Co-shaping of governance and technology in the development of mobile telecommunications

Master Thesis “Philosophy of Science, Technology and Society”

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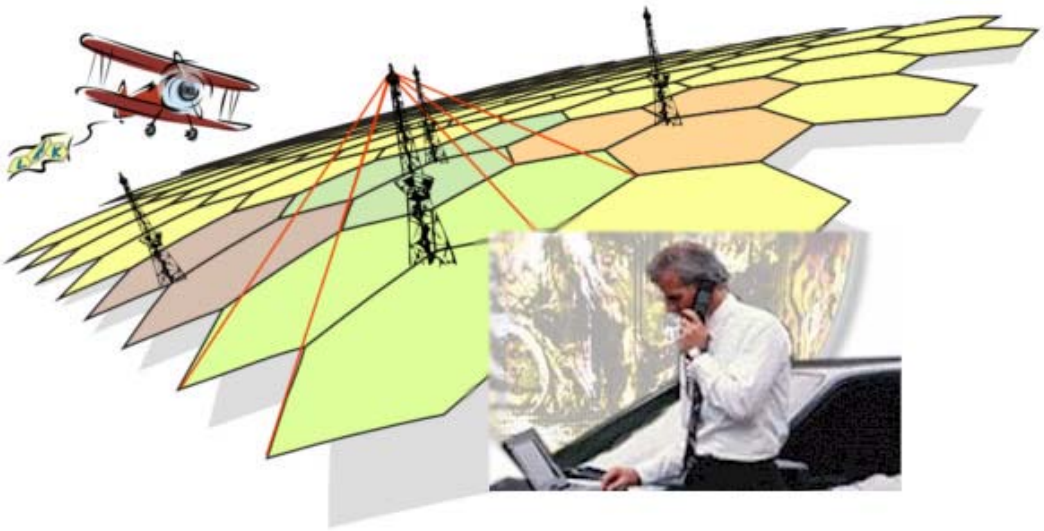

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Summary

How to govern technology so that it brings maximum benefits and minimum harm to society is a question with big scientific and practical importance. The modern way to govern technology is that public authorities (government in general) can set up goals for technological development and the scientific and technical community would achieve these goals and also provide expert advice to policy makers. This hierarchical approach is based on the assumptions that development of technologies can be anticipated and it can be steered in a desired direction by rational decisions made by experts, as long as the main goals and priorities are set by the government.

On the other hand, recent science and technology studies (STS) suggest that technological development is a contingent process depending on many (local) factors, in particular negotiations between various social groups and creative use of the technology – i.e. use that the designers of the technology haven't anticipated. The outcomes of these negotiations and creativity are neither fully predictable nor always rational. So there is a tension between the modern concept of governance of technology and the contingent character of technological development.

My goal with this thesis is to analyze this tension in case of a concrete technology, namely mobile communications. During the last 20-25 years mobile communications developed from a technical innovation to an essential infrastructure that penetrates entire society. Governance played essential role in this process, since no infrastructure can be build without organizing different parties, which means governance. So mobile communications are a good case study about how governance of technology happens in practice.

My main findings in this paper are the following. When mobile communications emerged as a new technology, various forms of governance of this technology also emerged. The variety was determined by (local) political, economic and cultural factors. Next, the technology and its governance evolved together. Organized through governance, various actor groups were able to inscribe their vision and values into the technology. In this process some forms of governance proved more effective than others, since they "matched" the technology better. Furthermore, forms of governance which were not suited (anymore) for developing mobile communications became obsolete and eventually replaced by other, more suitable forms of governance. **This process I call co-shaping of technology and governance.**

Over time, mobile communications and their governance evolved towards post-modernity. Post-modern technology is distributed technically and organizationally and it promotes post-modern values like pragmatism, combination of multiple social roles, pluralism and individuality. Contemporary mobile communications are certainly a post-modern technology. Post-modern governance includes many actor groups. It is very reflective and it is primarily network-based rather than hierarchical, but it is also pluralistic, so various forms of governance often co-exist. I have shown in my thesis that mobile communications as a **post-modern technology can't exist without governance,**

but only post-modern governance can be effective for such a technology.
Furthermore, because of its inclusiveness, dynamic reflection and ability to co-evolve with the technology, post-modern governance has less tension with the contingency of technological development than modern governance.

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Introduction

Our society is saturated with tools, technologies, appliances and objects that shape our everyday activities. Technology affects all aspects of our life. Technological systems and networks are everywhere in the modern society. From birthing babies to eating, to going to work, visiting friends, maintaining health to dying - all these human activities are mediated by technology. Technology is not only connecting tissue of the economy but it also enables and constrains social changes. It is difficult even to imagine the world without use of technology. Technology influences every human activity, structure and organization. Here comes the need to govern the technology. This need is not arbitrary or just a wish. It arises by necessity from the nature of technology as powerful social force. The goal of the governance is to achieve maximum benefit from technological developments and to avoid dangers coming from technology – from a nuclear war to a "private initiative" to build roads in the middle of nature reserve. Without goal-oriented, forward-looking governance, the risks of technology are simply too big. Not that if it is left with sort of self-governance, the technology will *necessarily* have negative social consequences. But because of potentially destructive power of technology, the self-defense mechanisms of society demand to minimize social risks of technological development.

Chapter 1 – Problem description and research questions

There are many theories about how to govern technological development. But there is a fundamental underlying question - is it possible at all to govern technology in a desired direction? Does technology have its own logic of development or is it the social demand that drives the technological development? These fundamental questions have to be studied as a prerequisite to answer the question "how to govern technology". I will make a short historical overview in order to look at how these questions were analyzed so far.

1.1 Historical overview of governance of technology

1.1.1 Modern governance of technology

The term "scientific and technology policies" (as predecessor of "governance of technology") appears explicitly in the years after Second World War [Arv2003]. Then the relevance of scientific knowledge for resolving practical problems and achieving military goals was demonstrated. In the post war period (1940s and 1950s) science policy institutions were created. The period was characterized by hegemony of science where science was hand in hand with political and industrial apparatus. It was believed that governance of technology is rational process conducted by authorities. Technological determinism was widely accepted model of technological development. The basis of this model is that technology develops on its own, follows an autonomous, rational logic and has overwhelming influence on society. Technological determinism denies any possibility for social choice in inevitable technological development and it is in consent with linear model of technological innovation. So there was little room for public governing organizations to really govern the technological development. Instead their role was to monitor the technological development and to find ways for speeding it up by removing obstacles and providing required resources for "promising" and strategically important technologies. The society had positive attitude to technological development in general and believed that public authorities and scientific community are capable to take right decisions in regards to technological development. "Implicit public trust has prevailed, based upon an image of science as a neutral and objective basis for making policy, and where science and technology have been seen as sources and drivers of uncontroversial, quasi-universal goals and values – progress, welfare and growth" [STAGE2005].

Technology Assessment (TA) theory was developed in response to the need of finding "promising" technologies that would bring maximum "progress, welfare and growth". Its role was to provide rational base for decision taking for policy makers. TA tried to predict effects form development of new technology. Based on these predictions authorities had to set up strategic goals for technological development and to choose between different technologies. Achievement of these goals and implementation of technological policies was left to the scientific and engineering communities and later on, especially in 1980s, also to the market.

As claimed by Collingridge the problem with this approach is that it is not possible to predict for sure what will be real effect from a developing technology. When there is enough information about effects of technology it is already too much entrenched in

society and it is very difficult and costly to be changed. The solution that Collingridge proposes is “Make decisions which are easy to correct; choose systems which are easily controlled and keep your future options open” [Col1980]. Collingridge still accepts the notion of policy making as rational decision-making by authorized governing institutions and the role of science as creator of objective knowledge.

These are typically modern standpoints; in this sense both Collingridge’s and the TA approach represent a modern view on the governance of technology. Reason and homogeneity can be seen as symbols of modernity. Based on the ideals of European Enlightenment, modernity assumes that reality is knowable through (scientific) rationalization. Modern culture is related to industrial capitalism and tightly integrated in organizations (public and commercial) with hierarchical structure. “This hierarchy became a source of power, continued growth, and permanence” [Huges1998]. So in general we can say that until the 1980s, governance of technology “was consistent with a modernist perspective in which technical progress was equated with social progress” [STAGE 2005].

1.1.2 Science and Technology Studies (STS)

In the 1980s demand for social relevance in scientific and technological development started to emerge. Accidents like Chernobil catastrophe and the spread of mad-cow disease (BSE) decreased public confidence in ability of authorities, scientific and engineering communities to predict, uncover and deal with hazards related to technology. The result was a demand for more citizens’ participation in governance of science and technology. Philosophy of technology also changed. In contrast to technological determinism emerged social shaping perspective. STS proposed the view of co-production of technology and social change. Social Constructivist theories explain technological development by reference to disagreements, controversies and difficulties that relevant social groups had with technology. A relevant social group consists of individuals or groups that are capable of acting and share common conceptual framework and interests regarding a technology. Thus technological development is explained by social demand and negotiations and this process is seen as contingent [Brey1997]. Actor-Network theory (ANT) explains technological development as continuing socio-technical interaction, again contingent, in which the social and the technical sides influence each other mutually. This principle of symmetry between technology (consisting of artifacts) and humans rejects both technological determinism and social determinism and analyzes the mechanism of interactions in human-technological networks. Both SCOT and ANT theories look primarily at micro level, i.e. the individual actors and their interactions.

Analyzing the interactions of individual actors is not enough to explain the path of the technological development. According to Rip, patterns emerge “behind actors’ interactions and are neither completely predictable nor completely manageable by a single actor” [Rip1995] and these patterns have long-term influence on technological development. A meso-level analysis would focus on development and evolution of such patterns. At meso-level the (quasi)evolutionary approach describes technological development as similar to Darwin’s theory of evolution. Since technological development is accompanied with lots of trials and errors and some technologies are developed further

but others are not, technological development can be conceptualized as variations and selection process. The process of variation is the creation of new technologies and the process of selection determines which technologies stabilize. Creation of new technologies is a random process, explained by the desires and visions of designers and entrepreneurs. Selection is determined by how well technology fits in society. More precisely, the selection environment for technical innovations consists of various components. These components include "scientific knowledge, engineering practices and beliefs, production processes, consumption patterns, institutions [and their rules and regulations], infrastructures and social values" [Kemp1998]. A stable combination of these factors is called a "technological regime" and the dominant technological regime is the main part of the selection environment. The quasi-evolutionary model emphasizes also that there are links (nexuses) between the variation and the selection environment, where the selection environment is more stable and more capable to influence the variation environment than versus-versa. On one hand, existing technological regime influences the thinking of innovators and the R&D funding thus influencing the innovations. On the other hand, when innovations stabilize, they influence parts of the selection environment (for example consumption patterns or social values) and in extreme cases may even lead to a change of the entire technological regime. These mutual links, though, don't make the innovation process *determined* by the technological regime.

This model explains why the outcome of technological development is not fully determined by the actions of any single actor. There is always an element of uncertainty, unpredictability and contingency in the path of technological innovations, just like it is with evolution of organisms.

1.1.3 Problem description

Here arises, according to Van der Meulen, "clear tension between the (modern) suggestion of 'governability' of technologies [e.g. steering technology towards given goals] and the contingency [of technology development] claimed by STS" [Meulen2005].

1.1.4 Post-modern governance and CTA

Influenced both by public concern and by changing philosophical base, the theories about governance of technology started to reflect on this tension. They evolved in a way that governance of technology should involve "concerted action at different levels. It must also accept the variety and heterogeneity of situation and adapt its goals accordingly" [Rip1995]. Informed by STS (especially using quasi-evolutionary theory) constructive technology assessment (CTA) shifted the focus away from assessing impact of newly developed technologies to constructing the desired outcome by involving all stakeholders into a "broadened design, development and implementation process" [Schot&Rip1996]. Dialogue and mutual learning between all stakeholders is seen in CTA theory as important part of design process. It helps to articulate problems and demands. If values, demands and problems of all involved stakeholders are made explicit and are taken into account in the early stages of the design process, then wide acceptability of the new technology becomes more likely. Consumers and pressure groups are asked to participate in "platforms" and to discuss technical options with firms. The responsibility for

managing development in society is thus not limited to governmental actors, but it is shared between three kinds of actors - technical actors, social actors and government agencies. [Schot&Rip1996] All these characteristics of CTA approach show a clear shifting in the governance of technology from command and control to collaboration. There are no authoritative governing bodies that are expected to take right, rational decisions but to the contrary - governance is more participative and network based. CTA ideas reflect the general post-modern tendency form authoritative to participatory governance.

Since CTA provides a framework for governance of technology and at the same time bases itself on the STS approaches, theoretically it is capable to resolve the tension described by Van der Meulen. But in practice, as a STAGE report claims, "European science and technology governance cannot be interpreted as a simple pattern of convergence or a linear, uni-directional development from one form to another" (i.e. from authoritative to participative). "Instead (there is) a more complex – but distinctive in international terms – pattern of diversity, co-existence, contradictions and complementarities between different modes of governance" [STAGE2005]. The report identified six types of governance - discretionary, educational, deliberative, corporatist, market and agonistic – each combining to different degree modern and post-modern characteristics. So, it is still relevant to study in practice the tension between governability of technologies and contingency of technological development. As Van der Meulen mentions in order to analyze this tension it is important to understand "how society (reflectively) governs technological development".

1.2 Goals of the thesis

The goal of this thesis is to describe "how society (reflectively) governs technological development" in the case of mobile communications. Based on such empirical description, I will reflect on the contradiction between the notion of governability of technology and the contingency of socio-technical developments.

My main stand point is, that this contradiction appears manly when defining governance in a typically modern way – as a (rational) decision-making process that happens outside the technological development and steers it almost uni-directionally. I will argue that *in practice* the governance and the development of mobile communications are constantly interlinked, shaping one another and co-evolving. The co-shaping means on one hand that the governing actors inscribe their vision into the new technology and on the other hand the (unpredicted) outcomes - opportunities and constraints - coming from the technology lead to changes in the vision, goals, structures and processes of governance. Governance not only *acts* on social consequences and controversy caused by technology, but it also *reflects* on them and evolves.

These observations are consistent with a post-modern view on governance that places it inside the technological development. Governance, seen from post-modern point of view, is not an entirely rational process, but it is influenced by irrational decisions and actions that are part of human nature. Furthermore, it includes various actors, not only

governmental institutions. Such post-modern governance, I will argue, has less tension with the contingency and complexity of technological development.

1.2.1 Research questions

In order to verify my stand point, my research questions will be:

- What types of governance co-evolved with the development of mobile communications technology and how technology and governance co-shaped each other? This research question can be split into sub-questions as follows:
    - How different types of governance of mobile telecommunications did emerge?
    - How different types of governance inscribed their vision in the mobile communications technology? How they influenced stabilization of this technology?
    - How mobile technology on its own turn influenced and shaped governance?
- Did mobile telecommunications and their governance evolve towards post-modernity? If so, did post-modern governance easy the tension between governability and complexity and technology of technological development?

1.2.2 Two sides of governance of mobile communications

When analyzing governance of mobile communications, we can distinguish two sides of it – governing the standardization and development of the technical infrastructure and governing mobile communications as a consumer technology – i.e. its marketing and use. Of course, these two sides are interconnected. First of all, the main actors are the same: operators of mobile communication networks, manufacturers that design and supply the hardware necessary for infrastructure as well as the mobile phones, national and international governmental regulating agencies, standardization bodies that manage standardization process and of course the users of mobile services. Most manufacturers supply both infrastructural components and mobile phones, so they are involved as well in infrastructure building as in positioning of mobile phone as consumer product[1].

Nevertheless, each side involves different interactions and alliances between the main actors, different governing institutions and different regulations. For example in design and standardization of infrastructure pre-competitive collaboration between manufacturers and network operators is common. National and international authorities often support and promote the development of the technology and there is limited direct user representation. On the other hand, governance of mobile communications as consumer technology is mainly market governance. There is strong competition amongst

[1] This is because main actors involved in system (infrastructure) building (manufacturers, network operators) are also involved in developing and marketing consumer products – mobile phones and services. This is completely different from electricity delivery infrastructure, for example, since electricity deliverers don't produce or market consumer electrical appliances. A deeper look into this difference reveals that the electrical consumer products are "loosely coupled" with electrical grid infrastructure, while mobile communication consumer products are "tightly coupled" with the infrastructure, since there is constant two-way data exchange between the infrastructure and mobile phones.

manufacturers as well as amongst network operators. Users are represented as consumers – in order to be successful on the market the manufacturers and telecom operators have to fulfill and even extend consumer demand. Regulators play an indirect, but important role by liberalizing the market and protecting competition.

Because of these differences I will study each side of the governance in a separate chapter with the goal to show that co-shaping of governance and technology happens in each of them. I will pay special attention to path dependencies in technological development and to continuity (or discontinuity) of different forms of governance.

1.2.3 Structure of the thesis

The rest of the thesis is structured as follows.

In the rest of this chapter I will define and analyze the concepts used in my research questions. This includes description and reflection on concepts of governance, technology and governance of technology in particular.

In chapter 2 and chapter 3 I will analyze the co-evolution and mutual influence between governance and mobile communications seen as infrastructure (chapter 2) and as consumer technology (chapter 3). The analysis will be based on the evolution of governance and technology in first, second and third generation of mobile telecommunications, from mid 1980s until today. These two chapters focus on the first research question.

In chapter 4 I will put the co-shaping of technology and governance in a more global perspective. Based on the empirical findings and the analysis from previous chapters I will show that mobile communication technologies and their governance co-evolved towards post modernity. This post-modern shift is related to a similar trend in the entire socio-technical landscape. This chapter analyzes the second research question.

In chapter 5 I will summarize the findings about co-shaping of governance and technology in mobile communications and their co-evolution towards post-modernity. I will then reflect back on the problem definition and will argue that post-modern governance has less tension with contingency of technological development than modern governance.

1.3. Conceptual Analysis

1.3.1 What is technology

In his book Peter Paul Verbeek describes a classical view of technology, based on the work of philosophers as Jaspers and Heidegger, and a contemporary view of technology, based on contemporary philosophers as Don Ihde, Borgman and Latour. Classical view of technology paints a very gloomy picture about the role of technology in the society. Technology alienates people from reality and from themselves. Reality and nature are not valuable in themselves but because they can bring raw materials, can be used and can be conquered. “Technology is radically transformative power, which estranges human beings from themselves, from each others, and from reality” [Verb2005]. People are not

important as unique individuals but as functional workers in the highly structured apparatus that ensures the mass production of goods. “Technological culture is seen as transforming human being into cogs in a social machine, and as transforming reality into raw material that can only be approached via domination and control” [Verb2005]. Classical view of technology doesn’t study concrete technologies in the specific contexts, so it sees *technology as an abstract social force*. Classical philosophers of technology try to understand technology from its conditions of possibilities - what must be presupposed in order for technology to be possible. So they use a sort of “backward approach” – from technology back to its pre-conditions.

Contemporary philosophy of technology uses a forward approach - i.e. it starts its analysis from concrete technologies “in themselves” and moves forward to their consequences - how they influence and change our every day life. In his book Verbeek means by term technology “… specifically modern, science based technological *devices* of the sort that began to emerge in the last century”.

These two examples represent sort of “extremes” in defining technology – one is very abstract and the other is very concrete, “thing”-oriented. “In between” there are many other attempts to define technology. Misa [Misa1992] systematizes them and describes four broad types of definitions of technology that can be found in recent writings. They are *technology as knowledge*, *technology as defined by series of empirical examples*, *technology as defined formally or explicitly*, and *technology as relationship between material and human worlds.*
First definition is rather simple, describing *technology as type of knowledge*. In fact, the term “technology” was introduced for first time in J. Bigelow’s “Elements of technology” as a body of useful art and accumulated knowledge. This means knowledge about handwork, production and manufacturing of artifacts and especially knowledge necessary for transformation of raw materials in products ready to use.
Some historians of technology describe *technology by series of empirical examples* and leave the definitions to their readers. In most cases the examples are *devices or artifacts*. As Misa writes, some authors find themselves puzzled why someone wants to define what technology is before analyzing it. They make comparison with politics, where authors analyze it without having any strict definition on beforehand.
The third approach, *formal or explicit definition of technology* uses different criteria to define technology, but focuses mainly on *process of creation* of artifacts. This leads to ‘narrow’ definitions, focusing attention on the technology apart from social, political and cultural context. For example “... technology is the process of applying power by some technique through the medium of some tool or machine to alter some material in a useful way”. Other formal definitions emphasize the differences between science and technology. They maintain that technology has a more hierarchical structure. In the process of creation of the technology it is necessary to have communication between different specialists and decomposition of the main problem into sub-problems.
A forth type of technology definitions claims that to understand technology we must understand the r*elationship between material and human world.* This topic has attracted many authors. Winner sees technology as form of life - “we do not use technologies so

much as live them" Various authors accept technology as 'symbolic activity' through which we construct ourselves.

It is not a coincidence that there are many definitions of technology. Concepts that are deeply embedded in our daily life are the most difficult and ambiguous to define. So this is just another indication how much the technology and contemporary society are tangled together. For the purpose of this thesis, I find a definition from Misa most practical and suitable. He writes that since the second half of 19th century, more or less together with key concepts of modernism, capitalism, industry, class, urbanization, culture, etc. a new definition of technology emerged. It describes technology as a combination of sets of devices, complex of industries as well as an abstract force that can change society [Misa2003]. This definition contains three different "faces" of technology which roughly correspond to artifacts, processes and social context – thus it integrates many of the definition types mentioned above. I will add to it the "knowledge face" of technology and this will form the working definition of "technology" in my thesis.

1.3.2 What is governance?

The term "governance" is not much easier to define than "technology" It has been used in different disciplines with somewhat different meaning. Kersbergen and Waarden identify seven uses of the term, especially in public administration, political science, law and economics [Kers2001]. As they point out, the use of "governance" is usually in a particular political context and often has a normative character – like "good governance", "democratic governance", "new public management", etc. There is no universal, descriptive definition of governance, which I need in my analytical study, but there are several definitions which are useful in this context.

The United Nations development program (UNDP) uses a definition that includes various notions of governance used by development agencies, international organizations and academic institutions. It says that "Governance is the system of values, policies and institutions by which a society manages its economic, political and social affairs [...] It comprises the mechanisms and processes for citizens and groups to articulate their interests, mediate their differences and exercise their rights and obligations. It includes the rules, institutions and practices that set limits and provide incentives for individuals, organizations and firms. Governance, including its social, political and economic dimensions, operates at every level of human enterprise, be it the household, village, municipality, nation, region or globe."[2]

In a similar notion, the European Commission states "Governance refers to the rules, processes, and behaviors by which interests are articulated, resources are managed, and power is exercised in society"[3].

I will base my understanding of governance on these two definitions, with explicit attention to the fact, that governance includes making and implementing decisions that affect *multiple* parties. So governance is an intrinsic characteristic of human society and it

[2] UNDP – "Indicators of Governance", available at http://www.undp.org/oslocentre/docs04/UserGuide.pdf
[3] Wikipedia – Governance, available at http://en.wikipedia.org/wiki/Governance

is linked to interests and goals of people and to their social interaction. It consists of structures (institutions), rules and processes (practices). Governance has three interlinked, but distinct dimensions – social, political and economic governance. Political governance includes political institutions, laws and other public regulations and procedures for electing institutions and creating laws. Social governance includes various institutions of the civil society, rules (formal or informal) of social control and processes of self-organization of citizens. Economic governance is usually understood as governance of firms (sometimes called more narrowly corporate governance) and governance of markets. In my thesis I will focus mainly on political and economic governance, which played biggest role in stabilization of mobile telecommunications technology.

1.3.3 Types of governance of technology

In order to analyze the evolution of governance of mobile telecommunications, I need a framework for distinguishing one type of governance from another, so a classification of the types of governance is necessary. I will mainly use the "STAGE Typology of Scientific and Technological Governance" [STAGE2005][4]. This taxonomy describes six types of governance of science and technology: discretionary, educational, deliberative, corporatist, market and agonistic. Although the report focuses on public governance, this classification in my view can successfully be applied to economic governance as well.

In *discretionary* governance "policymaking takes place with virtually no explicit interaction with 'the public'. Decisions are taken without much formal or informal input to the process by any group outside the governing bodies themselves". This type is also called sometimes "*authoritative*" governance. In areas where discretionary governance is dominant, there is usually a hierarchy of governing institutions, so this type is often called *hierarchical* governance. The report mentions that this was dominant type of governance of science and technology in typical modern times, when science and technology were seen as uncontroversial and there was big public trust in scientific institutions. In corporate governance this type of governance means that the management of companies makes decisions without negotiations with other involved stakeholders – like employees, suppliers, local authorities, consumer groups, etc.

Educational governance "assume, that a main source of and cause for the disturbances [between governing bodies and other stakeholders] lies in lack of adequate information and knowledge." Although the decision making is still rather discretionary, governing institutions rely on experts to explain and defend the rationality of the decisions to the other involved parties. If the other parties remain unconvinced and tensions arise, the governing institutions may reconsider their decisions, but still based more on expert advice rather than on negotiations with disagreeing parties. In this sense the educational governance is an "in between" form between discretionary and deliberative governance, since it involves communication between different actors and a feedback loop, but the communication is predominantly one-sided and the feedback is mediated by experts.

Deliberative governance accepts that differences and tensions between stakeholders exist and they have to be resolved. It has "a strong emphasis on consensus" that has to be

[4] All quotations in this section are from [STAGE2005], unless indicated otherwise.

reached through communication and negotiations between all involved groups of actors. "The choices [in governing of technology] are no longer seen to be only or even primarily technical in nature, but have to be framed in terms of their socio-political implications and consequences, and the outcome cannot – under conditions of expert disagreement and counter-expertise – be decided on the basis of superior knowledge and 'best expertise' alone." This doesn't mean that expert opinions are not used, but they are only part of the arguments; the interests of involved actors, that are not always rational, are also accepted as valid reasons in the negotiation. Discussions and negotiations often take place in the public space – mass media, citizen panels, etc. Because of its inclusive nature and because so many types of actors are involved with technology this type of governance usually results in a network of negotiations, alliances and confrontations between actors – so it is also called "network-based governance". In such networks there is no central point of control or authority, although there might be focal actors (nodes in the network) that have more influence on the decision making process then the others.

In *corporatist governance* "real differences of interests between stakeholders are recognized to be at stake and solutions that bridge the differences are sought within closed processes of deliberation and negotiation". Corporatist governance is similar to deliberative governance since it tries to solve differences of interests based on negotiations. The difference between the two types is that deliberative governance is more open for all sorts of actors and there are less institutionalized forums for discussions and negotiations. In this sense corporatist governance can also be seen as a form of *network-based governance*, but its network is more stable and formal. Some types of actors that are not included in the network may need to engage in deliberative or agonistic approaches in order to join the network. Corporatist governance, as the name suggests, is often applied in corporations, where procedures exists for negotiations between management and trade unions, authorities, etc. Standardization institutions also often use corporatist governance.

Market governance "is based on the notion that science and technology are governed with strong attention put on market orientation. This type of governance is illustrated in neo-liberal policies that emphasize results and customer orientation and competition." In this type of governance the feedback is based on the decision of the consumer to buy or not to by a product and to use it (or not use it) in a certain way. The main role of public institutions is to protect the competition on the market and to ensure that certain safety standards are maintained. Main decision makers in market governance are the suppliers on the market, since they decide on technological innovations and marketing strategies; but "the general public as consumer" has powerful ex-post influence on technological policies of suppliers.

Agonistic (or *antagonistic*) governance "takes place under conditions of confrontation and adversity, when decisions have to be made in a context where … compromises are not easily found, and conditions are not in favor of … negotiation and debate." The STAGE report mentions as examples of agonistic governance "direct actions, strikes, demonstrations, etc." In economic governance litigation (law suits) can also be seen as form of agonistic governance. It is important to note that agonistic governance is really a

type of governance, since it ultimately leads to making decision involving the antagonizing parties and through it “power is exercised in society”.

These types of governance are not strictly separated – there might be concrete forms of governance that are on the border between two or even more types. Furthermore, the types are not mutually exclusive – they can co-exist in practice. For example, while public authorities apply market governance for certain technology the market players may engage in corporatist practices – e.g. forming cartels, or setting up standardization institutions; or they may engage in agonistic practices – e.g. litigation. Furthermore, deliberative forms of governance may emerge involving public authorities, suppliers and consumer activist groups, etc. But the classification is a good base for theoretical analysis on different forms of governance and their change over time.

Chapter 2. Co-shaping of governance and mobile telecommunications as infrastructure

Infrastructures are so fundamental for our society that without them the society can't function at all. Infrastructures create sense of stability and regularity and create a feeling that they will always work. In this sense an infrastructure is an invisible background but at the same time it is a very important and influential part of the society. Infrastructures are *socio-technical* by definition [Edwadrs2003]. Although in everyday language the term infrastructure is often used as synonym of hardware, an infrastructure is not only interconnected hardware but also includes social organizations and socially communicated knowledge and it relies on wide acceptance by the users. Infrastructures are socio-technical not just because they are a combination of technology and social organizations around the technology. They have impact both on society and on technology that goes beyond this simple combination. Misa describes this impact as "technology… in the infrastructure of daily life, is socially *constructing*". Infrastructures are artificial environments that create possibilities for us to have at home clean water from the tap, heating installations that can be regulated, electricity, etc. So "we can live, work and play on agenda we designed" [Edwards2003]. Infrastructures enable us to design our agendas and in this way they are a factor that constructs our life.

On the other hand, infrastructures are themselves constructed by society, since every infrastructure is a result of cooperation and negotiation between social actors. As Edwards [Edwards2003] writes, an infrastructure presupposes "control, regularity, order, system". Governance is necessary to sustain proper working of every infrastructure. It is not possible for an infrastructure to work without governance, since it incorporates many social and technical sub-systems that have to work together. But governance is necessary not only for infrastructures to work – it is even more necessary when infrastructures are being created.

Edwards writes that there is well defined path for development of infrastructures. First, inventors of various technical systems create technological possibilities. Then system builders create "order and regularity" in the complexity created by the "unorganized set of inventions" [Edwards 2003] – in other words they make a system from various parts. Furthermore, system builders play a role of a nexus between technical inventors and the society. They understand not only how the systems have to be built but also what may seem attractive for the society. Only then commercial success can be expected.

After a chaotic and diffuse stage of inventions, there follows the critical point when standards are set. The rules that enable infrastructures to work are negotiated in a standardization process. In this sense the process of standardization of an infrastructure is a focal point of socio-technical interactions. Although standard creation seems to be a set of formal technical discussions about choosing best technical option, decisions are made by people and there are not interest free choices [Egyedi p.66]. Ultimately this leads to standards that are to a great degree products of negotiation of social interests. Standard creation is a highly complicated socio-technical process that is essential for infrastructure creation.

Once standards are set, competition becomes organized around a "stable system concept". Competition between standards often leads to a situation where the winner takes all. Non-standard devices have to find a way to connect to the standard network, otherwise they would die out. When the winning standard is proprietary[5], this creates conditions for monopoly, where competition is unacceptable. In fact, most infrastructures have been seen as "natural monopolies" for quite a long time – electricity, phone, water and sewage, etc. Only recently governments decided to remove their monopoly protection and to create a free market environment with competition.

In this chapter I will analyze the co-shaping between creation of mobile communication infrastructures and the governance of this process. Because of crucial role of standards for infrastructure development, I will pay special attention to the standardization process of mobile infrastructures.

Mobile telecommunications first became wide-spread and accepted as transparent and reliable infrastructure when the first-generation (1G) standards were created and 1G networks were developed in late 1970s and in 1980s. As described earlier, the 1G infrastructures were for mobile telephony (voice communication) only. Second generations (2G) mobile communication networks (like GSM) are digital, but still focused mainly on voice transmission. Third generation (3G) standards and networks are high-speed digital networks for both data and voice transfer.

2.1 First Generation (1G) Mobile Communications

1G mobile communication infrastructures were formed in a period when monopoly of national state in telecommunications decreased, but national telecoms were still dominant players on the market and there was little international competition. This led to development of several national and regional standards and networks. In this section I will compare the main standards and the governance of standardization process in several cases.

2.1.1 Comparative study of five countries[6]

USA

In the United States the liberalization of the telecommunication market happened at the same time as the development of the 1G mobile communications. The development of the mobile telephony started first by AT&T. AT&T was a private hierarchical organization and monopolistic provider of telecommunications in US in the late 1960s. With liberation of the market other potential providers of mobile telephony emerged, which created difficulties and administrative delays in obtaining frequencies for mobile communications. The AT&T system, which later became the basis for the **AMPS** standard, was mainly created by Bell Labs (AT&T subsidiary) and was driven by the vision of American engineers. In the development of the standard not many social groups

[5] Proprietary standards are standards that are not open, i.e. there is a commercial organization that can (partly) control who has access to the standard and who can implement it.
[6] The data for this section is complied from two sources – [Fomin2002] and [Bekkers2001]

were involved. This, together with the fact that the standard was not conceived as open standard from the beginning, created institutional problems when moving the system to commercial use. AT&T received permission for creating Chicago pilot mobile telephony system in 1977, but the FCC (Federal Communications Commission, American national regulator of telecommunications) did not license it for commercial use until 1983. As a result the 1G mobile services in US were delayed and since the beginning they were somewhat outdated. From a governance point of view I would say that no good learning was ensured and there was no anticipation for future de-monopolization of the sector. On the other hand, AT&T correctly anticipated the mass market and made sure that the system had sufficient capacity and affordable price. Later FCC demanded the opening of the AMPS standard and the actual development in its latest stages has been outsourced to spin-off R&D firms which improved exchange of knowledge i.e. the learning process. Despite its initial weaknesses and its delay due to institutional constraints, the AMPS standard first introduced the concept of a portable terminal and changed the perception of mobile communication from a car-based service only, to a service that allows communication from any place. Consequently the AMPS standard has been revised several times to cope with its initial weaknesses. Due to its openness and affordability, AMPS standard was used later also in Japan and UK.

Japan

Japan had the first commercial wireless service in the World in 1979. It was offered by Nippon Telegraph and Telephone (NTT), which was set up in 1956 as a governmental corporation that had monopoly in telecommunication business. Due to the growing interest in the emerging cellular concept, NTT developed a proprietary wireless analog system in 1970. The service was meant to be offered to the upper class businessmen and high state officials. NTT did not anticipate that there will be a demand for mass use of mobile services, so the system had limited capacity. There was a high subscription fee in order to prevent this service from mass use. Following Japanese business culture of tight informal and semi-formal links between big businesses and the state, the equipment was manufactured by pre-selected Japanese companies, closely related to NTT. There was little exchange of knowledge and no open standard.

With the liberalization of the market in mid 80s, NTT changed into a publicly traded company, although the biggest share was still owned by the state. At the same time competing cellular companies were licensed in each of the nine newly formed national markets (areas). Two of them used **NTT standard** and the other seven used the TACS standard – a derivative from US AMPS standard. The NTT system was expanded with introduction of other competing companies but the prices and capacities remained problematic, which created some difficulties with start of development of the next generation mobile service. The success of the NTT system was moderate and penetration rate was considerably lower in comparison with US. One important difference with US was that in US the AMPS standard was made open before a commercial system was actually in place, while in Japan there was a commercial system running before the standard was made public and competition was allowed – so both the standard and the physical network had to be changed later. Another difference is that NTT had regulatory authority in telecommunications, while in US the AT&T, although being a monopolist

operator, still had to obey the regulations from FCC. So in Japan, de facto the regulator, the monopolist operator and the leading manufacturer were in a pre-set alliance during development of 1G mobile infrastructure.

Germany

In the early 1980s, Deutsche Bundespost was Europe's biggest PTT with a lot of resources for research and development in telecommunications. The whole technical design and manufacturing of the mobile infrastructure was outsourced to Siemens. The situation was similar to that in Japan and also resulted in a closed standard and little exchange of knowledge.

The innovation process started in 1979. At that time wireless services had been started in USA and Japan and were expected to start in Nordic countries. Germany focused on the technological design and expected that this will provide future possibilities for exporting their system, so they decided to postpone the introduction of the wireless services in order to make a good design. The design was meant to be a national technology solution, so no other manufacturers, except Siemens, were allowed to sell their solutions to the operator. Siemens developed a technically sophisticated solution (C-Net) but the system went to the market relatively late and it was expensive. The technical design of **C-Net system** was a result of engineering's ambitions rather that driven by market demands. There was no good anticipation of the development of the market. The service concept was similar to early Japanese concepts which had been developed 10 years earlier. The success of C-net was very limited. The service was expensive and attracted very limited number of subscribers.

