Association for Information Systems
AIS Electronic Library (AISeL)

ECIS 2002 Proceedings

European Conference on Information Systems (ECIS)

2002

Understanding Information Technology and its Relationship to Organizational and Societal Change

Vladislav V. Fomin
The University of Michigan, vvformin@umich.edu

UNDERSTANDING INFORMATION TECHNOLOGY AND ITS RELATIONSHIP TO ORGANIZATIONAL AND SOCIETAL CHANGE

Vladislav V. Fomin

School of Information
The University of Michigan
300 West Hall
550 East University Avenue
Ann Arbor, MI 48109-1092
USA
email: vvfomin@umich.edu

ABSTRACT

In recent years, IT scholars have adopted from historians of technology a social constructivist approach to study IT and organizational change. Actor-network theory has also shown to be a promising tool to analyze the complexity of the intricate relationships between technical and non-technical aspects of change, and thus to serve as a framework for studies on IT and organizational change. In this paper we want to extend this argument by stating that the interdependence and influence of IT in the case of complex, networked, infrastructural technologies is not limited to that of organizational change, but has a broader scope that encompasses society as a whole. Thus, we want to explore ***how information technology is transforming our lives****, and* ***how to account for this transformation****. We base our argument on an evaluation of the criticism voiced of social constructivist approaches to technology studies, and on our observations gleaned from studies of the development of cellular technologies in Europe.*

INTRODUCTION

Today we are witnessing rapidly growing dimensions of Information and Communication Technology (ICT). A "wonder of the 20th century" as often referred to in the headlines of the technology sections of popular magazines is mobile telephony. In many countries around the globe, the annual growth in the number of subscribers and penetration rates for mobile telephony is unprecedented. We speculate that when use of a particular technology reaches a substantial portion of the population, as in the case of Finland and Hong Kong with the penetration rates over 80%, that this technology has become transparent to the users. When referring to the transparency, Edwards (in press) characterizes mature technological systems as "ordinary and unremarkable to us as trees, daylight, and dirt" and as an inseparable element of modernity. At the moment, when the technology becomes transparent, the very meaning of technology changes – from once an innovation from the user's viewpoint, the system has become infrastructure (Edwards in press).

Infrastructures link together macro, meso, and micro scales of time, space and social organization, and thus inevitably transform our lives (Edwards in press). However, since infrastructures are transparent in their everyday use, this very transformation is only seen from a macro perspective of time. How, therefore, is it possible to overcome this "infrastructural blindness" and account for the impact of complex infrastructural technologies on our lives?

RECEIVED THEORY

Infrastructure has a pivotal role within IT in today's society. B2B systems and intranets are being built on existing infrastructures for compatibility reasons. In contrast to intra-organizational IS, where the systems' developers are controlling the system's development, in the infrastructural system, it is the infrastructure itself which dictates the rules, by imposing its standards on the new systems which are connected to it (Monteiro and Hanseth 1995).

One way of understanding infrastructure is within a social constructivist framework. This suggests that an infrastructure is a fundamentally relational concept. It becomes infrastructure in relation to organized practices and can be learned as part of membership in communities (Star and Ruhleder 1996, pp.112-113). Thus, to understand the build-up of an infrastructure, communities of practice must be identified and their social practices must be taken into consideration.

Traditionally, studies of Information Systems (IS) and Information Technology (IT) development are focused on the micro aspects of organizational development and change – a focus inappropriate for large-scale infrastructural systems. More relevant to our study, Bijker (1995) has called complex technological systems "*sociotechnical ensembles*" and put forward three possible approaches to address them: the systems approach, the actor-network [theory] (ANT) approach, and the social construction of technology (SCOT) approach.

