Chapter VII

Modeling Static Aspects of Mobile Electronic Commerce Environments

Jari Veijalainen and Mathias Weske
University of Jyvaskla, Finland

ABSTRACT

Mobile phones and other small and powerful portable devices have revolutionized personal communication and affected the lifestyles of the people in the industrialized world. Following credible estimates, in a few years there will be one billion of such portable devices. An emerging trend is the electronic commerce performed using mobile terminals, often called mobile commerce. Mobile commerce environments are characterized by high complexity, including myriads of technical and organizational aspects. This property makes it difficult to distinguish the more fundamental issues, structures, and concepts in mobile commerce from the hype. To capture the fundamental aspects of mobile commerce environments, we have developed a model. It covers fundamental static aspects of the M-commerce environment and their relationships. We distinguish four spheres of concern: Regulatory Frameworks, Business Models, Enabling Technologies, and the Global Infrastructure. Rather than providing technical details of M-commerce environments, our aim is to model invariant properties that will evidently persist for years to come. Making use of the abstraction capabilities provided by the object-oriented approach, the model is represented by OO structure diagrams.

INTRODUCTION

Mobile phones and other small and powerful portable gadgets have revolutionized personal communication and affected, considerably, the lifestyles of the people in the industrialized world. In a recent development, voice capabilities of mobile phones are augmented with data capabilities of increasing speed, and stand-alone Personal Digital Assistants (PDA) are equipped with additional communication capabilities. The Mobile Electronic Transaction Forum (2001) indicates that small-size mobile terminals are currently converging and evolving into Personal Trusted Devices (PTD) that allow users to access mobile Internet services and run applications at any time and at any place. The telecom industry estimates that there will be 500 million Internet-enabled mobile phones in 2003. The number of these mobile Internet-enabled PTDs is expected to exceed the number of fixed-line Internet users around 2003. Mobile commerce (M-commerce) is an important emerging application class in the wireless Internet environment.

M-Commerce involves numerous domains, including network technology, business, government regulation, and standards. The main contribution of this chapter is organizing these aspects of mobile commerce environments and describing them using an object-oriented approach. This chapter focuses on the static aspects of mobile commerce environments; dynamic aspects are discussed briefly, mainly in settings where they have implications on the static structures. However a complete modeling of the dynamic aspects of mobile commerce environments—such as functioning of a particular protocol—is outside the scope of this contribution.

The overall setting we have in mind is shown in Figure 1. At the center is the global network infrastructure (called Wireless Backbone) that carries all kinds of high-volume data traffic. Currently, it is mostly the Internet. At the edges there are different wireline and wireless access technologies, such as wireline telecom networks, wireline local area networks (IEEE 802.3), wireless local area networks (IEEE 802.11), standardized by the LAN/MAN Standards Committee 802 of the Institute for Electrical and Electronics Engineers or wireless telecom networks (GSM, 3G) specified by the European Telecommunications Standards Institute (ETSI) (2000), and Bluetooth, specified by Bluetooth Consortium (Bluetooth, 2002). In computer network technology (as e.g., Tanenbaum, 1996 points out), these access networks represent OSI-layers 1-3. The electronic commerce (E-commerce) services are offered by the servers and are accessed by the terminals or other servers through the wireless or wireline access networks. Most electronic commerce services require end-to-end connections between the terminal and server at OSI-layers 4-7. This is necessary especially due to authentication and authorization.

Differences in the technologies at layers 1-3 are mostly uninteresting for the E-commerce services, including M-commerce services. This is true for data transfer and general connectivity, but the access network types have some important differences that suggest that the division in Figure 1 into the wireless and wired worlds will persist. First, wireless terminals are inherently mobile. This makes roaming between diverse technically compatible wireless access networks possible. Interoperability of roaming terminals and local E-commerce services obtainable "at spot" are a new emerging issue that must be resolved again and again. Second, wireless networks, especially telecom networks, tend to have much smaller transfer capacity than wireline access networks. This causes performance problems, should e-commerce services initially designed for much faster networks be used through mobile terminals. Third, the mobile terminal should be as portable as possible which means at the same time that they have much smaller physical dimensions, less memory, slower processors, smaller displays and keyboards (if any), and smaller batteries. For these reasons their usability for E-commerce applications designed for wired desktop terminals are far from good. Last but least, the possibility to dynamically position a mobile terminal with increasing accuracy opens up possibilities for new E-commerce services, often called Location Based Services or LBS. These make much sense for mobile terminals, but not much sense for fixed terminals, and are thus the crucial difference between M-commerce and internet E-commerce.

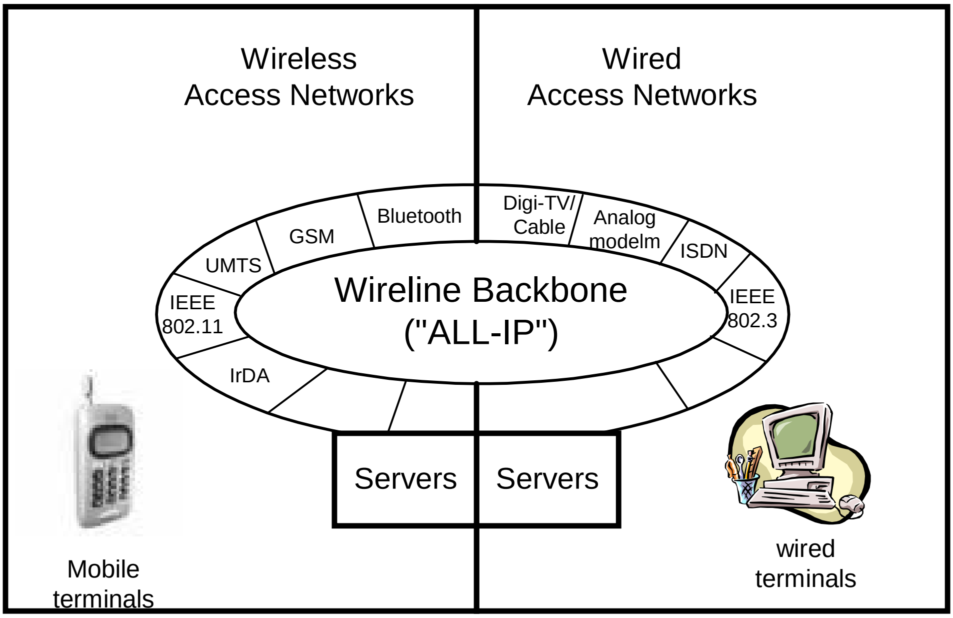
Rather than going into the details of the technical specification of wireless networks, we refer to the various 2G and 3G standards that are widely accessible. The interested reader is referred to ETSI (2000) and two recent contributions by Helal, Haskell, Carter, Brice, Woelk, Rusinkiewicz (1999) and Siau, Lim (2001), discussing the specific properties of these wireless network generations concisely.

In addition to nationwide wireless networks, a new type of short-range network, called personal area network (PAN), was developed recently. These networks aim at providing fast and convenient access within short ranges, rendering unnecessary the cumbersome temporary installation of wires between devices. For example, synchronizing the PDA agenda can conveniently be supported by a personal area network without fiddling with cables or managing docking stations. Wireless access to printers, and wireless link between an earplug and a telecom terminal, are other typical applications of this new technology. As mentioned in a Durlacher Report (2000), Bluetooth is an important product in this context.

For our purposes we do not make a distinction between a PAN or a more conventional terminal as a way to access the global infrastructure. A car as a mobile small-scale surrounding environment of a person that also has wireless access to the global infrastructure belongs to the same category as a PAN. Such devices or networks are modeled below as a terminal or a PTD.

As sketched in Figure 1, the new possibilities of mobile applications come from the ability to offer Location-Based Services that can be regarded as real-time and spatiotemporal. In particular, location-aware services and location-dependent services are available and described as follows: Location-aware services are able to answer queries, where locations of objects in a coordinate reference system and possibly metrics are used ("where is the X closest to Y"), but the objects do not move on earth. Location-dependent services use the actual, real-time ("now") location of the terminal or the object to be tracked to answer location-related queries ("Where is X nearest to me?"). The results can then be used to offer more complicated

Figure 1: Wireless and Wireline Access Networks and the Global Network Infrastructure. ("wired" should be capitalized in the figure)



services. A typical example of a location-dependent service—and mobile commerce—is ordering a taxi in any city just by pressing a button on the PTD a traveler carries. The location-dependent services are those that make the mobile commerce different from other forms of E-commerce.

