THE ROLE OF STANDARDS IN THE INFORMATION INFRASTRUCTURE DEVELOPMENT, REVISITED

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ABSTRACT

Development of national Information and Communication Technology (ICT) infrastructure is a kind of activity that government engage to in order to create a rubric of progress and to promote diffusion of information technology (IT) revolution. ICT infrastructure is perplexing because we do not have a good model to use to analyze its development. Besides, the modernist style of regulation in the countries promoting diffusion of IT revolution does not require the technology developers to consider the impacts of technology systematically, which creates substantial uncertainty in regard to possible trajectory of technological development. To improve the construction of effective policy planning for large information infrastructures, the conceptual link between the abstract enabling structures and concrete technologies – the building blocks of infrastructure – must be established.

This paper presents a work in progress on a conceptual model which should help us to do the analytical work necessary to improve the policymaking for ICT.

Keywords: standard, information infrastructure, policy, actor-network theory, modernity, micro-macro divide.

INTRODUCTION

"eEurope is a political initiative to ensure the European Union fully benefits for generations to come from the changes the Information Society is bringing. These changes, the most significant since the Industrial Revolution, are far-reaching and global. They are not just about technology. They will affect everyone, everywhere. Bringing communities, both rural and urban, closer together, creating wealth, sharing knowledge, they have huge potential to enrich everyone's lives."

(Council of the European Union 1999, p.2)

The first, focused statement of national policy for information infrastructure development was the Clinton Administration's policy initiative on National Information Infrastructure (NII), published as *The National Information Infrastructure: Agenda for Action* of September 15, 1993 (The White House 1993). It encompassed everything that produces, contains, processes, or uses information, in whatever form, or whatever media, as well as the people who develop the information, applications, and services, etc (Kahin 1997, p.163). Six years after the publication of NII's *Agenda for Action*, the European Commission (EC) presented a program *eEurope* aimed at accelerating the process of exploiting the potential of the *new economy* which "has tremendous potential for growth, employment and inclusion" (Council of the European Union 1999, p.4). Japan has seen initiation of a similar initiative in its Information Policy in 1997[1].

Development of national information infrastructure is a kind of activity that governments must engage to in order to create a rubric of progress, but also to promote the diffusion of information technology revolution (Castells 1996. p.219) in all spheres of social and economic activity and thus contribute to providing the infrastructure for the formation of a global economy, where informational production, knowledge generation and technological capacity are key tools for competition not only between firms and organizations of all kind, but also between countries (Castells 1996, p.124).

Indeed, the information technology revolution (Castells 1996, p.30) and what governments of nation-states refer to as Information Society, both refer to *technologies of information processing and communication* and are about building *pervasive* national information infrastructure (II), which must penetrate all domains of human activity (Castells 1996, p.29).

The kind of large-scale initiatives like building *e*Europe, is subject to mobilization of resources, creation of laws, formulation of political will, and legitimating of ideas. The common knowledge, however, goes that these programs usually don't work out exactly as envisioned. For example, The U.S. NII initiative was aimed at creating an advanced information infrastructure and an "information superhighway" (Kahin 1998, p.339) to be delivered to the public by private sector with encouragement from government. But the only visible achievement of the NII initiative was that it succeeded as a shared vision of transformative potential of ICT[2] and was instrumental in accelerating embrace of the Internet within the government (Kahin 1998, p.346). "Instead of a bigger and faster "highway" there was a paradigm shift from circuits to tiny packets of information as the organizing unit of telecommunications" (Kahin 1998, p.339). Do we have any confident reasons to believe that *e*Europe will be any bigger success than NII?

There are at least two reasons for separation between the policy (rhetoric) and reality in large-scale information infrastructures development. First, there is a problem in the complexity of the object of analysis – the infrastructure as a complex network of social, institutional, and technological actors. Second, the subject of policymaking, i.e., strategic planning, is a problematic procedure, too.