With the liberalization of the market in 1989 this business was transferred to another company - DBP Telecom. Monopoly of wireless communications was removed, so some new services were able to emerge on the German market during the introduction of the 2G services in early 1990s.

Nordic countries

The development of the first generation of mobile telephony services in the Nordic countries was organized by the four PTTs (Post, telegraph and telephone administrations). At end of 1960's, all of the Nordic countries had their own operational car-based mobile environments that were incompatible. They decided to create one new joint infrastructure instead of trying to link the existing incompatible systems. In 1970 Nordic PTTs established a joint committee (**called NMT**) to look at regional collaboration on radio telephony services. The committee was independent from any national PTT or device manufacturer. The PTTs were not in direct competition and that allowed for a completely new organization and control of the development process and also for knowledge sharing into a common design. The developers of mobile services had enough time to work in peace and create a robust solution for the technical part. The committee established pragmatic goals - common design, efficient use of common frequency, large subscriber base and low cost of the terminals. But the NMT group itself had no experience in manufacturing or in research and development. They had to overcome these weaknesses by outsourcing some part of the research to separate R&D

firms and by establishing good relationships with several universities and research institutes. Because of their lack of experience in manufacturing, the committee decided to create an open technical standard. So if one manufacturing firm said that something is difficult to be done then other manufacturers were able to take the opportunity. Nordic companies were not given any special preference in the competition between manufacturers. The intentions and comments of the manufacturers were eventually incorporated in the design but no single firm was in control of the design. During the process the NTT group became a nexus and facilitated the reconciliation of clashing visions of the technologists and entrepreneurs. The result was the **NMT standard**. It introduced many new services that were of great importance for the future wireless infrastructure - universal roaming[7], charging schemes similar to the fixed phone calls[8], quality of the calls similar to the quality of the normal phone calls. The NMT-450 MHz standard was launched in 1981. In 1983 NMT group started planning for an update of the NMT-450 in the 900 MHz band and the service began in 1986. Open standard, market driven services based on good anticipation of development of the market, reasonable pricing and big subscriber base led to largest penetration rates amongst 1G wireless system. Except AMPS/TACS family (in its later stages), NMT was the only other truly open standard.

Unlikely in Japan where regulators, operators and developers were represented by NTT in Nordic countries situation was completely different. No one of the four national PTT was in charge of governing process and also not any Scandinavian developer was preferred by the NMT. To the contrary, using network-based governance the NMT group created a competitive environment, while also promoting pre-competitive cooperation.

UK

While Nordic PTTs sought to increase the competition between manufacturers while keeping the monopoly of the respective PTT as service provider, in the UK, the government tried to increase the competition between telecom operators. Since the introduction of mobile telephony in UK there were two licensed operators - Cellnet and Vodafone. Both of them began service in 1985. Although it started 4 years after the Nordic countries, the UK market was the most competitive in telecommunications in the late 80s. UK did not have a big domestic manufacturer in the telecommunication industry at that time, so they were much behind USA, Japan and the Nordic countries in R&D of telecommunications. Thus, British regulators decided to adopt a modified version of American AMPS standard in 900 MHz band and they licensed commercial services immediately after that. The standard was called **TACS**. Although British regulators did not develop an innovative standard, their goal was to achieve fast diffusion of the service and to achieve "economy of scale". This was possible because of choosing of a proven (open) standard and the large open market. Short "time-to-market", intensive

[7] Roaming is a service that allows a terminal (mobile phone) to register and work in a network run by a different operator (not the operator to whom the user is subscribed). This allows users to use their mobile phones in areas where their operator has no coverage – especially in a foreign country.

[8] This requirement may seem self-evident nowadays, but for example 1G mobile telephony system in US followed "receiving party pays" charging scheme, in contrast to fixed phones, which discouraged many people from taking their mobile phones with them. I will analyze the role of different charging schemes in the next chapter.

competition, improved services, low cost of terminals and phone calls led to relatively good success of wireless service based on TACS standard.

2.1.2 Analysis of development of 1G infrastructures and their governance

In order to understand why such different types of governance emerged, we have to take into account the historical settings that dominated in the telecommunications during most of 20th century. It started with monopolization of telecommunications sector and, especially in Europe, with merging of two previously separated actors – a network operator and a regulating institution - in one, state owned PTT administration. [Bekkers2001][9].

This was the beginning of the "PTT era" in Europe and also in Japan. This period was characterized by an exclusive long-term relationship between national supplier(s) and a national operator. The operator usually selected one supplier to provide the biggest share of switching system and kept several alternatives to secure certain level of independency. This however did not secure competitive prices. The second characteristic was the direct governmental intervention in industry. It was done often by strengthening the national industry (operators and manufacturers) by investing only in national systems - especially in Germany and France. The third characteristic of this period was the (non-) use of intellectual property rights. During the time when there were long-term pre-alliances between network operators, suppliers and governments the intellectual property rights were of no importance since they could not be turned into market dividend.

Except national governments, PTT administrations and manufacturers there were some other actors like European Community (founded in 1957), standardization bodies and users of mobile services. These actors however are not much influential during the PTT era.

The main role of EC was to organize a common European market, but EC did not take any measurements in relation to telecommunication market during first 25 years of its existence. During that time there were several standardization bodies. International Telecommunication Union (ITU) founded in 1932, and European Conference of Postal and Telecommunications Administrations (CEPT) founded in 1959. Although one of the roles of ITU is to produce standards for telecommunications, these standards were only recommendations. In the cases when the interest of involved countries differed, ITU did not succeed in producing single standard. Instead it developed several standards. The decisions taken by CEPT during that time frame were not very different from the interests of the PTT administrations [Bekkers2001].

This was changed with the liberalization of the market in the 1980s and 1990s. Then competition between suppliers intensified and competition between network operators started.

In US conditions were somewhat different. The US was the only state with private telecommunications service among the developed countries. There was no alliance between national regulator and national operator; in this case these are FCC and AT&T.

[9] In several European countries the land-based telephone services were initially provided by private companies (one or more per country). Later these companies were nationalized and merged with the regulating institutions. For more information, see [Bekkers2001, p. 39]

AT&T had practically a monopoly over telecommunications and it was perhaps the most vertically integrated telecommunication company in the world. It was a network operator that owned its main suppliers of switches and terminals – so in terms of monopoly and pre-alliance between operator and suppliers US was not that different from Europe and Japan.

During 1980s US government took some measurements to limit market power of AT&T and to introduce the competition. In 1982 AT&T was forced to split up its local operations into seven independent regional companies. This governmental decision was called the "Consent Decree". With this decision FCC demanded de-monopolization in the sector, opening of the standards, introduction of competition amongst manufacturers and telecom operators. Unsurprisingly such direct intervention for decreasing the power of national operators did not happen in Europe.

These were the conditions in the world in the telecommunicating sectors when 1G mobile communication networks were created. The common problem that all European states (except Nordic countries) and Japan had was that the design and implementation of the standards for the 1G mobile telecommunications happened during PTT era, while the infrastructures had to function in conditions of liberalized market. It is not a surprise that under these conditions in most countries hierarchical national governance mode appeared initially. Such governance used significantly public (political) control and not so much market mechanisms. Exceptions were Nordic countries, where the governance from the beginning was international (although only at regional level) and more network-based. In US and the UK market mechanisms were relatively more used during standardization and development of mobile communication infrastructures.

The success of the 1G mobile communications, measured as penetration rate (percentage of subscribers) was biggest in the Nordic countries, followed by the US and the UK. The services in Japan (based on NTT standard) and in Germany (C-Net) wasn't successful.

The success can partly be linked to the absence of monopoly – in the UK and in the US already at the start of commercial services there were several competing service providers in the same markets. Although in the Nordic countries each PTT has a national monopoly as service provider, the market for mobile phones and other technical components of the infrastructure was liberalized. It is important to note that the possibility to build relatively quickly and easily parallel mobile communication infrastructures (since there is no physical connection between the terminal and the base station) makes mobile communications market potentially more competitive compared to, for example, electricity infrastructure. But market-oriented governance is necessary in order to actually create such competitive market.

Globalization also played a role in creation of mobile communication infrastructure – not only by linking international networks, but also by allowing international competition and collaboration between manufactures and by international public trading of telecom shares, which decreased control of national states over the infrastructure. So some level

of international governance was necessary in order to cope with this process of globalization.

Another important success factor in the 3 successful cases was that they were based on open standards and open exchange of knowledge. Governing parties did not try to control all knowledge created during the development of infrastructure. Instead, they were the nexus between all organizations and institutions that participated in the development of the infrastructure. All of them created together the necessary knowledge and the knowledge ownership was distributed amongst the participants. Nowadays the knowledge necessary to create an infrastructure is much more complex, multidisciplinary and expensive to create – as result of development of science and technology. So it becomes impossible for a single party to create and hold all this knowledge. Pre-competitive cooperation for research and development between separate firms is one popular solution to this problem. It means that companies in one branch, which usually compete between themselves, make joint investments in research and development and benefit together from its results. This cooperation usually happens with regards to long-term and/or fundamental R&D and it often involves universities and governmental organizations. Such cooperation is promoted by network-based, deliberative governance and by public funding, for example through EC (European Commission) programs that was obtained in many cases [Nueno1988].

2.2 Second Generation (2G) Mobile Communications

2G mobile communication infrastructures were formed in a period when liberalization, de-monopolization, and globalization of telecommunication markets were in full speed. In these conditions, a common European standard (GSM) and several American standards were developed. In this section I will compare the governance of standardization process and infrastructure creation in Europe and US and will show how different types of governance were linked to the creation of different technology.

2.2.1 Europe

National markets in Europe are too small for achieving low cost of production. This was the case of 1G standards. They were developed in several counties and were incompatible between each other. This meant that operators and producers never achieved large economies of scale, because of limited number of subscribers. Also as the biggest national manufacturers in the telecommunications had control over development of 1G standards (except in NMT standard), competition was not acceptable and as a result considerably high prices for the infrastructure and sometimes prohibiting prices of the terminals emerged [Fomin& Lyytinen 2002]. “Lock-in effects” occurred, where the biggest national telecom operators were dependent on one single supplier for their infrastructure technology [Bekkers2001]. The lock-in effect meant that when telecom operators needed additional functionality they were dependent on their main supplier. Switching to another vendor would mean big investments and sunk costs.

This situation with first generation standards was the point of departure for the second generation mobile communication infrastructures. As 1G systems ran out of capacity, network operators in Europe started to realize that development of mobile communication technology with increased capacity and aiming at mass market would be most feasible if based on common standard. Only a common European standard would ensure low-cost production, big economy of scale, good sharing of knowledge and will reduce lock-in effects. Even it can lay the foundation for common European market in telecommunications [Amendola2001]. In such an open market development risks can be shared. Furthermore operators would be able to offer expensive European wide service – roaming, that was missing in 1G standards (except in NMT). Therefore a number of incumbent operators took the initiative to create such a standard, which eventually became the GSM. In 1982 the initiative for development of such standard was taken in CEPT, which comprised all western European incumbent operators (not states). A working group was established called Group Special Mobile under chairmanship of Thomas Hough from Swedish PTT, who was a pioneer of NMT standard.

Early research showed that digital technology is promising to ensure high capacity and good performance for the mobile system. In attempt to ensure better start in 2G communications, Germany and France[10] subsidized national manufacturers to do early research exploring the use of digital technology in cellular communications. Their idea was to influence GSM group to adopt their design for digital standard and in this way to ensure good start for their national industries. In particular they wanted to combat Ericson's dominant position as international supplier of mobile technology[11]. In 1985 West Germany, France and Italy signed a contract for adoption of single digital standard. The United Kingdom joined this agreement a year later.

The German / French proposals for digital standard were designed with idea for high traffic capacity in mind. In 1986 four German/French designs were submitted to CEPT. All of them were broadband and CDMA based systems. An important advantage of CDMA modulation over TDMA is bigger re-use of frequencies. In fact all base stations of proposed system used the same frequency; this increase the capacity of CDMA based system allowing up to sixty simultaneous phone calls; but CDMA technology for mid 1980s was very new. TDMA technology was more mature in comparison to CDMA. CDMA proposal was cost efficient for areas requiring high traffic capacity – e.g. metropolitan areas - but for rural areas it was expensive. This design by German and French suppliers was influenced by demographic conditions – both countries are densely populated and have high percentage of urban population.
Other parties, mainly from Scandinavian countries, proposed less challenging design that better suited networks in rural areas with medium traffic density, reflecting their own demographic conditions. These systems were narrowband and TDMA based. Narrowband designs could easily co-exist with 1G services in the same frequency band. The idea was to reserve the 900MHz frequency band exclusively for GSM but at that time a number of other systems already worked in this frequency band, like NMT-900

[10] These countries were not very successful in developing 1G mobile communications.
[11] Ericsson had dominant position in 1G networks by offering NMT-450 and TACS in Europe and AMPS networks in US

(successfully used in Scandinavia) and TACS. So the new GSM system had to co-exist with the others for the first few years. Thus broadband designs were at a disadvantage here. The proposed Scandinavian system allowed up to seven simultaneous phone calls with a possibility for upgrade by adding channels in existing base stations. These systems envisioned moderate traffic capacity. From the eight designs proposed to CEPT, two were prevailing - the broadband, CDMA of SEL/Alcatel and narrowband TDMA of Ericsson. The SEL/Alcatel proposal was considered to be too proprietary. Holding of important patents would prevent other suppliers to enter the market which will be difficult to be accepted by other governments. The other candidate Ericsson proposed medium capacity approach based on mature technology claiming that this solution will be satisfactory for many countries. For same actors it was annoying that Ericsson is based in a country that is not a member of European Community at the time, namely Sweden (Sweden joined the EC in 1995). After fierce technical discussions, where operators compared different proposals, they rejected German/French proposal; although it was difficult decision. Political talks on highest political level were held to prevent those two countries from stepping out of GSM standard. Then there was an interesting move by Ericsson. This company went in cooperation with Siemens, which was not part of the German/French consortium, since it was fully occupied with the development of German 1G C-450 system. Thanks to this cooperation, narrowband design gained some support within German government. A similar process happened in France: this time Ericsson signed an agreement with LTC. These market moves and political arraignments, ensuring that German and French suppliers will play important role in the selected technology, made the CEPT decision acceptable for France and Germany.

After basic technical choices were made and France and West Germany were persuaded to get back to GSM standard, another important actor group – the suppliers - had to be convinced to develop products in accordance to forthcoming standard. The suppliers initially were not inspired by common European standard. Biggest national suppliers would lose their preserved special position that they had on their national market. They feared from competition form abroad, uncontrollable costs for product development and market and demand uncertainty. Despite initial lack of enthusiasm for a common European standard, most suppliers complied with it in the mid 1980s. An important reason was the above mentioned agreement between Germany, France, Italy and UK, which created a big market for future mobile communications infrastructures technology. When network operators signed GSM MoU (memorandum of understanding) in 1987 another fourteen countries joined the market for digital technology. This increased the market for GSM technology and made GSM standard even more attractive for suppliers.

In mid 80s European Commission recognized telecommunications as a very important sector for the economic and social development of Europe and wanted to include it into the common market. So GSM project got serious support form EC. EC developed policy that aimed to change telecommunication sector from strongly regulated, fragmented and monopolistic into deregulated and European wide. This strategy gained a lot of opposition because for many decades (the “PTT era”) the sector has had a special position. All this was to change with introduction of competition. In 1987 European Commission proposed to partly liberalize the market for telecommunication services and

terminal equipment. Actually for the first time the networks operations, the telecommunication services and the terminal equipment were separated. EC expected less opposition against opening of service and equipment market in comparison to full liberalization of telecommunication market. So they did not propose at that moment to open the network market for competition between operators. For national operators, which were fully owned by EC member states, it would have been very difficult to withstand the competition of newcomers, so not introducing a full liberalization was a political compromise. In 1994 the commission announced a plan for gradual full liberalization of the market. In 1997 the commission published its conclusion, that because of convergence between telecommunication, media and information technology separate regulations for each of them are undesirable, so common regulations have to be made.

Next to these general measures about telecommunications, European Commission recognized GSM in particular as a very important initiative. Since it was an open standard, it would stimulate competition in the telecommunication sector. Furthermore, it would allow for creation of common pan-European network (using roaming) which would help free movement of information, people and goods. For these reasons EC took special measures to promote the GSM standard. First, EC issued a recommendation for coordinated introduction of GSM services in all member states and a legally binding directive to member states requiring frequency reservation exclusively for GSM in 900 MHz band. In practice in each member state at least two GSM operators were licensed. Only six 2G spectrum licenses were auctioned - all in 1998 in the Netherlands. All others - nearly 90 licenses - were granted either through beauty contests[12] or as extension of existing 1G licenses or given on a first-come-first-served basis [Tanaka2001].

In 1987/1988 EC was seeing more and more CEPT as an unsuitable organization for developing the GSM project. One reason was that CEPT members were only network operators. Extremely complicated technology[13] and the need for industrial commitment made it necessary to involve manufacturers in standards development and implementation. This was the reason for changes in governance of standardization. In 1988 the members of CEPT agreed to create a new organization, ETSI (European Telecommunications Standardization Institution), and transferred the responsibility for GSM standard development to it. In ETSI all groups of stakeholders were represented – manufacturers (53%), network operators (16%), regulators and standardization organizations (10%), users (11%), research and consultancy organizations (10%). This was a novelty for the CEPT GSM project. In CEPT some favored manufacturers could obtain copy of specifications of a standard through their national PTTs, but never had opportunity to participate in standard development. In CEPT decisions were taken on consensus principle, where small parties could block decisions that are favored by all others. In ETSI, in most cases, a majority of 71% was necessary to approve a decision. Following ETSI rules, it became easier to agree on a standard because for small parties

[12] "Beauty contest" means here that license requests are evaluated not only on basis of prices but also on quality of service, affordability, conformance to standards, allowing competition, etc.

[13] Terminal manufacturers sometimes viewed abbreviation GSM as Great Software Monster, referring to the complexity of code to be written. [Bekkers2001]

there were incentives to drop their proposals and support those of a bigger party (perhaps in exchange to some concessions) otherwise the proposal of the small party will be most probably voted out [Bekkers2001]. Thus, the governance in ETSI in comparison to CEPT was more international and more network-based, not only because more parties were involved, but also because alliances between operators and suppliers form different nations occurred. In CEPT each national operator actually represented its state and this has been creating hierarchy in telecommunication sector for decades – manufacturers could only influence the standardization process by eventually convincing their national operator. Furthermore, national operators as state representatives often struggled to promote their national industries. In ETSI, direct alliances between manufacturers from different countries were common, in order to share knowledge and reduce the risk of new developments.

Knowledge sharing became a very important issue in the GSM project. For 1G standards, the national PTTs had a monopoly in their respective national market and they were often locked in the technology made by dominant national manufacturer(s). In such situation there was little need of protecting the intellectual property and few intellectual property rights (IPR) related conflicts appeared during standardization process of 1G mobile communications. But for 2G and 3G standards the situation was different – IPRs became one of the main discussion and conflicting points. Manufacturers and operators used different strategies in order to benefit from their accumulated knowledge and intellectual property. Some as Philips and IBM made their IPR available at no cost in order their technology to be involved in GSM standard [Haug2002]. Others like Motorola, holding an essential IPR for the GSM technology (actually it was the biggest IPR holder), refused to make general strategy declaration i.e. to make licenses available under fair, reasonable and non-discriminatory conditions. Originally it was normal practice that patented knowledge was available under above mentioned conditions but there was no force to make IPR holders to do so, if they didn't want to. Instead of giving IPR for free or licensing them under these conditions, Motorola wanted to exchange their IPR with IPR of other manufacturers.

Motorola's position created uncertainties about patented and licensed knowledge and caused difficulties for the involved parties that had to build networks infrastructures. There was sharp need for changes in the IPR policy. So ETSI was the first that opted for changes in IPR policy. In 1988 the operators that were planning to build network infrastructures announced that it would be compulsory for the suppliers to provide free world-wide licenses for any patents that were essential to the implementation of the GSM standard in order to be awarded an order. This was opposed by suppliers and the IPR policy failed. Ultimately operators revoked their claim for such general IPR policy, so licenses for building GSM networks had to be negotiated individually. Operators requested their suppliers to sign a declaration in which they agree to serve the whole GSM community (operators and suppliers) on fair, reasonable and non-discriminatory basis. So the IPR problem was not solved by ETSI, but it was circumvented by individual negotiations between operators and suppliers at international level. This process took 2-3 years, though and this delayed the introduction of handheld terminals for mass GSM market. George Schmitt, chief executive of Mannesmann (a German GSM operator), said

that GSM means “God, Send us Mobiles”, because Mannesmann in 1992 was losing $600,000 per day on operational costs, because not enough handheld GSM phones were available on the market. [Garrard1998]

These facts show some of the several different strategies used by holders of essential IPRs. First, the holder may decide to give the IPR for free, making sure that the IPR becomes part of the standards and gets widely accepted. In this case the holder will benefit from a head-start on the big market, since he has already the production infrastructure and the know-how in order to respond to the increased demand. Second, the holder may decide to negotiate a good price for licensing its IPR in “non-discriminatory” manner, benefiting from selling licenses to other suppliers and operators. In addition, an IPR holder may try to exchange their rights for other IPR. Finally, the holder may try to sell-off their IPR at once, for a big sum in order to capitalize immediately and risk-free on their knowledge (this didn’t happen in 2G standard development, but in 3G standardization it occurred). Of course, an IPR holder may also try to block the standard or to promote its own, proprietary standard, but in nowadays open world economy this strategy is very risky.[14]

The analysis of the role of IPR and technical knowledge in standardization shows that if governance of standard development is to succeed, it has to create conditions for successful knowledge sharing. This is because of the complexity and expensiveness of digital mobile communications. It also shows that governance of infrastructure design is a mixture of technical interactions, economic interactions and political interactions which each have specific rules. One remarkable characteristic of GSM case was that the ETSI became a central forum where most of these interactions happened

GSM standard was considered from the beginning to be a European one. European PTTs had no interest in developing a world-wide standard. Although a world-wide standard would bring more economy of scale and more competition to the market, it also would bring more complexities, delays and unwanted compromises. Nevertheless, in late 1980s several non-European countries considered the GSM standard for their 2G mobile networks. The GSM MoU, initially open for western European PTTs, was also made open for non-European operators. In the beginning of 1990s more countries were looking for ways to expand their limited in capacity mobile systems. Delays in development of 2G standards in US and Japan made the GSM the only readily available option. In most of the counties in the world the frequency band available for mobile telephony was the 900 MHz band. The existing standards working in this band were GSM, NMT-900, and TACS. Based on expectations for better cost efficiency and higher capacity, most countries chose the GSM.

2.2.2 US

US were late with the introduction not only of 1G mobile telephony but also with 2G. There were several reasons for this delay. In Europe digital mobile technology was helped by the introduction of a single European-wide standard that led to economies of scale and helped competition in the market. In US there was already such national wide

[14] Nevertheless, Microsoft is still successful in it.

standard –AMPS - and in all regions there were at least two working operators, so at least to some degree competition in mobile communications sector existed. The US regulator (FCC) saw development of a digital standard as solution of the capacity problem, but not as fundamentally new service. Furthermore federal government did not want to select a single 2G standard despite advantages achieved in 1G single standard. “In the early 1990s it became widely accepted that the success of the US personal computer industry and in particular Microsoft and Intel was due to the unbridled competition between multiple standards”[Funk2001]. Because US regulators believed in competition between standards, they opted for a “technology and standard neutral” policy, i.e. no standard or technology was favored. There were no reservations of frequencies for specific standards on beforehand. Industry firms could choose what technology to develop; the only requirement was that the new standards should be backward compatible with existing AMPS standard, so that digital network can interoperate with the existing AMPS networks. Because US regulator was not involved in the design of the standards it can’t be considered as an innovating actor in the process of standardization. In US standards that stabilize had to survive on the market. In this sense I speak about market governance in US. The ideology of market governance helped stabilization of several competing 2G standards for mobile communication. These were D-AMPS, CDMA One and PCS-1900.

The institutional environment for standardization in US was very different from Europe. The US has an internationally recognized standardization body - the American National Standards Institute (ANSI). Unlike ETSI, ANSI does not draft standards itself but accredits this to other organizations. In telecommunication sector these are Telecommunications Industry Association (TIA) and Committee T1. TIA represents equipment suppliers. T1 allows participation of network operators and equipment suppliers. TIA had been developing radio telecommunication standards for fifteen years. In early 1980s it standardized the AMPS, originally developed by AT&T. FCC made this standard compulsory in 1981. TIAs engineering committees responsible for producing standards for mobile communications are TR-45 ad TR-46. One of them was specifying standards for 800MHz and the other for 1900MHz. TIA developed the CDMA One and the D-AMPS standards.

Committee T1 makes standards for interconnection of networks. It is open to all parties that are interested in standardization process. One of its six subcommittees – T1P1 - is focused on mobile services. The work of T1 and TIA in technical standards may overlap. As a result T1 and TIA organized a Joint Technical Committee (JTC) in 1992. This committee organized working group consisted from members form T1 and TIA. This group drafted specification for PCS-1900 standard. So drafting of PCS standard involved both organizations – T1 and TIA. Each have own preferences, while TIA preferred CDMA technology, T1 preferred PCS-1900 - derivative from GSM. T1 later stepped out of JTC and agreed to work together with ETSI on common PCS specification. T1 was more open to international cooperation and even asked ETSI for harmonization of GSM and PCS-1900 standards.

Governing principles in TIA and T1 standardization committees are network based and deliberative. This means that the decisions were taken on consensus principles, where

comments of any interested party are taken in to consideration during standardization process.

In late 1980s US operators begun to explore possibilities for enhance the capacity of 1G networks through adopting digital technology. As described above, there were two important regulatory conditions for such technology – first, it had to be backward compatible with AMPS standard and second, it had to use frequencies that were already allocated to operators. For 1G mobile telephony, FCC awarded frequencies for free through a lottery, so a lot of the available frequencies have been already allocated. Since FCC demanded that digital mobile services should co-exist with the already working AMPS system, new additional frequency bands for digital services were initially not allocated.

In these conditions, North American operators initiated a certification program, called Cellular Telecommunication Industry Association (CTIA) that set up the requirements for digital mobile communications. On the basis of these requirements TIA considered various possible technologies and through balloting chose a TDMA technology. The first issued standard was IS-54 and it was approved by TIA in 1991 [Bekkers2001]. This standard, more familiar as D-AMPS, was an interim standard that can work in the same frequency band as the existing AMPS. It made possible to add digital channels within existing analog base stations. This meant that whenever more capacity was needed more digital channels could be added. This solution would resolve to some extend the capacity problem. Later IS-136 standard was approved by TIA. It provided big set of features because it was fully digital and sometimes it is called the "final" D-AMPS. But this standard was not the only digital standard. Some other standards were developed and with this the idea for single standard was completely abandoned.

The first alternative was proposed by Motorola. It proposed a narrow band analog system called N-AMPS. The width of AMPS channel would be reduced form 30MHz to 10MHz. In this way the system allowed three times as many channels than the AMPS within the same spectrum. This system was not approved by TIA since it only solves to some degree the capacity problem but postpones introduction of digital technology. The digitalization was supported by standardization institutions since at that time it was clear that digitalization will not only solve the capacity problem, but also would allow for more services and smaller and lighter mobile phones. So Motorola's proposal was rejected.

A second alternative – cdma-One - was developed by Qualcomm. In 1994 it was approved by TIA as second digital cellular standard under the name IS-95 or cdma-One. But because CDMA technology was very new most network operators preferred to stick with better known TDMA technology. Furthermore, the cdma-One standard was too closed and proprietary. Qualcomm misled many companies about the extent to which cdma-One (IS-95) would be opened. Although Qualcomm initially set up fair conditions for acquiring licenses for their patents, later when several companies declared that they would like to implement cdma-One standard for their networks, the prices for the patents were increased. The immaturity of technology and limited mobile terminals on the

market also delayed the introduction of this technology. First cdma-One infrastructure was implemented four years after the first TDMA.

Since both TDMA and CDMA-based standards had to work together with existing AMPS, the digital mobile terminals (handsets) had to be dual-mode (i.e. AMPS+TDMA or AMPS +CDMA). This made them not only significantly bigger but also twice more expensive than the AMPS handsets. So in 1994 only 10% of subscribers had dual-mode handsets [Gruber2005].

If standardization environment was different and if US regulators and standardization bodies had a vision for a common standard, IS-95 cdma-One could have been the American single digital standard. "If the US government had been able to create an agreement between US cellular operators and US manufacturers concerning the choice of IS95 CDMA as the US digital standard in return for low licensing fees for IS95 CDMA from Qualcomm, US consumers and manufacturers would have benefited [Funk2001]. The choice of this technology in US probably would cause it to be adopted by other AMPS adopters around the world. There are 85 AMPS adopting countries by mid 1998 [Funk2001].

In the mid 1980s it became clear that to create mobile communications for the mass market additional allocation of frequency band was necessary. This would allow for new players on the market, would increase competition and provide more capacity. So next to the existing band for analog mobile services, additional frequencies in the 1900MHz band were allocated for "personal communication systems" (PCS). A similar initiative for mass services was started in UK under the name Personal Communication Network (PCN). In 1990, two years before first GSM network was launched commercially, UK asked ETSI to develop such standard for 1800MHz band. This standard, a derivative from GSM, was approved by ETSI and was named DCS-1800.

Back in US, FCC changed rules for frequency allocation for PCS and opted for auctions. At the same time, the requirement for backward compatibility with AMPS network was dropped. These rules were applied for allocating frequencies for so-called narrow and broadband PCS licenses. The US territory was divided into 51 major trade areas (MTA) each subdivided into 493 basic trade arias (BTA). In each MTA would be allocated two licenses (A and B) each 2x15 MHz. and one 2x15 MHz in every BTA. Additionally in every BTA would be allocated three narrowband licenses (D, E and F) each 2x5 MHz. So every town in US would be covered by six PCS licenses. Although the first three biggest operators 'caught' one third of all PCS licenses, new actors did enter the market and the competition increased; but this process led also to fragmented market structure. The process of allocating PCS licenses took six years [Gruber2005]. First licenses in 1900 MHz band were awarded in 1995. Regulatory problems and changes in principles for frequency allocations were the main reasons for late introduction of these services.

Companies with licenses in this band had two options for developing a system. The first option was to upgrade the existing IS-54 (D-AMPS) or IS-95 (cdma-One) systems and to re-design them to work in 1900MHz band. The second option was to choose DCS-1800.

The US firm APC, which was granted trial PCS license chose to upgrade DCS-1800 (popularly called also GSM-1800) to work in 1900MHz band. This option was with low risk since this standard was implemented already in Germany and UK. APC was new player on the marked so it had no existing base from subscribers and backward compatibility was not a problem. This way for the first time a European mobile communication standard was used in US.

Governed by market mechanisms, three standards for 2G mobile telecommunications stabilized in US – D-AMPS (IS-54, IS-136), cdma-One (IS-95) and PCS-1900 (GSM-1900). Market-based governance stimulated technical innovations, but it also created uncertainties on the market and puzzled the users. Most metropolitan areas were covered by up to seven competing networks while in Europe they were three or four national operators per country. The competition among network operators decreased the prices for mobile services and terminals but still users of digital mobile communication could not use their phones when traveling, since there was no roaming service between operators. Because of market fragmentation US telecom industry could not achieve big economy of scale. And despite already existing digital services in US most users preferred the analog AMPS technology since it was national-wide so they can use their phones when they are on a move. Since FCC obliged telecom operators to run AMPS services until 2007, the users were sure that they can use their analog phones so there was no good reason to switch to digital services; thus AMPS remained with most subscribers (about 41 million in 2000). After AMPS next popular standard was D-AMPS. Initially it had more subscription base that cdma-One but in year 2000 cdma-One (27 million subscribers) overtook D-AMPS (26 million). GSM-1900 had smaller, but quickly growing subscriber base of about 9 million. [Gruber2005]

2.2.3 Comparison between European and US governance in mobile communications

The two types of governance, European and US, led to development of different technology and different penetration rates in terms of number of users.

The vision of European governance was to create a common European market. For telecommunications sector this meant that a single 2G European standard had to replace existing incompatible national standards. The political drive for European integration engaged regulators in standard development ("ex-ante" approach)[15] and frequency allocation and removed most obstacles in front of the GSM project. In order to increase chances for success of the ETSI standards – e.g. GSM – EC issued a directive that compelled member states to reserve certain frequency band for this standard. This, together with a coordinated introduction of GSM services in all member states, were most important measurements taken by EC that helped the success of single European GSM standard.

[15] "Ex-ante" means that standard should be approved by standardization institution before the start of implementation of network.

The vision of US governance was somewhat different from Europe. In US there was already a single standard - AMPS. US regulators were looking for backward compatibilities and increasing of competition, because 2G mobile communications were seen not as significantly new services meant to replace the existing 1G service, but as an extension of it. As a result the US governance did not favor any particular 2G standard and governing institutions did not engage in standard development. To the contrary - they approved successful de-facto standards from the market ("ex-post" approach).

Although both approaches were successful, each of them had specific impact on the technology and its stabilization. The ex-ante approach is considered to allow better inscription of a holistic ideology of mobile communications, including all necessary services that have to be provided and that are important for the whole network, like the roaming. It also promotes a more interconnected infrastructure. On the other hand the "ex-post" approach is deemed to stimulate technical innovations and to lead to more cost-effective solutions.

Differences in visions of the two types of governances are reflected in differences in institutional framework and in licensing.

In US there is a division between regulators and standardization institutions. Furthermore there are several standardization institutions. They were formed as alliances between actors based on their economic interests. These institutions standardized overlapping, competing standards.

FCC as regulator allocated frequency for mobile services to all interested parties initially through lottery and later on market principle through auctions. For the 2G services additional frequencies were initially not allocated, since 2G services had to work together with 1G. When later there were auctions for PCS frequencies, this process was administratively very slow and burdensome and delayed penetration of digital 2G services. Nevertheless this licensing led to a competitive market, but also to incompatible networks. The increased competition created conditions for low prices of services and for emerging of innovative and cost-effective technology.

In Europe the regulation and standardization was concentrated in EC and ETSI. ETSI was the standardization committee where alignment of interests of involved parties, like governmental bodies, engineers, entrepreneurs and consumers, happens. The result was an open, single European standard. Licensing in Europe was made trough "beauty contests". At least two telecom operators were licensed for each country. This process of licensing was faster that in US and led to moderately competitive market and compatible networks. Prices of services were higher than in US and from technical point of view GSM had least spectrum efficiency amongst all digital standards [Gruber2005].

These differences between European and American governance of mobile communications development and standardization are often analyzed as competing and mutually exclusive. Funk and Methe [Funk2001] for example call them committee and market governance mechanisms respectively and claim that for network technologies

committee-based mechanism is better. Such conclusion seems supported by the fact that in terms of adoption, GSM was by far the most accepted 2G standard. In 1997, 80% of the 40 million 2G subscribers in the World used GSM. GSM was also adopted in more than 80 countries, while cdma-One and D-AMPS were adopted in less than 5 countries each [Gruber2005]. But on the other hand, the main technical principles of cdma-One became the basis for the next, third generation mobile communications, as I will show in the following section.

2.3 Third Generation (3G) Mobile Telecommunications

During early 1990s the success of 2G mobile communications proved the existence of a significant market for personal mobile communications. At the same time the growth of Internet as communication medium and the merging of telecommunications and information technology in general created demand for mobile exchange of data, in addition to voice calls. So around that time much attention was paid to development of third generation (3G) mobile telecommunications. This generation was expected to offer high speed mobile internet, interactive services, high quality voice transmission, video telephony and video conferencing in addition to the plain telephony. The 3G telecommunication was seen as successor of 2G systems. 2G networks already offered some data services, like fax and SMS, but the capabilities of these services were restricted by a communication rate that did not exceed 10 kbit/s. For 3G services speed of hundreds of kbit/s or even some Mbit/s was needed. Various organizations tried to take leadership in design and standardization of 3G systems during 1990s, although the research about an integrated mobile telecommunication infrastructure started even earlier.

2.3.1 Development of 3G infrastructures

Ambition of ITU for World-wide 3G Standard

ITU was one of the first organizations that started to work on the third generation systems. In 1985 ITU received a proposal from PTTs from New Zeeland and Canada to start a new study group within ITU. This group had to study what was then called Future Public Land Mobile Telecommunications Systems (FPLMTS) and later renamed to IMT-2000 [Bekkers2001], [Gesler2002]. The group was called Interim Working Party 8/13. Almost 30 PTT administrations and 10 other international organizations participated in it. The study group had five meetings between 1986 and 1989. At these meetings questions were discussed like whether the new services should be in the existing or in a new frequency band, should digital or analog technology be used, is backward compatibility something important and is it necessary to have a common worldwide air interface. Answering these and other important questions, the Working Party (later renamed as Task Group 8/1), prepared detailed recommendations for FPLMTS on their fifth meeting held in May 1989. These recommendations stated the objectives of the system – "personal mobile communications at any time and everywhere. […] A low powered, personal station, that would interoperate with other fixed and mobile networks, was the concept under consideration. Both terrestrial and satellite based systems were discussed. […] The potential benefit of having a common, global air interface was identified." [Gesler2002] Both circuit switched and packet-switched services were recommended, and explicit reference was made to ISDN (Integrated Services

Digital Network) services, recommending (at that time) strong similarities between FPLMTS and ISDN.

