Contribution to the
International Summer Academy on Technological Studies
User Involvement in Technological Innovation
Deutschlandsberg, Austria, July 8-14, 2001

THE POLITICS OF TECHNOLOGICAL INNOVATIONS: NETWORK APPROACHES

Moses A. Boudourides

Computer Technology Institute and
Department of Mathematics
University of Patras
265 00 Rio-Patras
Greece

mboudour@upatras.gr
http://www.math.upatras.gr/~mboudour/

By now, it is well known that the essential components of technological innovation include not only production and design but also consumption and uses, not only technological-engineering and organizational-economical structures but also social and cultural processes. In fact, "innovation involves more than merely research and development or product launch" (Silverstone & Haddon, 1996, p. 44). Furthermore, the way all these components are interwoven is not simplistic at all. For instance, this can been seen by considering how RTD (Research and Technological Development) expenditure is related to both social and economic development. At first sight, these relations could be traced as follows: "Expenditure in basic research produces discoveries used by applied research to conceive new products or new processes which generate positive social and economic impacts in the mid-long term" (STOA, 1999). But this scenario is deceiving; for example, it cannot explain the European paradox that Europe invests less than the USA and Japan in basic research, achieves excellent results in this field but is not able to turn them into patents and economic competitiveness. Thus, innovation paths cannot follow a simple linear model but instead their trajectories should be rather complex, allowing connections among all components, and, thus, constituting what is better named an 'innovation system.' It should be also mentioned that this trend 'against linearity' belongs to the critical agenda adopted by science and technology studies as well as by modern perceptions of the public understanding of science and technology. As a matter of fact, these fields strongly criticize the assumption that the relationships among science, technology and society can be simple and unidirectional (Sørensen, Aune & Hatling, 2000).

In what follows, our aim is to explore how the complexities of an innovation system can be understood through a number of theories, which attempt to apprehend the interconnected, distributed and relational structures supporting innovative agencies. Our preference for network approaches is not intended to minimize the importance of other theoretical frameworks dealing with technological innovation. One such framework is that of the 'social shaping of technology,' which explores how a whole range of factors – organizational, political, economic and cultural – may pattern

innovation processes at the design and implementation stages (Williams & Edge, 1996). The length of the present paper has not permitted us to discuss this very important approach. Another approach, which is left aside in here, is that of evolutionary economics emphasizing the role of increasing returns, lock-in and path dependence on technological competition (Arthur, 1989). Although the modeling and simulations developed in the latter approach are perfectly accommodated inside the program of complexity theory and as such would successfully capture the complex dynamics of innovation processes, a discussion about them falls outside the scope of this paper.

Diffusion of Innovations and Social Networks

Given the increased penetration of technological innovations in private, domestic, public and working spaces and environments, the diffusion of these innovations becomes a very important issue to study (Rogers, 1995; Valente, 1995). The approach of the *diffusion of innovations* started with the pioneering work of Everett Rogers (1995, fourth edition - first edition in 1962). The roots of this approach come from a school in anthropology, the British and the German-Austrian 'diffusionism,' according to which all societies change as a result of cultural borrowing from one another, a theory which had influenced the American historicism in anthropology (Kroeber, 1937).

According to Everett Rogers, the eventual adoption of a technological innovation depends on the following five factors: (i) the relative advantage, which can be measured in economical terms but also in terms of social prestige and satisfaction, (ii) the compatibility with the values of the appropriating group, (iii) the complexity, (iv) the triability and (iv) the observability of the innovation. Note that all these mechanisms refer to an analysis of the adoption of a technological innovation valid from the time of its diffusion and afterwards without paying any attention to the production stage or the stage when the conception of the product was designed. In this way, Rogers considers that the corresponding decision processes for the adoption of a technological innovation follow five stages: knowledge, persuasion, decision, implementation and confirmation. Furthermore, Rogers distinguishes five groups of users: innovators, early adopters, early majority, late majority and laggards.

One of the first works following the diffusion approach was carried out by Ryan and Gross (1943), who studied the diffusion of hybrid corn among farmers in two Iowa communities. Theirs was the argument that the diffusion of an innovation is a social process because, if all individuals were acting as rational decision makers, then adoption should occur for everyone at the same time, while the time lag between the first and last adopters indicates that social structural and socio-psychological factors influence the process.