Personalization of the services is also possible, at least to the same extent as in the Internet, because PTDs are highly personal devices, and sophisticated user profiles can be maintained by the operators. In Devine and Holmqvist (2001), it was argued that the most promising M-services are those that belong to the categories: location-dependent, or personalized, or timely. The most sophisticated and promising services, however, belong to the intersection set, i.e., are location-dependent, personalized, and timely. These sophisticated services can be developed by collecting context information from the people, for instance, information on the profile and on the current physical location. But collecting private information compromises the privacy of the people. Thus, there is a trade-off between the quality of the services offered and the loss of privacy.

Services where the current location of the user device is crucial only make sense for a person on the move and are therefore a proper extension of Internet-based electronic commerce facilitated by terminals in fixed locations. Indeed, some reasonable but simple location-dependent services (e.g., simply displaying the current coordinates) can be provided by the wireless networks and/or by a GPS-enabled terminal, without the help of the Internet electronic commerce infrastructure. On the other hand, there are Internet electronic commerce services, which can be used from both wireline and wireless terminals. Typical examples are banking services in Scandinavia, as reported by Nordea Bank (2001). This shows that Internet electronic commerce infrastructure can be used to support mobile commerce. Technical, business, and legal issues become more complicated in M-commerce than in electronic commerce performed using stationary workstations and similar devices. See Veijalainen and Tsalgatidou (2000, 2001) for further discussion on this.

Given this technological background, the complexity and dynamic nature of technological as well as business advances in the electronic commerce area in general and in mobile commerce in particular overwhelms not only users but also business experts and information systems people. The general concept of M-commerce environments is rather imprecise, often even fuzzy, triggered by their highly dynamic nature: While current standards and technology are still not very well understood, new business models and applications are popping up almost on a weekly basis. In this situation, it is hard to identify the fundamental properties of M-commerce environments and to answer questions like, “What are the fundamental technological properties of mobile devices, independent of the current technology in place?”, “What are the main players in M-commerce scenarios and how are they related by particular business models?” and “What are the interrelationships between properties of mobile devices on the one side and business models and the players involved on the other side?” “What is the impact of the user’s willingness to use her time to interact with a wireless terminal?”

How to tackle the issues? First, we view mobile commerce to be a subset of electronic commerce. More precisely, as M-commerce we define any type of economic activity that is considered as electronic commerce by the legislation of some country or by the business community and that is performed using a mobile wireless terminal by at least one party. In most cases the mobile terminal is used by a customer (not, for example, by merchant or bank) and the wireless network used is a wireless telecommunications network, although any other wireless network, such as a wireless IP network or Bluetooth link, could be used, too.

The abovementioned definition of mobile commerce above is still vague and raises many questions. One reason for this is that the very concept of electronic commerce is currently not very precisely and uniquely laid down. Our view is thus that mobile commerce is a special case of electronic commerce, i.e., mobile commerce has all the opportunities and problems that Internet-based electronic commerce has, but it offers in addition some novel and very exciting possibilities—as well as new threats and challenges.

This chapter tries to remedy this fuzzy understanding of M-commerce environments by identifying the main fundamental and invariant structures and properties behind M-commerce application scenarios. This is aimed by organizing them using an object-oriented modeling approach. What we mean by an invariant here is a concept whose extension exists over a long period of time (years, tens of years in this case) before it vanishes entirely or changes so much that it becomes something else in quality. A typical example is a "terminal." We do believe that some kind of a portable device (or a set of portable devices) is needed at any point of time in order to perform M-commerce. This is because a human being is not able to directly exchange data and access services offered at a network but needs a technical device or devices in order to do it. This holds now and in the future. However, how these devices are constructed at a particular moment is another question; we have already seen during the last 5-10 years a tremendous development in the terminals; while the original size and weight was comparable to a voluminous book, they now are small like matchboxes—and have still more processing capability and memory than a PC 10 years ago. The newest telecom terminals already incorporate video cameras, and a person-to-person video service V-LIVE has been launched in May 2002 in Japan (NTT DoCoMo (2002)). The first really wearable terminals have also seen the light; they are integrated into the clothes, and the parts can use wireless Personal Area Network (PAN) or cables for communication (see, e.g., Kaario, 2000; MIT, 2002; Kahney and Leander, 2002). But they still have the same functionality as any terminal in our sense: they allow the people to access M-commerce services.

The other invariant concepts, like business model, are similar. Although at a certain moment a business model has one form and at another moment another form, the concept itself stays for long time. Examples of these kind of invariants in mobile commerce settings are the inherent mobility of users, limitations of user devices with respect to input and output capabilities and connectivity, where the latter is either due to the noncoverage of certain parts of the world by service providers, or because the user decides not to be reachable for some time. As shown by Veijalainen (1990) and Veijalainen, Eliassen, and Holtkamp (1992), one of the invariants at this level is that the terminal exhibits communication autonomy.

We are here not only interested in individual permanent concepts, but in a set of concepts that together are essential for the comprehension and development of M-commerce. We want to address the legal and organizational prerequisites of M-commerce, enabling technologies, and the actual global infrastructure in place. We thus identify four spheres of concern that refer to the above aspects. The most abstract but at the same time most pervasive sphere of concern addresses the patchwork of the *Regulatory Frameworks* emerging in different parts of the world. It influences the *Business Models*, *Enabling Technologies*, and the *Global Infrastructure,* the other spheres of concern. The essential criterion in establishing the spheres of concern is that they have a dynamics of their own that is relatively independent of the other spheres. Still, they are dependent on each other; for instance, even if the Regulatory Framework logically precedes M-commerce, deeming some forms of it "illegal" and others "legal," historically, M-commerce can be performed without a special legal framework, and in fact, the emergence of M-commerce is the reason for establishing a particular legislation.

This article is organized as follows: Section 2 introduces the object-oriented model for mobile commerce environments by presenting the individual spheres of concern, introduced above. This section concludes with an integration of the submodels to present an overall mobile commerce environment model. In section 3 the applicability of the model is illustrated by sample mobile commerce scenarios. A section on related work and concluding remarks completes this chapter.

MOBILE COMMERCE MODEL

By analyzing the complex environment of M-commerce applications, it appears that a variety of diverse entities and organizations are playing important roles, ranging from standardization organizations and technical specifications of the network infrastructure to user terminals and particular business models and, finally, to revenues. The approach presented in this chapter takes into account a wide range of these static aspects. Rather than viewing the environment as an unstructured collection of diverse entities and concepts, we organize them in four *spheres of concern* and describe them using object-oriented modeling techniques. As noted above, the organization of the entities into spheres of concern is based on the relative independence of the dynamics within the spheres. The spheres classify the entities into four broad categories, like government rules, enabling technologies, network/terminal technology, and business aspects (they will be specified more precisely below). Since the spheres of concern represent parts of the overall model, they can also be regarded as submodels.

Object-oriented approaches have been proven well-suited to capture the static aspects of complex application scenarios. However, their use is not limited to specific low-level design models used for systems implementation. On the contrary, due to abstraction concepts provided by the object-orientation paradigm like classification, association, and inheritance, it is well suited for modeling complex application level scenarios. In this chapter, we use the de facto standard Unified Modeling Language (UML) introduced by Booch, Rumbaugh, and Jacobson (2001) to model the static aspects of mobile commerce environments.

Based on the object-oriented approach, we organize the entities involved in M-commerce environments in classes and represent their relationships by associations between the classes. While typically each class belongs to one sphere of concern, there may—and must—be overlapping classes, as well as associations between classes of different submodels that act as the glue between the respective spheres of concern. Hence, each sphere of concern is characterized by an object-oriented submodel, and these are interdependent through overlapping classes and associations. We do not model all possible known concepts and their relationships as explicit classes and associations in our model. In order to be explicitly present as a class in the model, the corresponding concept must be essential for the existence and evolution dynamics of the sphere of concern it occurs in. Organizing the static aspects of M-commerce environments in this way aims at clarifying the concepts, technologies, and players in this highly complex and dynamic area.

To organize the presentation in the remainder of this section, the submodels are addressed in turn; finally, these parts are integrated into an overall model for M-commerce environments and the relationships between the spheres of concern are discussed. The spheres of concern are listed as follows:

- *Regulatory Frameworks*: The organizational and technical aspects of laws, standards and recommendations, as well as the bodies involved in their definition or ratification.
- *Enabling Technologies*: This sphere includes technical aspects like user terminal and network technologies and cryptography, and organizations developing these technologies.
- *Business Models*: Business aspects, including business players, provided services, business protocols, revenue sharing, and code of conduct are important artifacts in this sphere.
- *Global Infrastructure*: The global infrastructure sphere deals with the global network and the concrete terminals that facilitate M-commerce.