These two problems are well known to the scholars of social constructivism – the theories have been criticized for maintaining separation between structure and subject, or structure and agency (Marshall 2003, p.116). More specifically, there is a problem of non-integration, or incongruence, of different levels of analysis: local action and individual agency on the one hand, and longer-lived and more disperse social structures on the other (Marshall 2003, p.116).

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[1] http://www.miti.go.jp/intro-e/a228100e.html (Access: May 27, 2003).
[2] Information and Communication Technologies.

In this work, we propose a way to overcome the micro-macro separation that has plagued studies of social constructivist theories (Latour 1996; Marshall 2003; Russel et al. 1988; Winner 1993), economics (Rosenberg 1982), history of technology (Calhoun 1998), and other. In the following sections we elaborate on problems associated with policymaking for large-scale IIs and propose an analytical technique to deal with micro-macro divide. This novel analytical approach is necessary to improve the construction of effective policy planning for large information infrastructure initiatives, such as *e*Europe.

POLICYMAKING FOR LARGE-SCALE ICT DEVELOPMENT

Complexity of structure: re-opening the black-box of technology

The modernist[3] style of regulation adopted by governments of leading industrialized countries does not require technology developers to consider impacts of technology systematically, let alone at an early stage, while technologies are undergoing development and taking on their durable forms (Schot 2003, p.258). This might come as a surprise, since the common knowledge is that technologies interact deeply with society and culture, and these interactions involve mutual influence, "substantial uncertainty, and historical ambiguity, eliciting resistance, accommodation, acceptance, and even enthusiasm" (Misa 2003, p.3). Although technology promoters devote substantial resources to persuading the public to adopt a "better understanding" (acceptance and enthusiasm) of the issue at stake (Schot 2003, p.258), uncertainty, resistance and even failure have equal roles in the history (Latour 1996).

Unexpected turns in the technology developments can be to a large extent attributed to the popular discourse that technologies are "black boxes", fixed entities that irresistibly change society and culture (Misa 2003, p.2). Technology policymakers and promoters often seem to be ignorant of the fact that stabilization of a technology implies the embedding of the technology in a stable network consisting of humans and other technologies, and the acceptance of a dominant view on how to interpret and use technology (Brey 2003, p.52). Treating technology as a black-box, as "a "technology-with-a-capital-T" leads to vagueness, obscures differences between technologies, and fails to distinguish the varied ingredients that make up technology (knowledge, artifacts, systems, actions) and the way these relate to their context" (Brey 2003, p.56). These kind of generalizations about technology development on behalf of policymakers and alike go against many key ideas of technology studies (Brey 2003, p.58; Latour 1996).

To avoid over-generalization, promoters of technology must open the black-box of technology. This issue has been addressed before in regard to a technology in general (Rosenberg 1982; Russel et al. 1988; Star 1992; Winner 1993). In this work we seek to understand how to make better policy for building national information infrastructures by opening the black box in yet another way.

Complexity of subject: policymaking for infrastructure development

Ciborra (2001, p.2) described corporate information infrastructures and the design and implementation processes that lead to their construction and operation as *puzzles*, or *collages*, which are embedded in larger, contextual puzzles and collages (Ciborra 2001,

[3] The concept of modernizations (and hence the modernist regulation) refers to "a new mode of social organization, a new social order, and a discontinuity in history" Schot, J. "The Contested Rise of a Modernist Technology Politics," in: *Modernity and Technology*, T.J. Misa, P. Brey and A. Feenberg (eds.), MIT Press, Cambridge, MA, 2003, pp. 257- 278.

p.2). “Inter-dependence, intricacy, and interweaving of people, systems, and processes are the culture bed of infrastructure” (Ciborra 2001, p.2). If ICT infrastructure is perplexing, because we don’t have a good model to apply to its analysis (Brey 2003; Ciborra et al. 2001; Edwards 2003), then how policy makers can develop an appropriate policy given the complexity of the problem?