In fact, diffusion is the spread of new ideas, opinions or products throughout a society, i.e., it is a communication process in which adoption proceeds by persuasion. "Diffusion is the process by which an innovation is communicated through certain channels over the members of a social system" (Rogers, 1995, p. 5). Now, the technique to analyze communicative patterns as relational structures in society is provided by the *social network analysis*. In this approach, a *social network* is composed of *actors* and *relations* occurring among them. Actors are whoever and

whatever performs the agencies through which relations among actors develop and hold them together. Thus, actors (or agents) can be individual people, objects or events but they can be also aggregate units such as organizations, institutions, firms, communities, groups, families etc. The very idea of the social network approach is that relations or interactions between actors are the building blocks or the key elements that sustain and define social structure, despite actors' 'nature' or any other attributes they might be endowed with (Wellman, 1988; Wasserman & Faust, 1994; Scott, 2000). Typically, interactions between actors result from exchange of resources they hold in the specific social and cultural contexts they are living and communicating with each other, i.e., according to the existing distribution of power or authority relationships, accepted social norms, habits, dependencies, practices, expectations and preferences. In these interactions, exchanged resources can be either material or informational, such as goods, money, information, services, social or emotional support, trust, influence etc.

The first and extremely influential study of network diffusion was conducted by Coleman, Katz and Menzel (1966) on the diffusion of a new drug (tetracycline) among doctors in four Illinois towns. According to the results of this study, diffusion occurred more quickly among socially integrated doctors than among socially isolated doctors. In an example of a more recent diffusion study, coming from the new information and communication technologies, in the context of virtual reality (VR), Thomas Valente and Thierry Bardini (1995) argued that there are three key factors, which affect this diffusion process: technology, policy and social networks. These factors might either facilitate or impede the diffusion of VR systems and, so, they could generate a number of different scenarios for the time evolution of the diffusion process.

In fact, the time evolution of the adoption rate, which, as generally is the case in economics, constitutes the essential descriptive variable of diffusion processes, turns out to be described by an S-curve (Rogers, 1995). From the first diffusion studies, it was argued that adoption processes occur in stages. Individuals first become aware of a technology, then learn more about it, then try it and finally adopt it. In other words, the adoption process is divided into three stages: awareness, trial and adoption. In each of these stages, empirical data sets might generate different mathematical functions of best-fitted theoretical curves. For instance, according to Valente and Bardini (1995), in the diffusion of VR, awareness and adoption are described by exponential curves, while trial by logistic curves.

The main theoretical models of the network diffusion of innovations include *threshold models* and *critical mass models*.

Threshold models (Granovetter, 1978; Granovetter & Soong, 1983, 1986, 1988) are based on the assumption that individuals in general have varying thresholds for adoption of an innovation. Granovetter defined an individual's *threshold* as the proportion of adopters in an individual's network necessary for her or him to adopt an innovation - "the proportion of the group he would have to see join before he would do so" (1978, p. 1422). Since individuals tend to reckon costs and benefits, a more formal definition of an individual's threshold is the point at which the perceived benefits exceed the perceived costs (*ibid.*). Individuals have low, medium or high thresholds and it is the distribution of thresholds that determines the rate of diffusion.

In other words, thresholds manifest the degree an individual is influenced by others in her or his social network; low thresholds indicate low resistance (i.e., early adoption), while high thresholds indicate high resistance (i.e., later adoption). Generally, thresholds are believed to be a function of such factors as cosmopolitanism and media exposure (Valente, 1995).

The *critical mass* is a system-level measure of the minimum number of users needed to sustain a diffusion process. The main contributions on critical mass are from Oliver and Marwell (1988; Marwell, Oliver & Prahl, 1988; Oliver, Marwell & Texeira, 1985; Prahl, Marwell & Oliver, 1991) and Macy (1990, 1991). In communication and particularly in interactive technologies, critical mass has been studied among others by Rice (1990; Rice *et al*., 1990), Markus (1987) and Allen (1988). According to Oliver, Marwell and Texeira (1985), critical mass is composed of individuals who receive numerous nominations from others in the social network. Therefore, centrality is important in the spread of innovations in the sense that critical mass exists when high centrality individuals are early adopters. However, other network characteristics are also important for determining critical mass and rate of diffusion. For instance, low clustering (i.e., differentiation into subgroups) and presence of weak ties tend to increase critical mass and to facilitate the diffusion process. From a techno-economic point of view, reaching a critical mass for a particular technology insures that a market exists, which sustains the development and further improvement of that technology.

Let's conclude remarking some criticisms that the theory of network diffusion of innovations has received. According to Thierry Bardini (1996) the major problematic issue in this theory is the method of adopter categorization. This is about how to standardize categories of adopters through the time of adoption (innovators, early adopters, early majority, late majority and laggards). Everett Rogers does so by employing a behaviorist attribute of adopters that he calls *innovativeness* but he admits that "such classification is a simplification that aids the understanding of human behavior, although it loses some information as a result of grouping individuals" (1995, p. 261). On the contrary, Bardini argues that these categories of adopters constitute 'ideal types,' "conceptualizations based on empirical observations and aiming to effectuate comparisons," which are "supposedly explained in terms of allegedly independent variables covering the socio-economic traits, the personality and the communicational behavior of the studied individuals" (Bardini, 1996, p. 130). The problem with these fixed categorizations is that they do not permit to conceive the possibility that the adopter may change her or his mind. In fact, the adopter can decide even to reject an innovation at any time and not only during decision-making. Thus, Dominique Boullier (1989) accuses Rogers of propagating a false and 'positivist vision of technology,' according to which diffusion becomes effective only when innovation is completed and it is restricted inside the process of being adopted, a vision which apprehends users as passive subjects who either accept or reject innovations.