The systems approach emphasizes the *macro perspective* on technological development. It uses a somewhat technological deterministic view, assuming that technologies during the course of their development acquire a *momentum*, that "seems to drive them in a specific direction within a certain autonomy" (Bijker 1995, p.250). Similar ideas, with respect to networked technologies, can be found in the works of Ciborra and Hanseth (1998), Hanseth et al. (1996) and Monteiro and Hanseth (1995). They agree that the installed base of technology, that is, the "basement" of infrastructure, can be cultivated to enable a seamless growth of the infrastructure. The notion of *economies of scales* helps us to understand how complex networked technologies can gain momentum through the increasing installed base. The systems approach sees the inventors and developers of the technology as "system builders and their associates" (Hughes 1993) and tries to understand their mutual relationships in the process of the system's buildup.

Actor-network theory (ANT) helps us to address the issue of the technological development process by looking at actors who posses enough power to change the direction in which technology develops at critical points. The power of actors is not something inherently individual in them, but originates from networks they can influence (Callon and Latour 1981). The ontology of power in the actor-network approach makes it possible to break away from the traditional *micro-macro divide*. The *principle of symmetry* is applied by ANT in such a way that it analyzes the human and non-human world in the same manner, and thus "the explanation of the development of sociotechnical ensembles involves neither *technical* nor *social reductionism*" (Bijker 1995, p.251). The notion of *translation* (Callon, Latour, and Rip 1986) is central to ANT. It is used to describe the changes taking place in sociotechnical networks, as a negotiation process between the involved actors. A successful translation stabilizes the network of actors and creates a base and commitment to go ahead with innovation. ANT itself is not an explanatory theory of actors intentions, but of the processes of acting. It "places the burden of theory on the recording, not on the specific shape that is recorded (Latour 1999; 1997). It assumes no *a-priory* explanatory theory for the phenomenon under investigation, thus allowing the use of a number of theories to explain phenomena.

The SCOT approach posits that artifacts are socially constructed. It addresses the principle of symmetry by introducing a notion of **"***interpretative flexibility***"** – an acknowledgement that the meaning of the same artifact can be seen differently by different social groups, thus making notions of success and failure arbitrary and wholly dependent on the particular standpoint of a particular social group. Pinch and Bijker (1984) introduce a descriptive model where technological artifacts are first *deconstructed*, that is, different meanings of the same artifact attributed by different social groups are revealed. A process of reconstruction then takes place, where *social construction* has a crucial role in the stabilization of the artifact – relevant social groups come to understand it in a similar way. Social construction-deconstruction reminds us of Callon's translation – the creation of a common understanding among the actors involved.

Dynamic, evolutionary processes must be viewed over time in order to be clearly analyzed and understood. A view over time is particularly necessary when it is a question of attempting to understand how technological change is linked to social change and vice versa (Edwards in press). We have presented several theoretical approaches with relevance to the study of technology. The use of a single theory in studies of infrastructural technologies will not bring satisfactory results (Fomin and Keil 2000). A multidisciplinary approach has been previously suggested as appropriate for historical technology studies: "Given the wide range of concerns that technology assessment potentially embraces (technical, economic, social, political, cultural, and so on), a multidisciplinary approach is clearly essential" (Kranakis 1988, p.292).

To summarize the approaches proposed by Bijker, we suggest that the actor-network approach seems to be the most appealing for our purposes for it allows us to use multiple theories, while tracing the "seamless web" (Hughes 1986), the relations and dependencies between actors, and thus plotting a comprehensive story of, in our case, the development of cellular mobile communications, and how the technology has transformed our lives. "Following technology through its elaboration means recognizing that its proper object of study is neither society itself nor so-called social relationships but the very actor networks that simultaneously give rise to society and to technology" (Callon 1993, p.99).

None of the two other presented approaches should be rejected as inappropriate, as they help understand simultaneous macro level ecological evolution of the complex technologies and micro level activities of system builders, regulators, and users. Equipped with different approaches, it is easier to grasp the idea of infrastructural developments as networks in motion – socio-technical networks that continually span over time and space (Bijker 1995).