Axelrod and Cohen (1999), propose a way to deal with the difficulty of policy making, a solution to the Ciborra’s puzzle. According to Axelrod and Cohen (1999, p.12), a standard procedure of design and policy making for complex organizations is to develop expectations of how the future will unfold and to define actions that would lead to more desirable predicted futures. This approach requires an expert knowledge from similar past developments. The problem is, creation of a *new economy* is a novel undertaking. Many large-scale developments of the industrial age saw fiasco and, according to Ciborra, “those very principles that were supposed to govern the emergence of the industrial society are even less applicable to the information society” (2001, p.5).

An alternative approach to cope with difficulty of national policymaking is a generation of various forms of scenario derived from identification of the driving forces of the system (Axelrod et al. 1999, p.12). This approach requires a comprehensive understanding of the system and forces that operate within it. Moreover, understanding of processes that bring the elements together into a complex network is also required. Thus, it is our intention to remind the policymakers and modernists alike, that if a technology development policy is to generate positive results, the black box of technology must be reopened. And since success of creation of Information Society is critically dependant on *technologies of information processing and communication* and *pervasive* national information infrastructure (Castells 1996, p.29), the system under analysis is information infrastructure.

The micro-macro divide

The problem of analysis of large-scale ICT developments is that the promoters of technology often visualize it as a “technology-with-a-capital-T” (Brey 2003, p52), thus being unable to foresee many possible trajectories that the development can take. The problem of myopic understanding of the nature of and forces operating within information infrastructures is in “analyzing macrolevel phenomena... in terms of other macrolevel phenomena” (Brey 2003, p.62), and inability to see the actors and forces that operate at the micro level.

The problem of bridging the gap between micro and macro perspectives has received considerable attention in studies of management, policy, economics, and social organization (Callon et al. 1981; Fomin et al. 2000a). In spite of the attention, there is still no error-prone method on how to connect macrolevel and microlevel analyses. This comes as no surprise, since, according to Brey (2003), considerable confusion exists over what makes a phenomenon studied in the social sciences a macro or micro: one view is that macrolevel phenomena and the concepts that refer to them are abstract and general, whereas microlevel phenomena tend to be concrete and specific; the other view is the size of the object (small size is associated with micro, large size – with macro) (Brey 2003, p.63). To bridge the micro- and macrolevels, analysts have to work at level building, engaging in what Brey (2003, p.69) called decomposition, suibsumption, deduction, and specification.

Arriving at an adequate integration of levels of analysis represents a substantial problem for information infrastructure development policymaking: how do you get from a discussion of globalization, information society, and national information infrastructure to the development and use of specific technologies (Brey 2003, p.66)? This kind of bridging is possible trough the understanding of the nature of infrastructures and their building blocks: if the divide can be overcome at the level of the building blocks, than, perhaps, an adequate way to integrate micro and macro levels can be found, too.

In the following sections we argue that standards are the building blocks of infrastructure. We see the critical role of standards as the missing link between the micro and macro, the structure and agency, the function and activity. The dual nature of the standards – the activity of standardization and the boundary object – allows for linking practice of infrastructural development (microlevel) to its function and structure (macrolevel). Thus, the conceptual bridging of large, diffuse, and abstract infrastructures and concrete, small (in terms of part-whole relationship to the infrastructure), and singular standards becomes possible – the black box of technology can be reopened.

THE NATURE OF INFRASTRUCTURES AND THE ROLE OF STANDARDS

Standards as building blocks of infrastructures

Before different technologies are meshed into a single infrastructure, they evolve relatively independent from each other. To become integrated into II, they must be harmonized in technological and socio-institutional terms, meaning that relationships between the elements have to be reinforced and transformed. In this, not only "the whole is more than the parts" (Anderson 1972), but a novel socio-technical configuration linking regulatory framework, communications infrastructure, user practices, maintenance networks, etc. (Geels 2002, p.1257) have to be formed. Standardization (either *de jure* or *de facto*) becomes a crucial element in such harmonization process, because of its ability to coordinate activities between and within diverse social groups to reconcile their varying interests while still working towards a single outcome (Fomin et al. 2000b; Lyytinen et al. 2002). If infrastructures are the connecting tissue of modernity (Edwards 2003), then standards are the building blocks of infrastructures. Standards play a crucial role at the point when technology acquires a momentum, when competing or complementary components are being added to what is becoming information infrastructure (Edwards 2003; Hughes 1993).