Incidentally, it was only in the third edition of his book (in 1983) that Rogers incorporated the notion of 're-invention' (a term that had been originally introduced by Rice and Rogers in 1980). What is meant by re-invention is the possibility that "an innovation is changed or modified by a user in the process of its adoption and implementation" (1995, p. 174). Similarly, the work of Eric von Hippel (1986) at the

Sloan Management School at MIT on the role of *lead users* has shown that not only users can re-invent an innovation during the implementation stage but also they can even construct the corresponding uses, they can be a "source of novel product concepts".

The Politics of Actors

An interesting approach to conceptualize the social, technical and natural settings, in which innovations are embedded, is provided by the so-called *Actor-Network Theory* (ANT), sometimes also referred as *sociology of translation*. This is a theory coming from Science and Technology Studies, the field of modern sociology of science and technology (Michel Callon 1986a, 1986b; Bruno Latour, 1987, 1988; John Law, 1988, 1991). ANT sets out a structuration-type plan to describe the complex social processes underlying the construction, development and stabilization of forms of the social, the technological and the natural world and their combinations, a "mechanism by which the social and natural worlds progressively take form" (Callon, 1986b, p. 224).[1]

As conceptualized by ANT, processes of socio-technical development occur in a series of negotiations among the involved actors (to recall Latour's famous slogan "follow the actors"). Aligned actors construct and maintain a network by enrolling allies, mobilizing resources and translating interests. In this sense, *translations* are understood as the actors' activities of ongoing negotiations, which define actors' physiognomy and the relations among themselves, "their identity, the roles they should play, the nature of bonds that unite them, their respective size and the history" (Callon, 1986a, p. 24).

Actors of heterogeneous networks of translation, association and alliance more correctly could be labeled as 'actants' so as to emphasize the semiotic inclusion of both humans and non-humans. Thus, in ANT, heterogeneous networks, as concrete alignments between human actors, natural phenomena and social or technical aspects, result in the construction of scientific and technological objects (facts and artefacts, respectively). Furthermore, even social instantiations (for example, society itself) can be produced by such actor-networks (Woolgar, 1991). However, typically the actual products of such processes are never purely one or the other but they appear as 'hybrids' comprising all three domains simultaneously (Latour, 1987).

In this way, ANT conceives technological innovation as a heterogeneous 'socio-technical system' (Akrich, 1993a, 1993b) or 'socio-technical frame' (Flichy, 1995a, 1995b). "Neither the purely technical necessities nor the imposition of certain socio-political forms can explain the form taken by innovations. Particularly, the innovation process is described by the construction of an association network among heterogeneous entities, human and non-human actors" (Akrich, 1993b, p. 36). This means that "the elaboration of technology can be described as the elaboration of a

[1] What follows is an attempt to present a personal account of ANT, although the meaning of such an enterprise is questioned as problematic by the very protagonists of the theory, who hesitate to produce any summary of it. In fact, a better idea would be to follow John Law's suggestions: "That one might [better] represent actor network theory by *performing* it rather than *summarising* it. By exploring a small number of case studies rather than seeking to uncover its 'fundamental rules'. By telling of examples, representatives of actor-network theory, that are *both* faithful and unfaithful" (Law, 1997).

scenario made up of an action program, of the distribution of this action program to various entities (technological artefacts constituting the object of the innovation, but also other systems with which the innovation is going to be associated, users, of course, and even techniques, installers, distributors, etc.) and finally of a representation of the environment in which the action program can or must be carried out. In this perspective, the work of a sociologist is to describe the operations by which the starting scenario essentially appearing in a discursive form develops gradually in a series of transforming operations of translation which are articulated and sustained by an always increasing number of entities, human actors and technological artefacts" (Akrich, 1993a, pp. 91-92).

Any translation, through which an actor network is configured by the negotiated alignment of allies (both human and non-human), involves four stages (Callon, 1986b). First is the *problematization* stage, in which key actors are identified and persuaded that aligning themselves in the new network may provide solutions to their problems; this would involve that certain actors should become indispensable to others and, thus, access to obligatory passage points of the network should be negotiated. In the second stage, called stage of *intéressement*, actors are locked by other actors into prescribed roles so that old networks might dissolve and a new network might emerge. Third comes the stage of the proper *enrolment*, in which the identity of the new network is achieved through consent, seduction or even coercion. Final is the *mobilization* stage, in which the established representation delegations are assured and the fear of betrayal is removed.