The recommendations and eventual frequency allocations for FPLMTS were discussed at World Administrative Radio Conference in 1992 (WARC-92). WARC provide a forum within ITU for discussing and deciding upon frequency allocations. In 1990 Europe started preparations for WARC-92. CEPT formed an ad-hoc group whose objectives were to harmonize the opinion of the 31 member states into a single European position about suitable frequencies. At that time the work on a European 3G standard called UMPS had started, so in Europe there was already well established opinion about what should be the frequency band for the future services. Due to existing services the frequencies for the new services should be above 1900MHz and around 200MHz of spectrum would be required. CEPT also recognized that UMTS can be considered as part of FPLMTS so they strongly supported frequency allocations for FPLMTS. While Europe wanted first frequencies to be allocated and then a common standard to be developed, US preferred to leave standard setting to the market forces. Also US was more interested in mobile satellite services rather than in terrestrial mobile services. WARC-92 was the first conference that considered commercial communication applications for low earth orbit satellite services. This meant for US entirely new possibilities and they were not much interested in a terrestrial service, so they were not in favor of allocating spectrum for terrestrial FPLMTS at that time. As a consequence there was a conflict between European and US proposals. At the end of the conference a compromise was reached. Frequency bands 1885-2025 MHz, and 2110-2200 MHz were identified for the FPLMTS / IMT-2000 and in these bands spectrum was allocated for both terrestrial and satellite communications. But because this decision had no binding status for member administrations, it was not compulsory for these frequency bands to be used exclusively for IMT-2000 serviced so it was left to each national administration to decide how exactly to use these bands [Gesler2002].

The allocation of frequencies for 3G systems, even being non-binding, showed that the concept is gaining acceptance amongst ITU members (regulators and network operators) and this accelerated research and development in this area. The Interim Working Party 8/13 was reorganized into Task Group 8/1 and it continued to formulate requirements for 3G systems. In 1997 these requirements were finalized. The main requirement was the connection speed – 384 Kbit/sec in outdoor (urban or rural) environment, 2 Mb/sec in indoor (office) environment and 9.6 Kbit/sec for satellite communications. Furthermore, proposal would be evaluated on several other criteria based mainly on operators' interests – spectrum and coverage efficiency, quality of communication, flexibility of radio interfaces in respect to traffic density and types of services, compatibility with existing signaling protocols and capabilities of terminals (mobile phones). Once the requirements were ready, ITU issued a "call for proposals" for air interface standards. The closing date was 30 June 1998. This call for proposals was a turning point in 3G network development from research and feasibility study to standardization and (commercial) implementation. [Bekkers2001]

Early research and development in Europe

In Europe work on 3G communications started in 1988 [Henten2004]. EU sponsored several research projects concerning third generation networks, even before commercial launching of GSM services.

Three large scale EC research programs for 3G networks were initiated - RACE I, RACE II (Research and development of Advanced Communications Technologies for Europe) and ACTS (Advanced Communications Technologies and Services). Between 1988 and 1992 the RACE I focused on fixed broadband networks mainly but also included a project on advanced mobile networks. This project was focused on high capacity TDMA systems, called Advanced TDMA. In the RACE II (1992-95) program two projects for mobile communications were included. It became clear that other technologies are possible, except TDMA, as a base for the 3G networks. So the first project was focused on CDMA technology and the other was focused on TDMA. In 1995 there was an attempt, in RACE programs, to select one of the proposed technologies as a basis for 3G systems, well known now as UMTS, but such decision was not reached. The research continued in the ACTS program, with aim to define a proposal for UMTS. This project is known as FRAMES (Future Radio Wideband Multiple Access System) and it resulted in two air interfaces for UMTS, known as FMA1 (TDMA) and FMA2 (CDMA) [Bekkers2001].

Most of this research was done by scientific institutions and pioneering R&D companies with only limited participation from network operators. Partly because of this, most proposals envisioned the 3G standards as revolutionary new ones, not as extension or upgrade of existing standards. Despite considerable investments in 3G research the actual progress was slow and mainly theoretical. Most operators were more involved with implementation of their 2G and 2.5G (GPRS) networks and with increasing their number of subscribers; so they did not see a pressing need for jumping into next generation networks. In order to speed up the practical development of 3G standards the EC set up a UMTS Task Force in 1995, which was composed mainly from policy makers and had the task to set up goals and to recommend organization for creating 3G infrastructures – i.e. the main task was to look into the governance of infrastructure standardization and development. The Task Force presented its recommendations in March 1996. They set high goals: regulatory framework for UMTS should be ready by 1997, UMTS services should be working at 2Mbit/s and available by 2002, full bandwidth for UMTS should be available for mass use by 2005, etc. They also recommended creation of an UMTS forum, including broad spectrum of actors, that will provide “strategic guidance” to ETSI on matters like “spectrum allocation, licensing and regulatory issues, technology and market demand”. These recommendations were not welcomed by ETSI and CEPT since the UMTS forum would bypass their functions. Nevertheless, the UMTS forum was formed, but with less responsibilities and authority than recommended, as a result of “political lobbying and bargaining” [Bekkers2001]

Development in Japan

In Europe the work on UMTS was slow but in Japan progressive steps towards introduction of third generation networks were done. There were some reasons for

hurrying into next generation mobile communications. Japan had strong capacity shortage for their 2G networks and new frequency spectrum was not available so network operators were eager to use the extra frequency spectrum that was available for the IMT-2000. The second reason was the unsuccessful promotion of first and second generation Japanese networks (NTT and PDC) that were not adopted outside of Japan. It created strong desire to do better in 3G and to re-assert Japan as leading player in IT and telecommunications.

In Japan two bodies were involved in the third generation system standardization. The ARIB (Association of Radio Industries and Businesses) was responsible for radio standardization and TTC was responsible for signaling network (core network) standardization. In addition the Japanese Ministry of Post and Telecommunications (MPT) was involved as regulator.

In 1996 the MPT set up a study group to formulate a proposal to ITU for third-generation mobile phone system. In this group all Japanese operators and manufacturers were involved, together with some non-Japanese manufacturers such as Motorola, Ericsson, Nokia, Samsung, Nortel, etc. The study group has the options to choose a completely new third-generation system or to join proposals made in Europe or US. Several smaller Japanese operators that recently have adopted cdma-One for their second-generation networks were eager to upgrade that system to the successor of cdma-One[16] for their third-generation systems. But the biggest Japanese operator NTT DoCoMo (at that time also the largest operator in the world) had other interests. It used PDC, the dominant 2G standard in the country, which was developed in Japan, but was never popular outside it. PDC was a TDMA based standard, so for DoCoMo a switch to CDMA interface was not an easy option. In early 1997 NTT DoCoMo placed order for experimental third-generation network. Ten vendors have been involved in this project. As the MPT, DoCoMo involved in the experimental network not only Japanese companies like NEC, Fujitsu and Matsushita, but also non-Japanese vendors like Ericsson, Nokia, Motorola and Lucent. Eventually NTT DoCoMo chose W-CDMA for their third-generation networks. They were ahead of MPT's (Ministry of Post and Telecommunications) study group that hasn't chosen the technology yet. W-CDMA was not the technology that would be chosen by other Japanese operators, because it was not an upgrade from their existing 2G network technology. But NTT DoCoMo confronted all other Japanese operators, being the biggest operator.

By involving non-Japanese vendors in their R&D orders DoCoMo hoped that W-CDMA will be adopted in other regions as well [Bekkers2001]. And exactly this happened. Up to that moment Ericsson was producing analogue and digital communication technology following all world standards, *except* the CDMA. Adopting CDMA as a base for third generation networks would have been a major loss for Ericsson and Nokia [Funk2001]. They have been planning to upgrade their TDMA based GSM standard as a way of development towards 3G standard. The NTT's order was a great chance for Ericson and Nokia to accumulate knowledge also in CDMA technology. After receiving the NTT order Ericsson rapidly embraced CDMA technology and dropped their support of TDMA

[16] A 3G successor of CDMA-One has already been in design in US under the name cdma2000

for the 3G standards. Expected economy of scale and protection of investment in R&D were in this case the reasons for the change in position. In turn, Ericsson managed to convince NTT DoCoMo to use the "core network" component of the GSM standard, known as GSM-MAP. This was major victory for Ericsson and Nokia, enabling them to use a big part of their existing research and technology in the third generation network. This way Ericsson ensured a smooth migration path for its existing GSM network operators and customers. This attracted many other infrastructure suppliers form Europe to support WCDMA technology for the 3G networks. Eventually most other Japanese operators too jumped on the bandwagon and aligned their opinions to that of NTT DoCoMo. This is clear example how economic interests of actors influence the decision on a technical matter like using CDMA vs. TDMA. Japanese decision to adopt GSM network interface and upgrade path can be interpreted as deliberative and inclusive governance since it opened the standard for foreign actors that act as promoters of their standard and helped diffusion of it [Funk2001]

Further development in Europe and cooperation with Japan

After Japan's ambitious plans to introduce third generation networks were announced, many actors from Europe started to support the plans of the UMTS Task Force for development and introduction of UMTS. In next several years the attitude of European actors to UMTS changed as the threat from other world regions came and so UMTS forum became popular and was soon including 180 members; amongst them all major manufacture suppliers and network operators. Being a formal standardization body ETSI decided to complete the UMTS standard. After involving existing GSM operators and equipment suppliers the standardization process moved away from the theoretical sphere and the scope of UMTS changed a lot. First, instead of trying to standardize all mobile services, actors decided to focus on a limited number of services – telephony, video telephony, internet access, interactive services. Second change was in the relation between GSM and UMTS. Actors up to then believed that UMTS will be completely new system, so new networks would have to be build and users would have to migrate from one network to the other. In 1997 the idea for evolution from GSM to UMTS took ground. Although the radio interface and the frequency band were different, there were many other areas where the two standards can be harmonized and the core GSM network can be reused. Two intermediate (2.5G) standards were developed that can be used as "step stones" in the migration from GSM to UMTS – these were GPRS and EDGE. GPRS introduced packed-switching for data calls, which made possible to share a time slot between several users (GPRS was still TDMA based so time slots were allocated to each call). This increased the speed of the data transfer. Adding GPRS to a GSM network "requires additions of several new components to the GSM network, but fortunately, only few modifications to base stations and other existing equipment was necessary" [Bekkers2001]. EDGE introduced a new modulation and error-correcting scheme that theoretically allowed data speed of 384 kbit/sec., although on real networks the speed was somewhat lower. EDGE required "significant changes to GSM infrastructure, including new radio channel cards in the base stations and upgrade of transport links between base stations and their controllers". Some of these changes could be reused in UMTS networks, but other could not, so in practice some operators decided to migrate directly from GPRS to UMTS, without implementing EDGE as an intermediate step;

while others used EDGE as their main standard for a few years, while eventually gradually migrating to UMTS.

In 1997, realizing the increased interest in 3G developments, ETSI was dedicated to complete UMTS standard and announced procedure for selecting air interface technology for UMTS. ETSI received thirteen proposals. On a meeting held in Kristiansand, Norway in June 1997 all proposals were grouped in five so called "concepts". ETSI identified the "concepts" and the underlying technology by letter form Greek alphabet - alpha (WCDMA[17]), beta (OFDM[18]), Gamma (TDMA[19]), Delta (TD/CDMA[20]), Epsilon (ODMA[21]) [Bekkers2001], [Nenten2004]. The alpha and delta proposals were regarded as most promising. Alpha was based on FRAMES program FMA-2 proposal and underlying technology was WCDMA that already selected by Japan. It was supported from actors that already had received order form Japan for implementing trial version of WCDMA networks. Ericsson, Nokia, Lucent and Motorola hoped that WCDMA would be chosen in Europe as well. In fact, with this proposal Nokia and Ericsson pushed the already tested combination of GSM core network and W-CDMA technology as basis for UMTS standard. This proposal had support from vast majority of European GSM operators, because of reuse of core GSM network. The explicit support from the two largest telecom operators in the World - DoCoMo and Telecom Italia Mobile - was especially important.
Delta was based on FRAMES program FMA-1 proposal. It is predominantly based on TDMA GSM technology and it is supported by Siemens, Alcatel, Nortel and Italtel. Nokia dropped its support for delta proposal as it received the order for supplying Japanese operators with the experimental third generation network. This proposal was also with good chances since it was supported by France and Germany which had significant lobbying power in ETSI.
Recognizing that the third generation networks will be a worldwide infrastructure and taking into account the progress already made in Japan, ETSI gave Asian operators the chance to become Associate Members with full voting rights. In August 1997 the proponents of alpha and delta proposals agreed that they will use the evolved GSM core network for UMTS but the question concerning different air interface remained. The final decision about UMTS technology had to be taken in Paris on 28 and 29 January 1998. At that meeting the votes for proposals were distributed as follows: alpha received 61.8% of votes, delta 38%, gamma 0.2% and beta 0%. None of the proposal had the necessary 71% majority, according to rules of ETSI. After this inconclusive voting a hybrid proposal containing parts from both alpha and delta proposals was discussed. DoCoMo, present at the meeting as observer, agreed to support such a proposal and finally ETSI decided to adopt it.[Bekkers2001]

By participating on ETSI meetings Japan (through NTT DoCoMo) had possibilities to harmonize its proposal with the European UMTS. By adjusting the chip-rate and several

[17] Wideband Code Division Multiple Access
[18] Orthogonal Frequency Division Multiple Access
[19] Time Division Multiple Access
[20] Time- and Code Division Multiple Access hybrids
[21] Opportunity Driven Multiple Access

other parameters the ARIB W-CDMA proposal and ETSI UMTS proposal were made on a common design concept [Gesler2002]. But these proposals were sent to ITU in 1998 as two separate IMT-2000 proposals.

Developments in US

After the WARC-92 conference the Federal Communications Commission (FCC) noted that the envisioned Personal Communications System (PCS) is in essence similar to FPLMTS, and decided to allocate frequency spectrum for PCS in the frequency bands of IMT-2000. In September 1993 FCC allocated 110 MHz spectrum around 2 GHz for PCS. The operators were not obliged to follow any specific standard, so different operators developed multitude of competing systems. In reality, though, PCS systems were more like 2G mobile communications[22], both in terms of speed and in terms of services. They were based either on upgraded versions of D-AMPS, IS-95-A (cdma-One), or on PCS-1900 (derivative of GSM). Here as before the battle was whether PCS operators should go for TDMA (D-AMPS and GSM) or CDMA (cdma-One) systems. For both options a standardization process was started in order to create 3G standards.

The cdma-One line was followed by TIA and US manufacturer Qualcomm played a leading role in R&D and standard development. For cdma-One (IS-95A) maximum data speed was 14.4 kbit/s. The PCS version of this standard was called IS-95-B. This standard not only was adjusted to work in the PCS spectrum but also the maximum data speed was increased to 115 kbit/s. This required some software changes but the whole hardware infrastructure was possible to be reused. The next step was development of cdma-One 1XRTT (cdma2000 1x). This standard offered 144 kbit/s maximum data speed and it required some hardware changes in base stations and their controllers, but the capacity of the system was increased essentially. The final step to full 3G system was development of cdma2000 with maximum data speed of 2Mbit/s. It required significant hardware upgrades at the base stations. Despite the need for hardware changes (which were mostly upgrades), the entire upgrade path was relatively uncomplicated, because the chip rate for cdma2000 was three times cdma-One chip rate, which made multimode terminals feasible. Furthermore, cdma2000 networks were possible to be deployed within existing 5MHz-wide licenses [Bekkers2001]. So in conclusion the migration from cdma-One to cdma2000 was a step by step upgrade process, involving some replacements and some extensions. It happened as follows - cdma-One -> 1XRTT (cdma2000 1x) -> cdma2000 1x EV-DO (3G) -> cdma2000 1x EV-DV (3G+). In this path the cdma-One operators could fairly easily migrate their existing services to the cdma2000 platform and, at the same time, provide seamless introduction of new services and applications [Henten2004].

The other US standardization body, T1, continued to build upon PCS-1900 (or GSM-1900). Following the developments in Europe, T1 presented to ITU a 3G proposal called WCDMA N/A (N/A from North America). It would allow for a similar migration path as the GSM networks – via GPRS and EDGE.

[22] These services are sometimes called 2.5 G, because they have some more data transfer capacity than "pure" 2G systems, but they are far from full-fledged 3G.

The result was that two US proposals were presented to ITU – cdma2000 and WCDMA N/A. Still following the "ex-post" approach, the FCC as regulator did not intervene in this process and let the success of each standard to be decided on the market.

Although technically D-AMPS networks could have been upgraded to either cdma2000 or WCDMA at similar costs [Henten2004], most but not all D-AMPS operators followed the upgrade path of GSM. "High economies of scale, more attractive services including roaming and a more attractive in long-term terminal market all speak in favor of WCDMA. […] Simple spectrum management, gradual investments enabled by AMPS/CDMA terminals and better investment reusability speak in favor of cdma2000" [NSE2003]. The migrations path for D-AMPS networks to WCDMA was IS-136 (D-AMPS) to IS-136 phase II (or UWCC136+, similar to GPRS) to IS-136 phase III (or UWCC136HS) that is almost identical to EDGE, and then to WCDMA [Bekkers2001], [Henten2004].

Battles at ITU and outside

Based on research through the whole world, the ITU received 10 proposals for IMT-2000 by the submission deadline at 30 June 1998.

The main contenders for the IMT-2000 standard were the US developed cdma2000 and Euro-Japanese UMTS / WCDMA. The other proposals, except the Chinese TD-SCDMA, more or less gravitated around the main contenders. The initial ambition of ITU was to make a single standard, either by choosing one of the proposals or by combining several of them. This goal, though, was not achieved. The main obstacle was the licensing of intellectual property rights (IPR). ITU followed a similar approach as ETSI and demanded that all holders of essential intellectual property rights for the future 3G standard declare that they will provide licenses on a "fair, reasonable and non-discriminatory terms" [Bekkers2001]. Two major IPR holders – Ericsson and Qualcomm – refused to sign such declaration. Qualcomm stated that it will license unconditionally only operators and manufacturers migrating to cdma2000 (the US standard backed by Qualcomm). It would license WCDMA/UMTS products only if the WCDMA/UMTS standards were modified in such a way that allows Qualcomm to efficiently produce phone and network equipment for these standards and in this way to penetrate the European market. Ericsson in turn declared that it would grant licenses to Qualcomm only on reciprocal basis – i.e. if Qualcomm grants CDMA-related licenses to Ericsson. Furthermore, the two companies were in protracted legal battles both in US and in Europe for allegedly violating each other's property rights. Eventually Qualcomm and Ericsson settled their IPR dispute, but not before ITU failed to agree on a common 3G standard at its meeting in April 1999[23].

Although the IPR issue was the main problem for making a single 3G standard, it was not the only one. As Henten and Saugstrup point out, "this vision could not be realized because of strong strategic and economic interests of the different players" [Henten2004].

[23] In fact the settlement between Ericsson and Qualcomm was announced just hours after the failed ITU meeting, even before its press release was released. This makes some analysis wonder if Ericsson and Qualcomm were truly in favor of a single 3G standard, as they both claimed.

Furthermore, according to Bekkers, "the proposed options were so different technically that to reach a compromise would have been very difficult anyway". Ultimately, ITU gave up in 1999 the idea of having a single 3G standard and declared that all proposals meet the formal ITU criteria. ITU then set a new goal for itself – to facilitate the harmonization between various 3G standards.

The harmonization of 3G standards

The first step in harmonization direction was an attempt to consolidate similar proposals into a single standard. Realizing the similarities between some proposals, their ITU-member proponents (standard setting organizations from various countries) decided to form a 3G partnership project – 3GPP – in order to come efficiently to a common standard. In 3GPP initially 5 partners participated – Association of Radio Industries and Businesses (ARIB) from Japan, European Telecommunications Standards Institute (ETSI) form Europe, Committee T1 from US, Telecommunications Technology Association (TTA) form South Korea and Telecommunications Technology Committee from Japan. Later China Wireless Telecommunication Standard Group (CWTS) also joined. 3GPP develops IMT-2000 standards based only on Euro-Japanese WCDMA / UMTS standards.

A similar organization was created to facilitate development of IMT-2000 standards based on cdma2000. The project was called Third Generation Partnership Project 2 (3GPP2) and was establish in January 1999 by four "organizational partners"- ARIB from Japan, TIA from the United States, TTA from South Korea, and TTC from Japan [Gesler2002].

At the beginning both 3GPP and 3GPP2 were created as associations of standard making bodies (called organizational partners), but very soon they were open to individual members from the industry (operators and manufacturers) as well to research and consultancy organizations. The only condition was that individual members also participate in their national standardization organizations. Nowadays 3GPP has about 330 individual members and 3GPP2 has about 75 individual members[24]. Most of standardization decisions in 3GPP are made at technical group level. There each individual member and organizational partner has a vote and a majority of 71% is necessary to take a decision. Final approval of standards is done by voting by organizational partners only; again 71% of votes are necessary for approval. But despite these voting rules, the working procedures of 3GPP say that the organization will try to achieve consensus on all issues and majority voting will be performed only if consensus can't be reached. 3GPP2 has similar structure and voting principles (including consensus-orientation), except that even for final approval of standards individual members can vote (this is voting at steering group level) and a simple majority of 51% is sufficient for decision making.

3GPP and 3GPP2, supported by ITU, succeeded in creation of a single WCDMA (or UMTS) and a single cdma2000 standard. As mentioned before, the Chinese TD-SCDMA

[24] According to their official Web sites – www.3gpp.org and www.3gpp2.org, visited Dec. 2007

standard was taken under the "umbrella" of 3GPP, but it is not integrated with WCDMA. Remarkably, the responsibility of 3GPP group has been extended, so that it now "include the maintenance and development of the GSM Technical Specifications and Technical Reports including evolved radio access technologies - GPRS and EDGE"[25]

Another interesting phenomenon from governance point of view was the role of Operators Harmonization Group (OHG). This was an ad hoc group formed from network operators from around the world. Their main goals were to influence 3GPP and 3GPP2 groups to harmonize their (proposed) standards so that operators can cost-effectively migrate to 3G networks and the users would be able to roam on networks based on different standards. To achieve these goals, operators agreed on 3 demands:

- Limit the number of supported air interfaces to 3
- Limit the number of supported core networks to 2 – GSM-MAP (the core network of GSM standard and later used also in WCDMA and UMTS) and IS-41 (the core network of cdma-One)
- All radio interfaces must support both core networks. This was the most difficult requirement to achieve, because 3GPP group was in favor of GSM-MAP and 3GPP2 supported only IS-41.

Since OHG included operators from both 3GPP and 3GPP2 group, they managed to influence these groups and OHG got positive first reactions on their proposals; so the parties engaged in negotiations. Attracted by this initial success, a number of mobile phone manufacturers joined the OHG, and this led to another demand – to get the chip rate of two standards close to each other. When the chip rate doesn't differ more than 5%, this makes possible to use same chip set for both standards so that lighter, smaller and cheaper multi-standard phones can be produced. This was in the interest of manufacturers as well as in support of cross-standard roaming.

The negotiations of OHG with 3GPP and 3GPP2 were successful. 3GPP agreed to lower the chip rate and to support IS-41 core network in addition to GSM-MAP. 3GPP2 agreed to add support for GSM-MAP core network in the second version of their standard and to abandon a proposal for a forth air interface. On the other hand OHG accepted the TDMA based air interface, used in EDGE and UWCC136HS, at least as intermediate standard. Finally, in 2001 ITU recommended the following "family" of 3G standards [Henten2004]

[25] www.3gpp.org, visited 20.12.07

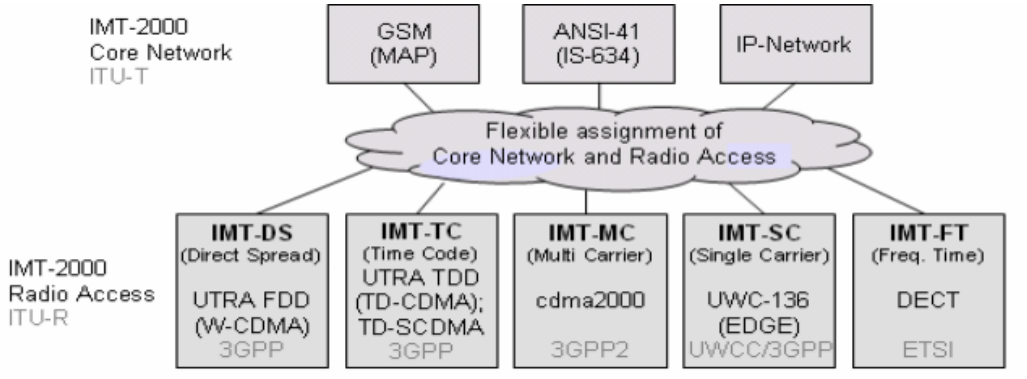

Figure X: The IMT-2000 family of standards. Radio Access is the same as Air Interface. ANSI-41 is the same standard as IS-41 for core networks. Finally, DECT is a short-range standard for connecting mobile handsets with a central fixed phone, so although it technically covers the IMT-2000 criteria, it is not a real mobile communications standard.

2.3.2 Analysis of development of 3G infrastructures and their governance

Probably the most obvious observation in 3G is that the governance of standardization became world-wide. Both 3GPP and 3GPP2, who emerged as standard setters, are international organizations with world-wide participation. They have similar composition (e.g. membership types) and similar working procedures. So it is difficult to speak anymore about different modes of governance in different countries or regions – there is one, world-wide mode of governance. At the same time, already in 2G, mobile telecommunication networks began to form a global infrastructure. This was not only because of technical interconnections between networks and possibilities for roaming, but also because of increased travel by people. Yet another factor in this "globalization of infrastructure" was the opening of telecommunication markets. First equipment manufacturers, but recently also operators (mainly through mergers and acquisitions), became global businesses, operating in different markets and in different standards.

Another important observation on governance in 3G standardization is that the "world-wide mode of governance" is quite heterogeneous, in several dimensions. For example, there is a combination of market-based governance and an "ex-ante", deliberative approach to standardization. The market component is clear from the fact that individual industry members decided to join 3GPP or 3GPP2 mainly depending of their economic interests in WCDMA or cdma2000 standard, which in turn was influenced by the migration and upgrade possibilities of their exiting networks and products. Furthermore, the success of OHG is an example of the power of an alliance between actors based almost entirely on (short and mid-term) economic interests. The "ex-ante" approach is clear from the fact that no operator or manufacturer dared to bring a commercial 3G network or product on the market before one (or more) international standards were agreed. This was probably a risk-reducing strategy, since a standard agreed by many parties has better chance to withstand the competition in the global infrastructure. Also in this way manufacturers and operators could share their R&D costs. To make the mixture of governance types even more heterogeneous, litigation as form of more formal and antagonistic governance (typical mainly for US business culture) also sneaked into the 3G standardization process. The lawsuit between Ericsson and Qualcomm was not the

only one. In recent years legal disputes have included Nokia vs. InterDigital, Broadcom vs. Qualcomm, several operators vs. T-Mobile, etc. Lawsuits are usually around property rights and anti-competitive behavior; although they are often settled before a final verdict is issued.

This combination of different types of governance puts an end to the "market vs. committee" dichotomy. In 3G standardization the "market and committee" were mixed and this mixture proved able to produce successful standards.

Another dimension of heterogeneity in governance is the participation of the same actor in several standardization organizations. For example Japanese standardization organization ARIB is founding partner of both 3GPP and 3GPP2. Furthermore, many members of OHG were also members of 3GPP and/or 3GPP2 and this was the main way for OHG to influence these groups.

Such heterogeneous mode of governance did not appear out of nowhere. It evolved from previous modes of governance in a sometimes "trial and error" process. The "ex-ante" approach of EU and the "ex-post" one of US were clearly visible at WARC-92 conference. Furthermore the FCC in US allowed use of 3G frequency spectrum for PCS already in mid-1990s. This was right after ITU published the general goals of the 3G mobile communications and much before the technical requirements for a 3G standard were developed. This move was in response to the lack of spectrum in US for growing mobile communications, but it also reflected the vision of FCC that the "right" standard will prove itself in the market. Something like this did actually happen – cdma2000 is one of the two main 3G standards – but not before intensive "ex ante" standardization effort was made by manufacturers and operators first at TIA and then at ITU and 3GPP2. On the other hand, in Europe there was much investment in R&D for 3G even before the main actors – manufacturers and operators – saw the potential market for such communications. This politically "sponsored" R&D led to a vision of 3G mobile communications as a new infrastructure that would replace the 2G infrastructures. Only after big manufacturers and operators got seriously involved, a gradual migration path was standardized. So in a way the involvement of operators and especially manufacturers (that were already global businesses at the time) aligned to some degree the governance modes in Europe and in the US.

Yet another interesting example of "trial and error" is the attempt of ITU to create a single 3G standard. One certain source of inspiration for this attempt was the success of the GSM. Many analysts believed that having a single, "ex-ante", open standard was the main factor behind the success of GSM networks and so the governance that led to such a standard would be suitable for next generation mobile communications as well. Nevertheless ITU did not achieve a single 3G standard. Why? The arguments about the different strategic and economic interests of the parties and about the technical differences between different proposals, as mentioned above, are both valid. But during development of GSM standard there were also different strategic and economic interests – for example between Germany and France on one side and Scandinavian countries on the other. The technical options were even more diverse – competing proposal included

analogue and digital technology, TDMA and CDMA, etc. Despite all this differences, ETSI managed to create a successful single standard. What has then changed between 2G and 3G, between ETSI and ITU? I would point out to two factors – the lack of political authority and the technological path dependencies. ETSI was supported politically and regulatory by the EU political institutions. Furthermore, existing 1G infrastructures in Europe were small and the number of users was low, so it was acceptable for operators to replace an 1G with a 2G infrastructure, especially realizing the possibilities to get to a bigger European market in this way. With 3G, the situation was different. Second generation mobile communications have achieved a mass market in most developed countries and different standards did have a big install base. Replacing a 2G infrastructure with a (incompatible) 3G one was for most operators very difficult option – not only because of costs involved for themselves, but also because they would have to persuade the users to change their phones. For manufactures such situation would also be undesirable since they have to change their production technology. So the issue of compatibility and upgrade became central for main actors – but this is a typical issue resulting from technology path dependency. On top of that, ITU did not have political backing, since there was no world-wide political authority. Said with a bit of exaggeration, at the level of a world-wide infrastructure there is only one global authority and it is the global market.

Seen from the perspective of path dependencies, there is an important difference between 3GPP groups and OHG. Formation of 3GPP and 3GPP2 was heavily influenced by path dependencies – 3GPP was largely GSM centered and 3GPP2 was largely CDMA centered. OHG, on the other hand, was more about the future economic interests of operators and manufacturers in a global 3G infrastructure. These interests pointed to harmonization of standards so OHG, as a marked-based force, played to some degree a similar role as political authorities in GSM case. But the interaction between OHG and 3GPP groups did not lead to a single standard – it led to a path towards harmonization of standards, an option which allows for better accommodation of existing path dependencies.

Speaking about the creations of 3G standards there is another interesting observation. ITU started the standardization process in quite hierarchical settings. Only national (or international, like ETSI) formal standardization bodies were able to propose standards and only these regulators could finally vote to approve the standard(s). Manufacturers and operators had only an indirect role, via the formal standardization organizations. Even 3GPP and 3GPP2 were initially formed on such principle, but later were open to direct participation of various types of actors. This can be seen not only as a shift from hierarchical to more network-based governance, but also from inter-national to a cross-national governance, where negotiations are not anymore between (representatives) of national states, but directly between various actors from many states.

2.4 Conclusions and discussion

So far I have analyzed the governance of infrastructure standardization in each generation of mobile communications. Now my goal is to put this analysis in an evolutionary perspective and to outline the co-shaping of governance and technology in this evolution.

In first generation (1G) mobile communications there were a number of different governance modes, since the governance was mainly national, except to a certain degree in Scandinavia. In many countries there was a de-facto or a statutory monopoly by one national operator, who had also regulatory functions and was in a predefined alliance with national supplier(s). In Scandinavia was an international alliance between national monopolist PTTs, combining operator and regulator's roles; there the market of mobile phones was liberalized. In UK several competing national mobile operators were introduced from the beginning. In US regulation of emerging mobile communications was left to individual states; the federal regulator FCC only demanded a single standard – AMPS. Competing local operators appeared quickly and the infrastructure was build "bottom-up". In general, 1G standards were developed at national level, except the Scandinavian NMT, but many countries chose to adopt an existing standard from another country rather than to develop their own. In Europe, for example, 11 countries have adopted NMT standard and 5 countries have adopted AMPS/TACS standards.

In second generation (2G) mobile communications there were two distinct governance modes – one European and one in US. In Europe there was a deliberative form of "ex-ante" standardization, leading to a politically promoted single standard – the GSM. This standardization process was open to operators, manufacturers and user representatives, but the important decisions were still made by voting by national delegations. In US there was "ex-post", market approach to standardization, where the regulator did not promote any particular standard and allowed stabilization of 3 different standards. The appearance of these governance modes though was contingent on many factors. The European governance was certainly influenced by the success of the NMT standard in Scandinavia – so the idea of international, open standardization became popular. "Nevertheless, there was attempt by French and German governments to use domestic standard setting as a way to promote national champions" [Funk2004] and they nearly left the GSM project; only a political compromise at EU level keep them in. In US, the FCC has already demanded a single standard for 1G and the reason not to do so for 2G was not so much the "market thinking" – FCC was no less market oriented in 1989 than in 1992 – but because of the impression that 2G mobile communications are not a new service, but merely an extension of the 1G systems – so backward compatibility with AMPS was requested rather creation of a new single standard. Japan largely followed the US model, allowing multiple 2G standard, but on the other hand there was political backing of "the Japanese standard" – PDC, developed by NTT DoCoMo. And still many countries relied on adopting existing standards instead of participating in standard development.
In third generation (3G) of mobile communications the governance of standardization was international; although national regulators still have significant authority over building and exploitation of actual mobile networks. Because the standardization was world-wide, there was practically one mode of governance; but such mode emerged from merging of previous modes, so it was (and still is) heterogeneous. Yet again, the merging was not straightforward. ITU attempted to follow the GSM governance model, in a similar way as GSM followed the NMT model. But this time, due to technological path dependencies and lack of political authority, this attempt was unsuccessful. History repeated itself also in another way – as in early stages of GSM development,

(representatives of) national regulators formed a “in between” layer in decision making; in later stages there were (in most cases) direct interactions between various types of actors from different states – I call this a “cross-national” governance.

This overview already shows one dimension of co-shaping between governance and technology – globalization. As the technology (mobile communication infrastructure) becomes more global, it needs global governance for its building – or at least for its standardization. As governance becomes more global, different governance modes converge; and so do the standards for mobile communications. But why did mobile communications technology globalize so quickly and furthermore, was the globalization of technology linked to changing modes of governance? To answer these questions I will take a closer look to the role of standards and standardization in mobile communications.

Mobile communications are a network technology. In most cases a network technology requires standards simply to be able to work. But standards have also an impact on the economics of network technologies - thus on their chance for stabilization – and also on their governance. I will use a theoretical model for analyzing this impact based on network externalities, bandwagon effect, lock-in effects and economy of scale.[26]

A very specific effect that occurs within interconnected technology like telecommunication technology is so called network externalities. The more users subscribe to given network the more users can be contacted. So the value of a network for the user depends of number of other users. As more users join the network the value of the network increases for all its users. Connecting one mobile network to land-based network increases network externalities for the both networks since users of both networks can communicate between each other. However joining the mobile network increases connectivity even more, since when having mobile phone people are more reachable and they can communicate from every place and not only when they are at home. Thus, despite the fact that mobile networks are connected to the fixed network, increasing number of subscribers of the mobile network gives extra positive network externality. Interoperability between mobile communication networks increases the positive network externalities. There are other, indirect network externalities too – if a network has many subscribes, it is more likely that more choice of terminals and more services will be provided. [Bekkers2001] This is especially important externality for 3G mobile communication infrastructures, since they offer big potential for services - all information that people need while they are outside is candidate to be delivered as service.