RESEARCH METHODS

A rich description of actor-networks is achieved through *network tracing*: "a network is not a thing but the recorded movement of a thing" (Latour 1997, p.9). Thus, instead of using actor-network theory, we use an actor-network tracing technique, or methodology. In order to trace a network, a comprehensive understanding of the processes underlying the technology development process is needed due to the path-dependant property of the technology. Different forms of practice, culture and norms are inscribed "at the deepest levels of design. Some are malleable, changeable, and programmable… Others… present barriers to users that may only be changed by a full-scale social movement" (Star and Griesemer 1989). The validity of our findings can be ascertained by asking whether they are a rich historical *record* of the processes that took place.

Evidence of the validity and richness of our work is shown by the large number of interviews conducted and archival materials collected in the undertaking of the presented case studies. An extensive literature review also helped to identify the directions of the theoretical propositions. Interviews with key personnel in the standardization process allowed us to obtain a first hand insight into the rationale and sequence of events. Furthermore, written documents, memos and public announcements were used to corroborate the findings from the interviews wherever possible.

THE CASES OF CELLULAR MOBILE TELEPHONY

The past

In 1953, a permanent body called the Nordic Council was set up by the governments of Denmark, Finland, Iceland, Norway and Sweden, to identify, study and recommend areas for co-operation between the member states across a wide variety of matters. Telecommunications was identified early on as an obvious area for Nordic co-operation and the idea of creating a mobile telephony system was in the air since the beginning of the 1960's (Toivola 1992). This co-operation was fostered by both economic and cultural factors. Geography and the high level of telematic services required meant that for any one of the five Nordic countries to develop a mobile system alone was economically not viable. Cultural factors were prominent in that there existed a long established tradition of co-operation between Nordic countries. This tradition thus played an extremely important role in creating the Nordic Mobile Telephone (NMT) standard and the subsequent technological success. This Nordic spirit of co-operation gave every participating individual the motivation to present his own, his organization's and country's "voluntary" expertise to the open standardization arena that was based on a free flow of innovations, inventions, contributions, and experiences.

The importance of this spirit of co-operation in the establishment of the NMT was evident, for example, in the co-ordination required to establish a common spectrum allocation, as frequency allocations were and still are, subject to a countries own control and regulation. By contrast, in Japan and Germany where no co-ordination was needed between different states, the telephony systems developed didn't achieve the same level of success.

For example in 1979 – two years prior to the introduction of NMT – Japan's Ministry of Post and Telecommunications (MPT) started it's monopoly teleoperator's NTT mobile communications service in order to provide a service for high state officials – *amukadari*[1]. Neither the MPT nor NTT believed there was a large market for mobile communication services in Japan and thus agreed to set user fees at high levels. Their aim was to prevent users who could not afford the service from adopting it (Funk 1998, p.434).

A similar "preventive" attitude towards mobile communications existed in the beginning of the 1990s in Germany. A VP of Nokia Telecommunications recalls:

> *I think this C-NET was more kind of Siemens' system, more kind of targeting for some kind of…I think Bundepost also thought that this is just a small niche market for the kind of high executives. And I think Finnish and Swedish PTT's, they had already in their minds …maybe it boils down to some kind of Nordic democratic way of thinking: it's not only for the high executives, it's maybe also for the at least [laughs] smaller executives, and maybe even to the man on the street.*

The difference in the attitudes of designers resulted in a situation where the NTT system after more than a decade since it's introduction still had a very low penetration rate compared to it's Scandinavian "counterpart": 0.06% vs. 1.4% in 1986 (Funk 1998).

Along with introduction of NMT in 1981, a number of radio telephone systems were simultaneously introduced across Europe and the European cellular market became very fragmented. However, from the early years of the cellular era, and already in the 1980s a shared opinion existed among European PTTs that each European country would benefit from the introduction of a pan-European system (Toivola 1992). It resulted in the establishment of Groupe Spécial Mobile (GSM, later renamed to Global System for Mobile communications). The aim of GSM was to harmonize technical and operative specifications for a public mobile system on the 900 MHz frequency band. The creation of GSM would end the traditional European fragmentation and incompatibility in the mobile field (Mouly and Pautet 1992).