The general approach for each sphere is as follows: We start by discussing in an informal way the concepts and artifacts specific to that particular sphere and those that should appear in the respective submodel. The artifacts are then classified using an object-oriented approach. Relationships between artifacts are represented by associations between the respective classes. As said above, we use structure diagrams provided by the Unified Modeling Language as notation.

It is important to stress that we are not focusing on specific technical or organizational properties of artifacts in mobile commerce as they have developed during their history, but—on the contrary—have general, long-lasting patterns and properties in mind. For instance, rather than modeling individual types of terminals, we introduce a class representing these terminals. This means that whenever a new terminal enters the market, conceptually, an object will be inserted in the terminal class. As a result, the model will not change in response to the introduction of a new terminal type. The same holds for a new standard, a new business model, a new network protocol, or a new modulation technology. Hence we regard the concepts of the model to be invariant against changes in mobile commerce environments in the foreseeable future. A schematic picture of the spheres of concern and their dependencies is presented in Figure 2.

Notice that the spheres are dependent on each other, as specified in Figure 2: the two up-most layers rely on Enabling Technologies; Business Models cannot be deployed without the Global Infrastructure that facilitates the concrete M-commerce transactions. The picture also alludes to the relative independence of the layers. One can change something in one layer without necessarily changing the other ones. For instance, offering GPRS data transfer service within the Global Infrastructure

Figure 2: The Four Spheres of Concern.

sphere does not necessitate changes in the existing concrete business models (albeit new business models might become feasible with the “always-on” functionality of the terminals). Business models can be developed and changed without the need to change the terminals or the network infrastructure in place. The limits for possible business models are still dictated by the infrastructure; think of selling video-on-demand services over 9.6 kbps wireless links to slow terminals. Putting it the other way round, certain business models set certain requirements for the infrastructure and new technologies. New enabling technologies can be developed based on the business requirements or for other reasons, but this does not have influence the Global Infrastructure as long as they are not deployed in the concrete networks; existing new enabling technologies are, however, a necessary condition for the changes in the global infrastructure. Therefore, Enabling Technologies is the lowest sphere of concern in the picture; the upper spheres stay on top it.

The difference between the Global Infrastructure and Enabling Technologies is exemplified by UMTS technology. The technology as such is ready and available since 2001, and the network components and terminals are in production. But only a tiny part of the wireless access networks are really currently (Spring, 2002) of this type, and there are much less than one million subscribers in Japan.

Regulatory Frameworks put forward requirements for all other spheres of concern and restricts their form. It stands on its own but leans on the other spheres. This reflects the relative independence of the governments, international organizations, and companies and their leading role against the other spheres of concern. The Regulatory Frameworks sphere influences directly all other spheres, but there are also indirect influences. For instance, legislation can require certain privacy rules to be obeyed by the business actors. This can be reflected by the business model applied, and further in the Global Infrastructure sphere, where technical support for privacy maintenance must be in place. On the other hand, developments in the three other spheres of concern can require regulatory measures to be taken. Typically, a new body must be formed to take care of some aspect of global interoperability (see below), a new consumer protection law passed, or emerging technology otherwise regulated, etc.

Regulatory Frameworks

The Regulatory Frameworks sphere represents the global organizational level that is needed to facilitate the interoperability of the underlying network infrastructure, terminals, and the higher-level—M-commerce—services. This level is also needed to foster and guide the development of new technologies, and last but not least, to provide the legislative framework for the M-commerce. Interoperability is closely related with the autonomy of the organizations offering M-commerce services. As was shown in Veijalainen (1992b), in order to guarantee interoperability of systems, one needs to establish an organizational entity called *global designer*. It is responsible for specifying the rules for interoperability within the *technical domain* controlled by it. A global designer has to have an exclusive power to control the domain, otherwise there almost certainly will be mismatch and confusion about what is the right way of handling things (of course, sometimes this is also intended for reasons of competition). Should several global designers design parts of the same environment they must guarantee that the parts are interoperable. Thus, they must cooperate with each other—or establish a higher-level global designer, and so on, if they want to ascertain interoperability of their standards and recommendations.

We distinguish between three main groups of organizational entities, namely *legal bodies*, *standardization bodies*, and *interest groups* that have formed so far and that most probably will persist in the foreseeable future, because the reasons for their existence will persist in the future. They all play a role *within* global designers for various aspects of the global environment.

The legal bodies are national governments and other organizations with legislative powers, like the European Commission or the United Nations. These issue legislation that regulate business in general and mobile commerce in particular. In general, laws say which business models are legal, which are not, and what has to be taken into consideration when performing M-commerce transactions. Especially the privacy of customers is of concern at this level, as well as jurisdiction and applicable law addressing consumer protection, liability of merchants, and dispute resolution. The governments also determine which wireless technologies and access networks using them are allowed in their territory, thus creating the basis for mobile commerce. In the legal respect, Japan, EU and USA currently form three different areas of rules as concerns wireless networks and business models for mobile commerce. So the domains controlled by these three legal bodies are geo-spatially separated and nonoverlapping. The rest of the world is mostly a “gray zone” but will join the hopefully commonly established domain (or one of the three domains).

Legal bodies can enforce and ratify laws and other legally binding rules. In this context, the laws set forth constraints that mobile commerce systems have to meet.

It is the responsibility of the business partners to guarantee that the legal constraints imposed by the legal bodies are met. Within the European Union, electronic commerce legislation in general and mobile commerce legislation in particular is to a large extent in the hands of the European legislative bodies. The European Commission and Parliament has issued Directives that are to be integrated into national legislations. The legislation has thus both a direct impact on technology, business models, and network infrastructure, and an indirect one through the adjacent spheres of concern. Interested readers are urged to visit the EU Information Society portal (2002) and EU e-Commerce legislation portal (2001) to learn more about the various activities performed and legislation issued by the EU.

Legislation can sometimes directly dictate a standard, but usually it just refers to an existing one that has been prepared by a standardization body or has become a *de-facto* standard. Agreements on common technologies and standards are the key to interoperability. This holds for a variety of domains, including wireless networks, software technologies, positioning methods, etc. Standards can be either international ones ratified by international standardization organizations, such as ISO (2002), national bodies, such as American National Standards Institute (ANSI, 2002), or international institutes like ETSI or IEEE (ETSI, 2002; IEEE, 2002). However, often industry best practices that act as *de facto* standards are eventually accepted as an official standard. This pattern has been prevalent in the past in various technology areas. It has also been observed in Internet network technology where TCP/IP became the standard transport and network layer protocol of the global network infrastructure, as well as the layers on top of it, and it does not comply with the OSI standard open protocols suggested by ISO. GSM technology as a wireless access technology has also conquered majority of the developed countries in the world, although Japan is an exception, as well as partly the USA. UMTS will most probably have a still wider applicability than GSM, because Japan and USA will be on board (UMTS Forum, 2002) and the rest of the world will follow, eventually.

While standardization bodies have—strictly speaking—no legal powers, they are an important instrument for the industry and governments to agree upon standards in a specific technical domain. Interest groups are a weak form of standardization body. In our sense they are an instance of the abstract global designer, that is, usually established for a limited period of time in order to solve a pressing technical issue. In mobile commerce, there are several very strong interest groups, each of which focuses on a specific technology, i.e., on a particular technical domain. The common behavioral pattern of interest groups is to get the key players of the field involved and define a *de facto* standard with the aim of pushing it into the market through their power. An ultimate case is NTT DoCoMo in Japan who led the specification of the i-Mode system, including the whole protocol stack, mark-up language, terminals and business model(s), and also deployed the core system.

In order to reach the true global interoperability in wireless communication systems at the application level, many companies are involved in various interest groups in diverse technical domains. These include manufacturing terminals, setting up wireless networks, and designing and implementing M-commerce services. The key factor for success in this context is indeed interoperability, meaning the ability of devices and network technology produced and provided by different manufacturers and network operators to communicate with ease and efficiency as desired by customers.

The division of the world into geographic zones or areas is an important issue for roaming customers who would like to use location-dependent services (like ordering taxi, see below). His or her PTD must be able to not only use the local wireless access network, but also the local services. 3G networks and compatible terminals might solve the first part of the problem, but the second problem area—the heterogeneity of the services—still remains. In 3G networks, ITU (2002) and ETSI (2002) played a central role as global designers, but as far as M-commerce services are concerned, there is no organization that has the power to dictate how they should look like. The M-commerce services are, first of all, regulated by the local legislation of the zones, and they are highly dependent on the local culture and rules, as represented, for instance, by specific business models issues and codes of conduct.