As several important network operators and suppliers commit themselves to a particular standard this creates great expectations that this particular standard will succeed. This effect may occur in the development phase of a standard or later in the adoption phase. This is called bandwagon effect; it may actually trigger expectations for success amongst suppliers and users and make them to support the standard attracting even more actors and users. This creates a positive loop and may increase even further the network

[26] This model is described and applied on mobile communications, amongst others, in [Bekkers2001] and, [Fomin2001].

externalities and ultimately make the standard even more widespread. For GSM for example such bandwagon occurred in 1997 when three important events happened: Germany and France accepted GSM technology, EC showed strong support for GSM and several network operators signed Memorandum of Understanding (MoU) stating their commitment to the GSM standard.

Lock-in effects can have negative impact on stabilization of technology, because they increase risks of the investments and decrease competition. Most common example of lock-in effects in mobile telecommunications is locking a network operator in a standard or with their equipment supplier. Operators can be locked into a standard in three ways: First switching to a different standard is very costly and investments made in the existing infrastructure will be sunk costs. Second, operators can be locked in specific standard because their subscribers have made already investments in phone terminals for that standard. Third, operators may be locked in a standard because their license obliges them to use this particular standard. Operators may also be locked into a supplier if during standardization process no intra-system interfaces are included, so the operators have to purchase the entire network equipment from a single supplier.

When GSM achieved huge penetration around the world, some analysis suggested, based on the above theoretical model, that a single standard is the best option (or even the only possible one) for success in the market of mobile telecommunications. Indeed, a single standard creates big possibilities for economy of scale, certainly has a bandwagon effect, reduces lock-in effects and enables positive network externalities by making interconnection between networks easy. However single standard some times does not create incentives for innovations. Between 1991 and 1996 GSM was not put in conditions of serious competition in Europe and very little progress was made on planed enhancements. But this changed seriously once GSM faced competition world-wide form other standards.

A more careful analysis of the theoretical model would show, though, that a single standard is neither necessary, nor sufficient condition for beneficial economic effects. For economy of scale, for example, it is the size of the market covered by standard that is most important. Two equally popular standards in a big market would offer more economy of scale each, compared to a single standard in a small market. The same applies to lock-in effects and to a certain degree to the bandwagon effect. As far as network externalities are concerned, there the interoperability is crucial and it depends not only on the standard(s), but also on gateways and agreements between suppliers and manufacturers. A standard needs a critical mass of support to “get off the ground”, but this mass can also be achieved by competing with other standards in a big market. Creating a big market and good interoperability were very important for the stabilization of mobile telecommunications. GSM indeed was a *means* to create a pan-European market in telecommunications that in turn was a *political* goal of EU. GSM certainly created a bandwagon effect, but its world-wide success was also due to the fact that it was the first commercially available open 2G standard.

During the 2G domination the suppliers (operators and especially manufacturers) realized that creating a world-wide market would bring them *economic* benefits through economy of scale, especially as national regulations for market entry were liberalized around the world. The demand side was also coming to the same understanding. As mobile communication networks stabilized, they became "black-boxed", i.e. users assumed that they are always there and are reliable. As mentioned earlier this is one of the characteristics of infrastructures according to Edwards [Edwards2003]. This black-boxing, together with increased international travel and because the mobile phone became so easy to carry around, created expectations in many users that their own phones should work all over the world – so there was a demand for a global world-wide mobile communication network.

Once a global network of interoperable mobile communication infrastructures was created, equipment manufacturers would benefit from further standard harmonization. The closer the standards, the more easy and cost-effective it is to produce mobile phones for different standards, to reuse components and even to produce multi-standard phones in order to satisfy the demand for "always working phones". This benefit is stronger when manufacturers become global market players. On the other hand, technological path dependencies did exists for each manufacturer, since they come from different national and regional markets. So a gradual harmonization rather than a "winner takes all" standard was preferable. There were various governance forms used by operators to shape harmonized standards. Next to membership in formal standardization bodies like 3GPP and 3GPP2, ad hoc groups like OHG and lobbying by various regulators were used. Also partnership R&D projects were established, together with operators, like in case of DoCoMo 3G feasibility study.

This brings us to another factor that stimulates cooperation between various actors in standardization. Mobile telecommunications include knowledge-intensive products. Both for operators and for manufacturers the R&D cost are higher related to production and operation costs, especially in comparison with other infrastructures, like the electrical grid. So suppliers have an incentive to share R&D costs and reduce risks through pre-competitive cooperation. But shared R&D increased the chances of arriving to consolidated standards (i.e. to small number of widely supported standards instead of big number of standards).

The point about the risk reduction in innovation deserves special attention. When speaking about risk reduction, we usually mean the risk of failure – so that either the goals of the R&D can't be achieved (there is no innovation) or the innovation would not stabilize on the market. My point here is that successful innovation in mobile telecommunication also can be a risk factor, especially for operators in a competitive market. If an operator creates a new, innovative network it has to invest not only in R&D but also in building or upgrading the physical network. If the innovation becomes a success, then there is a risk that competitors can also deploy this innovation, but somewhat later, benefiting from already accumulated knowledge and more mature technology. This applies both to initial network building (parallel mobile networks are relatively to be build, if there is spectrum and licenses available) and for migration. Yet

another aspect of “pioneer’s risk” especially for operators in the availability of phones for a new standard and network – this was a problem for early adopters as well of GSM as of 3G standards. So operators have an extra incentive to work together on standardization and to consolidate standards. Such consolidation creates a bandwagon effect for manufacturers and for 3G for service suppliers, so that it is more likely to have mobile phones and services available. On the other hand, through coordinated introduction of new standards the “pioneering risk” of early adopters from later competition decreases. The same consideration about the “pioneering risk” has an influence in a different direction – protection of knowledge. As market of mobile telecommunications becomes more competitive the technical know-how more and more becomes an asset that has to be protected – so formal disputes about intellectual property rights arise.

This multidimensional and sometimes contradictory picture of influences between technology and governance shows that there is no straightforward evolution path. Technological innovations and governance decisions are often contingent. But there is a trend for both mobile communication technology and its governance to evolve in the direction of globalization and consolidation, through mutual co-shaping. On the other hand, the differences in technology and in governance did not disappear entirely – they were to a certain degree “endogenized” into the global and consolidated system, making it more heterogeneous that it’s original parts - the early isolated mobile communication networks and their local governance.

So taking a look back now, is the path of infrastructure building, described by Edwards, valid for mobile communication development? My answer is yes, but with an important remark. It is still true that mobile communications became a real infrastructure when “order” was created in the set of technical innovations and possibilities. It is still true that standards played the crucial role in this transformation. But what was changed since Edison’s time is the role of system builders. There was no single or dominant system builder in the case of mobile telecommunications development. Instead, a choir of actors and especially standardization institutions played the system building role, through a complex system of network interactions and alliances.

Chapter 3. Co-shaping of market governance and mobile telecommunications as consumer product

In this chapter I will analyze the co-evolution of governance and mobile communications as consumer technology. Already at the beginning, it is a relevant question - is governance necessary at all when we speak about free market where different operators and suppliers compete for the consumer? I would argue that governance is involved in this process.

In the process of "catching the consumer" several parties participate, like telecom operators, suppliers of mobile terminals, service providers and regulators. They all have a common goal – widespread and profitable mobile communications. This common goal is related to specific characteristics of mobile telecommunications as a 'common good', essential for the functioning of the society. Public governance even developed the term "universal service", meaning that mobile communication should be available and affordable for everyone. Other consumer technologies that do not have such a 'common good' characteristic would not need such governance.

In order to achieve the common goal, alignment of actions is necessary because it is not possible for telecom operators to provide service without suppliers to provide enough mobile phones and versus-versa. Furthermore, operators should ensure necessary interconnections so that people can call each other from different networks – only then mobile communications become real infrastructure on which most people can rely. Regulators also have a role in this process, and it is not an easy one – on one hand, they have to provide conditions for competitive market; on the other hand they have to watch social consequences of mobile telecommunications and when necessary take action to limit negative effects and promote positive ones[27] – like for example achieving a universal service. So the mobile communication sector is subject of many regulations.

These interactions and collaborations of all parties striving to introduce mobile communications service on the market is de facto market governance of mobile communications. Although strategies of individual actors vary significantly, a dominant pattern is to achieve big penetration rate for mobile communications, satisfaction and extension of consumer demand (i.e. "catching the consumer") through offering innovative services in competitive market. Mechanisms for "catching the consumer" depend to a large degree on the structure of the market. Market structure is heavily dependent on regulations, so telecom operators and suppliers of mobile phones had to take into account the regulatory framework when they introduced mobile services on the market. Regulators are those who have to take decisions about structure of the market by fixing number of firms and conditions for entry on the market [Madden2003]. Mutual interplay of actors presenting mobile services on the market is very important for the success of these services.

[27] I use "negative" and "positive" here as from the point of view of the respective regulator(s), which in democratic countries in general should reflect the public opinion. It is not my goal in this thesis to evaluate morally the social consequences of mobile telecommunications.

To analyze market structure I'll use a classification of markets, following Gruber [Gruber2005]:

- *Homogenous* product market – when products offered by firms can not be differentiated by specific characteristics. Then products offered by different firms can be distinguished only by price. Consumers would buy lowest-priced product. This situation is not very winning for firms in competitive market, since the only way to make their products attractive is by reduction of prices. So firms strive always to make their products distinguishable.
- *Horizontally* differentiated products market – products in such market are also very similar to each other, but if the consumer wants to change his product for the same product offered at lower price form a different firm, the consumer has 'transport costs'. So firms try to lock-in consumers so that swing between different brands becomes difficult.
- *Vertically* differentiated products market – products in such markets are differentiated by quality. It is assumed that the consumer is willing to pay more for a better quality product, if he can afford to do so.
- *Goods-characteristic* market - goods are defined as 'bundle of characteristics' on which consumers express preferences. Consumers may consume more than one good and they can freely combine different goods from different suppliers.

Regulations are classified in two types – pre-entry and post-entry regulations. The pre-entry regulations concern spectrum allocation, technical standardization of infrastructure and phone terminal and market entry (licensing). The post-entry regulations concerns prices, interconnections between networks and services provision. Because of scarcity of frequency spectrum and necessity of equipment compatibility the pre-entry regulations are relatively strict for mobile communications. The role of post entry regulation was mainly to prevent incumbent operators from unfair advantages on the market. This can be achieved with regulation of the prices of the services and interconnection between networks and also through ensuring non-discriminatory network sharing and number portability. The post-entry regulations for mobile services are minimal especially in comparison to fixed telephony.

In the rest of this chapter I will analyze the development of mobile communications as consumer technology during 4 periods – the early stages in 1980s when analogue mobile telephony was luxury and mainly business service; the digitalization of technology and initial penetration of non-business markets in early and mid 1990s; the formation of mass market in late 1990s and integration of data and voice services in a mass, multifunctional communication infrastructure in mid 2000s. In each period I will pick up and analyze several phenomena in mobile communications development that are illustrative about its governance and the links between governance and technology: These phenomena will include:

- Market and service development
- Pricing trends
- Interactions between market players – e.g. competition, collaboration, agreements – and involvement of regulators

- Position of the customer and how it is mediated by technology (mobile telecommunications)

3.1 Pioneering mobile telephony – 1980s

In the early stage of mobile market development the mobile phone was marketed as tool for business use. This was the time of 1G analogue telecommunications. Since there was not enough frequency spectrum, the capacity of analogue systems was very limited. Therefore this service remained elite and expensive. In that sense the market for mobile communications was a niche market and the goal of operators and manufactures was to introduce and stabilize the technology in that niche. Business users were ready to pay high price for the service. For them the ability to get information and to make decisions at the right time, independent from the place they were, could bring significant value to the business. The marketing focused on this added value for the business people. So despite that first mobile phones were bulky and heavy and that initially only some geographical areas were covered by the mobile networks, there was significant demand for mobile telephony amongst the wealthy people and this resulted in enormous profits for telecom operators.

Seen from governance point of view, the late 1980s have been the years of solo playing pioneers in markets that undergo a transition from monopoly to liberalization. Even in cases where there was competition, market players did not interact much between themselves, but tried to build up their networks and attract consumers independently.

3.1.1 Pricing trends and post-entry regulations

In the early stages of mobile telecommunications operators and terminal manufacturers did not adopt strategies for differentiation of their products and services. First of all there were few opportunities to do so since the only existing service then was the telephony. This made the product market homogeneous, so the only way for product differentiation was through reducing the prices. But in 1980s reduction of prices was not achieved because in most European countries mobile communication sector was monopolistic. In countries where competition did exist (UK, US, France and to some degree Nordic countries, as described in previous chapter) there were some attempts for product differentiation. In UK, for example, the network operators were prohibited to sell services directly to the customers. Instead “service providers” had to buy a bulk of airtime at wholesale prices form telecoms and then sell it to the customers at retail rates. Since the frequencies spectrum was very limited it was not possible to increase the number of telecom operators a lot but there was no reason not to increase the number of retail firms. With this UK regulator aimed to increase competition and reduce the prices of mobile services. Service operators not only re-sold airtime, but provided value-added services like billing, customer support and even voice mail. But despite these measures, the prices charged by operators remained high mainly because the capacity of the system was limited and the demand from business people was not very dependent on the price of the service. The same applied to the prices of mobile phones. In 1989 the average fixed cost (i.e. subscription fees and phone costs) of a mobile network subscriber in OECD[28] has

[28] Organization for Economic Co-operation and Development (OECD). Its goals are ‘to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while

been around $1500 per year, while an average 3-minute call did cost $1.35. [OECD2006a] Furthermore, prices did not fall much even in countries with duopoly market, as the following figure suggests:

Retail prices for mobile telecommunications services, UK, 1985 and 1991 (£)

	Rental per month	Airtime per minute	
		Peak	Off-peak
1985			
Cellnet	25	0.25	0.08–0.15
Vodafone	25	0.25	0.10
1991			
Cellnet	25	0.25	0.10
Vodafone	25	0.25	0.10

Figure 3.1: Prices for mobile telecommunication services in UK, [Gruber2005, p.204]

3.1.2 Pricing schemes - Calling party pays and receiving party pays

Possibilities for price differentiation or reduction depend on pricing schemes underpinning the structure of the market. Two main pricing schemes exist in mobile telecommunications - calling party pays (CPP) and receiving party pays (RPP). In almost all OECD countries a CPP scheme was used in late 1980s, but in some important markets like US and Canada the RPP was used since the introduction of the service.

In CPP scheme the initiator of the call is responsible for paying the price for the whole call and the receiver of the call pays nothing for this particular call. In this paying scheme the network in which the call is initiated receives the total charge for the call. This charged price has to be shared with the network that terminates the call[29], since the receiving operator has expenses for terminating the call. This scheme requires certain agreements between operators for sharing the revenue from the calls. It furthermore means that the caller may pay different prices per minute depending on the receiving operator.

In RPP the initiator of the call pays to his telecom operator for initiation of the call. The receiver of the call pays to her operator for terminating the call. The caller pays always the same price per minute, independently of the receiving network and the receiver also pays the same price, independently of who is calling him. In RPP scheme such revenue-sharing agreements between operators are not necessary. This difference means that

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maintaining financial stability, and thus to contribute to the world economy'. The original member countries were Australia, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. Subsequently Japan, Finland, Austria, New Zealand, Mexico and Czech Republic became members"- "*Mobile Cellular Communication Pricing Strategies and Competition*", in Information Computer Communications Policy, 1996

[29] This means the network of the receiver of the call, i.e. where the end-point of the call is. "Terminating the call" in telecommunication terminology actually means to provide connection to the receiving party and to handle the call.

governance of mobile communications is also different between networks using CPP and RPP schemes.

When studying the evolution of market governance of mobile communications, it is important to understand why the different pricing schemes and their respective forms of governance emerged. Different charging schemes for mobile service were established mainly because of existing different charging schemes on the fixed networks. RPP was used in those countries with unmeasured local calls, like US and Canada. In US and Canada users were used to not to pay for local phone calls so it would be very strange for such user to be charged for calls to mobile network[30]. Furthermore in those countries there are no different prefixes in the numbers of the mobile phones so users don't know if they are calling mobile or fixed phone and that different charging schemes may apply - so RPP was more suitable.

In countries with measured fixed local calls CPP scheme was adopted. For those users who were use to pay for calls in the fixed network and the price depended form how distant is the call. So for them it was normal to pay when initiating a call. In those countries (almost all OECD countries) numbering system existed that identify mobile phones with specific prefix number. So users were aware that they are calling mobile phone.

Considerations about transparency and competitiveness also played a role. In US in some states telecommunication laws prohibited using of CPP scheme, because the caller couldn't know on beforehand the per-minute price he would pay (it depends on the receiving network, but as mentioned above in the US there was no way to know which number belongs to which network) [Madden2003] Furthermore, because of big number of operators in US it would have been very difficult to achieve agreements on income sharing. On the other hand, in Europe there were much less operators (at that time 1-2 per country), but they were nation-wide, so agreeing on interconnection charges was easier.

In summary, various factors played a role in defining the pricing schemata for the new mobile telephony service; but the main factor was the need to provide the consumer with a pricing scheme that is perceived as fair and not very different from familiar fixed phone charging schemata.

In terms of "fairness" from consumer point of view the main advantage of RPP is that the prices for outgoing and incoming calls are transparent. Every subscriber pays both types of prices and he knows how high they are. If these prices are high the subscriber may choose to change its telecom operator. Furthermore, for the consumer being reachable at any place (i.e. receiving calls on his mobile) had additional value, compared to the fixed phone for example, so it is fair to pay for it. Yet another advantage of RPP at that point in time was that since mobile subscribers were mainly business users, many incoming calls were service calls from consumers, originating from the fixed network. The RPP allowed

[30] One may argue that when calling a mobile user from a fixed network, it is a long-distance call (the mobile user can be anywhere), so paying for it is would not be unusual even in US. But at that time, most US mobile operators were local, so in most cases a fixed-to-mobile call would be actually a local call.

the businessmen not to add extra costs to their customers for such service calls. This was especially important in US since the business there is very service-oriented and consumers are very sensitive about “hidden costs”.

On the other hand, a consumer has full control over the call she makes, but much less control over the calls she receives. On this point RPP can be perceived as “unfair”. At that time there was no “caller ID” shown, so the receiving party had no idea who is calling. Although some operators allowed for a few free seconds of incoming call, it was still difficult to judge if the call should be accepted or rejected. So with RPP scheme the consumers had less possibility to control their expenses. They had to budget enough prepaid time for incoming calls. If they go over their monthly allowance they would have to pay more per minute calls. Some users kept their phones most of the time switched off so that they do not to receive unwanted calls. The script of the mobile phone however is to be always switched on so that subscribers are to be available and reachable at any time and place. RPP does not exploit fully the power that is in the script of the mobile phone. I will show further in this chapter that this fact had a big impact on penetration and stabilization of mobile telecommunications in society.

3.2 First penetrations into non-business market - early and mid 1990s

The early 90s were the period of introduction and stabilization of 2G (digital) standards for mobile telecommunications. With the digitalization of mobile technology the capacity of mobile infrastructure was improved. This allowed more calls to be carried over the same frequency band. So operators could answer the increased demand for mobile services and address not only businessmen but also all kind of mobile professionals, self-employed and salespeople [Madden2003]. This allowed for a growth of the penetration rate from 1% of the population in 1991 to 6.7% in 1996 in average in the OECD countries [OECD2000]. Scandinavia, Australia and the US had the highest penetration rates of about 28%, 21% and 16% approximately [OECD2000], [Gruber2005]. Operators and manufacturers achieved moderate, but steady market growth mainly by acquiring new customers.

Such growth was not possible by attracting only business users. As the network capacity increased, operators were looking to extend the current niche market. Traveling professionals, or professionals who are often “on call” were a natural next target group, since providing them with mobile phones would generate business value for their employers. But also relatively wealthy consumers were targeted as private users of mobile telecommunications. The main driver to attract these groups of consumers was the pricing; but the design of the mobile phone also started to play a role, although still limited in this period.

In this period in almost all European countries a second mobile telecom was licensed and in some countries there were even more than two operators. The role of regulators was to prevent incumbent telecom operators or firms that have market dominance to exploit their market power in related markets and gain unfair advantages. This trend can be explained by the overall drive to liberalize the telecommunication market, but also by the fact that

regulators see mobile telecommunications as essential infrastructure with deep social impact. They applied asymmetrical regulations in order to help new coming mobile operators to invest and build up the infrastructure - so there were less post-entry regulations for mobile operators than for fixed ones.

In US this period was characterized by consolidation of the market where bigger operators were established, often by merging or by acquiring smaller local operators. For example, in 1992 the top twelve cellular firms, of which the largest was McCawCellular, served nearly 60% of the US population. McCawCellular had accumulated 91 licenses for areas with a total residential population of 65 million [Gruber2005]. In general both in Europe and in the US the market for mobile telephony services became a competitive oligopoly[31].

On the manufacturers' side, as digital phones consumed less energy and the same time the battery-making technology has improved, it became possible to produce smaller and lighter phones that were more convenient to carry around. Because of steady market growth and the novelty of digital technology manufacturers did not have enough production capacity. As mentioned in the previous chapter, this was the time when GSM abbreviation was interpreted as "God, Send us Mobiles". So manufactures focused on producing limited number of mobile phone models and marketed them as suitable for broad target audience – this is what Steinbock calls "mass marketing", or "one size fits all" approach. Says Frank Nuovo, the chief designer of Nokia: "In the beginning there was only one model – the brand product. When you only have one or two models, you are not thinking how to extend the number of models – you are just trying to get your product out there". But even then Nokia started to differentiate models by color: "We gave the business professionals what they wanted – the black classic [phone] […] But when you using bright colors, patterns and textures, you are broadening the product appeal" [Steinbock2005, p.168]. We see by this example that targeting new types of consumers involved actions both from operators and from manufacturers – but in this period these were two parallel, not much coordinated processes.

As the number of operators increased and network coverage became more global, the issues of interconnection and roaming between networks became important, since consumers started to expect a global service. This required more interactions and agreements between operators, so in general in this period more deliberative governance forms appeared, although mainly on bilateral basis.

3.2.1 Pricing trends

Duopoly, or more generally the oligopoly model led to a moderate decrease of the prices, but the prices were sill considerably above the real costs. The fixed charges, such like connection fees and monthly rentals decreased form 1989 to 1995 with 30% in OECD countries, while the usage fees decreased for the same period form 1.35$ to 1.10$ only [Gruber2005]. In many countries introduction of a new operator initially led to some price drops but soon after the prices stabilized again and there was not much further

[31] Oligopoly is a market situation in which a few suppliers control the supply of a given commodity or service. Many economists see oligopoly as "imperfect form of competition".

price-based competition. In Economics this is known as Cournot's competition model in homogeneous markets; it is different from Betrand's competition model where prices drop quickly, close to level of costs. For explanation of these models see [Gruber2005].

Although increasing the number of network operators did not lead to big price cuts, it resulted in alternative pricing plans being offered for different types of users. According to an OECD analysis, with introduction of 3rd and 4th operator the number of pricing plans available on the market increases dramatically [OECD1996b]. The network operators in this period tried to differentiate their services by prices, offering separate price plans for business and non-business users. The packages for non-business users were with reduced monthly rentals and connection fees (with few free minutes included in the rental) but usage fee was more expensive. For example, UK firm Vodafone in 1993 had subscription for business user called "business call" with monthly rental 25£ and usage fee per minute call 0.25£ during peak hours. The "low call" subscription was directed to non-business user. There monthly rental was 12.80£ and usage fee per minute was 0.43£ [Gruber2005, p204]. The goal of operators was to attract more users by easing the subscription to the mobile service and to create incentives for them to use the service off-pick time, in this way to relax capacity constrains. Such off-peak use is less of a problem when the mobile phone is used for private calls rather than for business calls. An interesting observation in this context is that in RPP (receiving party pays) pricing models there were more opportunities for various pricing plans than in CPP, because in RPP a differentiation can be made between consumers who call more and consumers who are mainly getting called and separate pricing plans can be made for each groups

To what degree the introduction of various pricing plans decreased the real costs for the consumer is debatable. Gruber claims that these costs decreased significantly, because individual user could save money by choosing the right pricing plan for them. On the other hand, other analyzers point out that those different pricing plans made comparison of prices between different operators difficult, so they had more selling and lock-in effect, rather than price decreasing effect. This point view is supported by data about costs of "OECD mobile basket prices" that calculate actual costs of a user with certain "average" calling pattern. The cost of this basket has decreased only by about 15% between 1991 and 1995 [OECD2000]. But that the presence of different pricing plans helped to catch consumers from outside the "business market niche" is illustrated by the following diagram:

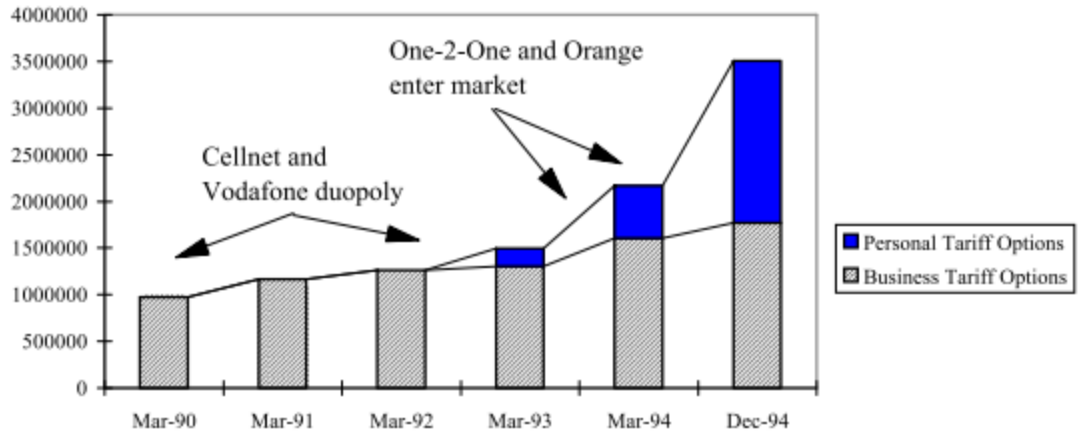


Figure 3.2. Tariff Diversification and Subscriber Growth in the UK [OECD1996b]

It is important to note that in this period there was almost no direct regulation targeting the retail price of mobile services and phones. In Europe the regulators were busy trying to limit the power of incumbent fixed operators. In US individual states were allowed to regulate the prices of mobile calls, but in 1993 FCC took this authority over and decided not to regulate the prices directly, but to increase competition between operators. [Gruber2005] The idea was that market mechanism will regulate the prices.

3.2.2 Network coverage

Although the market of mobile telephony was still homogeneous in early 1990s (offered services were telephony and the few other services included in the standard), the operators tried *vertical quality differentiation*. Coverage of network is one parameter for *vertical quality difference*. Broad network coverage is valued more from those users who travel a lot since they can use their mobile while traveling. As mentioned above, travelling professionals were especially targeted by operators in this period. If the same service is offered by two different network providers with different area of coverage the user on the constant move will prefer to subscribe to the network with bigger coverage, even if it is more expensive. If firms have the ability to differentiate their services by coverage by building networks with different sizes this may relax the competition though prices. Also the bigger area a network covers, the more potential subscribers it has, so the operators had several incentives to broaden their area of coverage. In practice in Europe, where duopolies existed, soon both network operators had national coverage. In other countries, like US, where nationwide licenses did not exist, all major telecom operators reached more or less the same coverage size. Often when coverage was not ensured by firm's own network it was by mid 1990s provided by national roaming at homogeneous prices. So product differentiation in terms of network coverage faded out. Nevertheless it was important strategic variable during initial roll out of the network [Gruber2005].

3.2.3 Lock-in effects

While network coverage was used for vertical differentiation of mobile telecommunication services, operators also attempted horizontal differentiation by trying to lock-in their users. This means that they made it difficult to change telecom operators. There were several ways for locking users. Some operators subsidized mobile phones (sold them at very discounted prices together with a subscription to their network) and in

exchange they made a contract with the user, obliging him to use services of this particular operator for one or two years. Other operators made the phones that they subsidize work only with particular SIM card – this is the so called SIM lock. Although operators tried to justify the SIM lock as a safeguard against lost and fraud, some regulators found it as anti-competitive and banned it. But even without the ban technical solutions emerged allowing to remove the SIM lock and they were widely used. Another way for consumer lock-in is through telephone numbering. In most countries every operator has a specific dialing code/prefix. If a user wants to switch to another operator she had to change her phone number. This was very inconvenient for professionals who communicate with a lot of people, like doctors, lawyers etc. Later on, in order to prevent lock-in by numbering, the regulators in many countries demanded number portability allowing the consumers to keep their mobile numbers when switching operators [Gruber2005].

The failure of the SIM lock and later the introduction of number portability can be seen as signs that the time of "solo playing" was over and this governance mode was not suitable anymore for the mature mobile telecommunications. Next two topics – interconnection and roaming between mobile networks – illustrate this point further.

3.2.4 Interconnection costs and agreements

High interconnection charges for transferring a call to another network form a significant part of the price of mobile calls. In the CPP pricing model the caller pays the price of the whole call. If a call is initiated in one network (fixed or mobile) but has to be terminated in another one, the mobile operator initiating the call has to pay to the terminating operator an interconnection charge. These interconnection charges are negotiated between operators. Usually in a free market prices are regulated by the balance between supply and demand and competition between suppliers in general pushed the prices down. But I will show in this section that there is almost no market pressure on operators to decrease the interconnection costs, so regulators take this role. Because of interactions between different operators and the involvements of regulators it is important to analyze from governance point of view the process of termination charge settings.

There are three main types of interconnection charges. One is for calls originated from the fixed network and terminated in a mobile network (FTM, fixed-to-mobile charges). There mobile-to-fixed (MTF) charges too and, when a call is made between different mobile networks, also mobile-to-mobile (MTM) interconnection charges. I will look at each type separately, because negotiations, markets and regulators play a different role in each type. These differences resulted in very different level of the interconnection charges: "Mobile-to-fixed interconnection rates average around US cents 2.32 in countries with CPP, in contrast to much higher rates [US cents 25.97] for the reverse direction. Termination charges on the fixed network are very low compared to the mobile retail pricing" [OECD2000]. Mobile-to-mobile interconnection charges were somewhere in between the MFT and FTM charges [OECD2000]. Since termination costs on fixed and mobile networks are comparable, how these differences in termination charges can be explained?

The FTM interconnection charges are negotiated between each fixed and each mobile operator. The retail (and user) price and the share of the revenue each telecom receive are also negotiated between operators. For example in The Netherlands in year 2000 there were a number of fixed operators like Versatel, Esprit Telfort, A2000 and KPN. There were also several mobile operators. In mid 1999 KPN, the incumbent fixed operator, decided to reduce the prices for fixed-to-mobile calls. Four of the mobile operators agreed and the prices of FTM calls were made uniform. The fifth operator Telfort Mobile did not agree on the reduced rated of FTM calls, so the retail price for a KPN to Telfort call was higher than for calls made to other mobile operators. Despite some variations in the way the retail prices of FTM calls were determined, the situation in most other countries with CPP was similar. Mobile operators were the most important arbiter in determining the retail prices for FTM calls and they retained the biggest share of the whole retail price for terminating the call on their its networks. [OECD2000].

The reason for such high interconnection charges for FTM calls is that neither the mobile nor the fixed operator has market incentive to lower these charges. Mobile operators did not mind high interconnection charges. For them this means that users on the fixed network will pay big price to call a user of their mobile network. In a sense mobile operator is monopolist in this situation since the user of the fixed network cannot use another mobile network in order to call the person she wanted. Also users of the mobile network were not interested what is the price that someone has to pay when calling them – such prices are even not included in price lists of mobile operators. [Gruber2005][OECD2000] Instead consumers were much more interested in prices they have to pay and they were used to think that the prices of incoming and outgoing calls are symmetrical. This thinking was inherited form the era of land-based telephone service. This was not the case with mobile communications, but most consumers did not realize this fact, since it was kept not transparent by the operators.

Fixed operators also had no incentive to press mobile operators to lower the FTM interconnection charges. In many OECD countries the fixed line operator was still monopolistic during 1990s. Furthermore, even after several fixed operators were operating on the same market, the incumbent often had a monopoly for fixed-to-mobile calls, since until 1998-99 no OECD country had "carrier pre-select"[32] for fixed to mobile calls. Monopolistic (at least for FTM calls) fixed operators don't have problems with high prices for fixed-to-mobile calls, since their users have little choice in making FTM calls. Also there was little danger of losing clients to mobile networks, since at that time mobile services were still expensive, so replacing completely a fixed phone with a mobile was not a common option.

In contrast to the FTM case, mobile-to-mobile (MTM) interconnection charges are subject of market pressure because of competition. MTM rates like the FTM ones are also not transparent to the consumer. As with FTM, the calling party has to pay the whole

[32] Carrier Pre-select is a service allowing a telephone subscriber whose telephone line is maintained by one company, usually a former monopoly provider, to choose to have some of their calls automatically routed across a different telephone company's network without needing to enter a special code or special equipment - Wikipedia

price of the call without knowing which the terminating network is and what the prices of call termination are. But MTM interconnection charges are lower compared to FTM. While mobile operators have little incentives for reducing the FTM termination rates this is not the case with mobile-to-mobile interconnection charges. First of all, interconnection charges reflect directly on retail prices and mobile operators, because of the competition between them, try to reduce their retail prices and thus have an incentive to press each other for lower interconnection charges. Furthermore, if all mobile operators set too high interconnection charges this will lead to very high prices of the mobile services and will reduce the number of mobile subscribers. So MTM rates were lower because mobile operators competed on retail price and also because they had a common goal - stabilization of mobile services and avoiding prohibiting price of the mobile services [SAM2001]. These rates are usually set by commercial negotiation between mobile operators and there was little regulation intervention, at least in 1990s.

Mobile-to-Fixed (MTF) call rates were lower in comparison with both FTM and MTM. The reason for this is that European directive 90/387/EEC advised national regulatory authorities to oblige incumbent fixed telecom to provide cost-bases termination charges to all other operators. So through 1990s in most European countries such national regulations were in place [EWERS2007]. The main reason of this regulation was to facilitate market penetration of new fixed operators. But since the termination costs on the fixed network are the same for all incoming calls (fixed or mobile) the incumbent operators were obliged to have the same termination charges for fixed and mobile calls. Thus mobile operators profited from cost based termination charges on the fixed network (for MTF calls), while they were not obliged to set cost-based termination charges on their own networks (for FTM calls). This was a big economical advantage for the mobile operators. “Revenues from FTM termination often represented one third of the mobile operators’ entire annual revenue” [EWERS2007]. This was the case not only because there was no market pressure on FTM termination costs, but also because the regulators applied asymmetrical regulations. These asymmetrical regulations were applied because the goal of the regulators (especially in Europe) was to help stabilization of mobile telecommunications as a service essential for the common good. As I described in the previous chapter, European regulators took a direct involvement in standardization and establishment of the GSM infrastructure; but when it came to bringing this service to the consumer, the regulators didn’t try to govern the service directly – they only influenced the market conditions in a “pro mobile” way.

The result of all this was, that during most of 1990s mobile operators were able to impose interconnection charges high above the actual costs of call termination. These high revenues coming especially from FTM interconnection charges were used by mobile operators to reduce subscription fees and to subsidy the price of mobile phones and so to attract new customers. Attracting new users was important for mobile operators not only because these users make calls and generate revenue, but also because they are called and then the operators receive termination charges (when the call originates from another network). So operators, especially relatively small ones, had interest to attract even customers with limited available budget, who were not willing to spend much money for calls. For such customers a low “entry investment” is essential, so it was a common

practice to offer mobile phones with discount (or even for free) to new subscribers. Operators spent some of their income from termination costs for this purpose, but they also received bonuses from manufacturers and their dealers for bundling their phones with the subscription package. This is a form of “alliance through competition” between phone manufacturers and network operators.

In summary, although it may sound as a paradox, the high and non-regulated FTM interconnection charges helped attracting new customers for mobile telecommunications and stabilization of mobile networks.

3.2.5 CPP, RPP and growth of the market

The extra revenue from interconnection charges was one of the reasons why CPP scheme helps faster penetration of the mobile services in Europe compared with countries with RPP. This trend was accelerated further with introduction of pre-paid cards.