The development of GSM took approximately the same time as that of NMT – 10 years. The first GSM network came into operation in Finland in 1991. Advances in technology and economies of scale drove the prices of handsets down, which in turn made them and the services offered affordable to a wider range of population (from businesspersons to blue collar workers, and to teenagers). Today, the GSM standard has the world's largest number of users when compared to other cellular telephony

[1] Amukadari literally means descent from heaven

standards. The experience and knowledge acquired during the development of NMT had a significant role in the making of this success story. For example, we can speculate that the attitude that mobile telephony "is not only for the high executives, … and maybe even to the man on the street" has helped the designers of the system to create a system which eventually spread around the globe and changed the lives of people to the extent that "contemporary societies cannot function" without it (Edwards in press).

The present

Transforming our lives

In a special issue of Scientific American, Harvey (2000) writes: "imagine it's the year 2005, and you're in New York City on a business trip." The fiction that follows is an exciting adventure of a couple, whose date is mediated by uses of cellular devices. However, all the "hot & crazy" things that the actors of the story do in NY City in 2005, was already possible in the Nordic countries in 2001, using the GSM network's services.

In Finnish schools, while entering a classroom, a teacher will collect cellphones from her pupils. She does not want to be disturbed by phones ringing during the class. Neither does she want pupils cheating by having the answers received as a short message on their phones. Some schools are reported to have even installed cellphone detectors at the school entrance. This is simply because virtually everyone from the age of 11 upwards has got a cellphone. What is interesting to mention, is that young people are using cellular phones to a large extent for other than voice conversational purposes. Sending short messages (SMS) and downloading ring-tones has become an essential source of income for service providers. In Finland alone, the number of downloaded ring-tones in the year 2000 increased by almost 100% reaching 9m. At the same time, most of the 20m subscribers of NTT's DoCoMo's i-Mode service are reported to spend more time typing in messages and reading them, than talking on their phones. The lives of ordinary people in Europe and Japan therefore have been transformed with the advent of cellular technology.

Transforming organizations

Cellular technology has not only changed our lives. It has changed business organizations too. Elstrom et al. (1998) report that incumbent operators are loosing business to new telecommunication firms. AT&T's executive vice president calls this ongoing trend "the paradigm switch" (Elstrom et al. 1998). Furthermore, as we know, Europe and Japan are preparing for the advent of a new generation of cellular technology (3G) which will bring to customers access to converged networks: voice, high speed data, and video simultaneously plus the advantage of mobility!

This introduction of 3G cellular telephony in October 2001 in Japan and 2003 in Europe is a real challenge to wireline operators – opening vast resources of converged networks and high data transfer rates to subscribers of the 3G network at affordable rates. Why would one need a fixed line telephone, if one could get all the services offered by wireline operators plus much more, at high speed coupled with the advantage of not being tied to a physical location if using a cellular telephone?

Increasingly, the major manufacturers such as Nokia and Ericsson, see the mobile Internet as their near future. While Nokia has sold more than 1m of its 7110 WAP phones, Ericsson has been chosen as a supplier for 3G contracts in a number of countries.

This convergence of mobile telephony and the Internet is crucial to the development of the IT sector (Brown-Humes 2000): "The emergence of this sector has been an extremely welcome development in Finland, not least because it has given the country an important third leg to balance its traditional dependence on pulp and paper and engineering". Companies like Ericsson and Nokia have provided something important for small Nordic countries – they have made sure that Sweden and Finland are known globally.

CHALLENGES IN STUDYING THE IMPACT OF IT

When following technology through its elaboration and early deployment, a micro scale perspective of time and social organization is appropriate, whether it be an intra-organizational IS or large-scale IT under investigation. The path- and choice-dependence of complex technologies suggests that the use of a micro scale of time and social organization alone, although appropriate for traditional IS/IT studies, is not viable when studying infrastructural technologies. In this section we want to stress the issues to be considered when studying complex IT's and their impact on society and organizations. In the introduction, we quoted Kranakis (1988), who suggested that the assessment of [large-scale complex] technology potentially embraces wide range of concerns, including technical, economic, social, political, and cultural. Following, we reflect on each of these concerns.