ANT is often presented as combining the insight of economics, which highlights material exchanges that actors draw in their relationships, with the insight of sociology, which prioritizes the fact that actors come to define themselves through their interactions. Thus, Michel Callon states that "actors define one another in interaction – in the intermediaries that they put in circulation" (1991, p. 135) and also that "an intermediary is anything passing between actors which defines the relationship between them" (p. 134). In this way, processes of mediation possess a key importance in an actor-network because they manifest how the entanglement between the social and the technical is inscribed inside technological artefacts. The latter are apprehended, according to Chambat, as "a sequence of compromises between different social actors, carriers of a social project, which is inscribed into their technical dispositions" (Chambat, 1994, p. 257).

As a concrete example, let us refer to the actors and intermediaries involved in the currently very significant process of *e*Governance (see, for instance, the *e*Europe Action Plan). First, let us say that we envision *e*Governance as a 'top-down' (e.g., service provision) process, which should be distinguished from digital democracy, the latter being a rather 'bottom-up' (e.g., socio-political interaction) initiative. Exploring the institutional administrative structures under which initiatives of *e*Governance may flourish and focusing on the constitutional, institutional and technological barriers to the viability of digital democracy projects, one easily realizes that three are the main categories of actors (or stakeholders) involved in these processes: the public (citizens and users), the state (public administration) and the market sector (including industrial producers, developers etc.). On first place, the role of the state in *e*Governance might be severely questionable. It's not only that democracy means less state and public intervention but also that information and communication technologies have been

already developing as market-led and primarily depending on private initiatives. However, many assure that the necessity of public policies in these processes is absolutely justified and that public authorities have an important role to play in the shaping of *e*Governance and digital democracy. The way Michel Catinat and Thierry Vedel (2000) put it, "the marketplace is not always the best mechanism to ensure the basic values associated to the notion of digital democracy (such as freedom of communication, equal access to information infrastructure)" (p. 184). As far as public authorities are developing best practices of *e*Governance and digital democracy and the public is well informed about their rights and responsibilities, it is expected that informational social inclusion will be promoted and that the development of a 'digital divide' will be prevented. Through these public actions, traditionally excluded strata (such as citizens living in remote regions, disabled people, women, 'migrant' and other ethnic groups etc.) might be protected from the risks and uncertainties of the information society. Furthermore, the form of public intervention which is needed should be responding to Commissioner Erkki Liikanen's call for "responsivity, sensitivity and accountability of fair regulation" (Liikanen, 2000). In this way, socially accountable best practices of information polity are necessary in order to increase the stability and sustainability of the information society and the new economy. As for the roles of the remaining two actors (users and producers), the basic methodological schemes through which one could understand how they operate will be analyzed in the next section.

Inscription, Configuration, Representation and Affordance

Methodologically the occurring transformations in an actor-network are analyzed by the concepts of 'description' and 'inscription.' *Description* is the "analysis of what the various actors in a setting are doing to one another" (Akrich & Latour, 1992, p. 259). The opposite movement, *inscription*, is the activity of understanding the way technical artefacts embody patterns of use: "Technical objects thus simultaneously embody and measure a set of relations between heterogeneous elements" (Akrich, 1992, p. 205). In fact, the notion of inscription represents the structurational model of ANT, in which concrete anticipations and structural constraints in the use are already involved in the development phase of a technology (for instance, through technical or usability tests, experimentations with hypothetical users, associations with other actors etc.). Madeleine Akrich explains this as follows: "Designers thus define actors with specific tastes, competences, motives, aspirations, political prejudices, and the rest, and they assume that morality, technology, science, and economy will evolve in particular ways. A large part of the work of innovators is that of 'inscribing' this vision of (or prediction about) the world in the technical content of the new object … an attempt to predetermine the settings that users are asked to imagine" (1992, p. 208). In this way, technological innovation can be interpreted as a series of "confrontations between the environment inscribed into the artefact and the environment described by its displacement" (Akrich, 1993a, p. 92). Note that one type of inscriptions is particularly helpful for the phase of description: *prescription* (or proscription or allowance), i.e., usually texts (such as manuals, brochures, promotional material, critical reviews of others etc.), which explain the technical object. Hence, prescription is "what a device allows or forbids from the actors (humans and non-humans) that it anticipates; it is the morality of the setting both negative (what it prescribes) and positive (what it permits)" (Akrich & Latour, 1992, p. 261). In fact, according to Laurent Thévenot (1993, pp. 100-102) technology

producers try to 'discipline the usage' of a technological artefact in the following three ways: (1) by issuing commands of *interdicted prescriptions* of the modes that the artefact should not be used; (2) by introducing *constraining conditions* in the design of the artefact; (3) by imposing *norms of* '*best usage*.'