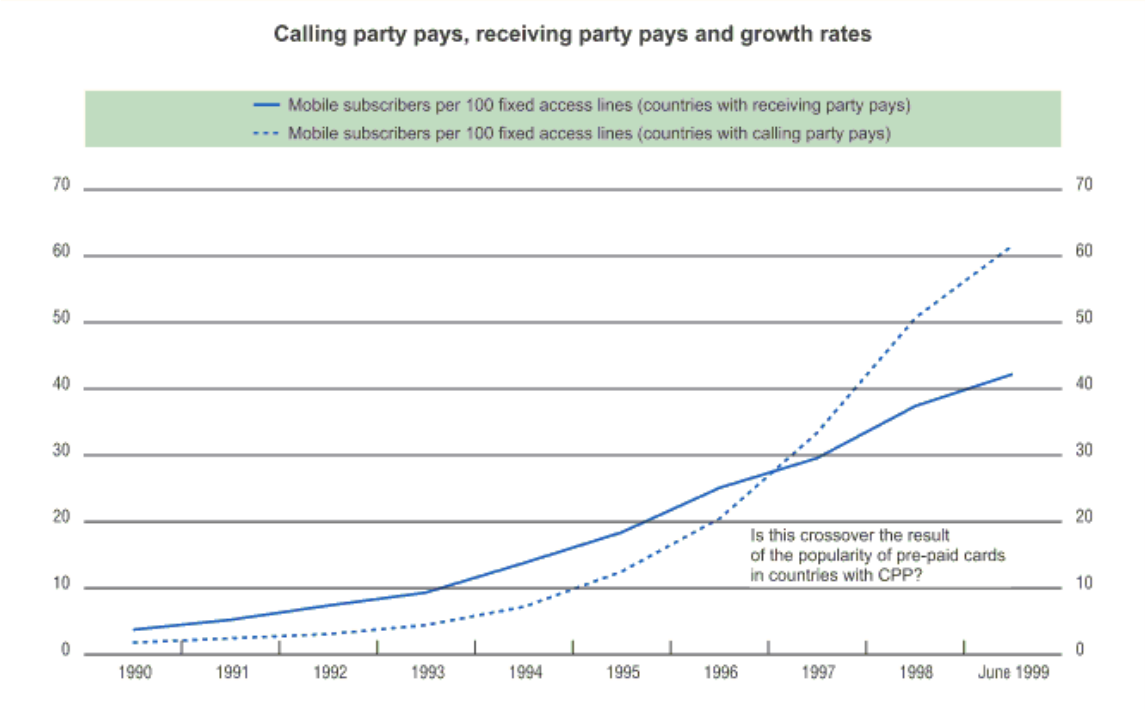


Figure 3.3. From 1994 penetration rate in countries with CPP starts to grow faster than in countries with RPP. Introduction of prepaid cards in 1996 accelerates the growth in CPP countries even more [OECD2000].

Seeing this trend, FCC in US removed some regulating barriers for introduction of CPP in the US. These included notification of the calling party and arrangements for passing billing information between operators. Encouraged by these changes, Vodafone-AirTouch, a telecom company with considerable presence in both European and US market started a trial with of CPP in Colorado, believing that CPP can increase market growth in mobile telecommunications also in US. The trial was not very successful and telecom operators and industry analyst remained not in favor of CPP, since previous successful trials haven’t been reported in US. One element that the FCC and CTIA have identified as being important to the successful introduction of CPP is a nation-wide

framework, which did not exist in US at that time [OECD2000]. Another factor, which was underestimated in the trials, was the consumer perception of the charging scheme. American consumers, at that time still mainly business users, were accustomed to the RPP system for reason I've described earlier. Vodafone-AirTouch did not make an effort to target new consumer groups, for whom the CPP scheme would be more acceptable; nor did it make a "value proposition" to business users explaining how CPP scheme can benefit them.

3.2.6 Roaming

With introduction of roaming a mobile phone can use another provider's network at higher price. When the newly visited network sees a mobile phone that is not registered, it tries to find the home network of the phone. The visited network has to check whether the "guest" mobile is authorized for making and receiving roaming calls. For this purpose the visited network contacts the home network and verifies this authorization. The verification uses a so-called IMSI number (International Mobile Subscriber Identity), which is a unique code written in every GSM SIM card. If the "guest" mobile is authorized for roaming calls the visited network gives to the "guest" mobile a TMSI number (Temporary Mobile Subscriber Identity) so that the home network can forward all roaming calls to this temporary number in the visited network. IMSI numbers follow an ITU numbering standard – ITU E.212.

If the visited network is in the same country as the home network, this is known as national roaming. If the visited network is outside the home country, this is known as international roaming or global roaming. If the roaming is between two networks with one and the same standard (for example GSM) the roaming service provides convenience of a single telephone number, bill and telephone terminal – in case of GSM within 210 countries worldwide[33]. For example, a British Vodafone user in Australia could log onto a network and roam within the coverage area of that Australian network. The price for the Vodafone user to receive calls would be USD 1.50 per minute. If the British Vodafone user makes a call from Australia back to the United Kingdom, he would be charged rates per minute ranging from USD 1.43 to USD 1.64 at peak times. The variation depends on which of the three networks in Australia the British user logged onto to make and receive call. [OECD2000].

If the visited network operates on a different technical standard than the home network, this is known as inter-standard roaming. In such cases the user has to purchase another mobile phone (unless the phone supports both standards) and a calling card from his operator. For example, an AT&T user can purchase a product known as "CellCard" for USD 49.99 a year. The AT&T CellCard is a "smart card" programmed with the user's AT&T wireless number and billing information that offers automatic international roaming. This card could be used in 90 different countries for USD 2.49 per minute for outgoing calls (plus long-distance on calls received by the user). [OECD2000]

Since in early and mid-1990s each operator was active only in one country, there was a difference in interests of operators to offer national and international roaming.

[33] GSM Association, http://www.gsmworld.com/roaming/index.shtml, visited 30.11.2007

National roaming

If two operators A and B compete on the same market and they cover the same geographic area there would be no demand for roaming since staying with the home network is always cheaper than roaming (because of interconnection costs, amongst others). But if operator A has much smaller coverage than operator B, than subscribers of A will benefit from a roaming agreement with B, because they will receive better coverage, albeit at higher prices. But operator B would not have interest to make an agreement with A, since in this way he would lose its competitive advantage based on wider coverage.

The situation is different when A and B cover entirely different geographic area in the same country. Then a roaming agreement is a win-win situation, because of network externalities – users of both networks will receive coverage in both areas. The market in US in early 1990s was exactly like this – many local operators covered relatively small geographic areas, so there were plenty of opportunities for roaming agreements between operators from different areas. Nevertheless, such agreements came much later and with a lot of difficulties, despite that in US there was a single mobile communication standard – AMPS. Why did this happen?

First of all, the AMPS standard did not include definition of roaming service. The standard was developed by AT&T during its monopolistic time, there was no vision that there would be several mobile operators and no one thought of roaming. Furthermore, because of licensing policies in US, most of mobile operators were really small and used only one switch for their entire network [Gruber2005]. So they didn't need to transfer data and calls from one switch to another and they did not build any technical possibility for this. But transferring subscriber's data between switches (in fact even between networks) is essential for any roaming – thus national roaming in US remained difficult even after the consolidation of the market, when main operators attempted to create national networks by acquiring and linking local operators. Ultimately, after more than 5 years, this technical problem was solved and a new standard IS-41 WIN was developed especially for exchange of subscriber's data. This story is a good example for interconnection between governance and technology – the governance in early years of mobile communication development (including standardization, licensing, etc.) led to technological solution that in turn restricted the possibilities for certain new forms of governance like roaming agreements, even when there was market demand for them.

International roaming

As long as operators operate in one country, international roaming doesn't conflict with any operator's interest. So it was introduced already in 1G NMT standard in Scandinavia, but became widespread when GSM standard was adopted in many countries.

Form price point of view if the 'guest' user is subscribed to a telecom with CPP pricing scheme but when he roams he the RPP scheme is applied. International roaming always involves RPP. This means that roaming users have to pay for incoming calls. The roaming prices are formed at two stages. First the guest network operator charges the

user's home network for originating the call, usually by adding 10-15 % above the normal prices. Next, the home network operator forms the retail price for its own end user by adding 10-30% margin on top of the wholesale price. The roaming price to the end user includes double profit margin.

This situation attracted attention of regulators, especially in Europe. During the early stage of the GSM, when the roaming service was implemented broadly, the international wholesale roaming prices were based on 'normal network tariff' (NNT). NNT was defined as "the basic tariff that the operator charges to majority of its users". Roaming prices were allowed to be maximum 15% higher than the NNT. During years prices reached this maximum and NNT remained fixed for long time without taking into account the reduction of domestic retail tariffs. European regulators decided later to allow operators to negotiate roaming prices between each other hoping to increase the competition and reduce the price. But there was no evidence for such competition to emerge. Let's illustrate the reason for this with an example, involving a home operator HO in Bulgaria and two visited operators VO1 and VO2 in The Netherlands. If visited operator VO1 agrees lower roaming charge with home operator HO, still HO has no control whether its users will register with VO1 or VO2 network when they come to The Netherlands. So VO1 will not get more roaming users because it has lower roaming price. It would have been different if HO users can choose if they want to use VO1 or VO2 when they are in The Netherlands – they users would prefer VO1 because of the lower price.

When users travel to another country, they can select a network by two ways – automatically (the phone decides in which network to register), or manually – the user selects network. But the manual selection is inconvenient, because when the user is the other country he sees all available networks, even these that have no roaming agreement with his home operator. The user should then try networks one-by-one until he finds a suitable one. This also involves a period when the user is not reachable – so most users who travel a lot simply use automatic option. Furthermore users usually don't know the roaming prices of the visited network. The result of all this was that after free roaming pricing was introduced, prices of some roaming services doubled compared with NNT pricing [Gruber2005]. Seen from market governance point of view, this shows that simply allowing free negotiation of prices, even in generally competitive market, does not automatically brings prices down. Only prices that are under direct pressure from competition are decreased. This was not the case with roaming prices.

International roaming was the first end-user service that required international cooperation (and competition) between operators and as such it also involved international governance. Although this governance was mainly market and network based, there were centralized components, like the European regulations and the ITU numbering standard. Furthermore having a single standard in many countries or regions was an important enabling factor for roaming in general.

3.3 Mass market formation – late 1990s and turn of the century

This period is characterized with further increase of the competition and proliferation of mobile communication services supplied to the mass market. The number of subscribes increased - on average it was 6.7% in 1996 in OECD countries and increased to 27% in June 1999 [Madden2003]. Nevertheless there were enormous differences in national penetration rates. The growth continued and in 2001 penetration reached 75% in EU, 60% in Japan and 45% in USA.

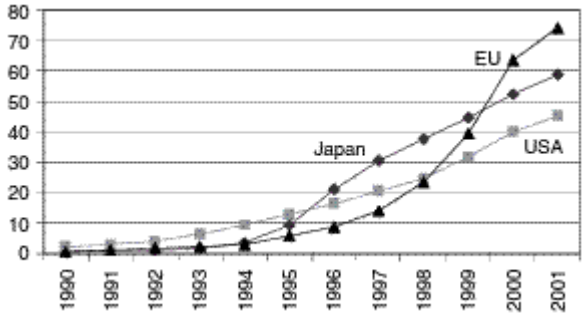


Figure 3.4: Penetration rate of mobile telecommunications in developed regions [Gruber2005].

Although in this period mobile telecommunications spread over almost the entire world, penetration rates in less developed countries remained much lower.

There were several factors enabling such growth. New licenses in PCS (DCS) spectrum in some of the OECD countries relaxed capacity constrains, increased competition and led to further reduction of prices. Continuing trends from early 1990s like diverse pricing plans and extensive subsidizing of mobile phones also contributed to the growth. But the most important innovation in this period was the introduction of the pre-paid cards. Pre-paid cards were very important innovation because they made subscription of new users to the mobile services very easy. For users it was not necessary to have permanent address and/or to show credibility in order to get mobile phone. Furthermore users got an easy way to control their expenses for mobile communications. So the relationship between users and operators changed significantly. I will analyze the prepaid card phenomenon in details in the following sections.

Prepaid cards were not the only innovation for the consumer in this period. With introduction of 2.5G standards like GPRS and EDGE, the possibilities for data exchange through mobile networks increased. Although the voice telephony remained by far the most used service in mobile communications, interactive data services like WAP and i-mode took off. Content providers for such services became actors in the governance of mobile communications; although in this period most of the data services were still developed by operators.

During late 1990s and around year 2000 the mass market for mobile telephony was well established and approaching saturation. In most countries there was real competition between mobile operators, and in many countries also between fixed operators. Mobile operator became powerful market players and this prompted regulators to replace the asymmetric regulations (mainly placing restrictions on incumbent fixed operators) from

early 1990s to symmetric regulations, preventing both fixed and mobile operators from abusing their market power to hurt the consumer for example by keeping high prices.

Saturation of the market also meant further market growth can be achieved not so much from new demand, but from replacement [Steinbock2005]. This means that operators couldn't get many more new subscribers to mobile services in general; instead they had to attract subscribers from other operators and/or to increase the revenue from their existing subscribers. Similar trend applied to mobile phones – most purchases were made not by people who bought their first mobile phone, but by people who replaced their mobile phone. This general trend had significant impact on the market – it intensified price competition and the same stimulated innovation and differentiation. When someone decides to join a mobile network, she can compare offers from different operators and even small price differences can be decisive in this case. For an existing user, a bigger price difference is necessary to make her decide to change her mobile operator[34], since there are always "costs" involved in the change. Number portability was not yet widespread in this period and changing a number is a "cost" (i.e. inconvenience) for the user. But also additional effort and risks are involved in the changing the operator. This means that for the operators a price-based competition would become very costly. In more general words, a homogeneous saturated market is very unfavorable for the suppliers. The mobile communications market was not homogeneous in this period, since horizontal segmentation through lock-in existed, but it was increasingly restricted by regulations. Vertical segmentation then became even more important goal of the operators and manufacturers, which provoked a lot of new inventions in mobile phones, mobile services and in their marketing. Operators increased differentiation of products not only by offering different tariff plans, but also by offering extra services like WAP and i-mode, MMS (multimedia message service), etc. Still, most operators offered their services "bundled together" – telephony, SMS and eventually other services. There were different pricing options, but rarely an opportunity for the consumer to buy individual services from the operator or third parties.

It was in this period when the mobile phone became a "fashion tool" and "item of self-expression" [Steinbock2005], because of different designs and extensive personalization opportunities. As the demand turned more to replacement, instead of initial demand, manufacturers had to differentiate their products too. So there was a shift from "mass marketing" in early 1990s to "targeted marketing" in late 1990s when different phones are designed and marketed to specific target audiences and life styles – youth, active, business, fashion, etc. Personalization, which started with a possibility to change color of the phone and select one of few ring tones, grew into an industry where "in 2002 ring tone sales alone were around $1-2 billion worldwide ... and there was enough critical mass to attract (music) industry players" [Steinbock2005]. Two new phenomena in the design of mobile phone especially deserve to be mentioned – the camera phone and Nokia Communicator, the first mass-produced smart phone. These two phone types changed the perception of the mobile phone as a device for only calling and SMS-ing. The phone started to evolve into a multi-functional device. Of course, the phone had some extra functionality since the digitalization in early 1990s – like an alarm clock,

[34] Under equal other conditions.

calendar and calculator. But these functions were apart from the main function – calling and so there were rarely a decisive factor for the consumer about what phone to buy. The camera phone in combination with MMS service and introduction of the Communicator in combination with Internet and e-mail access were first attempts to integrate the different functionalities into a personal communication device.

These examples show that as the mobile telecommunications market matured, more actors were involved in bringing this product to the market and the interdependencies between them increased. Alliances between different types of market players happened more often. Another sign of market maturation was that symmetrical regulations for fixed and mobile phone networks were developed and regulators preferred to protect the openness and competitiveness of the market, rather than to favor mobile communications or to regulate prices directly.

3.3.1 Pricing trends

The tariff for mobile services declined considerably in this period. Between 1994 and 1998 the connection fees declined form $ 547 to $ 180 i.e. showing a 16.9% decline *annually*. Subscription charges declined with 5.8% annually. The fall in usage charges was much more moderate, only 1.5% annually:

	1992	1994	1996	1998	CAGR[b]
Connection	547	410	231	180	−16.9
Monthly subscription	44.9	38.1	34.2	31.3	−5.8
3-minute call	1.04	1.12	0.99	0.95	−1.5

Notes: [a] Figures are unweighted average prices for pre-paid subscriptions in US dollars for the countries in the ITU sample.
[b] CAGR= Compound annual average growth rate (per cent), 1992–8.
Table 3.5: Decrease of mobile telephony prices, 1992 – 1998. [Grubber2005]

At the same time the price basket for mobile communications, calculated by OECD, dropped from about 90% in 1996 to about 70% in late 1999, compared with 1991 [OECD2000]

This decrease is linked to several factors that affected the prices. Increased number of operators in almost every country increased competition and the shift from initial demand to replacement made pricing competition fiercer, so prices were pushed down.

Other noticeable pricing trend was the difference between prices of mobile and fixed communication services. In 1989 the average OECD minute mobile call was $ 0.54 it had fallen to $ 0.40 in 1998 (a price decline of 3.7% per year). During the same period fixed line tariff had fallen form $ 0.17 to $ 0.10 (6.1% per year) [Gruber2005]. This was so because the mobile pricing schemes were much less regulated. But at the same time the quality of mobile services has increased considerably.

Despite the overall decrease, prices for mobile telephony in this period remained significantly above the costs of operators, even when mass market was emerging. This

was so because the operators exploited the willingness of users to pay extra for the fact that they can make and receive calls from any place and at any time.

In particular, FTM termination charges and so the FTM retail prices remained high, because there was little market pressure on them (see section 3.2.4 Interconnection costs and agreements" for explanation of this). At that time regulators realized that these high charges don't benefit the stabilization of the mobile services anymore (since the market is almost saturated). Furthermore, since FTM retail prices were higher than MTF retail prices, the fixed phone users de facto sponsored the mobile phone users. EC found this situation undesirable and adopted in 1997 the EC Directive 97/33/EC that proclaimed symmetrical requirements for fixed and mobile operators with significant market power (SMP). An operator is meant to have significant market power if it has more 25% market share in the market for a particular service. Operators with SMP were obliged to provide "non-discriminatory interconnection access" to their network, to make the interconnection charges public and to base them on actual costs, allowing only a "reasonable return of investment"[35]. National regulators where allowed to intervene if interconnection prices were too much higher than the costs. The implementation of this Directive by national regulators was somewhat slow (partly due to lobbying from mobile operators), but nevertheless "between February 1999 and August 1999, significant reductions in the price of calls from fixed-to-mobile networks occurred in a number of European countries." [OECD2000]. In US the Communications Act from 1996 ensured so called "reciprocal impositions", which meant that mobile operators should pay for interconnection between fixed and mobile network similar prices as other new entering fixed-line network operators. This was beneficial for mobile operators since they can offer lower costs of mobile-to-fixed calls. So the trend both in EU and US was to replace asymmetrical regulations with symmetrical ones.

3.3.2 Prepaid cards

First pre-paid card were introduced in Germany and Switzerland in 1995. Pre-paid cards were initially meant to be used by international business travelers. They were non rechargeable and the credit could be used within certain framework of time. In September 1995 Telecom Portugal (TMN) first made these cards rechargeable and targeted domestic users as well. The impact of this service was apparent by the immediate increase of the subscription base and penetration rate. The revenue from mobile services increased with 65% in 1996 in comparison with the previous year and Telecom Portugal attributed this to pre-paid cards. "By the end of 1997, 63% of TMN's customers used pre-paid products. By June 1999, some 85% of TMN's clients were pre-paid users" [OECD2000]. In 1996 Italy's Telecom Italia Mobile (TIM) introduced pre-paid service with some innovations like pre-paid card for analogue handsets and international roaming for prepaid cards. In 1999 80% of users of TIM were subscribed to pre-prepaid service [OECD2000]. In Nordic countries pre-paid cards were introduced rather late. In Finland, which had the highest penetration rate form OECD countries, pre-paid aords were introduced in July 1998 by Sonera - the largest telecom. The second biggest telecom in Finland Radiolinja introduced pre-paid cards in July 1999. This suggests that those operators that had biggest

[35] European Parliament and European Commission Directive 97/33/EC, available at http://www.icp.pt/txt/template20.jsp?categoryId=59481&contentId=94328

subscription base had little incentives to introduce pre-paid service. The same applies to entire countries – the prepaid cards were first introduced and most widely used in countries that had relatively low penetration rate of mobile telecommunications.

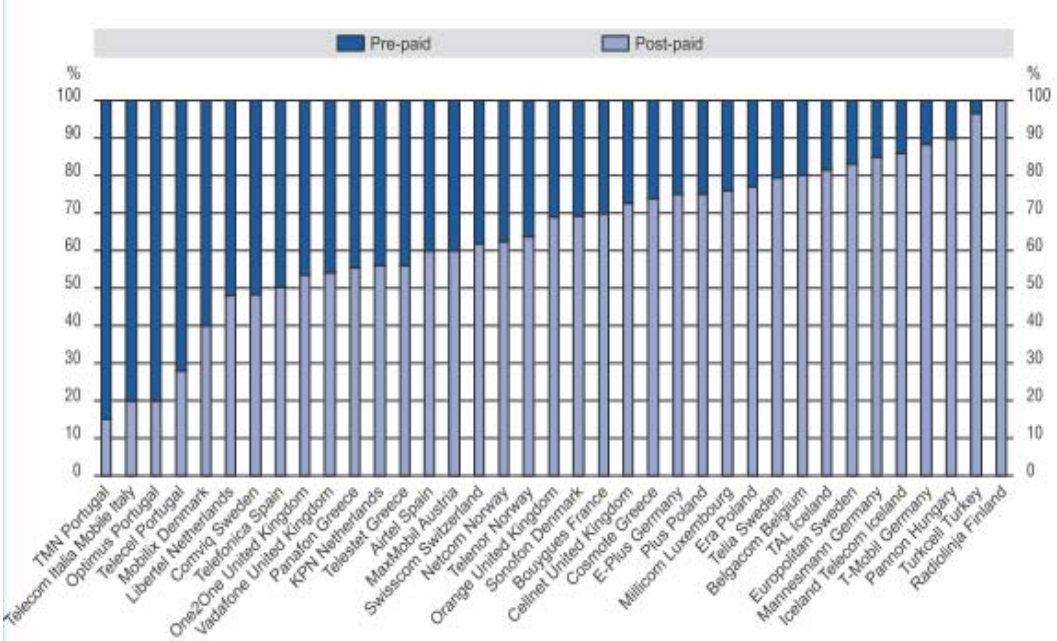


Figure 3.6: Percentage of pre-paid users for selected telecom operators, 1999 [OECD2000]

Despite the differences between countries and operators the overall impact of prepaid cards on penetration rate of mobile telecommunications was huge as shown in Fig. . The growth of pre-paid users compared to the overall user base was also spectacular:

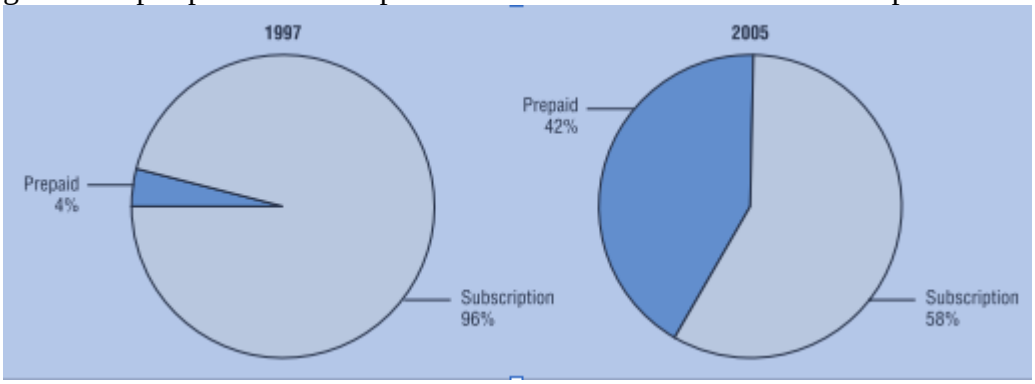


Figure 3.7: Percentage of pre-paid users for in OECD [OECD2007]

In order to explain this impact, we have to look at how prepaid cards are used. There was no contract between telecom operators and user, instead the tree charges existing up to that moment – for connection to the mobile network, monthly rentals and air time usage - were replaced with flat fee for recharging the account. The main concept was that users buy certain bundle of airtime in advance and can use it within given period of time. There were no monthly fees. Users pay per minute calls and they still can receive calls after

their cards have expired. The usage fees with pre-paid cars were higher in comparison to post paid subscriptions.

The attractiveness of pre-paid for the user can be explained with several reasons. One of main reasons was that there was no monthly fee, so only the actual usage was paid. For the user this meant better control of expenses. Furthermore the user could control the expenses by buying only so much air time as he can afford and it was easy to check how much credit remained on the card. Another reason was the fact that users still could receive calls after their credits have been finished – so users remain reachable practically at no cost (at least until the card expires). Finally, subscription to mobile services became easier then ever. With prepaid cards users did not need to show credibility. They did not need to have permanent address or job and still can have mobile phone[36]. All these factors overweighed the higher price for calls, especially because users of pre-paid cards intended to call less than the average subscriber, so the disadvantage of higher calling prices would be partly compensated by the absence of monthly fee.

For telecoms pre-paid cards were attractive mainly because they increased the number of users. Furthermore, because of the advanced payment for the service, there were fewer expenses for acquisition, selling and billing. And despite the fact that prepaid card users were calling somewhat less, they were profitable for the operators because of higher calling prices and the income generated from incoming calls via the interconnection charges. Operators were furthermore using loyalty schemes as a marketing tool in order to encourage users to call more – for example some operators added a “bonus” to users’ prepaid account if the users spend certain amount on calls.

So it is well-deserved to call the pre-paid cards the most important innovation in pricing of mobile telecommunications. So popular the prepaid cards became, that some mobile operators even started selling pre-paid cards of other operators. In the United Kingdom BT Cellnet sells the pre-paid cards of all four mobile operators. [OECD2000] Even general resellers started to sell pre-paid card. For example, in the Netherlands in supermarkets Albert Hein people can buy prepaid cards. From governance point of view this brought more stakeholders and a new role – a retailer - in the interrelation between telecom operators and end users. Offering this service in supermarkets and other shops made the subscription to mobile services even easier.

In countries with RPP paying system pre-paid cards were less attractive. It is so, because users have to plan enough credits for incoming calls – but it is more difficult to predict how much you will be called than to predict how much you would call. Furthermore when the credit is over, the users were not able to be called anymore. The effect of this was that the growth of penetration rate in countries with RPP was much slower in late 1990s than in countries with CPP.

[36] This doesn’t mean that the increase in penetration of mobile communications came from jobless and homeless people. Prepaid cards made mobile communications available for entire social groups that naturally have little or no independent income like teenagers and students.

It is also interesting to note, that the technical possibility for pre-paid calls was developed already in 1993 in US, soon after introduction of digital mobile standards. But it required an expensive resource from the switch in the mobile infrastructure, so this made pre-paid calls costly. Later a less expensive solution was developed and an international standard was set-up for handling pre-paid calls that made them cost effective. [Wikipedia][37]

The story of the prepaid cards is an example of co-shaping between technology and governance. If we look at CPP and RPP as forms of governance regarding billing of mobile services we see that both forms were initially suitable for bringing the service to the (niche) market and the choice for one or the other depended on local factors in every country. As mobile technology developed, especially when its digitalization increased spectrum efficiency and the miniaturization in electronics made light and small phones possible, mass use became feasible. The governance picked up the opportunity and set its goal to create mass market. It turned out in this process that prepaid cards were an essential means to reach that goal (also because technical solutions for cost effective pre-paid calls were found). But in this process the CPP scheme emerged as more suitable governance form for fast market penetration of mobile services.

It is important here to avoid a too deterministic approach. Theoretically speaking, prepaid cards are not the only possible solution to the problem of cost control and the credibility of the users. It might have been that, if another solution of this problem was found at governance level, the balance between suitability of CPP and RPP might have been different – but what actually happened was that exactly the prepaid cards brought the breakthrough for higher penetration.

3.3.3 New services

The successful introduction on the market of 2G digital standards created technical possibilities for transfer of non-voice (digital) data. The drive for vertical segmentation of the market prompted the operators to create new services that utilize these possibilities.

SMS (short message service) was the first service for transferring data, usually up to 160 characters. First SMS was sent from PC to mobile phone in 1992. The first commercial SMS between two mobiles was sent in Norway on the Telenor network followed by BT Cellnet (now O2 UK) in 1993 [OECD2000].The SMS service was part of the GSM standard. It was designed for broadcasting service-related messages from network operators to the users or for informing users for missed calls etc. Nevertheless, the standard included the capability of sending SMS from phone to phone so operators had to implements it. But the initial growth of this service was slow, with customers in 1995 sending on average only 0.4 messages per GSM customer per month [Wikipedia][38]. Initially telecoms envisioned SMS as sort of a paging service and not as part of mobile telephony service. They were reluctant to market SMS ahead of voice and against a very competitive paging sector in OECD countries. So this service was not advertised. Second, typing an SMS from tiny keypad of a mobile is not nearly as easy as making a call. So no one expected that SMS will be widely used for communication between users. But these

[37] http://en.wikipedia.org/wiki/Prepaid_mobile_phone
[38] http://en.wikipedia.org/wiki/Short_message_service#History

expectations proved wrong. In late 1990s the SMS became very popular. “In April 1999, users in Europe sent more than one billion SMS messages and some operators were reporting 800% increases in the number of messages over the previous year” [OECD 2000]

Very important factors for the take off of SMS were its low price and the introduction of pre-paid cards. These factors attracted many young people. “One analyst has reported that an increase in SMS traffic of 100% (and sometimes more) is not unusual when SMS for prepay is introduced [...] In February 1999, Vodafone’s pre-paid customers sent an average of 16 SMS messages per month. By way of contrast, customers subscribing to more traditional post-paid services sent an average of only 2.1 messages per month” [OECD2000]
What telecom operators didn’t realize initially, but many users did, was that SMS is not only cheap, but also helps easing the privacy problem. An SMS can be written and read without others overhearing it and it is much less disturbing to the recipient than a call. This was a reason for businessmen to use SMS as well. The SMS quickly achieved mass popularity, especially amongst young people [Lacohée 2003]. The difficulty of typing is less of a problem for teenagers and young people (they are not so pressed for time). The prices of sending message are also very suitable for this group. Teenage users even created own m-etiquette, similar to the netiquette in Internet and they invented a specific alphabet around text messaging that makes the messages unreadable for the outsiders. This helped them to show belonging to certain informal group that has own sub-culture. Furthermore, such informal groups often organize themselves almost entirely by SMS, using the capability to easily send SMS to groups of people. This is an example how inventive use of mobile phone by users makes them “co-designers” of the service.

This inventive use of the SMS by the consumers created some problems for the governance of mobile telecommunications.

First, there were charging problems. Initially operators were unable to charge pre-paid users for sending SMS. There was no connection between the SMS platform and the billing system, although the technical possibility for sending SMS existed since it was part of GSM standard. Telecoms did not mention at all that SMS was supported for pre-paid card. Several Web articles claim, that young users discovered this loophole in the system and suddenly, millions more SMS messages were being sent. When the billing system for pre-paid card was finally ready, all users were informed that short message service will be charged form now on. This led to an immediate and protracted decline in SMS usage to between 25% and 40% of the pre-charging levels as people suddenly stopped using SMS or using it as much[39]. Then again the SMS use increased because it was already way of communication of the young people. Analysts believe that SMS would be used broadly even without this period of free of charge, but it would haven’t taken off so quickly.

[39] http://wataniya.yahoo.com/smshistory.html. This article is often referred to, but I was unable to find confirmation of the “free SMS” phenomenon is scientific articles or in official documents from operators or regulators.

Yet another charging problem resulted from the fact that the SMS signal was registered in the network only at the point of entrance – not surprisingly, because the initial idea of SMS was to be used for broadcasting in operator's own network. As consumers more and more saw mobile telecommunications as a single, united infrastructure, mobile operators started to support cross-network SMS but the only possible charging model was "sender keeps all" [OECD2000]. It was not possible to make the receiving party paying for the SMS and also not possible to set termination charges for SMS. As long as SMS traffic was relatively small and symmetrical between operators, this was not a problem. In countries with RPP system for voice calls the users were usually offered the possibility to send and receive unlimited number of SMS for a flat monthly rate. But as the traffic increased and get asymmetric and also when Web sites started to allow sending SMS for free, the operators became worried about termination costs of SMS. Many operators blocked SMS coming from Web sites and some operators – like Swisscom in Switzerland – also blocked messages from competing operators [OECD2000]. This was not a sustainable solution though, because for users it was important to be able to send SMS to any mobile number without thinking on which network it is. So eventually a technical solution for billing of incoming SMS was found and standardized. Some operators then applied RPP scheme also for SMS (mainly in US), while others asked SMS termination charges from the sending network. Here again we see a loop when a design decision, authorized by governance during standardization, leads to a technical system that unexpectedly (this time because of creative use) leads to problems that require change of vision and action from governance; which in turn changes the design of technology.

Finally, there was the SMS spam problem. Unsolicited SMS messages with advertisements were perceived as intrusive by many consumers. This prompted governance to act. In Europe there was a legislative solution – EC Directive on Privacy and Electronic Communications [EU2002] from July 2002 prohibited sending "spam" e-mail and SMS messages. Since the originator of SMS is easier to track than the originator of e-mail and since spam by SMS originating from outside EU was too expensive, this directive was effective in SMS spam restriction, although not so much with e-mail spam. In US, in line with more "free market governance" in combination with a "litigation culture", there was another approach. Since most operators started charging users for receiving SMS (either per message, or for a bundle of messages), both operators and advertisers became liable to law suits for incurring loses on consumers by sending unsolicited messages. To avoid this danger, manufacturers, operators and advertisers negotiated a "code of conduct" that required all SMS marketing to be based on "opt-in" principle, so that the user explicitly registers for SMS campaigns, and also to include easy possibility for the user to un-register (opt-out) from the campaign [MMA2002].

As a result of all these arrangements SMS became a service that is popular by consumers and profitable for the operators. This enabled SMS to become in the beginning of 21 century a carrier for different mobile commerce services.

Another service that was introduced during this period was the Multimedia Message Service (MMS). It allowed sending of pictures and audio (mainly ring tones). Although MMS never achieved big popularity as consumer-to-consumer service, but it was widely

used to deliver pictures and ringing tones from operators and other providers to the consumers, so it became an essential part of personalization capabilities of the phone.

3.4 Integration of voice and data services - early 21st century

During this period, which begins roughly with build-up of first commercial 3G networks in 2001-2002, the overall number of subscribes to mobile telecommunications continued to grow, as figure X shows:

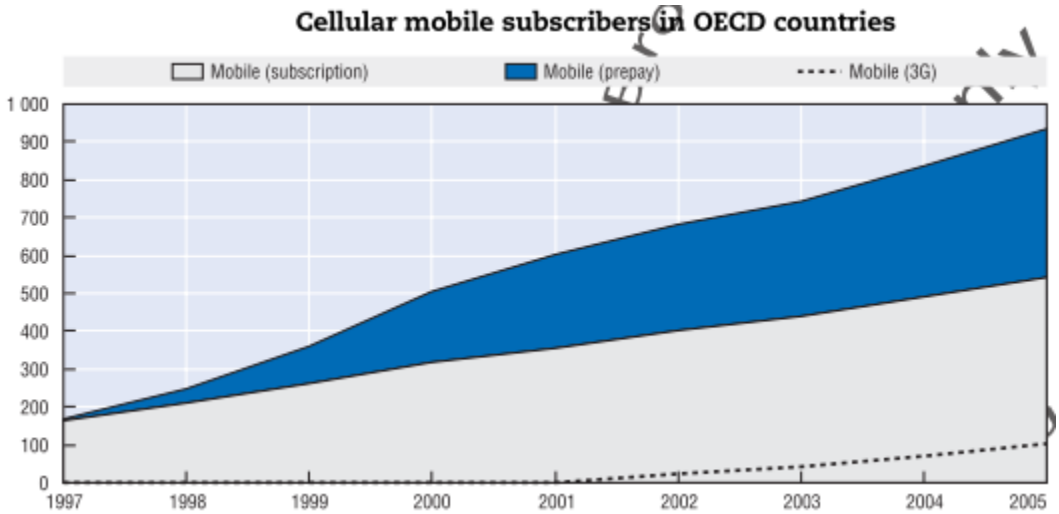


Figure 3.8: Cellular mobile subscribers in OECD countries [OECD2007]

Although the speed of growth declines slightly after year 2000, the total increase remains big and penetration rate reaches “nearly 80% of all inhabitants [above 16 years]” [OECD2007]. In some countries the total number of subscriptions is bigger than the total number of inhabitants (Luxemburg 160%, Italy 120%, etc.). This is explained by the fact that there is significant number of unused, but not yet expired, prepaid subscription; some people have more than one SIM card and the number of people under 16 years of age with mobile phones is increasing. These figures show that nowadays there is a well established mass market and the mobile phone is widely regarded as necessity for everyone rather than a luxury.