The companies involved in the wireless telecom business have realized that if the business models and M-commerce services become incompatible in different parts of the world, or indeed within a zone with the same legislation, roaming customers would suffer. This would have a negative effect on the whole industry. As a result, the world has now seen many global designers to emerge that try to tackle the problems. These include the WAP forum (WAP Forum, 2002), but especially the Mobile electronic Transaction Forum (MeT, 2002), Location Interoperability Forum (LIF, 2002), and last but not least, the Open Mobile Architecture Initiative (OMA, 2001, 2002). All these must closely follow the work of the W3C Consortium (W3C, 2002), as well as the work of many other similar bodies and standardization organizations. The situation raises many questions, like what guarantees that the diverse recommendations developed by all these bodies will be coherent and interoperable? Second, what chances does the work of these interest groups have to become global de facto standards or even a sort of guideline for concrete service design? The first problem is more or less satisfactorily addressed because the interest groups consist essentially of the same big players, and these coordinate the overall architecture development and the concrete work within the different forums. In general, however, there is no guarantee that many global designers specifying closely related recommendations would succeed in achieving interoperability.

The second question above is a tougher one. The OMA Initiative is the answer of the big players: "The objective of the Open Mobile Architecture (OMA) initiative is to create a non-fragmented, interoperable global market for the next generation of mobile services" (OMA, 2002). As the name suggests, the idea is to use only standard, openly available specifications and software. What is the controlled domain in this case? Formally software, but of course with software comes the functionality.

To which extent does this consortium want to specify the functionality of the software? Theoretically, the interest group can indirectly specify even the “open” business protocols embodied in the “OMA” software. Whether it wants to go so far remains to be seen. Currently, the emphasis is rather on open industry standards, standard tools, and open platforms.

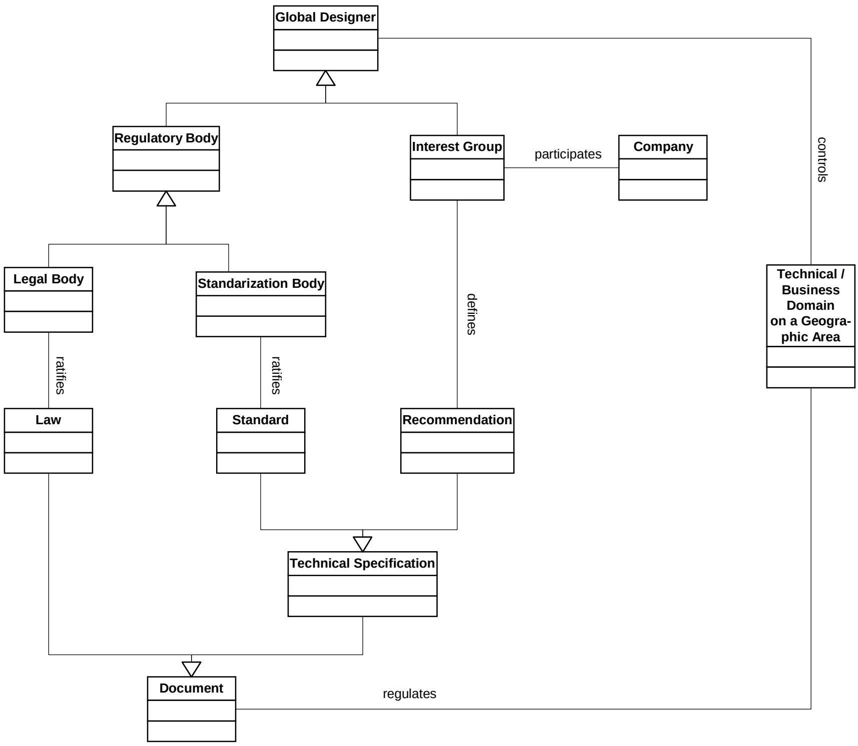
It is worth of noticing that a commonly agreed upon syntax, such as EDIFACT or a particular mark-up language in the XML family, such as XHTML, does not yet help to completely solve the interoperability problem; it remains to be decided by autonomous organizations, which concrete EDI or XHTML specifications to adopt and what the elements exchanged mean exactly. Furthermore, one must specify which protocol stack is used to exchange the content. The M-commerce protocols are application protocols that support the chosen business model, and these will most probably vary from zone to zone. The services should be paid in a uniform way so that the roaming customers are able to use their terminals smoothly. In any case, should this consortium be able to keep its promise, it will certainly have a strong impact on the way mobile commerce is conducted in the future.

Based on this general introduction to regulatory frameworks, their players and issues, we now take the step towards an object-oriented model of that sphere. This is shown in Figure 3. Starting with organizational aspects, regulatory bodies and companies are represented as specific classes of organizations, with inheritance relationships between them. Regulatory bodies can be either legal or standardization bodies, represented by subclasses of the regulatory body class. Companies join interest groups, which aim at defining *de facto* standards, represented by an aggregation association between these classes. If the interest group succeeds in defining a recommendation, the companies participating in the interest group have a considerable competitive advantage, since they already offer products and services complying with that new recommendation. The left side covers the legal bodies, like governments, the European Commission, and the United Nations. They regulate the technical or business domain in a specific geographic area, i.e., a country, or a larger economic region.

The model shown in Figure 3 provides a detailed, yet abstract view on the entities involved in the Regulatory Frameworks sphere. It is important to stress that it details the type level, not the instance level. In general, objects are the instances of classes. Thus, objects of the company class are Nokia, Ericsson and Siemens to name a few players in the mobile commerce arena. These companies participate in interest groups with the aim of setting up recommendations. For instance, the Mobile Electronic Transaction Forum is an interest group aiming at defining *de facto* standards for secure mobile transactions. Tens of big companies, including Nokia, HP, Sony Ericsson, Oracle, Sun, IBM, NTT DoCoMo, NEC, Siemens, Vodafone and AT&T Wireless have joined the OMA Initiative (see OMA, 2002 for further details).

We believe that the class structure of the organizational entities as shown in Figure 3 will persist in the foreseeable future. We are still fully aware that a deeper analysis requires populating the instances and grasping the concrete dynamic

Figure 3: Regulatory Frameworks.



relationships between interest groups, standardization bodies, and legal bodies, as well as the analysis of the individual organizations. For instance, the analysis of interest groups, the reasons for their emergence and dissolution, their impact on the technology and markets, their relationship to globalization, etc., could be studied in research projects. There is work done in this vein on the standardization of 1G, 2G, and 3G systems: see, e.g., Telecommunications Policy (2002).

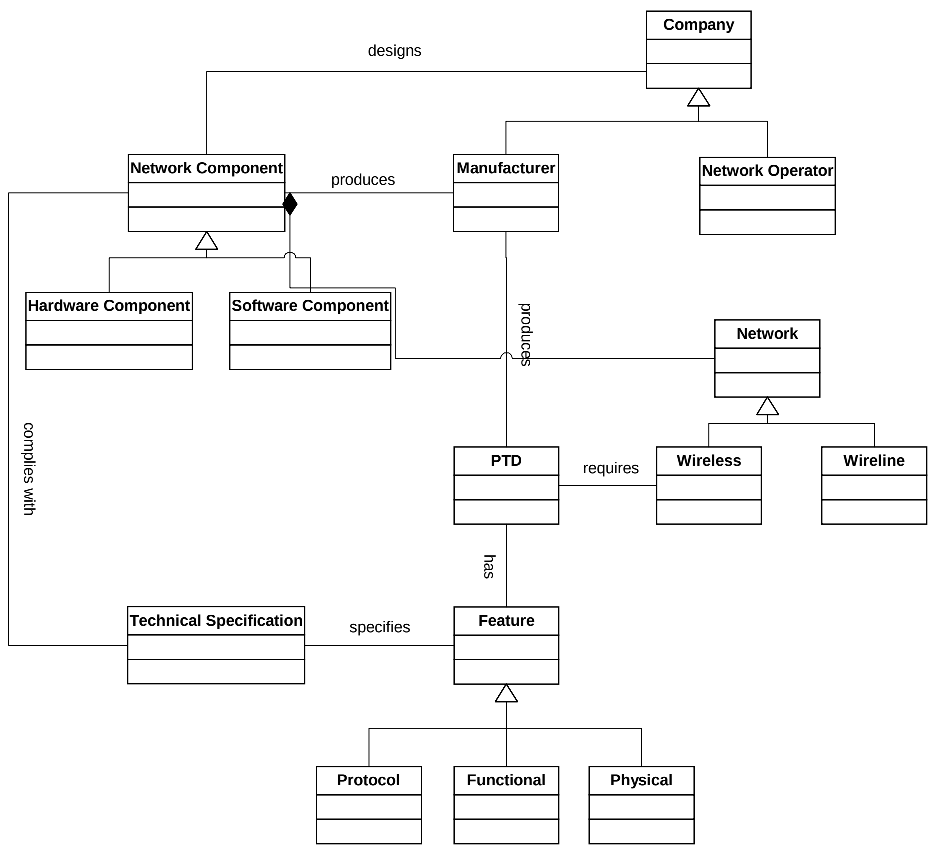
Enabling Technologies

Advances in electronic commerce, in general, and in mobile electronic commerce, in particular, have, to a large extent been spawned by technological advances, both with respect to wireless network technology and user device or terminal technology. In this section we focus the second part of the overall mobile commerce model, i.e., Enabling Technologies.

