problems were straightforward issues such as connecting a Mac to the WCS. *Second order* problems stem from unforeseen contextual effects, and included such issues such as understanding the consequences of choosing between a Unix workstation or a Mac. Another example was the tension between infrastructure problems and resources and attitudes of local IT departments. *Third order* problems arose from the combination of lower order issues, or from political issues. For example, the access to research for scientists outside the Worm Community was not part of the WCS project, and became an ideological issue.

To understand the reasons for the (relative) failure of the initiative the researchers conducted an analysis using Bateson's concept of "double bind." This is a psychological phenomenon that arises when an individual receives a message on more than one level simultaneously, or receives a message at one level and is expected to respond at another level. For example, when scientists were told to "just sign on" the WCS (first order) and experienced that this involved a number of compatibility problems (second order), they reacted with frustration or withdrawal. Similarly, the discussion of Unix versus Mac (second order) escalated to a conflict between different scientific cultures between computer scientists and biologists (third order). The researchers concluded that because of these (and several other examples of) double binds neither of the aims of the project was reached.

This very brief summary does not do justice to the sophisticated analysis of the case, but it still conveys the main point. Using a critical realist approach I will suggest an alternative interpretation. My view is that the reason for the WCS failure is not mainly associated with communication (as the "double bind" explanation indicates), but rather from a failure to understand the dynamics of II as an organizational form. In the structural condition phase they chose to disregard the existing structure, and developed a new solution based on new technology and new routines. They failed to understand the cultural issues involved in the choice of technology, the professional nuances associated with publishing in the Gazette versus online publishing, and the inclusion/exclusion of researchers outside of the worm community. In short, they failed to design a reasonable compromise between the existing ostensive and material structure and the new one.

In the social interaction phase this led to only partial adoption of the WCS, as many scientists instead used the Internet for communication and publishing in the Gazette instead of using the online facilities of WCS. In critical realist terms; the actions (the performative aspect) of the scientists were in (partial) conflict with the designed structure. This was not because of miscommunication, but because the solution was flawed in several respects. The result was that the WCS was not taken into active use, neither as a collaborative environment nor as an "ideal organization." Subsequently, the WCS was not reproduced as an organization.

Concluding Remarks: Advantages of the Suggested Approach

This paper examined the socio-technical tradition with the aim to understand the ontological aspect of information infrastructures. Two propositions were described and discussed. First, that it is fruitful to regard information

infrastructure as an ICT-based organizational form. Second, that a critical realist view allows us to conceptualise the object of study in a simpler and more intuitive way.

This approach has some distinctive advantages, which were illustrated by the case study and the re-interpretation of the WCS case. First, viewing II as an organizational form enables us to analyse new permanent ICT-based networks in more familiar terms, linking it to organization theory. Moreover, it allows us to understand the structure of IIs as the combination of material resources and organizational routines.

The advantages of the critical realist approach are – in contrast to constructivist approaches - the conceptualization of a temporal relationship between structure and use, and the identification of a number of socio-technical mechanisms. The temporal dimension is expressed by three phases of socio-technical change; *structural conditioning* (the pre-existing structure, produced by earlier actions), *social interaction* (the actual use of the structure) and *reproduction* (the reproduction and elaboration of the structure). An information infrastructure as organization is "real" in the sense that it consists of a structure that exists independently of potential users, being the result of previous action. In the Norwegian case the structure is successfully extended and reproduced. In the WCS case two competing structures lead to failure.

The identification of socio-technical mechanisms enables us to describe in more detail how the structure enables and constrains action, and conversely, how action reproduces and changes the structure. In the Norwegian case the extension of an existing infrastructure was accomplished by (almost) replicating the ostensive and material elements in the new structure, thus making the performative aspect more intuitive. As more customers gravitated to the solution, the structure was reproduced and improved. In contrast, the WCS solution lacked the mechanisms to transfer it into action, and also the mechanisms to reproduce the structure.

Certainly, it should be acknowledged that this explanation does not exclude the importance of communication or many other possible factors which influence the success or failure of an II. A mechanism is a non-deterministic and partial explanation. My point here is to show that critical realism gives II ontological depth; it offers a perspective and a method to look beyond actors' perceptions or superficial regularities, and instead look for mechanisms not immediately observed. This way, the attributes of the deep structure of II as organization may be investigated.

The power of II is not in the similarities with traditional organization, but because of the differences. Further research should investigate these differences in more detail, and also discuss demarcations against other new organizational innovations. Viewing II as a new organizational form draws on a historical perspective, in a long tradition of organizations as socio-technical structures. Bearing in mind the very short time span of this development, the number of global IIs is truly amazing. As the project work form was a central organizational innovation in the 20th century, the information infrastructure may play a similar role in the 21st.

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