From a technological standpoint, without standards, information infrastructure is merely a collection of separate independent connections and cannot function as integrated whole (Hanseth et al. 1998). It is through aggregation of elements by the means of standards that results in formation of large and complex systems bringing about entirely new properties at each level of complexity (Anderson 1972, p.393). Standardized technology enables large-scale integration and is the basis for a division of labor (Hanseth et al. 1998, p.56), which in turn is a necessary condition for the creation of societal benefits. Thus, the socio-institutional and the technological roles of standards are intertwined and inseparable.

Thus, one can define several important roles that standards play in the process of building information infrastructures (Table 1). On the technical level, information infrastructures demand standards that enable interconnectivity of multiple technologies, or "gateways" (Hanseth et al. 1997). Creating "gateways" is a highly complex socio-technological task which includes designing communication and technical interface standards, testing and adapting these to a wide range of different use situations, and ensuring that the standards are developed according to the procedures of recognized standardization bodies, if such exist (Hanseth et al. 1997, p.183; Lyytinen et al. 2002).

From organizational viewpoint, standards align diverse interests of participating groups (Fomin et al. 2000b; Hanseth et al. 1997). In fact, interests of these social groups (government organizations, engineers, entrepreneurs, consumers, etc.) *must* be aligned if the development of the technological system is to proceed (Latour 1999). Standards provide a means for system builders and entrepreneurs to share their perspectives, and to gain understanding how the technological potential can be made to meet diverse ends. By doing so participating groups can better negotiate the desired technical and economic properties of the technology (Bekkers et al. 1999). Hence, standards inscribe and embed large socio-technical networks of developers, users, and government institutions, and provide a powerful means to analyze relational aspects of infrastructures.

From economic viewpoint, competition between system standards leads often to a situations where "a winner takes all" due to strong positive network externalities and resulting increased returns. A body or a firm, which successfully establishes a technical standard in a new technical regime, receives normally large returns, whereas its competitors may be effectively locked out or provided only with residual market niches (Schilling 1998).[4]

Finally, technologies with a high momentum normally spawn a number of competing suggestions for the correct "technical solution". In such situations standards are both necessary and helpful in that they early on limit the technical design space and help obtain a sufficiently fast implementation of a working design with a large enough user base.[5] This is critical for the emerging markets, where chaotic competition needs to be organized relatively quickly around a relatively stable set of system concepts (Edwards 2003), otherwise the technology may lose its momentum. Standards thus help reduce the risk of entrepreneurs as well as consumers thereby increasing the momentum behind the dominant system solution (Edwards 2003).

[4] Sometimes this "battle of the systems" can culminate with the invention of devices that make possible the interconnection between incompatible systems Hughes, T.P. "The Evolution of Large Technological Systems," in: *The social construction of technological systems: New directions in the sociology and history of technology,* W.E. Bijker, T.P. Hughes and T.J. Pinch (eds.), MIT Press, Cambridge, 1993, pp.51-82.

[5] Currently we can see similar chaotic behavior in the area of pervasive computing where all major vendors are suggesting their own protocols for service discovery and integration including Sun, HP, and Microsoft.