It is not just one technology that makes mobile commerce possible. It must also be available for users through mobile terminals, access networks, and servers. Personal Trusted Devices (PTDs)—i.e., wireless terminals with personal flavor and security facilities as access devices in mobile commerce—are in a crucial position in this respect. This is due to the fact that the technologies incorporated in them (such as processors, protocol stacks, and local applications) largely determine which M-commerce services can be offered. Indeed, the current PTDs where a PDA and a GSM phone are integrated and run WWW and WAP browsers offer mobile access to the Internet and M-commerce services but use the basic GSM services offered since the beginning of 1990s. The GSM network technology was thus mature enough from the beginning for mobile commerce, but before the terminals had reached the current stage of development, mobile commerce could not be realized. For these reasons, PTD is in the center of the Enabling Technologies sphere in our model, as shown in Figure 4.

Each Personal Trusted Device is associated with a set of features, which can be classified as protocol features, functional features and physical features. Protocol features represent wireless network protocol stacks that the device supports (e.g., GSM and WAP stack). Functional features subsume a variety of different functional

Figure 4: Enabling Technologies.



aspects, for example, positioning (like GPS receiver functionality), and security and privacy features. As indicated above, features of PTDs are defined in technical specifications that manufacturers have to adhere to. Notice that the technical specification class is also present in the Regulatory Frameworks part of the overall mobile commerce model. These overlapping classes will act as the bridge between the Enabling Technologies and Regulatory Frameworks spheres. That is, the impact of the Regulatory Frameworks on the Enabling Technologies comes, among other things, through the technical specifications.

Besides the manufacturer, the network operator is another subclass of company involved in Enabling Technologies. While manufacturers produce Personal Trusted Devices, network operators also take part in technology development either directly or through various interest groups. For instance, NTT DoCoMo specified the i-Mode technology and let the manufacturers produce the concrete network components and terminals. In the WAP Forum, network operators try to influence technology development through technical specifications.

Global Infrastructure

Enabling technologies are a necessary ingredient for the concrete deployment of wireless network technology. We keep the deployed networks separate from the base technologies for several reasons. First, there are many individual technologies (such as encryption and protocols) that must be joined coherently in order to form a functioning global infrastructure. Second, the individual technologies were developed rather independently from each other and are controlled by players other than telecom operators or network providers. Third, the deployment of the concrete networks is largely on the responsibility of the individual telecom and other operators, such as Internet Service Providers (ISPs). It follows that the global infrastructure is fragmented into hundreds of wireless access networks and a (few) backbone network(s). Each network is conformant with the legislation of the country or area where it is deployed. This causes many potential differences. Although the different network generations might be interoperable among each other, the concrete networks still might be, technically, at different stages (e.g., 2G, 2.5G (GPRS), 3G). In addition, a terminal can roam and can or cannot get access to the wireless networks of different operators based on the roaming contracts. But getting access to the wireless network at the levels 1-3 does not yet guarantee that the terminal is able to, in fact, access the local M-commerce services. This is because the business model or the technical level implementation might be different (e.g., markup languages in the home network and in the visited network may differ), or it simply cannot find the services in the local network, because it does not know the address of the service directory or cannot access it due to protocol differences. Finally, even if the terminal would be able to find the services and offer them to the user, it might not understand the local language used in the services in order to properly use them.

The abovementioned problems are largely independent from the Enabling Technologies and also, as it turns out, from the Business Models. They all manifest the same phenomenon at different system levels. The phenomenon is sometimes called *roaming heterogeneity*. It is a severe issue of the wireless global infrastructure that is currently not fully understood, albeit recognized or even solved. For instance, the OMA Initiative (2002) does not use the term, but it addresses exactly roaming heterogeneity at the service level, as was discussed in a previous section.

We envision that the PTDs and the wireless networks will persist far into the future and the networks are deployed and managed by (mobile) network operators. Irrespective of the technology generation, the structure of the networks is rather coarse, such that the wireless link is between the PTD and a base station or another entry point and the backbone network is wired. We also assume that there are hundreds or thousands of operators in the world that have their own customer base. Each wireless network occupies a restricted geographical area. Because competition is allowed and required in the telecom markets, there are several wireless networks operated in the same geographical area. From this basic organizational arrangement, it follows that customer roaming requires a patchwork of contracts between operators. It also requires technical support within the network that is at least as powerful as in GSM networks. In theory, a user can roam between different network operators even if she would not leave her home country, but because of competition this is not common. Roaming precludes, thus, that the customer moves to the operation area of a foreign operator in another country or region.

The submodel of the Global Infrastructure sphere is shown in Figure 5. As represented by the inheritance hierarchy shown, the networks managed by operators may be either wireless or wireline. By definition, Personal Trusted Devices require wireless networks in order to operate. As indicated above, these wireless networks can be used to access wireline networks and the services provided. For instance, second-generation wireless networks, such as GSM, can act as access networks to wireline networks, typically to the internet. WAP 2.0 specification assumes that the wireless terminal can indeed be an IP-enabled device, although it is compatible with the complete WAP stack solution introduced earlier, as specified by the WAP Forum (2002).

To sketch the main classes of the submodel shown below, we remark that manufacturers deliver network components that are being used to build and run networks. Networks should obey local legislation, i.e., legislation is pertinent to areas. PTDs may roam to areas and networks. In particular, area binds the validity of the business models and extension of the networks into a specific geographic area. The terminal must roam on this area whenever it wants services from a specific network. It is worth mentioning that there is also a direct relationship with Figure 1. The PTDs are a special case of the mobile terminals, and the wireless access networks are usually those deployed by network operators. To this end, Figure **1** can be seen as a more detailed representation of the different network types and their instances, as well as a rather abstract topology of the components of the overall global infrastructure.

Business Model

The abovementioned spheres of concern provide the environment for the business aspects of mobile commerce. After all, economic aspects are the driving force behind mobile commerce developments and applications, and are the source of revenues for the companies involved.

Timmers (2002) defines business models as follows: A business model consists of:

- an architecture for the product, service and information flows, including a description of the various business actors and their roles;
- a description of the potential benefits for the various business actors; and
- a description of the sources or revenues.

In brief, a business model thus describes the economic player categories, the products and services offered, how the players interact, the information and goods that flows, the sources of revenue, how the economic yield is shared among the players, and how they are related with the above flows. We add the code of conduct to the above list, because it has a considerable local impact on the form M-commerce can adopt.

Japan is probably the most advanced mobile commerce market today. Therefore, we look more closely at it. Devine and Holmqvist (2001) distinguish the following players on that market: user, mobile network operator, telecom operator, application provider, facility supplier, information provider, contents holder, solution

Figure 5: Global Infrastructure.

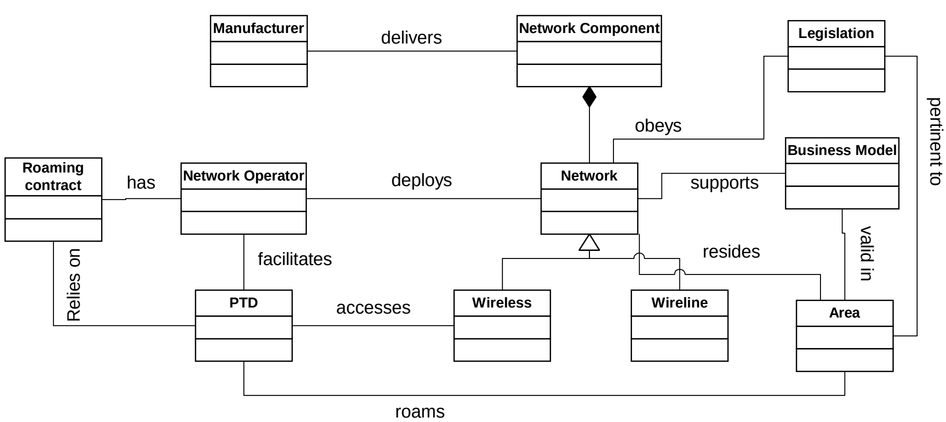
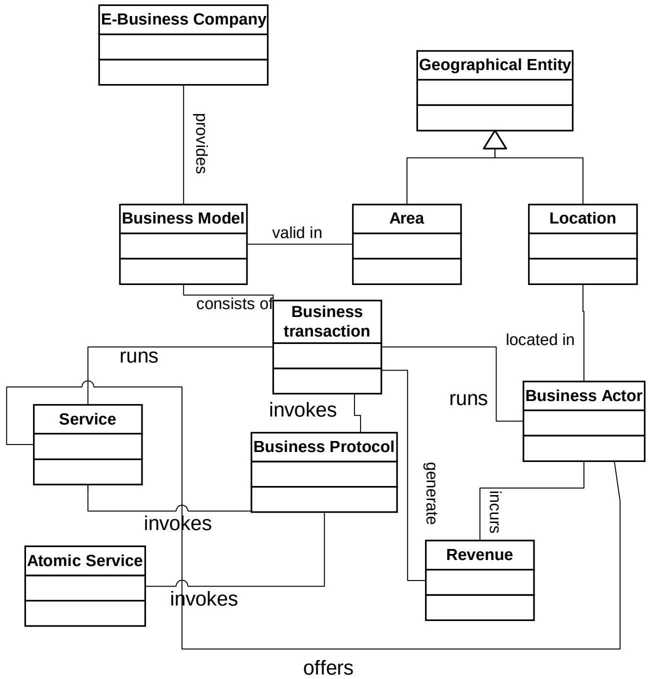