Already in the beginning of this period regulators acknowledged that the goal to create affordable and reliable infrastructure for mobile communications has been achieved. So in most countries the asymmetric regulations favoring mobile operators were replaced with symmetric regulations valid for all players in telecommunication market. The regulators then focused on keeping this market open and competitive.

The main change of mobile telecommunications in this period is that they became a multi-functional technology, interconnected with other communication technologies – fixed phones, Internet and mass media. The consumer sees more and more the mobile phone as an essential part of an integrated information and communication infrastructure. New information services that can be accessed via the mobile phone were the main driver

in this change. These services were made possible by stabilization of 2.5 mobile networks and by the introduction of 3G mobile telecommunication standards.

Most data services, except SMS, did not stabilize quickly on the market. When telecom operators paid huge amounts of money for 3G licenses, they did so because they expected that they can benefit from offering broadband data services, especially streaming video. These expectations proved quite exaggerated. The demand for such services was little and the difficulties in making such services available were greater then expected. Nevertheless, the usage of data services increased steadily, but mainly due to services that were offered as well as in 3G as in 2.5 G networks (i.e. services that required moderate network traffic). According to ITU, in 2007 "Data transfer accounts for around 20% of mobile operators' revenue in the EU" [ITU2007]. In 2005 the non-voice revenue of Vodafone was about 17% and varied significantly per country, with Germany leading with 20% and US last with 9% [OECD2007]. According to the same OECD report about 1/3 of the subscribers in Western Europe report a "significant" use of mobile data services.

The design of the mobile phone in this period also evolved dramatically. Steinbock writes about "the device formerly known as mobile phone" [Steinbock2005, p.180], because the phone nowadays integrates many different functions. According to him, early 21st century brought new type of differentiation in phone design and marketing – the functional specification. Without stopping the differentiation by life style and fashion, manufacturers also "concentrated on single-purpose phones with one dominant function like games, data (business applications), music, messaging, etc." [Steinbock2005, p.184] Such differentiation became possible by the various services supported by the network infrastructure and it followed the approach that started with the camera phone – to offer integrated set of functionalities for and around communication and information exchange.

The introduction of variety of services and functionality of mobile phones is changing the mobile telecommunications market towards a "goods market". This means that the consumer can choose and combine services individually. Although subscription to most of the data services is done via the network operator, the consumer pays separately for each service so he has the choice which ones to subscribe to. Furthermore, some services can be bought from other suppliers. Another important change of telecommunication market from governance point of view is the further increased interdependence between different types of actors. Many services, like for example streaming video, require certain functionalities of mobile phone – like a screen with sufficient size and color depth. Some features of mobile phones are much more usable with combination with certain services – e.g. camera in the phone combined with MMS service. Another interdependency is between content providers and operators – no data service can succeed on the market if there is not enough content for it. Thus all these actors had to make alliances so that their products can be put on the market together. These alliances were formed in the free market, on bilateral or multilateral basis, but were rarely institutionalized. This resulted in truly network-based governance, although network operators largely remain the nexus between the consumer and the suppliers.

3.4.1 Pricing trends

The overall trend of price decrease of mobile communications continued in this period. In 1999, the average annual price for a personal basket of digital mobile service was $ 792 [OECD2000]. In 2007, OECD defined 3 different baskets for mobile services – low-use basket ($198), medium-use basket ($408) and high-use basket ($690). It is important to note, though, that the baskets include only domestic calls and SMS, no international calls and roaming and no data services.

This price decline can be explained with similar factors like in the previous period. Although not many new operators were licensed in this period (most of the 3G licenses went to existing operators), the market remained competitive partly due to the regulations keeping the prices of operators with significant market power under review. The demand came mainly from replacement, not from new subscribers to the mobile services and as explained earlier this puts additional downwards pressure on the prices. Although data services offer plenty of opportunities for differentiation between operators, they were not yet so important for most of the consumers to justify operator change. So the price-based competition remained the main way to attract new customers.

At the same time regulators kept looking into price areas that are not pressed downwards by market factors. Interconnection charges are one such area. There various national regulators pressured the operators (mobile and fixed) to lower charges. In Austria, for example, “national regulator determined [in negotiation with operators] a ‘glide path’ towards lower mobile call termination rates rather than enforcing the introduction of cost-oriented mobile call termination rates at a certain date. The glide path starts on 1.6.2005 at different rate levels, reflecting the different levels of cost incurred by mobile operators. However, the glide path also features a uniform terminating point - from 1.1.2009 onwards, operators will have to apply identical rates for call termination on their individual networks” [EWERS2007]. In Greece and France there have been similar interventions by national regulators. This way the regulators negotiate solutions with operators, rather than imposing rate reductions through authority; but nevertheless the “threat of regulations” was used in the negotiations. An exception from this approach is a EC Directive specifying maximum international roaming charges in EU.

In general I can say that in this period there were no significant changes in the governance of price formation of “traditional” mobile communication service – voice and SMS. This is yet another sign that this market is becoming mature.

The price formation of data services (except SMS) was more dynamic, since this market is emerging and not mature. There are practically no regulations regarding pricing of data exchange, maybe because the market is not developed yet and/or regulators don’t yet see data services as essential part of the “universal mobile service”. After initial period of charges per MB of data transferred, many operators were concerned that data services don’t pick-up quickly in the market. They introduced flat-rate data subscription packages allowing unlimited data transfer [OECD2007]. For example KPN offers the “surf & mail” package for EUR 9.99 per month. This pricing scheme was accepted better by the consumers, since it is difficult for them to estimate the amount of data they are

downloading when using data services. Although for streaming video most operators charge separately, because of the wide bandwidth that this service consumes. It is important to note, that these data packages are not part of the main subscription packages. Consumers are free to choose whether to buy one and if so, which one. Although it is not possible to buy a main subscription from one operator and data package from another one, separate offerings of voice and data packages represent a step towards a goods-characteristic market in mobile telecommunications.

3.4.2 Data Services

The introduction of data services had significant impact on the governance of mobile telecommunications as consumer technology. In order to analyze this impact, I first will make an overview of different types of data service.

The term "data service" is used two different contexts. Let's take as an example ABN Amro (a Dutch bank) that can send its customers an SMS alert when the amount of money in their account reaches certain limit. The customers can subscribe to this service at ABN Amro offices or online via bank's Internet site and then they specify when they would like to receive an alert. The service provided by ABN Amro is a data service. But the SMS service itself is also called a data service. So I will distinguish in this chapter between platform services, like SMS, and content services, like the service of ABN Amro. Content services are offered by content providers and they often make use of platform services, which are usually offered by network operators.

Platform services include "premium SMS", WAP, i-mode and mobile Internet. Premium SMS service allows a content provider to send an SMS to a recipient and to charge the recipient for receiving the SMS. These SMS'es usually contain information that the receiver has requested, either by subscription, or by sending an SMS to the content provider. The network operator subtracts the "standard" SMS costs from the fee paid by the receiver and gives the rest to the content provider. The WAP and i-mode I will analyze comprehensively in the next sub-section, because they are new and specific services for mobile telecommunications. Mobile Internet is the possibility to access regular Internet sites using a browser on user's mobile phone. Several such browsers are offered nowadays, mostly for free – like Opera Mini. This service is getting increasingly popular, but there are significant restrictions to it, since many Web sites are not (easily) usable on the small screen of a mobile phone.

Content services can be classified in the following groups (adapted from [Steinbock2005]):

- Communication and messaging services – these include access to user's e-mail, various kinds of SMS alerts, etc. They often use SMS and WAP as platform services, but there are also e-mail clients based on their own platform.
- Information and entertainment services. These include access to news, financial data, downloads of games, music, pictures or video, location-based services, etc. Location-based services offer the possibility to find information that is relevant to the location of the user – e.g. nearby petrol stations, local weather forecast, etc.

- E-commerce (or m-commerce). These services offer possibility to make financial transactions from mobile phone. Payments via SMS are already possible for small amounts in many countries, especially for downloading content to the mobile phone (e.g. ringing tones). In The Netherlands it is also possible to pay parking fees via SMS. Also some banks offer electronic banking via WAP or customize their e-banking sites for mobile Internet. But in general m-commerce services are still not fully developed.
- Specialized services. One example of such service is "turn your mobile into a car navigation system", offered by KPN in The Netherlands. Other services, still in research phases include telemedicine, collaborative writing, etc. Specialized services use their own, dedicated delivery platform.

Development and marketing of both platform and content services reveals important facts about co-evolution of technology and market governance. I will look first at two platform services.

WAP and I-mode

In mid 1990s after increased popularity of internet and mobile communications in Europe it started to appear that next big demand is for data service on mobile phones. Major players in mobile telecommunications started to develop a protocol for data transfer on the wireless network in order to provide added value to the voice telephony to their customers. Ericson, Nokia, Motorola and Unwired Planed started to work together on protocol for data transfer and searching of information interactively, realizing that developing similar but different protocols might reduce the chance for success of any of the developed parallel protocols. Instead of standardizing this protocol under ETSI, the four companies founded their own joint company Wireless Application Protocol Forum Ltd. and thus formalized their relationship. Initially no other companies were allowed to participate in negotiations in the development of application protocol, but later the WAP forum was open for other participants, so in June 1998 there were 40 participating companies. In May 2000 they became 200, including software vendors and content providers. [Bekkers2001] According to Bekkers, the first commercial WAP services were launched in 2000. From the beginning WAP was envisioned as an open standard. Operators that would like to deploy WAP don't need signing a contract with WAP Forum or to pay a fee in order to use WAP. Users of WAP also don't need to pay any subscription or royalty fees for having access to it. Companies behind the WAP expected that this will help WAP to be widely accepted like other license-free protocols like TCP/IP. WAP can be used on all kind of devices like mobile phones, pagers, personal organizers, etc. Another important characteristic of WAP is that it is only a protocol; it doesn't prescribe the business model of service delivery. Each operator that deploys WAP has to organize its own business model in terms of cooperation and revenue sharing with content providers, types of content, marketing to end users, etc. The vision of founders was that WAP will be used by business users for searching information for weather forecast, flight time table, stock prices etc.

Another service for interactive searching of information is “i-mode”. It was introduced in 1999. It became soon the most successful subscription service in Japan for browsing information in Internet and sending e-mails. “I-mode” is also a trademark and/or service mark owned by NTT DoCoMo. The "i" in "i-mode" stands for information, internet, etc[40]. I-mode is used for variety of purposes like: on-line shopping and banking, receiving stock prices, sending and receiving e-mails, checking local weather, news, checking for free parking places, downloading pictures and ring tones etc. i-mode is proprietary protocol. Actually it is not just protocol it is whole infrastructure owned by DoCoMo. DoCoMo can determine the conditions under which other network operators or content providers can use the i-mode infrastructure and deliver content to end users. DoCoMo also has control over the provided content.

This brief introduction of WAP and i-mode shows how two different services with different governance types emerged in response to the same demand. I will show in this section how a combination of technical and governance-related factors influenced the success of each service in “catching the consumer”.

Initially i-mode proved as much more popular in comparison with WAP. While the adoption of WAP was slow the number of adopters of i-mode six months after its introduction was 1 million and this numbers increased to 10 millions a year later, while WAP subscribes, who actually used WAP services, remained below 1 million [Steinbock2005, p.74].

How could the initial success of i-mode be explained? There are several factors.

Technical differences between WAP and i-mode affected the billing models behind the two services, which on its own turn affected the way these two services were used and the penetration level. WAP first was implemented on GSM network that is circuit switched. By the time of i-mode implementation Japanese PDC network already had a 2.5G packed switched extension - PDC-P – so the i-mode was packet switched. What this meant for the end users? While a WAP user needs to dial-up in order to get connected to the searched information, an i-mode user is constantly connected to the Internet. Furthermore the i-mode user is charged for the downloaded data, which is perceived as very logical and fair – while the WAP user is charged for the time during which he had been connected to the WAP site. This led to a wide usage of sardonic phrases about WAP such as "Worthless Application Protocol", "Wait And Pay", and so on[41].

The charging scheme of i-mode was not only perceived as more fair, it was also more convenient for the consumers. Micro billing system existed as part of i-mode protocol so that content providers can charge users for every tiny price of information. Since i-mode is closed and proprietary standard DoCoMo (or its franchisees in Europe) takes care for all billings. This for end users provides convenience of receiving one single telephone bill including charges for usage of the i-mode infrastructure, for data transfer and for usage of

[40] http://eurotechnology.com/imode/faq-gen.html , visited at 30.12.07
[41] http://en.wikipedia.org/wiki/Wireless_Application_Protocol, visited at 30.12.07

the information from the i-mode sites of the content providers. This revenue is than shared with the content providers according to fixed rules. For content providers this means less hassle with billing systems and an opportunity to focus on content creation. On the other hand, WAP users first had to subscribe to the service with their telecom operators and then to subscribe to the each site they want to use. This means that users had to provide personal information, like number of credit card to the content providers. Users send this information through SMS for which they pay to the telecoms. Then users received reverse SMS with link allowing them to access the demanded information. For receiving this reverse SMS users are charged as well and this revenue then is shared between telecom operator and the content provider. Since WAP standard is open sharing of revenues is negotiated individually between each telecom and content provider.

Reasons for this massive pick up in the numbers of i-mode subscribers are rooted not only in the billing, but also in the availability of many sites well visible through the tiny display of the mobile phone and with easy to use interface. Since the beginning DoCoMo made sure that there were enough services and sites provided by the content providers. There were 500 official i-mode sites that were listed on the display menu of the i-mode phones and were easily accessible through one click. There were also 20 000 unofficial i-mode sites, although they were accessible only through typing the URL of the site, which is difficult to do given the sizes of the keyboard of the mobile phone. This has led to a situation where only 15 per cent of traffic comes from outside NTT DoCoMo's portal site[42]. In April 2002, i-mode users had access to over 3,000 official content sites and 53,000 unofficial sites [Oiu2007].

The technical language for developing i-mode and WAP sites also played a role in how quickly and how much content can be produced. The language used for developing WAP sites was WML, which is subset of the XML language – a new language used for data exchange. I-mode sites were based on cHTML language which is subset of HTML, then widely used for developing Internet sites. I-mode benefited for using cHTML because most simple existing Internet sites could easily be adjusted so that to be used on the mobile phone. Also developers could benefit from their previous experience and can easily start to develop sites using cHTML while WAP site developers had to start to learn WML form scratch. As the WWW community migrates away from HTML and towards XML in the next years it may turn out that this is beneficial for WAP.

The user interface of i-mode also included featured like “web to”, “phone to”, “mail to” that integrated the data services with the voice telephony with the e-mail. Because NTT DoCoMo is the exclusive provider of iMode, it was able to assign all users an e-mail address automatically (based on their DoCoMo mobile phone number). This allows users to participate in one of the Internet's most popular activities (sending and receiving messages) without having to worry about finding a service provider or configuring software. Because of limited bandwidth and hardware considerations, e-mails are limited to 500 bytes (250 Japanese characters or 500 Latin characters) and attachments are not allowed. Because of relatively low Internet penetration rate in Japan (13.4 per cent in

[42] http://ntrg.cs.tcd.ie/undergrad/4ba2.01/group2/imode.html , visited at 30.12.07

1998) than in other developed countries (e.g. 37 per cent in the US in 1998)[43], for many if not most i-mode users this was their first e-mail address. In fact e-mail was one of the most successful applications of i-mode – in 2003 14% of all i-mode traffic was due to e-mail [Steinbock2005, p.73]. WAP, on the other hand, did not support e-mail.

Other important feature of i-mode phones is the 256 colorful displays. Some advanced mobile models could also display simple animations. All i-mode models could view pictures in GIF format, already de facto standard on WWW. Displays of many i-mode phones are also suitable for entertainments and games. Steinbock refers to a market research showing that "it was not the content that caught customer's attention, but the color and the pictures" [Steinbock2005, p.77]. On the other hand, WAP phones were with small, black and green colors displays. This technical difference affected consumer behavior a lot in a sense that mass user was attracted by the colors and less by the content. It is important to note that this technical difference was itself influenced by the governance. Having a mass-market service in mind, DoCoMo was able to pressure the manufacturers to deliver color-screen phones, because DoCoMo was the dominant operator in Japan and manufacturers were producing special phones for Japan because of the Japan-specific 2G standard. WAP creators, themselves manufacturers, either did not think much about the marketing of the service, or they envisioned it as service for business users and they thought color will be less important.

The two technologies were marketed differently and the way i-mode was marketed proved to be more successful in terms of numbers of subscribers. I-mode was marketed as service while WAP was marketed as a technology. Since WAP was meant to be used by business users, the focus of its inventors was more on providing the technical possibility for data transfer rather than on making it appealing. So that was one of the reasons why WAP phones initially were not colorful. In contrast i-mode was marketed as service for mass use and the displays with 256 colors attracted many consumers. Other problem with the marketing of WAP was that enormous expectations were created. Actually it was marketed as technology that provides full access to Internet. So business users expected that if they buy WAP phone they can brows in Internet freely. Although technically WAP provided access to Internet, there was very little WAP content and services suitable for using on mobile phone, so many users were disappointed. Furthermore, there was no e-mail functionality and for users especially in Europe and US e-mail was an essential part of Internet.

The comparison of market penetration of WAP and i-mode shows that the governance model of i-mode contributed a lot to its success on the market. DoCoMo manage to create unique business model behind i-mode service. It was based on the ability of a singe operator to coordinate centrally the whole chain of handset vendors, platform vendors, and content providers. This meant that DoCoMo controls the whole industry value chain, including the content of the sites[44] [Steinbock2005, p.68]. For DoCoMo it was clear form the beginning that what attract consumers is not the technology it self but the

[43] http://ntrg.cs.tcd.ie/undergrad/4ba2.01/group2/imode.html, visited 5.01.08

[44] The control over content means that DoCoMo had to approve the content of a site in order to make it "official". Unofficial sites were not subject of approval.

services. So the i-mode model ensured big number of services to the end users of i-mode. Next to the centralized business model and the closed standard, content providers had development tools to deliver quickly sites with information especially made to be displayed on mobile phones. The choice for cHTML was made deliberately by DoCoMo especially in order to make development easier for content providers. Yet another important aspect of i-mode governance was that the technical specifications were made of the same actor who brought the service to the market so he was able to inscribe a vision of the future users of the services that matched later the actual users.

On the other hand inventors of the WAP expected that once the technical possibility for data transfer is invented, content providers will start to deliver information. So there was no governing actor who could organize content providers to develop sites for mobile phones and developers had to use new software language to develop WAP sites. This resulted in a delay in provision of content for WAP that had negative impact on the (potential) consumer. Other inconvenience with WAP from consumer point view was that users had to pay separately to the content providers.

The faster market penetration of i-mode compared to WAP led some analysts in 2002-2004 to declare WAP a "failure" and to regard the i-mode business model as recipe for success in data services. Steinbock [2005] writes "as WAP flopped in Europe, NTT DoCoMo launched i-mode in Japan, with an ingenious business model." But as the time went by, this nicely explained winner/looser picture started to crackle.

First of all, despite its quick build-up in Europe, i-mode never achieved the penetration rate it had in Japan. From almost 50 million i-mode users, only about 7 million are outside Japan and the numbers stabilized (didn't grow much) in recent years[45]. Various operators outside Japan decided either to "phase out" i-mode services or to stop them in the near future. Examples include KPN in The Netherlands, the biggest operator Telstra in Australia, O2 in UK and Bouygues Telecom in France [IHT2007]. The main cited reason for this is the insufficient of number of users.

At the same time a new version of WAP protocol, called WAP 2.0, was adopted. It resolved most of the technical issues – it was based on XHTML, allowing for easier content development, it supported color screens and it was updated to be used over GPRS which is a packet-switched network and support charging based on data, not on time. Furthermore, independent software vendors developed solutions for easy micro-payments via the mobile phone bill, so the billing also became more convenient for the users. In fact the user experiences of i-mode and WAP became so similar that many operators combined WAP and i-mode sites in a single portal. Many big providers of free e-mail, like Yahoo and Google provided WAP access to their e-mail systems, so consumers could check *their own* e-mail via WAP. That proved an important difference in Europe, where by introduction of i-mode in 2002 many people already had own e-mail addresses, so the dedicated i-mode e-mail address was less convenient for them.

[45] Data for 2007 from NTT DoCoMo Web site - http://www.nttdocomo.com/services/imode/global/index.html, visited 6.1.2008

Although it is difficult to find summarized data about WAP use in Europe as a whole, the data from Mobile Data Association – an association of mobile network operators in UK – shows that the total number of WAP users in the UK alone has grown from about 13 million in May 2006 to more than 16 million in October 2007[46]. This shows that WAP service has stabilized on the market and it continues to grow.

Why did the situation change so much regarding WAP and i-mode? "I-mode's major drawback, Nicholas [the head of communications for O2 in Europe] said, was that it was a closed system, requiring users to obtain i-mode software [from NTT DoCoMo] and forcing mobile content providers to adhere to rigid i-mode rules for designing Internet data and games for i-mode devices." [IHT17072007]

So although the centralized governance of i-mode was better able to anticipate consumer needs and to create a working and attractive environment quickly, the open character of WAP protocol and more flexible governance of WAP services helped WAP to adapt better to the consumer need over time. There was one important external factor that accelerated this trend – the introduction of 3G mobile infrastructures. 3G standards allow for direct connection to Internet, using the standard HTTP protocol. "Conventional" Web browsers, like Opera mini, started to appear for mobile phones. They allowed the user to go directly to any Web site, like using personal computers. Although most sites are nowadays not suitable for showing on mobile phone screen, the user "is moving away from the 'walled garden' approach to the Internet to the totally open Internet experience" [IHT17072007] and nowadays WAP looks more suitable for this than the i-mode, both in terms of technology and in terms of its business model.

I spent so much effort on analyzing the WAP and i-mode, because their story reveals several aspects of the link between technology and governance. It shows how different governance modes emerge in competition to capture the same consumer demand and how the governance influences the technical standards. It shows also that there is no single success model of governance – as technology changes the influence and power of each governance mode also changes. Finally it shows that factors influencing the success of the technology in the consumer market can't be split into governance factors and technical factors – most factors are combinations of technology and governance.

Governance of content services

Figure 3.9 depicts relations between different actors in providing a content service.

[46] Mobile Data Association – Latest mobile internet figures (WAP) - http://www.text.it/mediacentre/wap_figures.cfm , visited 6.1.2008

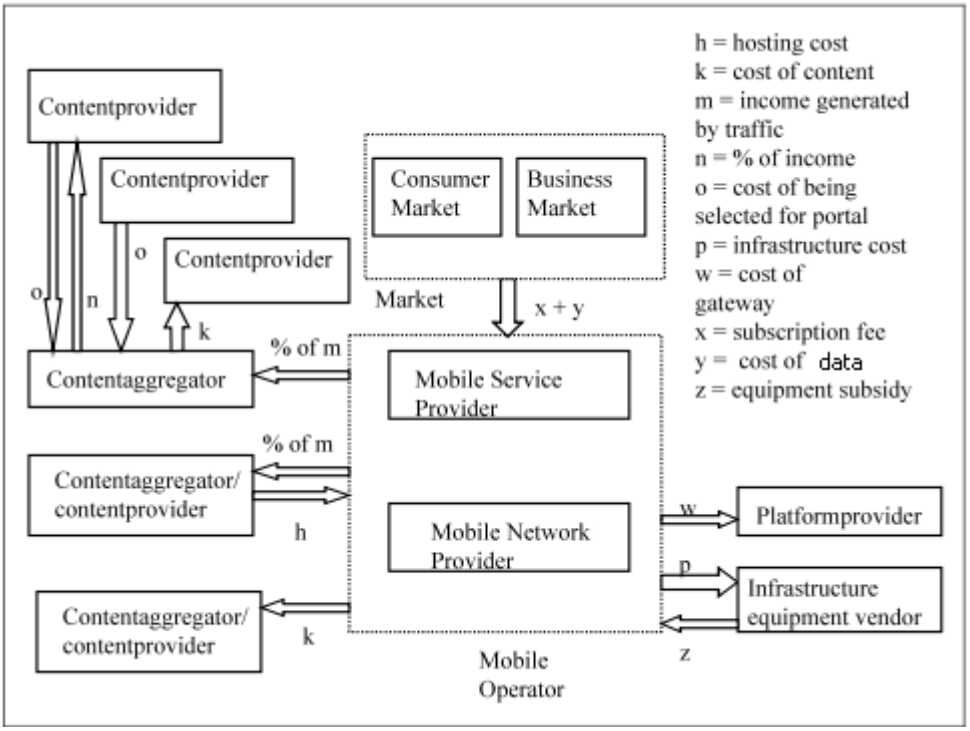


Figure 3.9: Content service business model with integrated mobile operator [Ballon2001]

This picture shows the complexity of relations and dependencies between the parties, even without showing the mobile phone vendor, who certainly plays an essential role in the provision of the service.

What this picture doesn't show directly, but can help understand, is the variety of possible alliances between the parties. For example, a content provider can simply sell its content to a content aggregator or directly to the operator. The operator then keeps all profit from consumer using that content, but he also bears the risk of the content not being used. Alternatively, the operator, content aggregator and content provider may agree to share the profit from content use, thus also sharing the risk. The operator or the content aggregator may even charge the content provider a fee for being selected in operator's portal. On the other hand, an operator in some cases may even pay to a content provider to develop and maintain certain content. All these options have been used in practice [Stainbock2005] and they actually represent different forms of market governance.

The same is true for platform development (software and hardware) for service delivery. "Governance modes include internal development by the telecom operator, several forms of collaboration between telecom operator and service firm, and just providing a network by the telecom operator to the service firm, which then develops and provides its services (external)." [Ende2002]

All this confirms one of main standpoints of this thesis – with the emergence of a new technology, various modes of governance (in this case market governance) emerge. In this case they emerged through negotiations between parties in an open and competitive

market. Because the market was open and there were no institutionalized forums where different types of actors can negotiate collectively, the necessary alliances were formed through bilateral and multilateral negotiations and this contributed to the variety of arrangements. These alliances were dynamic and non-exclusive, i.e. operators worked with many content providers and phone vendors, content providers worked with many operators (often using content aggregators as nexus), etc. As Ende [2005] mentions, this is a typical picture of network-based governance. A notable exception of this trend is Apple's iPhone, which can be used exclusively with pre-selected network operators.

How these different governance modes will co-evolve with the content services and how they will influence future service development remains to be seen. But there are already some general patterns, which probably will affect the evolution of governance of services. Ballon et al. describe the following patterns [Ballon2001]:

- Network operators have traditionally integrated the whole network operating value chain. They are still in a strong position because of their access to the customer (in terms of billing relationships, but also in terms of trust). In general, though, they are retreating to their core activities.
- Mobile phone vendors are a well established part of the mobile value system. As they provide hardware as well as software solutions, they not only have access to the user because of the direct buying relationship, but they can also preset the operating and browser systems running on the handsets to their own advantage.
- Payment processing is no longer the exclusive domain of operators. With the possible advent of mobile commerce, other parties, such as banks, specialized billing companies, and mobile commerce platform vendors, have opportunities to get involved in this activity.
- Network equipment vendors traditionally provide a relatively standardized product. However, this is changing as new applications and middleware are being developed by these companies so their position in the value network has become of much greater importance.
- Middleware/Platform Provisioning is becoming an ever more important part of the wireless value system. Examples are WAP gateways, SMS gateways, mobile portal platforms, mobile commerce platforms, and other specialized applications platforms.

These points illustrate how an emerging consumer technology changes position of different actors on the market, requires certain alliances and discourages others and in this way influences the governance. The alliances are not only necessary in order to design and develop the technology, but even more importantly, to bring it to the market and to "catch the consumer".

3.5 Conclusions

The stabilization of a consumer technology on the market requires that the strategies and interests of suppliers and consumers match. When the product is such a high-tech, multifunctional artifact as the mobile phone, the process of market stabilization becomes quite complex. The complexity comes from the fact that there are different types of

suppliers whose strategies also have to be aligned even before the end product gets to the consumer. Of course, there is a supply chain behind any technological product; but what is specific about the mobile telecommunications as consumer technology is that there are various types of producers (of infrastructure, mobile phone, services) that have *direct* contact with the consumer and they bring (partial) products that have to be put together so that the consumer can use the technology.

Already at the introduction of mobile telecommunication two types of producers were active at the consumer market – network operators and mobile phone manufacturers. They were dependent on each other, since every consumer needs both a phone and network access in order to use mobile telecommunication. So alliances were made already in 1G period (or even before), so that, for example, users can buy mobile phone when they make a subscription. Some subscription packages even included the price of the phone in the connection costs.

From mid-1990s onwards content and service providers and software vendors became involved as producers in the market of mobile telecommunications. I distinguish here content providers, who develop digital content mainly for broadcasting (news bulletins, traffic information, sport events video, etc.) from service provides who provided personalized, interactive services like flight tracking, bank account information, etc. Broadcasting content is delivered usually via i-mode or mobile web and the interactive services are often delivered via WAP or premium SMS.

Here I can already describe one dimension of co-shaping between consumer technology and its governance. The more hybrid and multifunctional the technology becomes, the more alliance between different types of actors are formed at the market place, since they were required for the technology to work for the consumer. This leads to network-based, participative governance. The more network-based the governance becomes (not only in terms of number of alliances, but also in terms of strength of the alliances, the trust between individual actors and their interdependence), the better the visions of various actors are aligned and put into the design of the technology. Since these visions have different focus and goals, the technology becomes even more hybrid and multifunctional. One example of this is the development of the WAP protocol, especially when software vendors and service providers joined the WAP forum. Another example is the introduction of 3G standards that provide opportunities for high-speed data transfer. Attracted by these opportunities many new content providers, including media and music companies, entered the supplier network. Since then we have seen unprecedented growth in new services and new functionality, which is reflected even in the design of the mobile phone. Interestingly enough, many of these services actually don't require a 3G network – they are used reasonably well in 2.5G networks. So 3G standards have played a role of a technological catalyst for more inclusive network governance and the results are innovations that even not depend on that technology. So, one dimension of co-shaping between consumer technology and market governance is the design of the product for the consumer.

As I've shown, alliances between actors are in the core of governance and they also shape technology. But what sort of alliances are we talking about when analyzing the governance of mobile telecommunications as consumer technology? Mobile phone vendors did not produce "music-player" mobile phones because they were asked by or paid by music companies. They did so, because they anticipated good market for such phones. But they still had to make agreements with music companies about, for example, dealing with copyrights, billing of customers and revenue sharing, etc. This example shows that the market mediates the alliances – in fact in market governance most alliances between actors are actually commercial agreements[47]. It also shows that consumers, through their real or imagined preferences and values, are always present in any alliance made between actors.

This brings me to the area where suppliers and consumers come in direct connection – the pricing of the product. When I look at the prices of mobile telecommunications, there is a stable downwards trend in all the analyzed periods. This could be explained by the supply and demand rule – the supply of mobile telecommunication services has grown tremendously (in fact faster than the demand) in a competitive market and this pushed the prices down. This is how open markets coordinate strategies of consumers and producers through price formation. This explanation is true, but a more detailed analysis is necessary in order to see the role of the technology and the governance in this process.

First of all, the supply could grow so much only when spectrum-efficient technology became present in 2G networks. Second, the open and competitive market is not a "given", neither has it come on itself. It was helped and maintained by various regulations coming from public governance. Third, price competition is not the only possible form of competition, but it was the main one in mobile telecommunication factors because of some specific factors. Initially the technology offered limited options for vertical differentiation of the consumer product – the technology was highly standardized and the infrastructure supported very few services. Horizontal differentiation trough lock-ins was hindered by regulations and even more importantly by consumer rejection. Telecommunications are a very interlinked technology, it is perceived as such by the consumers too, so consumers are not willing to accept much "lock-in" effects. These technological influences made the market close to homogenous, so price competition was the main option. Because the market in 1G was monopolistic, initial prices were high above the actual costs. When competition was introduced, suppliers could afford to decrease prices and this led to intensive price competition, especially when the number of competitors increased. With introduction of 2.5G and 3G networks and the variety of new services, the market is changing gradually to a "goods market" and possibilities for non-price competition increase. Nevertheless, this coincided with market saturation and switch from initial demand to replacement, which put downward pressure on prices, as explained in section 3.3.1 Pricing trends. Thus, technology developments influence price formation. This influence happens also more directly – I've shown how technical factors led to a possibility for free SMS exchange using prepaid cards and how because of technical restrictions the initial release of WAP

[47] Other forms of alliances, like participation in WAP standardization forum or joint R&D are also possible, but less common.

had to use payment per time, instead per data. In both cases the impact on the commercial success of the services was big.

On the other hand, there are ways how price formation and the level of prices shape technological developments. The CPP pricing scheme helped stabilization of pre-paid card technology in Europe, even though it was invented in USA. High interconnection charges in early and mid-1990s resulted in heavy subsidization of mobile phones by network operators. This encouraged customers to change their phones often, which in turn created extra demand for phone manufacturers and also increased the competition between them, because it was easy for users to change the brand of their phone. All this contributed to fast innovations and differentiation of mobile phones. The overall price decrease and the introduction of prepaid cards attracted many young consumers and this set-up a new trend of mobile phone design – a "fun" phone whose appearance can be personalized.

This analysis show not only the governance and technology co-shape each other through price formation, but also that the two dimensions of co-shaping – pricing and product design – are interlinked.

Yet another dimension of co-shaping between consumer technology and governance is globalization. Similarly to governance of standardization, we see that as technology becomes more global – meaning not only the networks are interconnected but also consumers use their phones globally, as they travel – the governance also becomes more global. But in market governance this trend means that main actors – operators, manufacturers, content and service providers – become global businesses, operating in many countries. Public governance, which has the goal of keeping the market open and competitive and telecommunications available as universal services, also needs to follow the trend and to globalize also. This has already happened at EU level, as it is clear from the many EC directives concerning mobile telecommunications.

Despite the overall trend to globalization, the governance of consumer technology in a sense is much more local and contingent then governance of standardization. This means that negotiations and alliances are formed usually on bilateral or multi-lateral basis, but they are rarely institutionalized. In fact the only relatively stable institutions are the regulators. Other focal actors – operators, manufacturers, content and service providers, software suppliers – find each other, negotiate and make agreement in the open market space. There is no central forum where negotiations take place and decisions are taken, like in standardization. This explains why so many business models emerged in the area of mobile telecommunications. Each business model is actually a mode of market governance, and many of them have appeared – the CPP and RPP charging schemata, various ways of handling interconnection charges, pre-paid vs. subscription models, the i-mode vs. WAP business model, variety of business models for content services, etc., etc. I've shown how some of these models have co-evolved with the technology – like CPP and RPP, pre-paid and subscription, i-mode vs. WAP. Each of them have influenced mobile telecommunications and their use in certain direction and as the technology and its use evolved, some business models become more suitable for governing the

technology and some less. The same applies for methods of public governance – from direct regulation of prices in late 1980's is some US states, to asymmetrical regulation in favor of mobile operators, to regulating interconnection charges through review and negotiations with operators, to EC specifying maximum retail prices for international roaming in EU – these are different modes of governance and they co-evolve with the technology too.

Thus, despite some important differences between governance of infrastructure and governance of consumer mobile telecommunications, the co-shaping between governance and technology is present in both cases. In both cases governance has become an internal part of the process of technology development and marketing.

Chapter 4. Mobile telecommunications and post-modernity

Taking a "helicopter view" at the development of mobile telecommunications I can clearly distinguish an evolution towards a distributed system. First of all, there is an interconnected, world-wide infrastructure of mobile telecommunication networks, but each network has a high level of autonomy. Second, there are many autonomous services, but they are connected to one another and dependent on communication networks and on capabilities of mobile phones. The control of these technically distributed systems is also distributed between different types of actors. For Rip, this is a sign of post-modern technologies that "are emerging already, under our own eyes; even if [...] promoters of technology and contenders for economic dominance may not be [consciously] working toward a situation of post-modern technology." [Rip&Groen2005] The emergence of post-modern technology has implications on its governance. "Distributed systems escape central control and make it difficult for actors to appropriate the benefits of their interventions and [...] to influence technological developments in the 'right' direction".

Such considerations prompt me to analyze the relationship between mobile telecommunications, their governance and post-modernity. I will show in this chapter that mobile telecommunications and their governance co-evolved in a post-modern direction. To do this, I first have to analyze the concepts of modernity and post-modernity.