A very illustrative inscription analysis was performed by Steve Woolgar (1991; Grint & Woolgar, 1997, pp. 65-94), who, for eighteen months, committed a participant observation study in a company manufacturing computers. Underlying his investigations are two incentives: First is a version of the argument of 'taking the social dimensions of technology into account,' according to which technology is socially shaped in such a way that its resulting material form should reflect the social circumstances of its development. Thus, technology can be regarded as incorporating 'congealed social relations,' i.e., practices, predispositions, assumptions, beliefs and other factors involved in its design and manufacture (in the production stage) but which might have consequences in subsequent usage (in the consumption stage). Second is Woolgar's determination to explore the metaphor of 'the machine as text' in order to discern the 'social dimensions' of technology. In fact, "when construed as a text, technology is to be understood as a manufactured entity, designed and produced within a particular social and organizational context. Significantly, this is often done with particular readers or sets of possible readers in mind – it is fabricated with the intention that it should be used in particular ways" (Woolgar, 1996, p. 92). Now, such processes do not simply result the (social) construction of the user, because it is not just the identity of the putative user, which is constructed through them. Concurrently to negotiations (translations) over the user's identity, it is a set of design activities (but also involving manufacturing and sales), which are attempting to delimit and constrain the user's possible actions. In this sense, Woolgar is arguing that "by setting parameters for the user's actions, the evolving machine effectively attempts to *configure* the user" (1991, p. 61). Furthermore, by an analysis of audio and video records of usability trials, Woolgar suggested the importance of this type of 'boundary work' in "deciding the adequacy of the relationship between machine and user" (p. 59). Let's add that, in another study, Rachel and Woolgar (1995) examined 'technical' talk as a categorizing device intended to do boundary work by expressing social relations and norms of acceptance. They argued that 'technical' talk invokes and performs a disjunction between networks of social relationships and stipulates a moral order with associated norms to acceptance and transition. Therefore, the difficulty of penetrating the intelligibility of 'technical' talk is construed as a struggle for familiarization with the routine social actions of a separate community.

Another interesting theory about the politics of technological innovations has been advanced by André Vitalis and Thierry Vedel (Vitalis, 1994), a theory based on the notion of the '*socio-politique des usages*.' What is meant by the latter term is that technology should be analyzed at the intersection of four determinant factors, four 'logics,' as Vedel calls them: technical and social logics, which group together into the concept of *socio-technical configuration*, and production and use logics, which together form the concept of *user representation*. Although the social dynamics of technological innovations develop through the process of socio-technical configuration (Vedel, 1994, p. 30), the politics of innovations is forged through the process of representation (p. 31). In fact, according to Vedel, the concept of representation of users has two meanings: "at the same time [it is] the political expression of interests and the image that one has of something or somebody" (*ibid*.).

However, the idea that users can politically represent their interests poses a number of serious problems. Usually, users have difficulties in organizing themselves as pressure or lobbying groups because of "aggregation of dispersed interests, which are sometimes conflicting if not contradictory" (*ibid*.). According to Pierre Chambat (1994, p. 49), in front of a highly fragmented and specialized technology, users tend to become rather 'atomized' and individualized without common identity and, hence, incapable to mobilize collective action. As users lack technical expertise, a number of experts and spokespersons of users are emerging, who are often poorly representing their whole group. Consequently, Chambat remarks, one attends "an assimilation of market to democracy, of users to consumers or clients and of liberty to choice" (*ibid*.). Moreover, he highlights that "the privatization of telecommunication companies, the deregulation of the sector and the marginalization of public services push towards the direction, on the one hand, of a debilitation of the institutionalized representation of users and, on the other hand, of a reinforcement of the image of the user as a consumer" (*ibid*.).

The second notion of representation refers to the image of usage and users that designers have in mind at the production stage of the artefact. Of course, the way users think of a technology and its potential uses is a result of a multiplicity of social, economical and cultural factors. But, up to a certain degree, some of these thoughts are sought to be induced and configured by users themselves. Thus, Vedel argues that it is interesting "to study how the producers of technology try hard to intervene on the representations of technology that the users form so as to attempt to direct the uses of technology towards their own objectives" (Vedel, 1994, p. 31). For this purpose, producers and designers are utilizing a number of different techniques, such as advertisements, directions and instructions for ways of use, technical guides, testing periods, accompanying discourses etc. (*ibid*.). In particular, they often resort to various marketing approaches as well as certain socio-psychological experiments and other technological evaluations in order to accomplish their purposes (Chambat, 1994, p. 49). However, as far as the information and communication technologies are concerned, Chambat argues that an obstacle to strategies of users' configuration might be the possibility of users to strengthen their social links and cohesion through communication (p. 50).