Figure 6: Business Model and Related Concepts. ("transaction" should be capitalized)



provider, financial institution, and terminal manufacturer. All these players get their revenues from the user, but only the mobile network operator, the information provider, the application provider, and the financial institution are directly involved in individual M-commerce business transactions. Thus only these directly participate in providing the mobile e-commerce services and in direct revenue sharing. The other players (like solution provider and contents holder) get their revenues indirectly. NTT DoCoMo's i-Mode service has currently over 30 million subscribers, and the average monthly revenue per subscriber is about 40-50 US $.

The Business Model sphere of the mobile commerce model, reflecting the above narrower view, is shown in Figure 6. The E-Business Company class contains the enterprises involved in electronic business. Business models are in the heart of the e-business companies. A business model consists of one or more business transaction specifications. A business transaction specification consists of a business protocol and service descriptions the protocol can access and handle. One can, for instance, imagine that the business protocol is an abstract protocol specification and a service is a WWW page that delivers the content needed or runs a program changing a database state at the requested organization, e.g., modifies a balance in a bank. The service can be atomic, in which case it does not invoke further business transactions. Notice that the business protocol can also, in this case, still invoke several request-response pairs towards the service. A service can further require other services to be invoked at different sites. Therefore, it runs a new business transaction. Typically, this happens, for instance, if somebody is ordering a book and paying with a credit card. The payment would be a new business transaction between Amazon and VISA. Upon running this business transaction, revenues are generated. We thus model revenue generation at this level of abstraction.

A simple request-reply PDU pair may access a service, but it may also be a complex of services accessed by many request-response pairs. This means the service consists of a set of other services, which are related by a Business Protocol. The concept of Business Protocol is treated in more depth in the next section when discussing an example. At the model level, Business Transaction has Business Protocol as a direct component, but this can invoke Service or Atomic Service.

A business protocol specifies the steps that occur when business partners cooperate, as well as the format of the data exchanged during the cooperation steps. Each step within such a business protocol is typically characterized by the received message and the response sent in another message. A simple one is where upon receiving an order, a mail order company responds by sending a message, acknowledging the order. We remark that there are a number of technologies for business-to-business data exchange, known as business protocols. There are also a number of standards for business protocols in place, e.g., Electronic Data Interchange (EDI). These technologies cover static as well as dynamic parts of e-commerce environments, because they provide data format standards (e.g., data structures of orders) and data exchange standards (messages sent during a successful cooperation). An Atomic Service is conceptually indivisible in that it does not require a further business transaction to be run. An example of a very simple atomic service instance is responding to a weather forecast request with the respective temperature forecasts. As these brief examples show, on the one hand business protocols are used to implement business models; on the other hand they make use of the global infrastructure to enact the services. They are thus the crucial link between these two worlds.

Service composition has recently emerged as an important aspect to develop Web applications based on so-called Web services, sponsored by the World Wide Web Consortium, W3C (2002). Web services are basically applications provided by a company that can be accessed via the HTTP network protocol. Using suitable wrappers, many services that are implemented by back-end systems, e.g., Enterprise Resource Planning systems, can be made available to a large market by Web services technology. While Web services are developed in the context of electronic commerce, they can also be used in mobile commerce environments to provide the base functionality required by a complex mobile commerce application. Consider, for example, a mobile commerce application, where customers can make reservations and book and pay for flights via WAP devices. While the interaction with the customer is provided by mobile commerce technology, the back-end functionality like flight reservation and payments has to be offered by a suitable back-end system.

Web services are a new technology based on accepted standards. While the key technologies are already in place, the composition of Web services is currently under research. The basic understanding of Web services is that the individual functionality accessed by individual Web services (e.g., making a flight reservation) can be combined with other services within a predefined order. It is in this way that application processes can be developed based on individual steps, covered by Web services. For example, a payment step can be followed by a successful flight reservation step. In the next level of abstraction, the new Web service processes, flight reservation and payment, can be made available. We model these aspects of service composition, in general, and Web service compositions, in particular, in the static structure model by a recursive federation between the Services class through Business Transaction and Business Protocol.

Business partners provide services to their customers, i.e., business actors. A business actor can either be an individual (e.g., a person ordering a weather forecast of southwestern France for next Friday), or it may be a corporate business actor. These can make use of services to offer value-added services to their respective customers. The goal of each of the business partners involved is to generate revenue from service's executions. Notice that the legislative bodies provide the legal environment in which the business models are developed.

The Business Models sphere also addresses the geographical validity region of a Business model, represented by the class Geographical Entity, associated with the Business Model class and with the Business Actor class. This is important, as the business actors and the models applied do have a location on earth where they are legal and accessible. It is interesting to notice that the association between business models and geographical location are quite stable: As defined by legislative rules (in the Regulatory Frameworks), a given business model is associated with a geographical location on earth. This may not only be a XYZ-coordinate, but it can also be an organizational entity associated with an area, such as a state or an association of states (for example, the European Union). Hence, the geographical entity class has subclasses geographical location and geographical area, representing the abovementioned concepts in the model.

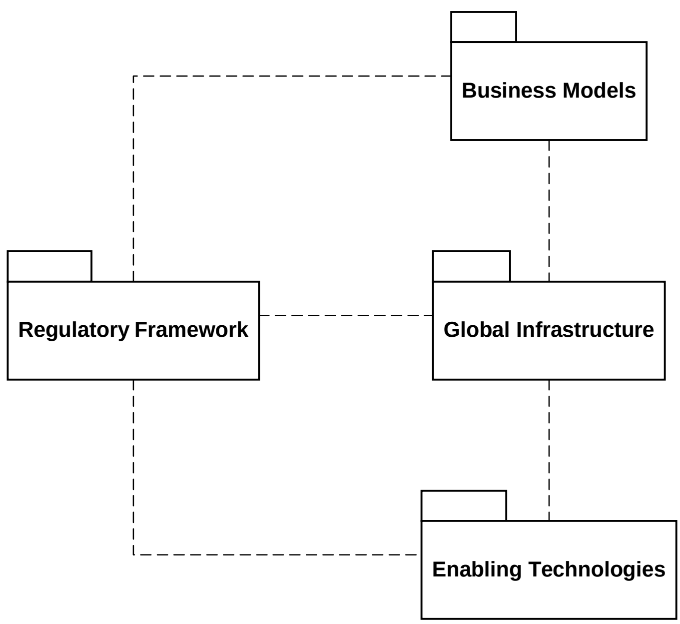
Complete Model

The four spheres developed above are now integrated into the complete mobile commerce model. As discussed above, the glue between the submodels is provided by the associations between classes of the different spheres as well as by common classes. As an example, the Technical Specification class of the Regulatory Framework submodel is associated with the Feature class of the Enabling Technology submodel, gluing the two submodels together. The same holds for the Business

Model sphere and the Enabling Technology sphere, where the Service class is associated with the Feature class. Another form of glue between the spheres is characterized by inheritance: The E-Business Company class of the business submodel is a subclass of the Company class. The overall mobile commerce model is shown in Figure 7. For ease of convenience, each submodel is represented by a package in that figure. These relationships between the packages are represented by the dotted lines in Figure 7.