Social

Winner (1993), criticized actor-network and SCOT perspectives for not considering the impact of technology on society. Bijker (1995), attempted to address this issue with the introduction of his concept of a "technological frame", where a particular technology would directly structure the interaction between relevant social groups and vice versa. The concept "forms a hinge in the analysis of sociotechnical ensembles; it is the way in which technology influences interaction and thus shapes specific cultures" (Bijker 1995, p.252). This however, still leaves open to debate question regarding the actual nature of different social groups; "Who says what are relevant social groups and social interests? What about groups that have no voice but that, nevertheless, will be affected by the results of technological change?" (Winner 1993).

Nonetheless, we agree with Hughes's (1986) suggestion, that actor-network theory can be used to conduct a sociotechnical historical study irrespective of the above, because actor-network theory traces the interactions between actors regardless of their status and so the question of relevance doesn't arise. As technology itself is an actor, not only "inventors, engineers, managers, and financiers who have taken a lead in creating and presiding over technological systems show a way of grasping the seamless web" (Hughes 1986, p.285), but also vice versa.

Economic

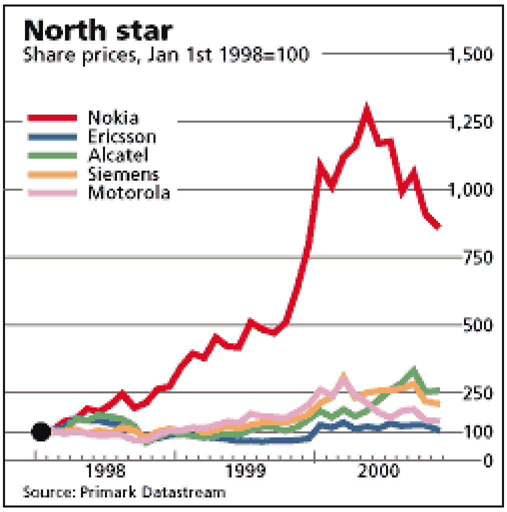
Layne (2000, p.353) gives an example of "the technological fix" that "seeks to use the power of technology in order to solve problems that are nontechnical in nature". From this point of view, the NMT and GSM systems can be seen as technological fixes designed in response to broader economic or political events or issues, such as The Treaty of Rome and growing globalization. Technological systems form a part (sometimes a very significant one) of a country's economy. This has been especially evident in the recent spectacle of frequency spectrum auctions for the 3G systems in many European countries.

Table 1. R&D investments in the ICT sector. Source: (OECD 2000)

	R&D in ICT (million PPP USD)	R&D/value added for ICT (%)	(R&D in total business sector (million PPP USD)	Share of ICT R&D in total business sector (%)
Finland	962	15.7	1'887	51.1
Norway	324	6.3	1'111	29.2
Sweden	1'427	12.1	5'123	27.9
Denmark	329	N/A	1'558	21.1
United States	59'916	10.3	157'539	38.0

Irrespective of whether national and global technologies are a source of income or spending for a nation-state when implemented, they first have to be developed. Howells (1990, p.275) stresses that increasing attention by policy makers has been focused on research and technology as a means to stimulate and expand national economies. High R&D investments foster the growth of technological systems, which in turn either directly (Table 1, Figure 1) or indirectly (as in the case of the spectrum allocation auctions in Europe) bring economic benefits to companies and/or nation-states.

Figure 1. Stock prices of mobile handset manufacturers



Political

We are studying technologies, which although they might have been developed in the lab of a single organization, cannot be utilized without appropriate legislative actions. The special thing about mobile technology is that it uses the radio spectrum – a scarce and strictly "regulated" resource in any country. Mindful of the importance of "relevant social groups", we realised that actors representing legislative bodies needed to be taken into account in our studies. If regulatory legislation is influential, then the design of the device will reflect this. Technical artifacts will always reflect the socio-economic background or environment in which they exist (as in the case of NTT in Japan vs. Nordic democracy), in this way the "so-called social and political backgrounds are embodied in the technology" (Hughes 1986, p.290). Politics is not only an attribute of legislative bodies. Kumar et al. (1998, p.200) write that organizations can be considered as a forum of political activity where actors are engaged in conflict, intrigue, and negotiation based on their private interests. Consequently, power and politics become key concepts, where the interplay of conflicting objectives and the operation of supposedly "non-rational" choice processes determine the consequences of technology.