Table 1. Different scalar views on standards in the developing of IIs

View	Organizational	Technical	Economic
Scale	Micro	Meso	Macro
Function	*Boundary object*	*Gateway*	*Technological fix/ solution*
Example	Linking individuals, organizations, and technologies. Accommodating /inscribing different views and interests.	Allowing different technologies to interact. Interface standards, etc.	Access to market. Limiting design space to allow technology gaining momentum

Understanding infrastructures

Edwards (2003) provides an excellent analysis of the nature of infrastructures. According to Edwards (2003, p.186), infrastructures simultaneously shape and are shaped by the conditions of modernity; they are ubiquitous and critical in that their failures can affect lives of millions; they have persistence and longevity due to the large installed base; and they have become community dependent thus involving participation from a large number of constituencies from manufacturers, service providers, users, regulators, and so on (Edwards 2003, p.186; Hanseth et al. 1997; Star et al. 1996). Finally, infrastructures form the stable foundation of modern social worlds by *linking* micro, meso, and macro scales of time, space, and social organization (Edwards 2003).

If infrastructures are linking different scales of time, space, and social organization, they can also be studied on different levels (Table 2), each producing different pictures of how they develop, as well as their constraining and enabling effects on social and individual life (Edwards 2003, p.220). Different scalar views lead to different understanding of the “modernist settlement” (Latour 1999, p.14) that brings together nature, society, and technology (Edwards 2003, p.221).

Microlevel analyses illustrate how individuals and small, spontaneously organized social groups shape and alter infrastructures, creating their own version of modernity (Edwards 2003, p.221). Relational concept of infrastructure is appropriate for micro-scale analysis. As Star (1999) points out, an infrastructure is “fundamentally a relational concept, becoming a real infrastructure in relation to organized practices.” In consequence, an infrastructure must be studied as a set of relationships: how do specific actors relate to it, and what is the significance and impact of the given infrastructure for a given actor, and how this relationship evolves over time. Thus, micro scales provide a constructivist view on infrastructure development.

On *mesolevel*, infrastructures follow a development pattern visible only on a historical time scales. Infrastructures consist not only of technological, but of legal, corporate, and political elements (Edwards 2003, p.199). Because of these properties, building regional infrastructure, similar to *e*Europe, requires large institutions with long lifespan, and sufficient political and social powers, and huge private investments (Edwards 2003, p.200).

Macro-scale perspective reveals entire societies and economic systems as functional and systemic, rather than constructivist infrastructures (Edwards 2003, p.186; Misa 1994) and in contrasting light: as technologies, infrastructures on macro scale die (they become obsolete and phase out); seen as function, on the other hand, infrastructures grow (the obsolete technology is replaced by a newer and superior one) (Edwards 2003). On macrolevel infrastructures can be studied mainly through their technological trajectories and expansion as indicated by functionality, diffusion rates, traffic volume, or coverage, and their possible decay (Lyytinen et al. 2002), and thus similar to analysis performed on mesolevel are seen as ecological systems. Infrastructures are best studied on macrolevel, but they mediate among the actors that are studied in microlevel analysis (Brey 2003, p.60).

Table 2. Different scalar views on infrastructures. Adopted from (Edwards 2003)

View	Relational	Ecological	
Scale	Micro	Meso	Macro
Function	*Organized practices*	*Force amplification*	*Solution to systemic problem (technological fix)*
Example	Defines a set of dependencies between technological artifacts, actors, and sites.	Not under control of any individual actor	Adapts to demands of environment.

STANDARD – THE MISSING LINK IN MICRO-MACRO DEBATE

Infrastructures-as-technologies phase out and die, but as functions – live and develop (Edwards 2003). This contradiction points at interesting phenomenon – a sort of gradual regeneration process typical for biological organisms – there is an ongoing process of aging and renewal, in which infrastructures are seen as macrolevel ecological systems, which constantly adapt to the demands of various environments including technology push, market pull, and regulatory intervention.

To understand how the activity (the ongoing process of renewal) is related to the structure (the function that infrastructure is carrying) is but one way to overcome the micro-macro and concrete-abstract divide. In the following, we deploy actor-network approach to propose an analytical technique to develop a functional connection model linking infrastructures to standards by way of functions through specific dyads – social practices and boundary objects, technology and gateways, institutional arrangements and technological fixes.