Additional associations between classes can be drawn. For instance, Regulatory frameworks have a validity region on earth; in particular, the three main regions (US, JP, EU) can be regarded as three geographical regulatory frameworks. Business models adhere to a certain legislation and thus to a certain region, and a terminal is in a certain location on earth that belongs to a certain validity region. The issues in this context are of two kinds: the terminal is able to interact with the rules of a certain region. These rules are characterized by the wireless access network in place, the business model that the services implement, and the protocol stack that is used to facilitate the M-commerce services. While roaming to another region, roaming heterogeneity can occur, i.e., the terminal (or user) is not anymore able to take advantage of the services. Second, and this is a general problem of electronic commerce, as well: the terminal can use services in another validity region than where it is located. If the rules applied to the services differ, whose rules should be followed? Examples of these rules are legislation, governing taxation, duties, and the handling of disputes.

Figure 7: Complete M-Commerce Model.



Some of the above classes have also a direct relationship with the entities presented in Figure 1. The PTD is a subclass of the wireless terminal and the wireless access networks are instances of wireless network in the Enabling Technologies sphere.

SAMPLE SCENARIOS

In this section we look closer at some mobile commerce scenarios in order to illustrate the feasibility of the model presented and in order to discuss location-dependent services —which are at the heart of mobile commerce—in more detail.

Ordering a Taxi

The first scenario is a typical situation in urban environments, where a traveler arrives in a city and wants to order a taxi for local transport. Different phone numbers of taxi agencies in different cities and—in case of foreign countries—language problems render traditional ordering by phone cumbersome, so that mobile commerce services will provide a more convenient solution for the customer.

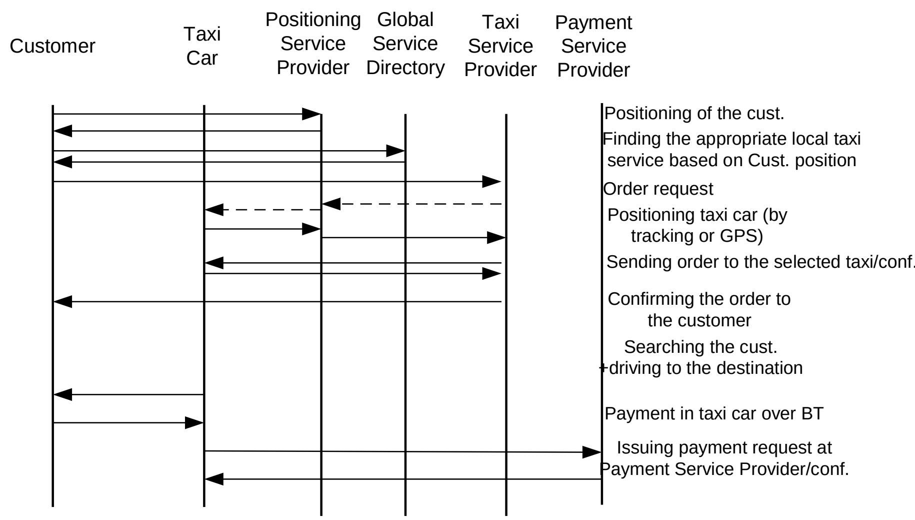
The presence of location information on both the traveler and the taxi facilitates this new convenience. The basic idea of this service is that once the terminal (i.e., the traveler carrying the PTD) and a taxi can be positioned accurately enough, the taxi can be ordered based on that information without the need for the customer to know local phone numbers or local business practices.

At the business model level, it can be expected that a taxi that is closest to the terminal can offer the transportation service cheaper than a more distant taxi. The overall business protocol involved is represented by a simple sequence diagram shown in Figure 8. For each party involved in the scenario, there is a vertical line. The messages between different parties are represented by arrowed lines between the vertical lines associated with the parties. More elaborate techniques to specify business protocols are feasible, but for the purpose of this chapter, the notations based on sequence diagrams will suffice.

Briefly, the steps go as follows:

1. Positioning of the customer terminal (triggered by the terminal)
2. Sending the coordinates and other parameters to a global directory service server that determines an appropriate service provider based on the position and service type
3. Sending the coordinates and other parameters to a taxi server instance, selecting an appropriate taxi (terminal and server involved)
4. Selecting the taxi and guiding it to the customer (server, taxi involved)
5. Finding the customer and picking him/her up (taxi, terminal)
6. Transport as determined by the customer (taxi, physical step)
7. Taking care of payment (terminal, taxi)

Figure 8: Business Protocol, Taxi Scenario.



In brief, the M-commerce infrastructure does the searching and possibly the negotiation for the customer. It is evident that in step 1 the terminal must be able to position itself and in step 3 subsequently send out the coordinates to a server instance that takes care of the taxi ordering. The first step can be performed using the GPS functionality of the terminal or asking the wireless telecom network to find out the coordinates (existing technology for this tasks includes E-OTD, a GSM-based location technology). In the latter case the terminal uses a special positioning service offered by the network.

In step 2, the main task is to find the address of the local taxi service instance to which the taxi order request should be send. This corresponds to the problem of finding the phone number of a local taxi service. In principle, the country, city, and suburb can be deduced from the coordinates of the terminal, but a rather heavy infrastructure service is needed in order to determine the appropriate taxi service center server in the network to which the request should be sent. Marketplace and auction mechanisms can be deployed to trade transportation resources.

Assuming that step 3 is successful, step 4 is taken. It is more complicated than the former ones. During this step, the specific taxi to serve the customer is selected. It is immediately clear that the location of the individual taxis must be tracked by the taxi service center in regular intervals so that the location is known with a reasonable accuracy. Which taxi to select? An obvious answer is “the closest one which is not occupied,” but this is evidently not the only optimization criterion. The closest in Euclidean sense is not necessarily the most appropriate, because the street network might require the closest to drive a long way and maybe stop at many traffic lights before reaching the waiting traveler. Second, the customer can give as part of the order the destination and timing parameters. The latter might indicate that the taxi is needed in, e.g., 10 minutes at the latest. This gives possibilities to optimize the allocation. The destination is also important. Based on the parameters, the taxi service center can optimize the allocation of taxis ahead of time: It knows, at least partially, what will be the location of the fleet in the next 10, 20, or 30 minutes. Knowing the destination might also prune some allocations, because certain drivers would not want to go to the destination indicated by the customer for various reasons. Finally the number of people to be transported as well as specific constraints such as large luggage items are also important and could be provided by the customer. Based on this information the taxi service center can allocate an appropriate vehicle.

Step 5 is about finding the customer. This can be tricky, but ordering the taxi through a PTD helps in several ways. The customer could get as part of the response to his/her order the order number, the license number of the taxi (and even a color picture of it), and the driver's phone number. An even more sophisticated way is to let the taxi track the customer's position while approaching. This is would be handy, if the customer wants to move from the ordering location while waiting. With customer tracking, the need to order the taxi to a certain address and wait there is not necessary anymore. In step 6, the actual trip is performed. The customer can express the destination by giving the address or just confirming the destination given earlier. The point is that the driver and customer need not have a common spoken or written natural language in this phase. The trip is paid in step 7. This can be based on cash, physical credit card, or PTD with payment functionality. PTD can communicate with the payment infrastructure in the taxi using a Bluetooth link and the customer can confirm the payment on the PTD.

Of course, the scenario presented is simplified with respect to numerous aspects. There might be disputes about whether the taxi arrived on time or not, whether the shortest path was chosen, etc. Although important, location-related disputes are for further study (see Tang and Veijalainen (2000) for more on disputes in e-commerce). The commitment to an order and disputes are tricky aspects that are dependent on the business habits (code of conduct) in a country and contribute to the roaming heterogeneity, i.e., business model and technical heterogeneity between countries and mobile network operators. These become evident because people roam and need services from different local providers. Another not so trivial aspect is to map the (XYZ) coordinates to <address>. It is by no means easy in an arbitrary country that uses local coordinate systems. It requires, most probably, coordinate transformations and attachment of them to the local map. Using the XYZ coordinates of the customer directly (in WGS-84 format) is rather hopeless, because they do not tell the taxi driver how to reach the customer. Which player provides this mapping? It can be the taxi ordering company, each individual taxi owner (GPS car map), or an external service provider that upon getting a coordinates <XYZ> returns the <address>. These are actually issues that must be solved within the Global Infrastructure. These infrastructure issues are for further study.

From a business model point of view, it is interesting to investigate what types of players exist and how the revenues obtained from the taxi customer are divided among the parties in the above case. The customer pays both to a mobile network operator and to the taxi company after the trip has been done. If the automated service is not better than the current voice based, the customer is hardly interested in paying more than now. There are still many benefits both from the customer point of view, as well as from the taxi company point of view. Thus, it could be expected that these kinds of systems would become common in the future.

This simple specification of the taxi scenario can be extended in multiple ways. For instance, the ordering system could also support small-scale auctioning; who takes this customer to the destination, how fast and for what price? The result of the auction could then be returned to the customer as a response. These are business model ideas made possible by technology, but the local taxi companies and legislators should endorse them before they become reality.