Inter- and intra-organizational political processes can be seen as a trans-national phenomenon, as technologies rarely stay within boundaries of sovereign states. Ancarani (1995, p.654) points out an interesting implication of globalization, stating that the emergence of great multinational corporations has affected world politics. These new actors "by vigorously challenging the authority of the nation-states, may compel governments to adjust their policies."

We can see this situation clearly in the case of GSM, where an EU directive was issued to force EU countries to allow GSM handsets to be used freely, despite these countries' own regulations. In Greece for example, radio receivers and transmitters were strictly controlled as a potential threat to national security. As a member of the EU however, Greece had to comply with the directive, and the use of cellular telephones became possible.

Ancarani (1995, p.656) emphasizes the issue quoted above: "growing interdependence means that increasingly a variety of issues cannot be addressed, let alone solved, on a national basis. They require a wider approach and deserve ample international agreements, effective control and management activities, and huge allocations of resources." This quotation very well depicts the environment, in which the GSM standard has been developed. International coordination was needed and crucial at some points. To an even greater extent this coordination and steering is required in the development of the 3G cellular systems. The dilemma however of the political situation characterized by the term "globalization" is that countries are trying to preserve their national freedoms and at the same time benefit from international interdependence (Ancarani 1995, p.659). This contradictive endeavor is reflected in the design of the technological systems these countries cooperatively develop. "States are responsible for guaranteeing strategic resources such as science and technology, because of their high vo1ati1ity, through setting up costly infrastructure and selected policies" (Ancarani 1995, p.655).

Cultural

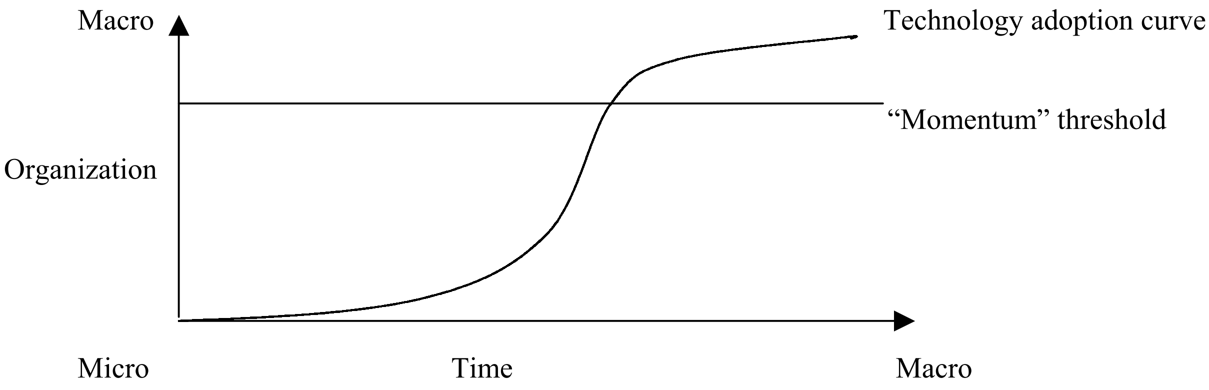
Does the culture of a particular actor determine her behavior? How does the social constructivist approach deal with the issue of culture in studies of technology? (Winner 1993), critically argued, that "insofar as there exist deeper cultural, intellectual, or economic origins of social choices about technology or deeper issues surrounding these choices, the social constructivists choose not to reveal them." We overcome this criticism by including cultural and political aspects in our study. We do not regard actors as having homogenous patterns of behavior, but as having a possibility to bias the "standard" decisions depending on their cultural, political, intellectual or other considerations. Lets not understate the significance of the cultural aspect. "Just as the addition of "gender" to anthropological (and other social) theorizing meant more than "add women and stir," the inclusion of a broader understanding of "culture" in Science and Technology Studies is transforming some of the fields fundamental understandings of where and how technoscience is produced" (Layne 2000, p.369). The importance of the cultural issue in technology studies has been shown by Kumar and his colleagues (1998). Results of a case study on inter-organizational information systems revealed that techno-economic and socio-political perspectives are insufficient to provide an explanation of the failure of the studied system, and that a culture of actors plays an important or even a crucial role. "While economic, technical, informational and logistical elements of the bond may be self evident in industrial networks, the relevance and significance of non-economic dimensions such as social or legal dimensions are mainly culture specific"(Kumar, Dissel, and Bielli 1998, p.214).