When we deploy what Bowker and Star (1999) called “infrastructural inversion” and look at the micro level of social practices, an infrastructure – the object of analysis – can be seen as an actor-network (AN) (Geels 2002; Latour 1999) consisting of both technological elements and social practices. At any point of time of infrastructural evolution, [ecological] adaptation of the infrastructure to environmental demands (of any nature) is possible if and only if translation (Latour 1999) of associations that infrastructure holds together is permitted by the AN constituting it. Translation generates ordering effects, which in turn can result in durability of the infrastructure in time (Law 1992, p.9) holding together the structure and the activity (Suchman 2000, p.316) – the social practice of actor networks and technology-as-a-function.

An information infrastructure dictates rules through which new components and/or services are connected to it by imposing a set of *de facto* or *de jure* standards (Monteiro et al. 1995). Standards, although not seen as readily available from the shelf, are integrated into the infrastructure according to their functional purpose: gateways for [data] interconnection with existing modules/systems; technological fix for technological solution to economic, social, or organizational demands; or boundary object for aligning interests between different [groups of] actors. The process and outcomes of infrastructure formation vary depending on how the actors interacted, who had the initiative, how the entrepreneurs could build their visions of the technology or service, and how it affected the actual design. The institutional and industrial context plays also a role here (Table 3).

Table 3. Dyadic connection model linking infrastructures and standards

Infrastructure: Dyadic connection model linking infrastructures and standards

Function (Structure)		
Social practices	Technology	Institutional arrangements
Development and integration activity		
Boundary object	Gateway	Technological fix
Function		

Standard: concrete miclolevel object

Standard commands a central role in the network as a boundary object that other actors can relate to (Fomin et al. 2000b). As an actant in the network it constrains actions of other actors, and inscribes certain behaviors. Standard is never separated from the activity, actors, or structures (Fomin et al. 2003), and thus bridges the micro- and the macro. Such links between activity and structure have already been established in recent empirical technology development studies (Carlson et al. 1990; Gorman et al. 1990), but have not been applied to standards.

The duality of standards opens the way to dealing with micro-macro divides in analysis of infrastructure development, and, consequently, provides a solution to more effective policy planning for large information infrastructures, such as the U.S. NII, European *e*Europe, and Japanese Information Policy.

CONCLUSIONS

Information infrastructures development is not easily explained by any of the classical theories. Moreover, institutional actors assigned key roles in the process often have either a myopic views on the problem, their scope being limited to the immediate tasks of their institutions.

Given these inhibitors to analysis and formulation of policies for very large-scale socio-technical initiatives, our goal was to present an analytical framework to harnessing complexity of the system by means of providing better understanding of the system itself, its constituents, and forces that operate within it.

One of the major problems associated with policymaking for diffusion of information technology revolution, creation of information society, or any other large-scale ICT development, is the separation between the micro- and macro- in problem definition: marcolevel accounts typically adopted by policymakers can not adequately represent the microlevel processes taking place in the actornetworks (Brey 2003, p.59). As a result, the technology development and implementation for establishing/ sustaining the needed structures and functions can take on different trajectories, often unanticipated and unwanted.

Although substantial amount of literature has previously addressed the problem of micro-macro divide in technology and management studies, looking at the same problem as a structure-activity divide is a novel contribution. The analytical technique deployed in this paper should help us to do the analytical work necessary to improve the construction of effective policymaking for information infrastructures development initiatives.

Through exploration of the nature of infrastructures, their formation, and forces that operate within them, we concluded that the notion of standard becomes a cornerstone in the analysis – it connects technological artifacts and social networks, activities of actors and environment in which these actors operate. Standards allow for bridging the views of policymakers and technology developers, “harnessing complexity” by narrowing uncertainties associated with technological development.

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