4.1 Modernity and post-modernity

There is no single, formal definition of post-modernity. After all, the pluralistic and relativistic character of the post-modernity itself makes such definition almost impossible. So the most used way to describe post-modernity (and post-modern society) is to compare it with modernity. But before making this comparison, it is important to look first at another distinction – (post)modernity vs. (post)modernism.

According to Klages, there are two general approaches towards defining modernism. "Modernism", according to her, "generally refers to the broad aesthetic movements of the twentieth century; 'modernity' refers to a set of philosophical, political, and ethical ideas which provide the basis for the aesthetic aspect of modernism… modernity is older [and broader as concept] than modernism". In a similar distinction, "definition, of post-modernity comes more from history and sociology than from literature or art history. This approach defines post-modernity as the name of an entire social formation, or set of social/historical attitudes; more precisely, this approach contrasts post-modernity with modernity, rather than postmodernism with modernism."[Klages2007]

Although this terminological convention is not universally accepted (many authors use the term "postmodernism" in a broad sense, close to Klages' definition of "post-modernity"), I will use in this chapter the terms modernity and post-modernity in order to emphasize that I analyze the social formations of modern and post-modern societies and not only the aesthetical movements of modernism and postmodernism.

Reason and homogeneity can be seen as symbols of modernity. Based on the ideals of European Enlightenment, modernity assumes that reality is knowable through (scientific) rationalization. Modern culture is related to industrial capitalism and it reflects mass-

production and the industrial design of artifacts. It was important for modern designers to create durable and functional artifacts - “Forms follows functions” as Verbeek has put in his book [Verbeek2005]. Modern engineers and managers embrace standardizations and uniformity and they focus on efficiency. Modern firms valued highly educated engineers specialized in certain domain. They were tightly integrated in organizations with hierarchical structure. “This hierarchy became a source of power, continued growth, and permanence” [Hughes1998]. A hierarchy also represents order. Klages explains, following Lyotard, that “totality, stability and order are maintained in modern societies through the means of "grand narratives" or "master narratives," A grand narrative can be seen as a kind of meta-theory, or meta-ideology, that is, a fundamental story that explains the belief systems and theories that exist in the society” [Klages2007]. As result of this, only one representation of the reality is possible and reason alone can help us to reach the truth. If there are several representations (e.g. several grand narratives) only one can be the real and true and others are untrue. Pluralism is in general not acceptable.

One of the main characteristics of post-modernity, according to Lyotard, is rejection of grand narratives. Linked to post-industrial, consumer society, post-modernity is pluralistic and relativistic. There can be different interpretations of the reality, e.g. different grand narratives, which are true at the same time – especially in different cultural contexts. But furthermore, there is no need of a grand narrative at all – it is not necessary to have a total, hierarchical system of beliefs. Reality can be accepted as fragmented and sometimes contradictory. This is reflected in what Kockelkoren calls “decomposition of self” [Kockelkoren2003] – i.e. participating in different social network and in different roles and switching them freely. In this context, personal autonomy and choice become more central. Artifacts are not anymore only function but they have a meaning and show personal life style – so “form follows fun” [Verbeek2005].

Another defining characteristic of post-modernity, according to Lyotard, is its interconnection with information technologies. The development of IT, he argues, changes our perception of knowledge – knowledge is something that can be digitalized and processed by a computer. Furthermore, the role of knowledge changes – in modernity it is an end in itself, in post-modernity it is a means to achieve practical goals. In other words, knowledge becomes more pragmatic. Pragmatism in a broad sense is often seen as important characteristic of post-modernity. As Lyotard writes “social development in postmodern epoch… will be a *pragmatic* matter of inventing new rules, whose validity will reside in their effectiveness rather than in their compatibility with some legitimizing discourse.”[Lyotard1999]

Post-modern management and governance also differ from modern one. According to Hughes, post-modern organizations are with horizontal, network and project based governance. Hughes writes about distributed control in “networks with nodes” as distinct feature of post-modern governance. Decisions are made not so much in “bureaucratic structures”, but often in “collegial communities”, often based on consensus [Hughes1998]. In post-modern society changes in development of technology are fast and interdependent, so post-modern engineers and managers embrace interdisciplinary approach and value more generalists. Today, previous experience is of less importance

because problems that arise in research and development projects are often unprecedented. Furthermore, concerns of various interest groups (like environmentalists, for example) are of interest for the designers and engineers. Governance tries to align these various concerns and interest and to include them in the design process.

4.2 Post-modernity and infrastructures

In the description of infrastructures in the beginning of Chapter 2 I mentioned that infrastructures play a socially constructing role. For Edwards, infrastructures construct a modern society – "Building infrastructures has been constitutive of the modern condition in almost every conceivable sense. At the same time, ideologies and discourses of modernity have helped define the purposes, goals and characteristics of those infrastructures." [Edwards2003]. He further points out that "control, regularity, order, system, and techno-culture" are symbols of infrastructures but also basic characteristics of modernity. The sense of stability, created by infrastructures, is also something that naturally makes infrastructures to be modern.

On the other hand, according to Ross, mobile telecommunications are a "very postmodern phenomenon" [Ross1999]. Lyon writes that what distinguishes modernity form post-modernity is that in post-modernity there is "a wide spread and deepening reliance on computes and telecommunications as enabling technologies and an intensification of consumer cultures" [Lyon2003]. Misa claims that modern society changed into a post-modern with distinctive cultural changes brought (in part) by a high reliance on communication and information technology. [Misa2003]

Here comes seemingly a contradiction. On one hand infrastructures look naturally modern; on the other hand, as several authors mention, mobile communications are a fundamental technology for our post-modern world. If post-modernity as philosophy and culture is a rejection of modernity and has fragmentation and relativism in its core, does it mean that it is "anti-infrastructural" by definition? Or are infrastructures themselves changing, reflecting the post-modern values in society? If they do, what is the role of governance in this process?

Edwards [Edwards2003] suggests that the link between infrastructures and modernity has to be analyzed at three levels (scales) – macro, meso and micro. The analysis at each level emphasizes different aspects of the link between infrastructures and modernity. *Micro-scale* approach focuses on the role of the users in design and usage of technology and often shows that the technology promotes diverse values, not all of them necessarily modern. Furthermore these values are co-constructed by the technology and by the users. *Meso-scale* approach is concerned with interactions between organizations, corporations, standard setting bodies during periods like decades or more. It focuses on how the necessary organization is created so that the infrastructure can be built and maintained. My analysis in Chapter 2 is actually at this level. *Macro-level* analysis, claims Edwards, requires a time scale of "many decades or entire centuries" and "[analysis of] entire political economies or social systems". The goal of this analysis is to explain in a "functional and systemic way" the creation, development and decline of infrastructures, focusing on the general trends and on continuity of functions.

I will apply Edwards' framework in order to see if mobile telecommunications became less linked to modernity and more to the post-modernity. This theory is applicable for studying links between infrastructures and post-modernity, if we accept Misa's proposition that "post-modernism is no more and no less than modernism tangled with technology" [Misa2003]. In other words, technology remains the distinctive feature of post-modern society, as it is for modern society. Furthermore, although the symbol-making technologies of the post-modern society (media, information and communication technologies, etc.) are different from these in modern society, the co-construction of technology and society works in a similar way.

When applying Edwards' theory, the question arises if macro-level analysis can already be performed on mobile telecommunications and post-modernity. To what degree post-modernity can be seen as a new social system is a matter of discussion. Furthermore, we certainly don't have yet the time frame of "many decades or centuries" in order to do a macro-level analysis. So I will focus on the micro and meso level.

4.3 Micro-level analysis

At micro level, following Edwards' approach, I will analyze the actual use of the mobile telecommunications infrastructure by various social groups, individual preferences for services, the design of the technology and the social changes that it has influenced. In some cases, I'll make comparison between mobile phone and land-based communication (fixed phones) to show the similarities and differences between them, seeing the land-based telephony (especially in 1970s and before) as an example of a modern infrastructure.

4.3.1 Post-modern use of mobile phone

Just like the landline telephone, mobile telephone has been initially marketed to business class people. And in the same way as fixed telephone was used for socialization (somewhat unexpectedly by operators), the mobile phone was included in more and more spheres of our every day life. In fact in the initial marketing of mobile telephony the similarities with fixed phones were emphasized. The emergence of CPP and RPP calling schemes is a very good example of this. And similarly to the evolution of the fixed phone, when mobile phones became mass used they served less as symbol of status in society and more as sign of intense social communications. "If you are without mobile phone this means nobody depends on you for urgent directions and no one needs to get in touch with you at all times "[Geser2004]. Edwards wrote about fixed phone that "users appropriated telephone to their own ends and they employed it for a decidedly pre-modern purpose – socialization". This observation can be applied to the mobile phone as well[48].

[48] Socialization is of course a pre-modern value. In pre-modern times when people living in a small village used to know where is everyone – when you sit in village centre, this information simply comes to you. Today, in the "global village", we use our mobile phones to know where is everyone *who matters to us.*

But as mobile telephony achieved mass popularity in mid 1990s, the way the socialization happened through social networks started to change. The difference is that the world we live in is extremely complex and there is a need to participate in social networks that are not limited to our geographical position. We often need to do most of our social relationships from distance and mobile telephony answers these needs. Mobile telephony serves to free and unbound us from any specific location. This process can be seen as part of what Harvey describes as “compression of time and space” [Harvey1989]. Harvey writes that society experiences now a second round of compression of time and space. The first round has happened in the early 1970s with the increased mobility and internationalization of the capital. The second round comes now with increased mobility of people. This compression of time and space he links directly to the globalization and post-modernity.

Indeed, space is not very big obstacle for communication anymore; people can communicate over big distances and still to be able to retain significant social relationship. For example, in UK parents give mobile phones to their children when they leave home to go to university. Mobile phone helps students to be tightly connected to the home and also to overcome the potentially traumatic experience of living in foreign environment [Lakohee2003]. Mobile communications also help to fold the time. There is no need to schedule the time for calling someone, because everyone is accessible even if s/he is not present at home or at the office. Or if the moment is not convenient – other less disturbing services exist, like SMS or voice mail. So we are able at least to send information at any time and from any place.

Ross finds that the post-modernity is not in the fast speed of the processes in the society or in using fast cars and aircrafts – this all is part of modernity. What makes mobile communications typically post-modern is the combination of mobility and permanence. The caller is mobile, while the person who is being called is "always there". To make someone to seem as if she is “always there” when she is actually traveling, is a combination of ambivalences. “Being free from fixed location and being simultaneously locally reachable is one of prime criteria in distinguishing postmodern from modern”, claims Ross [Ross1993]. Mobile communications strengthen this combination of mobility and permanence in various ways. Mobile phones are not just phones but they combine different functions, like agenda, voice mail, SMS, MMS, I-mode, WAP, GPRS, access to Internet and e-mail, games, camera. This strengthens the “permanence” part of the mobility-permanence combination – the more things you can do and the more means for communications you have while you are on the move, the more permanent (or present) you appear. For example with multimedia functionalities people can show their friends what they are seeing although they are not at the same place. This allows people to express themselves more visually and so they look more present. In this way people “individualize” their environment by keeping connection with their closest ones. Mobile phone strengthens already existing relationships rather than enlarging social interaction to wider circles. [Gesser2004]

Another aspect of “individualization of environment” is use of location-based services. Through these services people can find information for an unknown place, like where is

the nearest pharmacy. In this way they create their own environment as if it is well known for them.

Gesser observes that if in the beginning the mobile phone was used for transmitting specific information, now it is used more and more for expressing emotions and feelings and just to stay in touch with the closest people [Geser2004]. Governance helped this form of communication – called sometimes "social grooming" - by enabling the various functions of mobile phones and by providing special pricing packages for family, friends, colleagues, etc.

Mobile communications allow flexibility and lead to more coordinated decision making and action both in business and in every day life. Adjusting of schedule, informing when there is a delay in the traveling or calling someone for chat while waiting on the bus stop - these are only some of the examples that show how much the mobile phone is needed. Parents nowadays can stay informed about where their children are, not only from work office, but from any place. People become so accustomed to flexibility of scheduling and possibility to inform others for their geographical position or personal opinion so they almost can't imagine living in another way [Townsend2001]. Mobile communications help people to combine multiple social roles at the same time and blur the distinction between work and home. Such pragmatic combination of social roles and of work and non-work related communications I see as essentially post-modern, as an opposite to the "grand narrative" of "work" and "private life" as separated spheres.

The mobile phone is not only a communicator – it also shows personal style and identity, and it became sort of a fashion tool. It is the first really individual device for communication and it is also an accessory, that shows who you are or who you want to be. To facilitate individualization there are many ways to personalize the phone. It is possible to change the standard ring tones with more pleasant ones for you and to change black face-plate with a more colorful plate, which is in line with postmodern "form follows fun" design. But the individualization goes beyond colors and tones. You can choose which services to use, which information you need and which charging scheme you want. The hybrid role of the mobile phone – as communicator and fashion item – and its extensive personalization are post-modern phenomena.

Another important characteristic of a post-modern infrastructure is the easier access. "Easier" means that the infrastructure is less bureaucratic and joining the infrastructure is more dependent on individual initiative instead of on a number of pre-conditions. Contrary to the fixed phone infrastructure, one doesn't need to have a permanent address, bank account or even passport in order to get a mobile phone, at least with a pre-paid card. If you want to stay anonymous you can also choose a prepaid subscription. The easy access and flexibility of options are not only pragmatic, but also lead to more respect for individual choices of subscribers. In that sense the infrastructure is less constraining and more open.

In summary, mobile telecommunications are both shaped by post-modern changes in society and shaping them. Combining multiple social roles, compression of space and

time, pragmatic combination of work and private life, drive for self expression and plurality of informal social groups - all these are post-modern phenomena, which were strengthened by the mobile phone. But the mobile phone plays its social role because it is part of the infrastructure and because it was brought to the market in a certain way and at certain moment. As Townsend says "the mobile telephone arrived at just the time when it was needed to facilitate dramatic decentralization of communications channels required by new social systems in the postmodern age. In fact, the mobile phone is so well-designed for this task that it has been even called a "postmodern form of communication" [Townsend2001]. I would add that pragmatism, flexibility, individualization and hybridization are key characteristics of this post-modern form of communication.

4.3.2 Post-modern governance of mobile telecommunications as consumer technology

The post-modern use of the mobile phone was helped by the governance of its marketing. The main factor in this was a changed strategy how to catch the consumer. How was it changed? I will emphasize two elements of the change – inscribing post-modern values into the design of the phone and accepting and promoting creative use of the phone and the infrastructure by its users.

Post-modern values in design

At the beginning the mobile phone was considered a business tool and basically business users were the single target group. Now governance targets the individual or all individuals. "And when you appeal to an individual you can begin to target the life style value" [Steinbock2005]. The focus of marketing has moved from technical characteristics of the phone to users' experience and life style. In the beginning of 1990s the governance aimed at mass market in mobile telecommunications and this goal was largely achieved by mid-1990s. In order to attract as much as possible consumers from different social groups the market players drifted away from the strategy 'one size fits all' and tried to segment the market. I have looked in Chapter 4 at the economic factors behind this market segmentation – mainly related to shift from initial demand to replacement due to market saturation. Since in early and mid-1990s there were few technical opportunities for segmentation through functionality, the focus was put on segmentation through appearance of the phone and through different types of pricing packages. But there were more than pure economic and technical factors behind this shift of strategy. In fact, the main actors – especially the big phone manufacturers - were very proactive in choosing the strategy of segmentation for 'catching the consumer'. Segmentation as marketing strategy is not something new - there has been segmentation in the car industry for decades [Steinbock2005]. But in the car industry the segmentation was used only after saturation of the market, while in mobile phone design and marketing the segmentation was used even before saturation of the marked. In addition to this it is not possible to personalize your car yourself, as you can do this with your mobile phone. So the new elements in the strategy of phone manufacturers were to proactively use market segmentation and to emphasize personalization. No one before has made fashion out of an infrastructural device. As shown earlier in this section, this strategy promoted enormous variety of post-modern uses. On the other hand this strategy shows that the governance has adopted post-modern values like importance of personality and pluralism

of life styles. The adoption of these values was based on anticipation of future market and social developments.

There were several waves of segmentation of mobile phone market. Segmentation was based on technology, lifestyle, functionality or experience [Steinbock2005].[49]

In 1982, the Nokia Mobira Senator was the first transportable telephone weighting 9.8 kilos. It was followed by Nokia Mobira Talkman, in 1984, weighting 5 kilos less. In Japan the first portable telephone was launched in 1985. The DoCoMo shoulder phone weighted 3 kilos. In US in 1983 Motorola produced DynaTAC 8000x, often regarded as the first hand-held mobile phone [Wikipedia][50]. In 1987 Nokia also introduced a hand held phone, Mobira Cityman, weighing only 800 grams. By the 1998, the weight of the phone was reduced to less than 100 grams.

Motorola DynaTAC 8000X

Historically first segmentation was based on technological characteristics. Up to the beginning of 1990 the only function mobile phones had was telephony, although the phones were technically different – some of them light other heavier. Size of the phone and the battery life were other important characteristics for segmentation and thus for pricing. During 1980s (1G) variations of the Motorola 'brick phone' were the only phones offered to the business niche market.

Segmentation by technology is a modern approach. There are clear and universal criteria which model is better and more expensive that the other. This segmentation creates sort of hierarchy and a vertical segmentation of the market. As in the car industry in the past, there are small and cheap and big and expensive cars.

The second wave of segmentation is segmentation by lifestyle. With segmentation by life style there are no universal criteria what phone is better than the other. What is important is what phone is *suitable* for someone. Different models for different lifestyles were created so that different users can find the most suitable phone for them. This segmentation emerged together with the digitalization of the mobile telecommunications, in the early 1990, but it became dominant in mid and late 1990s. What mattered then was not only what the phone can do but also what it represents. Users' personal style, as well as belonging to a certain social or age group, became very important when choosing a phone. There were various types of phone models – e.g. generic, entertainment, youth, fashion and business.

Generic segment includes mobile phones that can offer characteristics that are common for all lifestyle segments. These are from first WAP phones to Siemens ME45 and Samsung SPH-i330.

Siemens ME45

[49] This section follows a classification from Steinbock [2005] and all empirical data is taken from there, unless stated otherwise.

[50] http://en.wikipedia.org/wiki/Motorola_DynaTAC, Visited April 2008

The entertainment segment includes phones with large colorful screen and camera and they have focus on multimedia. In this segment are attracted established mobile players as well as players from consumer electronics like Sony Ericsson, Sony, Panasonic, and Samsung. In 1999 The Japanese 502i series was amongst the first with colorful screen.

502i

Youth culture segment. These phones are typically cheap and chic. Personalization of the phone by the users and customization by the vendors are very important. Nokia's changeable covers and the downloading of ring tones are among most important tools for personalization. Personalization and SMS functionality in late 1990s were characteristics that boosted penetration and usage rates in developed world. A typical model for this segment is Motorola T191.

Motorola T191

Fashion segment includes phones with stylish design. Here style and appearance prevail over function of the telephone. These phones are not entry level models like in the youth segment. They are closer to the entertainment segment. Models like Nokia 8910, Siemens Xelibry and also high luxuries models like Nokia's Vertu are representatives of this segment.

Vertu

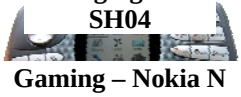
Business segment includes phones where the function is more important than the style. The business phone is a productivity tool for corporations and more recently also for self-employed professionals. Form Palm and Blackberry to Nokia Communicator and Microsoft smart phone is all about good data exchange capabilities, business and office applications and connectivity with PC.

Nokia Communicator

Segmentation by life style represents post-modern values like importance of personality and pluralism. Offering different designs for different groups and life styles is an acknowledgement of their importance in a pluralistic society. Furthermore, the design follows the postmodern "form follows fun" approach.

Since the late 1990s the industry also concentrated on single-purpose phones, with one function that prevail over others. This function can be imaging (making and sharing pictures), messaging, games, music etc. This kind of segmentation is complimentary to the other two and it is a tool for further segmentation inside the lifestyle segmentation for example. Here is important not only what you can do with the mobile phone but how well you can do it. The function of the phone as phone is combined meaningfully with the other function. Furthermore,

Imaging – J-SH04



Gaming – Nokia N series

these functions are of good quality. For example in the case of imaging the phone is provided with good quality camera. This is not anymore a phone that happened to have a camera; it is a hybrid device designed for talking, making and sharing pictures. Such phones not only include good cameras, but also convenient access to MMS service, possibility to easily copy the pictures to a PC, etc. With this segmentation the focus is the individual, not the whole social group. So hybridization and individual choice are the post-modern values behind this form of segmentation.

Acceptance of creative use

Initially both fixed and mobile telephony were intended for business purposes and in both cases users re-defined and extended the purpose of the technology. I may look at this as a post-modern feature, since individual users have found pragmatic way to bypass the intended order of the infrastructure. But then does this mean, that post-modernity was present already in 1930's, when housewives socialized by telephone? Or was it present in 1920's, when American farmers were using their Ford cars also as static power generators in the farm [Kline&Pinch1996]? Is any creative use of technology a sign of post-modernity? I think that in regards to modern/post-modern distinction it is more important to see how such creative use was accepted by the governance. After an initial period of silent tolerance, Ford tried to restrict such use of their cars by limiting the guarantee if cars are used as power generators – especially after Ford started producing mobile power generators. Fixed phone operators largely ignored the "social" traffic or tried to limit it by making longer calls more expensive. Only during 1970s this policy started to change. On the other hand, mobile operators and mobile phone vendors picked up the creative use, encouraged it and tried to capitalize on it. Because the governance was open and flexible, it could react on the "social talk" by offering special pricing packages for families, friends, etc. It also picked-up on the unexpected rise of SMS use not only by offering "SMS oriented" pricing packages, but also by starting new SMS based services and text-based services in general.

So I can conclude that while creative use of technology has always been present (creativity is a human feature in all societies), it influences post modern governance and through it the design of technology stronger and faster than during the modern times. The creative use of mobile telecommunications was linked to post-modern values. As the governance picked-up and elaborated the creative use, it promoted these values even further; but during this process the governance itself had to adapt it goals and processes so it also acquired more post-modern features.

4.4 Meso-level analysis

The history of the development of mobile communications shows a clear shift form centralized to decentralized governance. The technology itself became more interconnected, but less hierarchical. These are signs, according to Hughes [Hughes1998], for a shift from modernity to post-modernity.

What means this in reality? Mobile communications are a network technology by definition, but in the beginning of 1G period their governance was mostly centralized and

hierarchical; although the liberalization process had started. Most national mobile infrastructures were based on closed standards. Closed standards required that operators had a predefined alliance with the biggest national manufactures. They were tightly coupled organizations, which is a modern characteristic. During the PTT era the network operators were also national regulators in telecommunications. This situation shows the centralized governance of the infrastructures in 1G period. In this period there was no serious competition on the telecommunications market. Competition in economy is in general accepted in modernity. But when it comes to building and managing complex engineering structures, then systems approach was applied, as described by Hughes. System approach claims that "Behavior of a system is a consequence of interactions of its parts; parts that themselves [are systems and] must be understood and interconnected" [Hughes1998] The modernist approach to govern such systems was to mirror the hierarchy of components into a hierarchy of governance and to see the entire infrastructure as an integrated system that requires integrated governance. That's why from modernist point of view infrastructures were long seen as natural monopolies, the competition was not desirable and making a single standard was seen as the best option for designing infrastructures.

The situation in 3G was a lot different – governance was network based and participatory. All kind of actors participated in the governance process, which speaks for heterogeneity that is a post-modern characteristic. Examples are the 3GPP and 3GPP2 - both organizations were open for national standardization institutions as well as for individual members, like manufacturers, suppliers, operators and others. 3GPP and 3GPP2 groups were formed and became part of the governance process after ITU failed to produce a single 3G standard. The goals of 3GPP and 3GPP2 were loosely defined because they were not obliged to produce a whole standard but it was acceptable if they end up with certain agreed technical elements. Also some of the members were engaged in the work of both projects, which helped the resulting standards to be close to one another. But given the heterogeneity of the both projects it was difficult to agree on one single standard. Only after another dynamically formed organization – the OHG - entered the governance of standardization process, the 3G standards were harmonized.

As described in Chapter 2, the world did not manage to agree a common 3G standard. The reasons I pointed to then were the lack of political authority that can impose a single standard and the path dependencies in technology. When I look into the idea of single standard from more philosophical point of view, it seems that it is modern idea, because it means *homogeneity*. Furthermore it is based on the rational understanding that a network technology would be most efficient when based on a single standard, because of the economy of scale. The economy of scale is linked to the mass-production, which in turn is the "grand narrative" of the modern economy. Finally, a single standard means, at least to a certain degree, possibility for central control coming from the standardization institution. So may be it is not a surprise that such an idea proved unfeasible for a post-modern technology like mobile telecommunications.

Nowadays the governance of the global mobile infrastructure is extremely complex process that cannot be concentrated in the hands of one actor. To the contrary – the

governance is network based, there are several governing institutions and they are often dynamically formed. This network governance is a result of the fact that system builders and infrastructure operators operate in a competitive environment (national and international) and the institutional framework in which they operate reflects the post-modern orientation towards de-centralization and pragmatism. Furthermore, the necessary knowledge for creating and operating an entire infrastructure is so complex[51], that cooperation between different parties is necessary to produce it. The answers to this need were the open standards and the "pre-competitive cooperation". The more and more widespread concept of pre-competitive cooperation itself can be seen as typical post-modern example of pragmatism and acceptance of contradictions.

All this shows that the control over standardization of 3G mobile telecommunications is *distributed*, which is another post-modern characteristic. The control of functioning of mobile telecommunications is also distributed, because there are parallel, but so tightly interconnected networks that no one of them can function independently from the others. Furthermore, 3G infrastructures are hybrid both in terms of the underlying technology and in terms of the services provided.

Another dimension of the post-modern shift in governance was the acceptance of the various interests of actors. The modern "systems approach" is based on technical and scientific rationality as ground for making decisions about technical systems. In standardization of 2G and especially of 3G infrastructures, though, the economic and political interests of actors were more prominent and openly communicated. Even standardization institutions were formed along such lines. This doesn't mean that economic and political interests didn't exist also in modern times; the difference is that now they are accepted as a legitimate ground for decision making and they are openly negotiated. This in a way means that there are several "rationalities" that are valid at the same time, not only the scientific-technical rationality promoted by the systems approach.

The transition of governance of the mobile communications form modern to post-modern did not happened at once. The governance of the GSM project had modern as well as post-modern characteristics. One modern characteristic as I explained above is the singe standard. The idea of homogeneity coming from the single standard was even increased when the GSM standard was introduced in almost all European countries at the same time under political pressure from highest EC level. In this way EC created a sort of hierarchy over national telecommunication regulators. As mentioned in the introduction of this thesis, the role of governing organizations according to modernist understandings was to monitor the technological developments and to find ways for speeding it up by removing obstacles and providing required resources for "promising" and strategically important technologies. The support from EC for the GSM standard fits this pattern. But the support for the GSM, as an *open* standard, was for the EC also a means to create an open market with competition as well on national as on European level – which is already a post-modern idea, especially when it comes to an infrastructural technology. This idea was implemented gradually, by liberalizing first the market for services and phones and only

[51] This is a result both from the technical complexity of contemporary artifacts and from the (post-modern) demand to create multifunctional, hybrid infrastructures.

in 1997 for network operators. The delay in network market liberalization was a result of a political compromise.

The result of all this is a kind of paradox – the modern approach of creating and promoting a single standard not only helped creation of an open and competitive market, but it contributed significantly to the stabilization of a technology that became a symbol of post-modernity.

A similar mixture of modern and post-modern elements is recognizable when I look at the standardization institution for GSM – the ETSI. The organization of ETSI is hierarchical. It consists of General Assembly, a Board, a Secretariat, Special Committees, and Technical Committees. The General Assembly is the highest authority. Decisions in ETSI are not taken on the consensus principle but through voting. The voting system promotes alliances between the actors in the standardization process which shows pragmatism that is post-modern characteristics. On the other hand it may lead to situation where the majority subordinates the minority. In the General Assembly the Heads of the National Delegations vote on behalf of all national members for the most important decisions. [Bekkers2001]. The individual members, like operators and manufacturers, participate in the Technical Committees. This speaks for heterogeneity and pluralism because all kind of actors could participate in ETSI. Furthermore, the GSM group was "exempted from certain ETSI rules concerning the form of standards and it was allowed to have its own deliverable – the GSM Technical Specification." So in reality most important decisions were taken outside of the General Assembly. [Bekkers2001, p.333] This reduced bureaucracy and allowed the GSM to function, especially at technical level, as a "collegial community". The knowledge sharing was improved in comparison with the time when CEPT was the European standardization institution. In CEPT only national operators participated and suppliers could eventually receive a draft of the standards trough their national delegations but not to participate in standard development. In ETSI all king of stakeholders were able to share knowledge; but even more importantly pre-competitive collaboration between manufacturers and operators emerged as a way to create common knowledge and to share R&D costs and risks

4.5 Post-modern technology and post-modern governance

The analysis at meso- and micro-level shows that mobile telecommunications as technology and its governance have co-evolved towards post-modernity. Is this a coincidence for this particular technology, or are there more global factors that link post-modern technology and post-modern governance together? To answer this question, I will first look at the characteristic of post-modern technology.

Post-modern technologies are complex, distributed, multifunctional and often global. In my analysis of mobile telecommunications I've repeatedly shown that these characteristics are present; but they are not limited to this technology. Hughes uses the complexity and the distributed character of the ARPANET as main criteria classifying it as a post-modern technology [Hughes1998]. According to Edwards "the distributed and multifunctional architecture of ARPANET, Internet and [in particular] World Wide Web, and the open design that became their hallmark, made possible distributed networks of

power and control, …, connected to the arrival of post-modernity" [Edwards2003]. Rip also mentions "distributed systems" as evidence of emerging post-modern technology [Rip1995].

Distributed systems consist of relatively autonomous, but interlinked sub-systems; furthermore the links between components form a network, not a hierarchy – so there is no possibility for central *technical* control. This means that changes in one sub-system (e.g. a failure, but also an innovation) would have influence on many other parts of the system and because of the variety of links, cascading effects may occur that are difficult to anticipate. In Chapter 3 I've described the introduction of SMS sending from Web sites and what impact it had on mobile operators. Since SMS messages at that time where registered only at the point of entrance in the system, no one was able to charge senders of SMS via Web – but the receiving operators incurred costs for delivering the message. The short-term effect was that some operators stopped accepting SMS from outside their network; the longer term effect was a change in the design of the infrastructure, so that SMS can be registered also in the receiving network. This enabled receiving party pays scheme for SMS and became the basis for now hugely popular premium SMS services.

Hybridization is a post-modern phenomenon that shows up strongly in technology, since post-modern technology is often multi-functional. As the consumer society emerges and stabilizes the logic of bundling technical features into artifacts becomes more consumption-oriented. In other words, artifacts are designed to support certain tasks of the users. For this reason different functionalities are combined that are often quite far apart technically. Examples from mobile telecommunications are the combining of voice and data transfer, functional specialization of mobile phone, etc. A similar trend exists in other symbol-making post-modern technologies, like IT and Internet. Such multi-functional technologies, as well as their marketing, are very complex and require knowledge from different domains, which is rarely available by a single actor. Since I look at knowledge as an integral part of technology (see section 1.3.1 What is technology), I can say that post-modern technology is distributed not only in terms of its physical topology, but also in terms of knowledge - which in turn requires different types of actors to participate in design, marketing and maintenance of post-modern technology.

This analysis of the post-modern technology outlines serious problems for modern governance of technology. Modern governance of technology relies on decision-making and control by authorized (public) institutions, helped by experts in technology that can provide rational argumentation for decision making. But "distributed systems escape central control" [Rip1995] and post-modern projects "involve many conflicting interests – technical, economic, social, environmental" [Hughes1998]. The necessary knowledge is distributed between many types of actors that may have conflicting interests, so it is unlikely that there will be non-controversial expert advice to policy-making bodies; furthermore, it is more difficult for authorities to control a technically distributed system. Globalization adds to the depth of this problem. As markets globalize more quickly and effectively than public governance, and since post-modern technology is often interlinked in global markets, there might simply be no public institution that can make decisions controlling the entire market or the entire technology.

But all this is only a part of the problem. The other part lies in the changes of governance in society in general. Modern governance of society in general assumes that authority and control belong to public institutions that are formalized by law and formed and controlled by means of representative democracy[52]. The development of civil society challenged these assumptions. "Civil society refers to the arena of un-coerced collective action around shared interests, purposes and values... In practice, the boundaries between state, civil society, family and market are often complex, blurred and negotiated. Civil society commonly embraces a diversity of spaces, actors and institutional forms, varying in their degree of formality, autonomy and *power*" [Wikipedia][53]. Although analyzing the link between civil society and post-modernity goes far beyond the goals of this thesis, this definition shows that contemporary society accepts legitimacy and authority (power) of less formal actors, organized around different principles and operating on different procedures. On the other hand, as mentioned above, the post-modern technology requires collective action of actors with different "interests, purposes and values". Thus, in governance of technology a variety of power-holding bodies can – and in most cases will - be legitimately formed. Distributed systems in such an environment "escape central control" not only technically, but also socially and politically. So the idea of a single institution (e.g. the government) that controls the entire process of technological development becomes a myth.

Paradoxically, the very characteristics of post-modern technology that make modern governance impossible, presuppose that post-modern technology can exist only when it is governed. A distributed system can be designed, build and operated only by collective action from many different actors, some of whom may have conflicting interests. The multi-functionality of the technology, which allows for variety of uses, means that the social impact of technology becomes deeper and more social controversies are like to arise, especially in a pluralistic society. So the cooperation between many involved actors needs to be strong and effective in order to overcome the problems and controversies. This requires finding and negotiating common values, interests and goals, as well as effective procedures for decision making and feedback – thus, governance is a condition of possibility for postmodern technology. And since post-modern technologies exist, so post-modern governance of technology must exist too.

My analysis of mobile telecommunications shows not only that such governance exists, but also the big role it has played in the design and stabilization of this technology. It also shows some important characteristics of post-modern governance. First, it co-evolves with technology and it penetrates all processes of design, implementation and marketing – in this sense it is endogenous (internal) to the process of technological development. Second, the governance is very reflective. Acceptance of creative use of mobile phone, the evolution of WAP protocol and the dynamic formation of standardization organizations in 3G mobile communications are all examples of reflection on technical and social developments. The reflection means not only that the governance adjusts its decisions about technological development based on the feedback from market and

[52] At least in the developed, democratic countries, which are the subjects of this thesis.
[53] http://en.wikipedia.org/wiki/Civil_society

society, but it also means that the goals, processes and institutions of the governance change as well. In fact, the reflection is one of the means through which the co-evolution of technology and governance works. Third, the governance takes many different forms. Although in the overall picture the network-based types of governance dominate, in practice all governance types of STAGE classification can be recognized. Furthermore, governance takes place at different levels, from worldwide harmonization of mobile telecommunication standards to local market alliance for supplying content-oriented services. There is a network of contexts in which governance takes place – e.g. context of standardization, context of licensing and network building, context or price formation, context of data service provision, etc. In each context several forms of governance have initially emerged, depending on local, contingent factors, and in the process of co-evolution with the technology some have stabilized and others not.

These characteristics of governance of mobile telecommunication might be quite common for post-modern governance of technology in general. The highly interlinked distributed systems make anticipation of "cascading" effects of changes difficult. This difficulty can be partly avoided by increased reflection. Increased reflection stimulates co-evolution between governance and technology. The variety of contexts for governance and the many accepted ways to form governing bodies make it natural that various forms of governance emerge. Finally, the lack of central authority, the diverse types of involved actors and the need for knowledge sharing promote network-based, inclusive and deliberative type of governance – but don't predetermine it. The STAGE report says "there is [in EC] a complex pattern of diversity, co-existence, contradictions and complementarities between different modes of governance". For me this statement doesn't describe an intermediate state in the transition from "authoritative to participative governance" [STAGE2005], but an intrinsic characteristic of the post-modern governance of technology.

Of course, more empirical and theoretical research is necessary in order to describe what means post-modern governance of technology in general. But my analysis in this chapter provides arguments for acknowledging the existence of post-modern governance and for understanding it as a prerequisite for creation and use of post-modern technology.

4.6 Conclusions

If I come back now to the initial question, is post-modernity anti-infrastructural, the answer seems to be "no". Not only a new infrastructure has developed and stabilized in our post-modern times, but it further shaped typical post-modern characteristic of the society.