CONCLUSION

In this paper we aimed at bringing to the reader's attention important issues to be considered when studying the impact of IT on society and organizations. We show that while multiple explanatory theories are needed to interpret the findings (Kranakis 1988; Fomin and Keil 2000), obtaining a rich historical record of complex "sociotechnical ensembles" (Hughes 1986) can be achieved by deploying actor-network theory.

In this paper we tried to show that understanding complex infrastructural technologies requires abandoning a single-theory and single-scale approaches. On the early stages of technological development, a micro perspective of time and social organization is helpful in studying the "system builders", their relationships, and interrelatedness with the technological system. The elements of "*circulatory system*" (Latour 1999, pp.99-100) required to be brought into the discourse of the technological development – alliances, public representation, enrolment of colleagues, and inscribing nonhuman artifacts – all can be studied from a micro perspective. As the circulatory system is in place and actor-network stabilized, the technological system with a time gains momentum, reaches the level of autonomy (See Figure 2). It becomes infrastructure, transparent to the end user. Infrastructural blindness is caused by inability of an end user to grasp the scale of technology from a micro perspective due to its complexity, ubiquity, and past history. The scale has changed from micro- to meso-, and to macro scale of organization and time. And while the users of technology are doomed to remain "blind", scholars may not be so. Understanding becomes a skill of maneuvering between the scales, transcending them, while still tracing the actor-networks in motion using Latourian circulatory system.

Figure 2. Evolution of technology and change in perspective



REFERENCES

Ancarani, V. (1995). Globalizing the World: Science and Technology in International Relations. In *Handbook Of Science And Technology Studies*, edited by Jasanoff, S., E.Markle, G., Petersen, J. C. , Pinch, T. Sage Publications London.

Bijker, W. E. (1995). Sociohistorical Technology Studies. In *Handbook of Science and Technology Studies*, edited by Jasanoff, S., E.Markle, G., Petersen, J. C. , Pinch, T. Sage Publications London.

Brown-Humes, C. Access (2000). World dances to a Scandinavian tune [WWW]. Financial Times 2000 [cited May 11 2000]. Available from http://www.ft.com/ftsurveys/industry/sc229d2.htm.

Callon, M. (1993). Society in the Making: The Study of Technology as a Tool for Sociological Analysis. In *The social construction of technological systems: New directions in the sociology and history of technology*, edited by Bijker, W. E., Hughes, T. P. , Pinch, T. J. MIT Press Cambridge.

Callon, M. , Latour, B. (1981). Unscrewing the big Leviathan: how actors macro-structure reality and how sociologists help them to do so. In *Advances in social theory and methodology. Toward an integration of micro- and macro- sociologies*, edited by Knorr-Cetina, K. , Cicourel, A. Routledge and Kegan Paul London.

Callon, M., Latour, B. , Rip, A., (eds). (1986). *Mapping the Dynamics of Science and Technology*. Macmillan, Basingstoke.

Ciborra, C. U. , Hanseth, O. (1998). Towards a Contingency View of Infrastructure and Knowledge: an Exploratory Study. In *Proceedings of the 19th Annual International Conference on Information Systems (ICIS)*, Hirscheim, R., Newman, M. , DeGross, J. I., (eds). December 13-16, Helsinki, Finland, 263 - 272.