Finally, let us mention an interesting example of an empirical study focusing on an exploration of the concrete mechanisms of users' configuration. This is the work of Thierry Bardini and August Horvath (1995) on the social construction of the personal computer user. The authors studied the history of the early days of personal computing that took place around two of the most important institutions in the field, Stanford Research Institute and Xerox Palo Alto Research Center. Their aim was to reconstruct the social networks linking early personal computing pioneers and to identify the socio-political ideologies, images and representations that were translated inside these networks in order to explain and justify the performed designs and the committed user configuration through them.

Now, coming back to the notion of inscription, clearly, the recourse to it expresses the semiotic turn to a 'textual' analysis of technology which is 'read' by its users. However, as Thierry Bardini remarks, such an interpretation presupposes that the code or the language of the designer in which a technological artefact is 'written'

(constructed) should be identical with that of the analyst who is 'reading' (using) the artefact (Bardini, 1996, p. 128). In fact, "the role of the analyst is the inverse of that of the designer: the designer in-scribes, the analyst de-scribes" (*ibid.*). In order to relax this disturbing symmetry, Bardini is employing the notion of 'affordance' that he is borrowing from the ecological psychologist J.J. Gibson. According to Gibson (1979), the affordance of an object is a combination of its substance (objective characteristics) and the ways an animal perceives it (subjective characteristics) but in such a way that neither of the two characteristics prevails. By replacing inscription with affordance, Bardini intends to "re-introduce the materiality of objects in our analyses" (*ibid.*). Therefore, conceiving objects in terms of their concrete and material relations with users, the main consequences are two: (i) an inversion of the literary model, which is implicit in the notion of inscription, and (ii) an extension of "the symbolic and literary mediation of inscription into the wider perspective of an ecology of perception" (p. 141). Furthermore, Bardini sees all technological artefacts to be constituted by two kinds of virtuality in the sense that there are two conditions of existence of a technological artefact, which can or cannot be actualized in its uses. From the one side, there is the 'virtuality of the user' consisting of representations of usage that the designer implants into the artefact as affordances. From the other side, it is the 'virtuality of the designer,' i.e. limits of usage appearing as affordances that a user confronts when using an artefact (p. 142). In these two virtualities, "one could say that the notion of affordance integrates (and transcends) the two fundamental dimensions of negotiations between designers and users … [those of] delegation and inscription" (*ibid.*).

Quite close to the previous discussion of virtualities of artefacts is the work of Patrice Flichy (1995a, 1995b) on technological innovation, in which the author stresses the importance of the 'technological imaginary' as "one of the resources which are mobilized by actors" (1995b, p. 179). Influenced by the notions of 'natural and social frames' introduced by Erwin Goffman, Flichy distinguishes two different frames of reference for an artefact. On the one side, he talks about a 'frame of function,' which concerns the functionalities of the artefact and its technical usage and it may involve several actors (including designers and users). On the other side, he defines a 'frame of usage,' which refers to the social usage of the artefact, it is never fixed and it can be modified through technological innovations. For Flichy, an innovation constitutes a complex system (1995a, p. 412) and it "is not stabilized unless the technological actors might succeed to create a *mixture* between the frame of function and the frame of usage" (1995b, p. 219). Furthermore, it is interesting to remark that, in his analyses, Flichy is employing a model of agency based on de Certeau's (1980) distinction between strategy and tactics. Through this, he is able to apprehend the fact that different actors may hold unequal positions. In fact, 'strategic designers' are the ones possessing a competitive advantage with respect to other actors when they develop a successful innovation strategy. As for users, most often they are rather 'tactical users,' although, Flichy argues, there are cases when their political mobilization (cf., organizations of consumers) might orient them towards strategic movements.

References

Akrich, M. (1992). The de-scription of technical objects. In W. Bijker & J. Law (eds.), *Shaping Technology / Building Society: Studies in Sociotechnical Change*, pp. 205-224. Cambridge, MA: MIT Press.