The need of the society to function in an artificial, controlled environment instead of in the "raw" nature hasn't changed – so infrastructures remain essential for the society. They continue to provide stability and order. But the order is somewhat different than in modern society. Mobile telecommunications, as a post-modern infrastructure, increasingly reflect and reinforce individualization, pragmatism and hybridization. This trend is most clear when we make a micro level analysis and focus on the use of the

technology. The use of the mobile telecommunications changes fast and it reflects the culture changes in society. Meso-level analysis shows that infrastructures themselves change more slowly, but even small changes have significant effects in society.

Although the symbol-making technologies of the post-modern society (media, information and communication technologies, etc.) are different from these in modern society, the co-construction of technology and society works in a similar way. In particular, in post-modern society infrastructures like mobile telecommunications play socially-constructing role as they do in modern society; the "constructed" society, though, looks different. This is in line with Misa's overall statement that "post-modernity is not more or less tangled with technology, than modernity". Analyzed at both meso- and micro-level, infrastructures in post-modern times show a clear tendency towards network-based governance, establishment and use of open standards, and service-orientation.

Philosophically speaking, these similarities in the social role of infrastructures in modern and post-modern society may be seen as an evidence for the idea, that post-modernity is not a rejection of modernity, but as its further development. David Harvey mentions further, that "there is much more continuity than difference between the broad history of modernity and the movement called post-modernity" [Harvey1989]. When we look at the roles and development of infrastructures in society, this conclusion seems well supported. On the other hand, if we take a look at the governance of mobile telecommunications there are some principle differences between modernity and post modernity. Post-modern governance is distributed among many actors. Hierarchical governance is not the main type of governance but all styles of governances are intermingled. Post-modern governance is internal for the process of development of technology and co-evolves with it. For that reason governing institutions and rules and regulations can't be determined by a single actor, even if it the government. These three fundamental differences between modern and post-modern governance show that the concept of governance changed. Even the terminology changed, the term "governance" emerged together with post-modernity to reflect the changed vision about how control in society is distributed. In modern times the term used instead of "governance of technology" was "science and technology policies", implying that the government can set up the "policies" that have to be implemented by technological community.

When we look at any major social change, there are some areas and values which change dramatically and some where the changes are more gradual and more continuity is present. While infrastructures and their social role changed dramatically during pre-modern to modern transition, their changes are more gradual during modern to post-modern transition. Governance, on the other hand, shows more fundamental changes. But both the technology and its governance have co-evolved in a post-modern direction.

Chapter 5. Conclusions and Discussion

5.1 Conclusions

In my thesis I analyzed the development of mobile telecommunications as an infrastructure and as a consumer technology and the development of its governance. My goal was to investigate in a concrete case study the tension between "modern suggestion of governability of technology and the contingency of technological development". The main conclusions of my analysis are the following:

- ✓ When new mobile telecommunication technologies emerged, different forms of its governance emerged. The emergence of the new technology and its governance was dependent on many political, social and economical factors that were sometimes very local and unpredictable.
- ✓ The mobile telecommunications technology and its governance co-evolved and mutually co-shaped each other. In this process it turned out that some governance forms were more suitable for the mobile telecommunications than others.
- ✓ The co-shaping between the technology and its governance was influenced by the existing social landscape. Mobile telecommunications technology and its governance co-evolved towards post-modernity.
- ✓ Mobile telecommunications as a typical post-modern technology cannot be governed through modern governance. Instead, post-modern, deliberative and reflective governance is necessary for development of mobile telecommunications.
- ✓ Post-modern governance in mobile telecommunications has less tension with the contingency of technological development.

5.1.1 Different modes of governance emerge

In first generation (1G) of mobile communications infrastructures there were different governance forms. Despite that all countries had to develop their national mobile telecommunications in conditions of un-liberalized market, different forms of governance in the mobile telecommunication sector in different countries did emerge. Some very important factors that influenced development of different forms of governance were the time of liberalization of the telecommunications market and the idea for common open market.

In many countries there was a de-facto or a statutory monopoly by one national operator, who had also regulatory functions and was in a predefined alliance with national supplier(s). The national operator developed a proprietary standard for mobile telecommunications and built a single national network.

In Scandinavia the telecommunication market was also monopolistic but the idea for common Scandinavian open market helped establishment of an international Scandinavian open standard and open and interconnected telecommunications networks. In Scandinavia there was an international alliance between national monopolist PTTs (Post, Telegraph and Telephone administrations), combining operator and regulator's roles; there the market of mobile phones was liberalized.

In US regulation of emerging mobile communications was left to individual states; the federal regulator FCC only demanded a single, open standard – AMPS. What is important to mention here is that US standard was open before first networks have been built. As the standard was open and the biggest monopolist AT&T was de-monopolized, different competing local operators appeared quickly and the infrastructure was build "bottom-up" i.e. different unconnected and small networks emerged.

In UK several competing national mobile operators were introduced from the beginning, despite that at European level the telecommunication market was still not open. No national standard was developed, but the US AMPS standard was adopted and modified and parallel, competing networks were built.

In the area of mobile telecommunications as consumer technology also different forms of governance emerged. One example is the governance of different charging schemes for mobile calls – calling party pays (CPP), initially used mainly in Europe, and receiving party pays (RPP), initially used in US. These different charging schemes emerged because the charging schemes for mobile calls were made similar to the existing charging schemes of the land-based calls.

Behind the two charging schemes there are different forms of governance. In the CPP scheme alliances between network operators are necessary in order to share the income from users' calls, since the caller pays the entire price of the call, but the receiving operator has costs for delivering the call to the recipient. In RPP scheme each operator charges the users for the calls they make and for calls they receive – so all costs of the operator are covered by these charges and there is no need for income sharing. Since in the RPP scheme the initiator of the call and the receiver have to pay for the call, the prices for initiation and receiving of a call are well known to the users. There is direct price competition between operators. In the CPP scheme users usually are not interested in the prices that others pay to call them, so these prices are not well known to the uses and this is one of the reasons why interconnection charges remain high. In the CPP scheme the market mechanism cannot reduce the high interconnection prices so this is one area where regulators had to take actions and regulate the interconnections prices. This example shows that local existing patterns influenced the governance of the charging schemes in mobile communications.

During initial development of mobile telecommunications there were also different governmental approaches towards price regulation. For example in US individual states were allowed to regulate the prices of mobile calls, but in 1993 FCC took this authority over and decided not to regulate the prices directly, but to increase competition between operators. In most of Europe in 1980s the national markets were monopolistic and prices were very high. The governments and PTTs were more interested to get the service running (for the business market), rather than to reduce the prices. In UK the government aimed for open and competitive mobile telecommunications market from the beginning. There two network operators were introduced since the beginning and also "virtual operators" were allowed to re-sell services of the main operators and to add their own extra services.

In respect to data services the emerged governance was also different. WAP and i-mode were the first widespread data services. The i-mode was based on a closed, proprietary standard developed by DoCoMo. The business model behind i-mode was also determined by DoCoMo. All service and content providers had to buy rights from DoCoMo in order to develop i-mode services and content. In exchange DoCoMo included the links to i-mode sites in its main portal and advertised the i-mode service as a whole. This reduced the risk and the initial investment for the service providers.
On the other hand there was no business model behind WAP protocol. WAP was just an open technical standard and the developers of the WAP believed that once the technical possibility is available the service providers will start to develop services. But this required negotiations between service providers and operators. This is one of the reasons that in the beginning WAP services were just a few in comparison to i-mode services. Why the difference of i-mode and WAP was so big is difficult to figure out exactly. The dominant position of DoCoMo – at that time the biggest operator in the world – certainly played a role. On the other hand WAP inventors were mainly manufacturers so had no possibility to create an actual network – instead they had to persuade the operators to start supporting the data service. Also the general business culture in Japan, which is more hierarchical than in Europe and US, may have played a role. In any case, this is an illustration how unpredictable are the forms of governance that emerge together with a new technology.

In summary, various forms of governance have emerged both in infrastructural and the consumer side of mobile telecommunications. On the infrastructural side public authorities played an important role in formation of governance. On the consumer side, each business model is actually a form of market governance, and many of them have appeared – the CPP and RPP charging schemata, various ways of handling interconnection charges, pre-paid vs. subscription models, the i-mode vs. WAP business model, variety of business models for content services, etc., etc.

5.1.2 Co-shaping of technology and governance

After the various forms of governance emerged together with the initial development of the technology, each of them evolved together with the further development of mobile telecommunications. In this co-evolution the technology and the governance shaped each other. A good illustration of this mutual influence is the globalization of both governance and mobile telecommunication networks.

We can see how governance of mobile communications globalizes. In the 1G mobile communications there were many forms of governance. Every country that developed its own standard established its own national governance of mobile communications. In the 2G there were mainly two different forms of governance – European and American. In the 3G all forms of governance converge into one world mode of governance. So did the mobile telecommunications networks. Starting form national, isolated networks in 1G and in 3G there is a global and interconnected “network of networks”. Interconnected networks mean not only that there is a possibility to call from one network to another, but also international roaming, existence of cross-net services and multi-standard phones.

How the co-shaping between mobile telecommunication technology and its governance happened? EU saw mobile telecommunications as very important sector for realizing their goal for common European market. First of all, a European-wide open and competitive market for mobile telecommunications would be an essential part of the overall common European market. Furthermore, an integrated European mobile telecommunication infrastructure would help connections between actors from all EU countries, thus strengthening the common market even further and promoting free movement of people. Partly due to the success of Scandinavian and US models of governance in 1G mobile telecommunications, EU institutions chose to develop a single 2G standard in Europe. So GSM was a *means* to create a pan-European market in telecommunications that in turn was a *political* goal of EU. Since EU was aiming at an open (non-monopolistic) market and at the same time at a single standard, it was necessary that most interested parties accept the standard; so the standard development process was open to all relevant actors and it was based on negotiations and deliberations. The national model of governance from 1G in which the monopolist PTT developed a proprietary standard was abandoned – partly due to political pressure from EU and partly due to market liberalization. Although the GSM form of governance seems a continuation of the Scandinavian form, there was a significant evolution – the GSM model included many more parties and many more technical and political compromises.

In US, there was also globalization of mobile telecommunication networks, although from local to national level. The driving force behind this globalization, though, was not politics, but market. Since the mobile telecommunications market was completely liberalized, the many local operators were largely replaced by big, national operators, capitalizing on economy of scale and network externalities. The governance of mobile telecommunications in 2G became even more market-driven- it did no support any specific technological standard, but let market to decide which standard was better- than it was in 1G and this led to creation of several competing standards.

During the 2G period, when national regulations for market entry were liberalized around the world, the operators and especially manufacturers realized that creating a world-wide market would bring them *economic* benefits through economy of scale. Equipment manufacturers would benefit from standard harmonization because the closer the standards, the more easy and cost-effective it is to produce mobile phones for different standards, to reuse components and knowledge and even to produce multi-standard phones. This benefit is stronger when manufacturers become global market players. The demand for global mobile communication also increased. As mobile communication networks stabilized, they became “black-boxed”, i.e. users assumed that they are always there and are reliable. This black-boxing, together with increased international travel and because the mobile phone became so easy to carry around, created expectations in many users that their own phones should work all over the world – so there was a demand for a global world-wide mobile communication network.

After the success of GSM standard in the 3G ITU tried to create a world–wide standard applying a similar form of governance as in GSM case. But because of path dependencies

in technological development and lack of political authority this was not successful. Instead, operators and manufacturers found ways to harmonize 3G standards. Since manufacturers came from different national and regional markets, there were various path dependencies. So a gradual harmonization rather than a "winner takes all" standard was preferable. Manufacturers and later operators formed alliances and standardization organizations mainly around the path dependencies. When biggest manufacturers and operators joined these organizations, they were able to create a bandwagon effect sufficient to drive the market into harmonization of standards.

The international governance in 3G standardization and network development combined deliberative and market mechanisms. Inside standardization organizations there were deliberation and consensus seeking; the harmonized standards, though, were enforced through market mechanisms. In this sense the 3G governance was a "merge" between the European and American forms of governance from 2G mobile telecommunications.

This analysis shows that the evolution of governance of mobile communication infrastructures was continuously influenced by the essential characteristics of network technologies - the network externalities and the possibilities for economy of scale. The script of the mobile telecommunication infrastructure – to connect people independently from time and space – also played an essential role in the co-shaping process. External factors, like globalization of economy and political drive for European integration, were important too.

Looking at mobile telecommunications as a technical infrastructure, globalization is the most prominent direction of co-shaping between technology and governance. Looking at the consumer side of mobile telecommunications, the co-shaping is most visible in the hybridization of technology. The more hybrid and multifunctional the technology becomes, the more alliance between different types of actors are formed at the market place, since they were required for the technology to work for the consumer. This leads to network-based, participative governance. The more network-based the governance becomes (not only in terms of number of alliances, but also in terms of strength of the alliances, the trust between individual actors and their interdependence), the better the visions of various actors are aligned and put into the design of the technology. Since these visions have different focus and goals, the technology becomes even more hybrid and multifunctional.

In this process, just like in infrastructure development, some forms of governance stabilize and evolve further, while others fade out. After its initial success, the i-mode form of governance lost ground and the forms of governance around the WAP protocol became more widespread. This was because the WAP approach was more open and flexible, since it allowed operators, content and service providers to negotiate how they share investments, risks and profits from WAP-based services. Furthermore, all involved parties had a better opportunity to influence the technology since WAP is an open standard maintained by a committee with broad participation; while i-more is based on proprietary DoCoMo standard. But recently, as mobile telecommunications and Internet are becoming more connected, both i-mode and WAP based forms of governance are

under pressure, because of rise of mobile Web. The main difference from governance point of view here is that i-mode and WAP rely on users to pay for the content they get, while mobile Web – like Internet in general – don't require payment for content, only for the connection. This difference leads to different agreements and alliances between actors and especially to different role of advertisers.

The stabilization of a consumer technology on the market requires that the strategies and interests of suppliers and consumers match. Price of the product is very important element of such a match. In mobile telecommunications there are various types of producers that have *direct* contact with the consumer and they bring (partial) products that have to be put together so that the consumer can use the technology. Price formation for mobile telecommunication requires interactions not only between supplier and consumer, but also between suppliers themselves – so it implies governance. Price formation is another area where the co-shaping of technology and governance takes place.

When I look at the prices of mobile telecommunications, there is a stable downwards trend in all the analyzed periods. This trend was influenced by various economic, technical and political factors. The supply of mobile telecommunication services and the competition between operators grew a lot when spectrum-efficient technology became present in 2G networks; although the open and competitive market was also helped and maintained by various regulations coming from public governance. Furthermore, price competition was the main form of competition in mobile telecommunication factors because of some specific factors. Initially the technology offered limited options for vertical differentiation of the consumer product. Horizontal differentiation trough lock-ins was also hindered by regulations and rejected by consumers. These factors made the market close to homogenous, so price competition was the main option. With introduction of 2.5G and 3G networks and the variety of new services, the market is changing gradually to a "goods market" and possibilities for non-price competition increase. Nevertheless, this coincided with market saturation and the switch from initial demand to replacement, which put downward pressure on prices. Technology influences pricing of telecommunication services also more directly – I've shown how technical factors led to a possibility for free SMS exchange using prepaid cards and how because of technical restrictions the initial release of WAP had to use payment per time, instead per data. In both cases the impact on the commercial success of the services was big.

On the other hand, there are ways how price formation and the level of prices shape technological developments. The CPP pricing scheme helped stabilization of pre-paid card technology in Europe, even though it was invented in USA. High interconnection charges in early and mid-1990s resulted in heavy subsidization of mobile phones by network operators. This encouraged customers to change their phones often, which in turn created extra demand for phone manufacturers and also increased the competition between them, because it was easy for users to change the brand of their phone. All this contributed to fast innovations and differentiation of mobile phones. The overall price decrease and the introduction of prepaid cards attracted many young consumers and this set-up a new trend of mobile phone design – a "fun" phone whose appearance can be

personalized. All this, on the other hand, made CPP charging scheme and its form of governance more widespread and popular than RPP. Although both CPP and RPP schemes continue to evolve, it seems that CPP approach, including its underlying governance form, was more suitable for mobile telecommunications in late 1990s and the beginning of 21st century[54].

This analysis shows not only the governance and technology co-shape each other through price formation, but also that the two dimensions of co-shaping – pricing and hybridization of technology – are interlinked.

In general governance of consumer side of mobile telecommunications is more local and contingent then governance of standardization. Negotiations and alliances are formed usually on bilateral or multi-lateral basis, but they are rarely institutionalized. The only relatively stable institutions are the regulators. Other focal actors – operators, manufacturers, content and service providers, software suppliers – find each other, negotiate and make agreement in the open market space. There is no central forum where negotiations take place and decisions are taken, like in standardization. This explains why so many business models emerged in the area of mobile telecommunications. But despite some important differences between governance of infrastructure and governance of consumer mobile telecommunications, the co-shaping between governance and technology is present in both cases. In both cases governance has become an integral part of the process of technology development and marketing.

5.1.3 Evolution towards post-modernity

Over time, mobile telecommunications have evolved to a typical post-modern technology. Its governance has also become post-modern. This overall trend is clear for mobile telecommunications both as consumer technology and as a technical infrastructure.

When looking at the consumer side of mobile telecommunications – its use and marketing - the post-modern use of mobile phone is obvious. Its use strengthens such post-modern phenomena like combining multiple social roles, compression of space and time, pragmatic combination of work and private life, drive for self expression and plurality of informal social groups But the mobile phone plays its social role because it is part of the infrastructure and because it was brought to the market in a certain way and at certain moment. As Townsend says “the mobile telephone arrived at just the time when it was needed to facilitate dramatic decentralization of communications channels required by new social systems in the postmodern age. In fact, the mobile phone is so well-designed for this task that it has been even called a “postmodern form of communication” [Townsend2001]. I would add that pragmatism, flexibility, individualization and hybridization are key characteristics of this post-modern form of communication.

[54] This doesn’t mean that CPP is “per se” the better form of pricing. Both technology and governance evolve and future social and technical development may change the balance between CPP and RPP again – or may lead even to new charging schemes and forms of governance.

When looking at the governance of mobile telecommunications as consumer technology, the shift to post-modernity is in the strategy for "catching the consumer". Important points of this strategy were to proactively use market segmentation and to emphasize personalization. In order to attract as much as possible consumers from different social groups the market players drifted away from the strategy 'one size fits all' and tried to segment the market by offering a big variety of phone models with different capabilities and by linking them to life styles and personal expression. No one before has made fashion out of an infrastructural device. As shown in Chapter 4, this strategy promoted a bulk of post-modern uses. On the other hand this strategy shows that the governance has adopted post-modern values like importance of personality and pluralism of life styles. The adoption of these values was based on anticipation of future market and social developments. The design of the phone also changed from emphasizing its functionality to emphasizing the experience of using it. This is a post-modern shift in design, according to Verbeek, from "form follows function" to "form follows fun". Yet another post-modern element of the marketing strategy was acceptance of creative use. Mobile operators and mobile phone vendors picked up the creative, unexpected use of the phone, encouraged it and tried to capitalize on it. Although the mobile telecommunications were envisioned for business use, the governance accepted and encouraged the emerging "social talk" by offering special pricing packages for families, friends, etc. It also picked-up on the unexpected rise of SMS use not only by offering "SMS oriented" pricing packages, but also by starting new SMS based services and text-based services in general. While creative use of technology has always been present (creativity is a human feature in all societies), it influences post modern governance and through it the design of technology stronger and faster than during the modern times. The creative use of mobile telecommunications was linked to post-modern values; it was accepted by the increasingly post-modern governance and was reflected in post-modern design of the mobile phone and the entire mobile telecommunications infrastructure.

Nowadays the governance of the global mobile *infrastructure* is extremely complex process that cannot be concentrated in the hands of one actor. To the contrary – the governance is network based, there are several governing institutions and they are often dynamically formed. This network governance is a result of the fact that system builders and infrastructure operators operate in a competitive environment (national and international) and the institutional framework in which they operate reflects the post-modern orientation towards de-centralization and pragmatism. Furthermore, the necessary knowledge for creating and operating an entire infrastructure is so complex, that cooperation between different parties is necessary to produce it. The answers to this need were the open standards and the "pre-competitive cooperation". The more and more widespread concept of pre-competitive cooperation itself can be seen as typical post-modern example of pragmatism and acceptance of contradictions. All this shows that the control over standardization of 3G mobile telecommunications is *distributed*, which is another post-modern characteristic. The control of functioning of mobile telecommunications is also distributed, because there are parallel, but so tightly interconnected networks that no one of them can function independently from the others. Furthermore, 3G infrastructures are hybrid both in terms of the underlying technology and in terms of the services provided.

The transition of governance of the mobile communications form modern to post-modern did not happened at once. Diversification of mobile phone models and the personalization features were developed gradually. On the infrastructure side, the governance of the GSM project had modern as well as post-modern characteristics. The very idea of having a single standard is a modern one, because of homogeneity and hierarchy that it involves. But paradoxically, the modern approach of creating and promoting a single standard contributed significantly to the stabilization of the mobile telecommunication technology that became a symbol of post-modernity. This gradual co-evolution of mobile telecommunications and their governance is related to the similar trend in the entire socio-technical landscape. So, mobile telecommunications are shaped by post-modern changes in society, as well as shaping them. The governance is a focal point in this process of co-shaping between the society and the technology.

5.1.4 Post-modern technology, post-modern governance and contingency of technological development

Post-modern technologies are complex, distributed, multifunctional and often global, as I have shown in my analysis of mobile telecommunications. Distributed systems consist of relatively autonomous, but interlinked sub-systems; furthermore the links between components form a network, not a hierarchy – so there is no possibility for central *technical* control. The complexity and multi-functionality of technology mean that the necessary knowledge is distributed between many (types of) actors, who have to act collectively in order to create and stabilize the technology. Such different types of actors would often have different interests, purposes and values. In post-modern (civil) society a variety of legitimate power-holding bodies are formed along the lines of these different interests and value. As a result, distributed systems escape central control [Rip&Groen1995] not only technically but also socially and politically. The modern idea of a single institution (e.g. the government) that controls the entire process of technological development becomes a myth and modern governance of technology, based on hierarchy of power and on scientific rationality can't be effective anymore.

Paradoxically, the very characteristics of post-modern technology that make modern governance impossible, presuppose that post-modern technology can exist only when it is governed. The "collective action" of different types of actors has to be organized, i.e. governed. The multi-functionality of the technology, which allows for variety of uses, means that the social impact of technology becomes deeper and more social controversies are like to arise, especially in a pluralistic society. So the cooperation between many involved actors needs to be strong and effective in order to overcome the problems and controversies – which requires governance even more.

My analysis of mobile telecommunications shows some important characteristics of such post-modern governance. First, it co-evolves with technology and it penetrates all processes of design, implementation and marketing – in this sense it is endogenous (internal) to the process of technological development. Second, the governance is very reflective. The reflection means not only that the governance adjusts its decisions about technological development based on the feedback from market and society, but it also means that the goals, processes and institutions of the governance change as well. In fact,

the reflection is one means through which the co-evolution of technology and governance works. Third, the governance takes many different forms. The variety of contexts for governance and the many accepted ways to form governing bodies lead to emergence of various forms of governance. The lack of central authority, the diverse types of involved actors and the need for knowledge sharing promote network-based, inclusive and deliberative type of governance – but don't predetermine it.

When governance is seen from this perspective, there is less tension with contingency of technological development. "Governability of technology" is an intrinsic characteristic of a (post-modern) technology. Only the governance doesn't mean steering the technology by an external social force. Instead, governance is a constant interaction between people and technology. These interactions are as well contingent as part of general patterns and trends. The patterns and trends can be influenced, although they can't be directed. As Rip and Groen claim, "a prospective theory of socio-technological change is probably impossible. Making smaller and larger invisible hands [that influence technological development] visible by sociological analysis is possible, and it is a step in the right direction". I hope that my work has been such a step in the area of mobile telecommunications.

5.2 Discussion

My analysis of technology and its governance in this thesis was limited to mobile telecommunications. Interesting questions for further, more theoretical research, are how much of my findings apply to governance of (post-modern) technology in general and to which technologies most of these findings apply and why. In this context I like to point out to some characteristics of mobile telecommunications that influenced the way the technology and the governance co-evolved. First of all, mobile telecommunications are a network technology, with significant network externalities. Second, mobile telecommunications combine a technical infrastructure with consumer products that are personalized almost as fashion objects. Third, mobile telecommunications are an essential infrastructure for post-modern society and in this sense they have some characteristics of a "common good". This prompts public authorities to play an active role in making this infrastructure reliable and affordable – for example through the concept of universal service.

On one hand, this combination of characteristics makes mobile telecommunications fairly unique. On the other hand, these characteristics may also be part of an ongoing trend. Post-modern technologies tend to be distributed and networked. The number of "smart" (interconnected) devices increases dramatically – from radio-controlled watches to medicines marked with RFID tags that register the entire path of the medicine from the lab to the patient. Personalization and self-expression through artifacts is also a general trend in post-modern "form follows fun" design. Finally, although not every technology is essential for the functioning of society, the overall power of technology as social force increases. As technology in general gets more grips on our daily life, public governance may attempt to regulate use of technology in more and more cases. So, more technologies could get similar characteristics as the mobile telecommunications.

If the shift to post-modernity in society continues, then my conclusion that "post-modern governance has less tension with contingency of technology development" may sound optimistic to those who want to govern technology. But a more careful reading of the arguments behind this conclusion may create concerns. If in case of a new technology governance emerges anyway and if the governance is so reactive that its goals, institutions and processes change constantly, shaped by technology, then how can governance achieve pre-defined goals? And if achieving strategic goals is not possible, how can governance be an intentional process? Is this governance at all?

Here I will emphasize the **co**-evolution of governance and the technology, their *mutual* influence. Looking only at one direction of this mutual influence can easily lead to determinism – either technological or social. Governance can shape a technology and some forms of governance can do it better for that particular technology than others. On the other hand, even most effective governance can't achieve *every* goal. "Materiality of technology" is enabling and constraining what can be achieved. In many cases it would be impossible even to know on beforehand what can be achieved in the development and use of a technology – so constant reflection and adaptation of goals is necessary.

A possible way to theoretize about this link between governance and technology is to look again at the evolutionary theory of technological development. There we see that governance is part of the selection environment for the technology and also a nexus between the selection and variation environment – this explains how governance can shape technology. On the other hand, I think that an evolutionary model for development of governance may also me meaningful. Forms of governance emerge with new technologies, perhaps not as random as technological innovations, but so contingently that it is very difficult to predict them. So we can speak of a "variation environment" for governance. But some forms of governance are more suitable for the given technology. These forms of governance shape the technology in such a way that it stabilizes. As the technology stabilizes, it becomes essential part of "selection environment" for the governance. Governance can succeed only if it is "fit" for its socio-technical environment and in particular for the technology it governs. Forms of governance that are not "fit" and can't evolve are replaced by other forms of governance that are more suitable for the socio-technical environment.

This idea for an "evolutionary theory" for development of governance of technology is only a rough sketch. There are many differences between evolution of technology and evolution of governance that have to be taken into account when building such a theory. But the idea emphasizes the co-evolution of technology and its governance and the mutual influence between them – which is the central point of this thesis.

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Appendix A – Explanation of some technical terms

In this appendix I explain some technical concepts that were frequently used in the thesis. The information is compiled from the following sources:

- Wikipedia – articles on air interface, core network, CDMA, TDMA
- Erik Arnold, Barbara Good & Henrik Segerpalm - "The GSM Story". Technopolis Group, ISBN: 978-91-85959-14-3, 2008
- http://www.telecomspace.com/cdma.html - tutorial on CDMA

Cellular network

A mobile telecommunication system that uses many base stations to divide a service area into multiple 'cells'. Mobile phones connect to base stations via radio-waves. Cellular calls are transferred from base station to base station as a user travels from cell to cell.

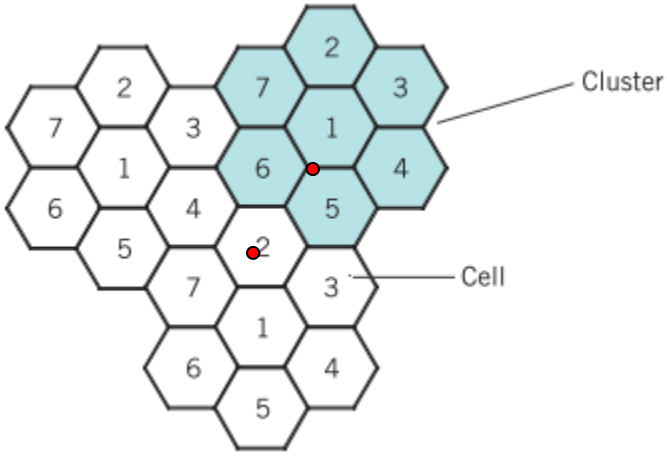


Figure A.1. A cellular network. This figure shows frequency reuse by clusters and typical locations of base stations (red dots).

Figure A.2. A base station serving 3 neighboring cells.

Cellular networks have some important advantages compared to a network with one powerful transmitter. Since base stations cover a limited area, there is always a base station relatively close to the mobile phone. This allows the phone to use low-power signal during the call and makes possible to use smaller and lighter batteries and so to make smaller and lighter phones. Furthermore, because low-power signals do not travel far, frequencies could be re-used by other base stations some distance away. This is achieved by clustering base stations in patterns that can be repeated. Each cluster can use the same set of frequencies, while adjacent cells always use different frequencies. In this way the available frequency spectrum is used very effectively.

Base stations are located either in the centre of a cell, or at the edge of the cell. When located at the edge of cells, a base station can serve 3 different cells, emitting radio-waves in 3 segments using different frequencies.

Roaming

Roaming is a service that allows a terminal (mobile phone) to register and work in a network run by a different operator (not the operator to whom the user is subscribed). This allows users to use their mobile phones in areas where their operator has no coverage – especially in a foreign country.

Air Interface

In cellular telephone communications, the air interface is the radio-frequency portion of the circuit between the cellular phone set or wireless modem (usually portable or mobile) and the active base station. As a subscriber moves from one cell to another in the system, the active base station changes periodically. Each changeover is known as a “handoff”.

A standard of mobile telecommunications includes two main components – the air interface and the core network specification. Each of main 2G mobile telecommunication standards – CSM, D-AMPS and cdma-One included its own air interface and its own core network. The main 3G standards – WCDMA/UMTS and CDMA2000 allow (at least theoretically) combining the air interface from one standard with the core network from the other.

One of most important advantages that digital air interfaces offer is the possibility for **multiplexing** – i.e. carrying several calls over a single air communication channel. In this case the base station services a number of calls on the same frequency simultaneously, because the voice from calls is carried in digital packages. This means that the air interface should contain a method (algorithm) to tell which package belongs to which call.

Multi-band mobile phones support several air interfaces, but only one of them can be active at a time.

Core network

The core network is the component of a mobile communication network that carries out switching functions and manages the communications between mobile phones and the fixed telephone network. It is owned and deployed by mobile phone operators. It is sort of “telephone central” (telephone exchange or switchboard) for mobile phones and allows mobile phones to communicate with each other and telephones in the wider telecommunications network. The core network also collects information about calls and their duration for billing and accounting purposes.

But a mobile core network includes additional functions which are needed because the phones are not fixed in one location. It controls which mobile phone can connect to the network, the location of the phone (in which cell it is currently), to which services the

subscriber has access, etc. For this purpose the core networks defines standards about how a phone should identify itself to the network and how necessary data can be transferred from one base station to another when the phone moves from cell to cell.

Roaming is possible only between mobile networks that have compatible core networks.

TDMA (Time-Division Multiple Access)

TDMA is a multiplexing method – i.e. a way to transfer several calls simultaneously between phones and the base station in the available frequency spectrum for mobile communications. So TDMA is part of the air interface.

TDMA is a **narrow-band protocol**. This means, that in TDMA one call needs a frequency band that is much narrower than the entire available spectrum. So, first of all, TDMA splits the available spectrum into a number of channels. It allocates to every call a single frequency channel for a short time and then moves to another channel. In this way the digitized call data is submitted in small packages. The packages from each call occupy different time slots in several bands at the same time as shown in Figure A.3.

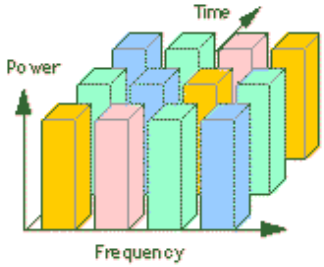
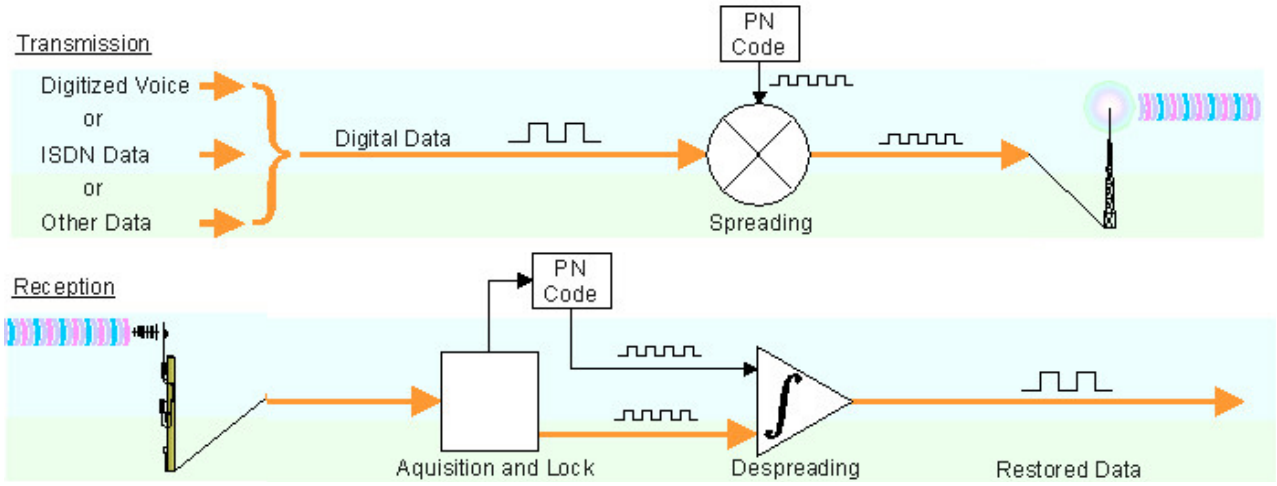


Fig. A.3. TDMA –based communication

In US the abbreviation TDMA is also used as synonym for the D-AMPS standard, a 2G standard that uses TDMA in its air interface.

CDMA – Code Division Multiple Access

CDMA is also a multiplexing method, like TDMA, but it uses an entirely different principle of combining calls. CDMA is a **broadband protocol**, which means that each call uses the entire available spectrum, so there are no different channels. Instead, the data from each call is spread over the spectrum using a “pseudorandom code” (PN code). At the beginning of each call the mobile phone and the base station generate the same PN code. When data is transmitted, it is modulated with this code and when it is received it is de-modulated with the same code. The other calls that are transmitted at the same time are “filtered out” because they use a different PN code. This process is shown at fig. A.4.



The abbreviation CDMA is also used (mainly in US) as synonym for cdma-One and CDMA2000 standards for mobile communications.

Comparison between TDMA and CDMA

There is an analogy that it is often used to compare TDMA and CDMA (taken from Qualcomm web site):
"Imagine a room full of people, all trying to carry on one-on-one conversations. In TDMA each couple takes turns talking. They keep their turns short by saying only one sentence at a time. As there is never more than one person speaking in the room at any given moment, no one has to worry about being heard over the background din. In CDMA each couple talks at the same time, but they all use a different language. Because none of the listeners understand any language other than that of the individual to whom they are listening, the background din doesn't cause any real problem."

TDMA was the main multiplexing method for 2G standards (all except cdma-One). All major 3G standards use CDMA for multiplexing.

There are various discussions about the advantages and disadvantages of TDMA and CDMA, but there is more or less a consensus about some points:

- CDMA uses the frequency spectrum more efficiently, although experts disagree how much more efficiently
- CDMA is more difficult to jam (disturb with external radio-waves) and to intercept
- TDMA offers a guaranteed quality of voice calls; in CDMA the quality decreases as more calls are transmitted simultaneously. On the other hand, TDMA has a hard limit on the number of simultaneous calls – when all time slots are full, no new calls can be made. In CDMA adding one more call is always possible, but in heavy load it would decrease the quality of all other calls
- TDMA phones use less power for calls, since they transmit only during their time slots. So they can have smaller batteries.
- TDMA base stations are simpler and cheaper than the CDMA base stations.

- TDMA is better compatible with analog mobile networks, although this factor is not so important nowadays.