Edwards, P. N. (in press). Infrastructure and Modernity: Scales of Force, Time, and Social Organization in the History of Sociotechnical Systems. In *Technology and Modernity: The Empirical Turn*, edited by Brey, P., Feenberg, A., Misa, T. , Rip, A. MIT Press Cambridge, MA.

Elstrom, P., Reinhardt, A., Jackson, S. , Yang, C. Access (1998). Telecom's New Trailblazers [WWW]. Business Week 1998 [cited Apr. 6 1998]. Available from http://www.businessweek.com/1998/14/topstory.htm.

Fomin, V. V. , Keil, T. (2000). Standardization: Bridging the Gap Between Economic and Social Theory. In *Proceedings of The Twenty First International Conference on Information Systems (ICIS 2000)*, Orlikowski, W. J., Weill, P., Ang, S., Krcmar, H. C. , DeGross, J. I., (eds). December 10-13, Brisbane, Australia, 206-217.

Funk, J. L. (1998). Competition between regional standards and the success and failure of firms in the world-wide mobile communication market. *Telecommunications Policy*, 22 (4/5), 419-441.

Hanseth, O., Monteiro, E. , Halting, M. (1996). Developing Information Infrastructure: The Tension between Standardisation and Flexibility. *Science, Technologies, and Human Values*, 21 (4), 407-426.

Harvey, F. (2000). The Internet in your hands. *Scientific American*, 283 (4), 30-35.

Howells, J. (1990). The globalisation of research and development: A new era of change? *Science and Public Policy*, 17, 213-285.

Hughes, T. P. (1986). The Seamless Web: Technology, Science, Etcetera, Etcetera. *Social Studies of Science*, 16, 281-292.

Hughes, T. P. (1993). The Evolution of Large Technological Systems. In *The social construction of technological systems: New directions in the sociology and history of technology*, edited by Bijker, W. E., Hughes, T. P. , Pinch, T. J. MIT Press Cambridge.

Kranakis, E. (1988). Technology Assessment and the Study of History. *Science, Technology, & Human Values*, 13 (3&4), 290-307.

Kumar, K., Dissel, H. G. v. , Bielli, P. (1998). The Merchant of Prato - Revisited: Toward a Third Rationality of Information Systems. *MIS Quarterly*, June, 199-226.

Latour, B. Access (1997). On actor-network theory. A few clarifications [WWW] 1997 [cited March 2000]. Available from http://www.tao.ca/fire/nettime/old/4/0071.html.

Latour, B. (1999). *Pandora's Hope: Essays on the Reality of Science Studies*. Harvard University Press, Cambridge, Mass.

Layne, L. L. (2000). The Cultural Fix: An Anthropological Contribution to Science and Technology Studies. *Science, Technology, & Human Values*, 25 (3), 352-379.

Monteiro, E., Hanseth, O. (1995). Social Shaping of Information Infrastructure: On Being Specific about the Technology. In *Proceedings of the IFIP WG8.2*, Orlikowski, W. J., Walsham, G., Jones, M. R., DeGross, J. I., (eds). 7-9 December, Jufge Institute of Management Studies, University of Cambridge, Cambridge, UK, 325-343.

Mouly, M., Pautet, M.-B. (1992). *The GSM System for Mobile Communications*. Michael Mouly and Marie-Bernadette Pautet, Palaiseau, France.

OECD. Access (2000). Measuring the ICT Sector [WWW]. OECD 2000 [cited December 2000]. Available from http://www.oecd.org.

Pinch, T. J., Bijker, W. E. (1984). The social construction of facts and artefacts: or how the sociology of science and the sociology of technology might benefit each other. *Social Studies of Science*, 14, 399-441.

Star, S. L., Griesemer, J. R. (1989). Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley 's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science*, 19, 387-420.

Star, S. L., Ruhleder, K. (1996). Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces. *Information Systems Research*, 7 (1), 111-134.

Toivola, K. (1992). *Highlights of Mobile Communications development*. TELE, Helsinki.

Winner, L. (1993). Upon Openning the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology. *Science, Technology, & Human Values*, 18 (3), 362-378.