Akrich, M. (1993a). Les formes de la médiation technique. *Réseaux*, vol. 60, pp. 87-98.
Aktich, M. (1993b). Les objets techniques et leur utilisateurs: De la conception à l'action. *Raisons Pratiques*, vol. 4, pp. 35-57.
Akrich, M., & Latour, B. (1992). A convenient vocabulary for the semiotics of human and nonhuman actors. In W. Bijker & J. Law (eds.), *Shaping Technology / Building Society: Studies in Sociotechnical Change*, pp. 259-264. Cambridge, MA: MIT Press.
Allen, D. (1988). New telecommunications services: Network externalities and critical mass. *Telecommunications Policy*, vol. 15, no. 4, pp. 257-271.
Arthur, W.B. (1989). Competing technologies, increasing returns and lock-in by historical events. *Economic Journal*, vol. 99, pp. 116-131.
Bardini, T. (1996). Changement et réseaux socio-techniques: De l'inscription à l'affordance. *Réseaux*, vol. 76, pp. 125-155.
Bardini, T., & Horvath, A.T. (1995). The social construction of the personal computer user. *Journal of Communication*, vol. 45, no. (3), pp. 40-65.
Boullier, D. (1989). Du bon usage d'une critique du modèle diffusioniste : Discussion-prétexte des concepts de Everrett M. Rogers. *Réseaux*, vol. 36, pp. 31-51.
Callon, M. (1986a). The sociology of an Actor Network: The case of the electric vehicle. In M. Callon, J. Law & A. Rip (eds.), *Mapping the Dynamics of Science and Technology: Sociology of Science in the Real World*, pp. 19-34. London: Macmillan.
Callon, M. (1986b). Some elements of a sociology of translation: Domestication of the scallops and the fisherman of St Brieuc Bay. In J. Law (ed.), *Power, Action and Belief: A New Sociology of Knowledge?* pp. 196-233. London: Routledge & Kegan Paul.
Catinat, M., & Vedel, T. (2000). Public policies for digital democracy. In K.L. Hacker & J. van Dijk (eds.), *Digital Democracy: Issues of Theory and Practice*, pp. 184-208. London: Sage.
Chambat, P. (1994). NTIC et représentations des usagers. In A. Vitalis (ed.), *Médias et Nouvelles Technologies: Pour une Socio-Politique des Usages*, pp. 45-59. Rennes: Éditions Apogée.
Coleman, J.S., Katz, E., & Menzel, H. (1966). *Medical Innovation: A Diffusion Study*. New York: Bobbs Merrill.
de Certeau, M. (1980). *L'Invention du Quotidien*. Paris: UGE.
Flichy, P. (1995a). L'action dans un cadre sociotechnique: Comment articuler technique et usage dans une même analyse? In J.-G. Lacroix & G. Tremblay (eds.), *Les autoroutes de l'Information, un Produit de la Convergence*, pp. 405-433. Sainte-Foy: Presses de l'Université du Québec.
Flichy, P. (1995b). *L'Innovation Technique: Récents Développements en Sciences Sociales. Vers une Nouvelle Théorie de l'Innovation*. Paris: Editions la Découverte.
Gibson, J.J. (1979). *The Ecological Approach to Visual Perception*. Boston: Houghton Mifflin.
Granovetter, M. (1978). Threshold models of collective behavior. *American Journal of Sociology*, vol. 83, no. 6, pp. 1420-1443.
Granovetter, M., & Soong, R. (1983). Threshold models of diffusion and collective behavior. *Journal of Mathematical Sociology*, vol. 9, pp. 165-179.
Granovetter, M., & Soong, R. (1986). Threshold models of interpersonal effects in consumer demand. *Journal of Economic Behavior and Organization*, vol. 7, pp. 83-89.
Granovetter, M., & Soong, R. (1988). Threshold models of diversity: Chinese restaurants, residential segregation, and the spiral of silence. In C.C. Clogg (ed.), *Sociological Methodology*, vol. 18, pp. 69-104. Washington, DC: American Sociological Association.
Grint, K., & Woolgar, S. (1997). *The Machine at Work: Technology, Work and Organization*. Cambridge, UK. Polity Press.
Kroeber, A.L. (1937). Diffusion. In E.R.A. Seligman & A. Johnson (eds.), *The Encyclopedia of Social Science, II*, pp. 137-142. New York: Macmillan.
Latour, B. (1987). *Science in Action*. Cambridge, MA: Harvard University Press.

Latour, B. (1988). The Prince for machines as well as for machinations. In B. Elliott (ed.), *Technology and Social Process*, pp. 20-43. Edinburgh: Edinburgh University Press.

Law, J. (1988). The anatomy of a socio-technical struggle: The design of the TSR2. In B. Elliott (ed.), *Technology and Social Process*, pp. 44-69. Edinburgh: Edinburgh University Press.

Law, J. (1991). Introduction. In J. Law (ed.), *A Sociology of Monsters: Essays on Power, Technology and Domination*, pp. 1-23. London & New York: Routledge.

Liikanen, E. (2000). Remarks on better regulation. Conference "Fair Regulation Campaign," Brussels, 28 November 2000.

Macy, M.W. (1990). Learning theory and the logic of critical mass. *American Sociological Review*, vol. 55, pp. 809-826.

Macy, M.W. (1991). Chains of cooperation: Threshold effects in collective action. *American Sociological Review*, vol. 56, pp. 730-747.

Markus, M.L. (1987). Toward a 'critical mass' theory of interactive media: Universal access, interdependence and diffusion. *Communication Research*, vol. 14, no. 5, pp. 491-511.

Marwell, G., Oliver, P.E., & Prahl, R. (1988). Social networks and collective action: A theory of the critical mass, III. *American Journal of Sociology*, vol. 94, pp. 503-534.

Oliver, P.E., & Marwell, G. (1988). The paradox of group size in collective action: A theory of the critical mass, II. *American Sociological Review*, vol. 53, pp. 1-8.

Oliver, P.E., Marwell, G., & Texeira, R. (1985). A theory of the critical mass, I. Interdependence, group heterogeneity, and the production of collective action. *American Journal of Sociology*, vol. 91, no. 3, 522-556.

Prahl, R., Marwell, G., & Oliver, P.E. (1991). Reach and selectivity as strategies of recruitment for collective action: A theory of the critical mass, V. *Journal of Mathematical Sociology*, vol. 16, no. 2, pp. 137-164.

Rachel, J., & Woolgar, S. (1995). The discursive structures of the social-technical divide: The example of information systems development. *Sociological Review*, vol. 43, no. 2, pp. 271-273.

Rice, R.E. (1990). Computer-mediated communication system network data: Theoretical concerns and empirical examples. *International Journal of Man-Machine Studies*, vol. 32, pp. 627-647.

Rice, R.E., Grant, A.E., Schmitz, J., & Torobin, J. (1990). Individual and network influences on the adoption and perceived outcomes of electronic messaging. *Social Networks*, vol. 12, pp. 27-55.

Rice, R.E., & Rogers, E.M. (1980). Re-invention in the innovation process. *Knowledge*, vol. 1, pp. 449-514.

Rogers, E. (1995). *Diffusion of Innovations*, fourth edition. New York: The Free Press.

Ryan, R., & Gross, N. (1943). The diffusion of hybrid seed corn in two Iowa communities. *Rural Sociology*, vol. 8, no. 1, pp. 15-24.

Scott, J. (2000). *Social Network Analysis*, second edition. London: Sage.

Silverstone, R., & L. Haddon (1996). Design and the domestication of information and communication technologies: Technical change and everyday life. In R. Mansell & R. Silverstone (eds.), *Communication by Design: The Politics of Information and Communication Technologies*, pp. 44-74. Oxford & New York: Oxford University Press.

Sørensen, K.H., Aune, M., & Hatling, M. (2000). Against linearity – On the cultural appropriation of Science and Technology. In M. Dierkes & C. von Grote (eds.), *Between Understanding and Trust: The Public, Science and Technology*, pp. 237-257. Amsterdam: Harwood Academic Publishers.

STOA Study (1999). Cost-benefit analysis of EU Research and Technological Development (RTD) Programmes. PE 168 439. European Parliament. Electronically available at: http://www.europarl.eu.int/stoa/publi/168439/default_en.htm

Thévenot, L. (1993). Essai sur les objets usuels: Propriétés, fonctions, usages. *Raisons Pratiques*, vol. 4, pp. 85-111.

Valente, T.W. (1995). *Network Models of the Diffusion of Innovations*. Cresskill, NJ: Hampton Press.

Valente, T.W. & T. Bardini (1995). Virtual diffusion or an uncertain reality: Networks, policy, and models for the diffusion of VR technology. In F. Biocca & M.R. Levy (eds.), *Communication in the Age of Virtual Reality*, pp. 303-322. Hillsdale, NJ: Lawrence Erlbaum Associates.

Vedel, T. (1994). Sociologie des innovations technologiques des usagers: Introduction à une socio-politique des usages. In A. Vitalis (ed.), *Médias et Nouvelles Technologies: Pour une Socio-Politique des Usages*, pp. 13-43. Rennes: Éditions Apogée.

Vitalis, A. (ed.) (1994). *Médias et Nouvelles Technologies: Pour une Socio-Politique des Usages*. Rennes: Éditions Apogée.

von Hippel, E. (1986). Lead users: A source of novel product concepts. *Management Science*, vol. 32, no. 7, pp. 791-805.

Wasserman, S. & K. Faust (1994). *Social Network Analysis: Methods and Applications*. Cambridge, UK: University of Cambridge Press.

Wellman, B. (1988). Structural analysis: From method and metaphor to theory and substance. In B. Wellman & S.D. Berkowitz (eds.), *Social Structures: A Network Approach*, pp. 19-61. Cambridge, UK: Cambridge University Press.

Williams, R., & Edge, D. (1996). The social shaping of technology. *Research Policy*, vol. 25, 865-899.

Woolgar, S. (1991). Configuring the user: The case of usability trials. In J. Law (ed.), *A Sociology of Monsters: Essays on Power, Technology and Domination*, pp. 58-99. London & New York: Routledge.

Woolgar, S. (1996). Technologies as cultural artefacts. In W.H. Dutton (ed.), *Information and Communication Technologies: Visions and Realities*, pp. 87-102. Oxford: Oxford University Press.