The above service requires privacy protection measures and customer trust. For instance, the tracking of the phone number should only be enabled for this particular purpose, this taxi-order here and now. In general, M-commerce transaction security can probably be improved through location-based authentication, as it is shown by Denning and MacDoran (1996). Location, as calculated from a location signature, adds a new dimension to user authentication and access control. It can be used to determine whether a person is attempting to log in from an approved location and using approved services. It is for further study, how this kind of authentication can be combined with the M-commerce infrastructure services.

From the discussion of this sample scenario the mapping of the artifacts involved to the mobile commerce model, as presented above, is quite clear. Rather than discussing this mapping in detail, we state the main entities for each submodel:

- *Regulatory Framework:* The Regulatory Framework submodel determines the form of the overall infrastructure and facilitates the terminal and the servers to communicate. While the sample scenario does not rely on any particular wireless network (e.g., no video streams have to be passed), the terminal and the servers have to be connected in a way that facilitates their communication. But technical specifications are not only necessary for wireless networks, but also for the terminal itself and the positioning functionality provided. In some cases the network allows a positioning provided by cell information, unless the terminal can provide the coordinates itself by using a satellite positioning method (GPS, or GALILEO). To provide a more detailed mapping from the entities of the example to the classes of the model, we mention that the device that the traveler carries must conform to some standards (class Standard) set by an organization (Standardization Body). Standards define technical specifications (Technical Specification) consisting of a set of features (Feature) that the personal trusted device (PTD) of the customer offers.
- *Enabling Technology:* The Enabling Technology submodel concentrates on

the terminal and its features. In particular, the personal trusted device was built by a manufacturer that is a company, represented by a super-class relationship between the Manufacturer and the Company class in the model. In order to operate in a particular network environment, the PTD requires a wireless network (Wireless), which is a sub-class of the Network class. Networks are provided by network manufacturers, as specified by the association in the class diagram. In this sample scenario, the PTD has to offer specific features, mainly the ability for positioning to make use of the taxi-ordering service. In the class diagram, this feature is represented by the named association called *Requires* between the Feature and the Service class.

- *Global Infrastructure:* The Global Infrastructure models entities that are relevant for facilitating mobile commerce applications from an infrastructure point of view. In the example at hand, this submodel is required for defining the network communication standards as well as specific PTD properties that, e.g., enables the traveler's PTD to connect to the local mobile network. In addition, roaming contracts between the network operators involved have to be in place to allow the traveler to use services in his or her destination city. Appropriate business models, as well as the legal context, have to be present at that location. As this brief discussion shows, the main classes of the global infrastructure diagram shown in Figure 5 are required in this particular example.
- *Business Model:* The business model is implemented by a set of services, which are executed according to some business protocol. While an exact specification of the protocol is outside the scope of this chapter, we mention that the customer requests the service using his or her terminal. The service is transferred to a service provider, which now performs a series of activities in order to serve the customer well. In particular, location information has to be tracked and an appropriate taxi has to be triggered to serve the customer. The PTD must thus be able to run the business protocol in Figure 8. This is a tricky requirement, unless there is a global standard that the terminal can rely on. The global directory service is an easy issue, because one can assume a globally specified protocol. Particular questions arising from step 3 are: in which format are the coordinates presented to the local taxi service? How are the parameters encoded? What parameters are allowed? How is the result to be interpreted? The taxi service is also a service in our sense, but the special feature is that this service uses a physically moving object (a car) to realize the service. In the business protocol sense a taxi is a service provider and is accessible through the wireless network.

As indicated above, complex positioning issues may arise, taking into account physical aspects such as streets, and maybe even traffic. However, the geographical entity class represents the location-dependent properties of the example quite well, including the location of the taxi and the customer (by the Location sub-class of the

Geographical Entity class) and the area specification where the taxi service is provided (by Area class).

Wireless Payment

Just like fixed payment terminals, PTDs can be used to pay for goods or services, but there are new possibilities, too. A PTD can contain the private key and credit card information of the customer. This information can be used to build services that are based on electronic commerce infrastructures, on the one hand, and on a wireless short-range link on the other. Concretely, the PTD can communicate with the cash register over Bluetooth in order to pay for the (physical) goods in the shopping cart.

In a standardization effort, the Mobile Electronic Transactions Forum (MeT, 2002) has developed a protocol to facilitate wireless payment. As a result, MeT set up recommendations that service providers have to adhere to in order to provide interoperable and efficient M-commerce solutions, e.g., in wireless payment. But wireless payment also requires Enabling Technology and Business Model aspects. For instance, the Enabling Technology includes a public key infrastructure, which can be modeled as a feature of PTDs. Just like previously, these features are defined by Technical Specifications that in the context of payments may also be specified by law (cf., privacy issues related to payment). In addition, wireless payment is organized as a business model of financial institutions. These payment services are provided to the customers, and they consist of a number of services, which are executed, in some order, according to the business protocol in place. Business actors (for instance, the traveler using a taxi) use that service for convenient payment. The financial institution maintains an infrastructure and business relationships that enables it to organize the payment between the parties involved.

Ticketing

The idea of ticketing applications is structurally similar to the location-based services where the customer first determines the location and then uses it to access some service. In the case of ticketing, however, the customer gets the ticket from a merchant, similarly to the goods in the wireless internet e-commerce. The payment scheme can be a credit card, online banking, and also billing. Goods are, of course, in this case intangible, i.e., bit strings that are stored into the memory of the PTD, encoding the ticket information. Days or even months later after loading the digital ticket into the memory of the PTD, the ticket is used when entering the event, for instance a concert hall or an aircraft in case of a travel ticket. The reasonable usage of this form of electronic tickets requires that the PTDs are capable of communicating over short distances with the cash registers or ticketing devices in the busses and concert houses, etc. This can currently best happen over Bluetooth, although Infrared connections might also be feasible in some cases. The general scheme looks as follows:

Tickets can often be cancelled or modified before they are used. If cancelled, the money charged is typically paid back. The cancellation transaction assumes that paying back is possible by knowing, for example, a terminal owner's identity. In practice, money return is possible by using credit card or bank account number stored at merchant's database for customer with the recorded identity. Notice that the ticket could also be modified (typically, an airline ticket is often changed before it is used) and even transferred to other person's PTD, using a Bluetooth or infrared link. We stress that MeT develops schemes for standard ticket formats. In this scenario we refrain from discussing the various classes of the mobile commerce model but leave these considerations to the interested reader.

RELATED WORK

As concerns related work, we are not aware of as extensive approaches covering wide aspects of mobile commerce environments as ours. A work somewhat relevant to the one presented in this paper is Siau and Lim (2001), where the authors provide an overview of mobile commerce and a research agenda. A clear separation between Enabling Technologies and Business Models is drawn, but no particular modeling incentive is applied. That paper concentrates on Enabling Technologies and Business Models spheres of concern in our sense. The Regulatory Frameworks sphere is hardly touched, and it is not treated as a special theme requiring attention.

A somewhat similar framework for M-commerce applications, as ours is presented by Varshney and Vetter (2001). The framework also uses a layered approach, but it focuses strictly on technological layers. The main purpose of that work is to assist in the development of M-commerce applications. It analyzes M-commerce application types, such as mobile financial applications. The paper shows, in a pragmatic way, that the properties of wireless network technology can be reflected to the application under development. Thus, the paper is well equipped to improve the development of M-commerce applications. The focus of our chapter is different: it is broader and more formal. It is broader since not only technical but also organizational and legal aspects are covered in the four spheres of concern. It is more formal, since for each layer the main artifacts are modeled using an object-oriented approach. Finally, we seek to find invariant properties of mobile commerce environments, which are not covered in Varshney and Vetter (2001).

CONCLUSIONS

This chapter discusses mobile commerce environments from a bird's-eye perspective. The focus is on organizing the main concepts and players in mobile commerce into four spheres of concern with the aim of a better understanding of this complex and dynamic area. The fundamental basis is the Global Infrastructure. It consists of wireless and wireline access networks and a global backbone, able to transmit huge amounts of data between terminals and servers. The Global Infrastructure covers a huge number of wireless terminals, soon more than 1 billion. This basic structure facilitates mobile commerce and will persist a long time into the future, although the concrete wireless and wireline access technologies and those of the backbone itself will change over time. We expect the digital convergence to homogenize the backbone technology, and it is also rather probable that all wireless and wireline terminals will have a unique global network address in the future. The access technologies will show more variety and at least the big division into wireless and wireline technologies will persist.

From an M-commerce point of view, transmission speeds have an important role, because faster—and cheaper—wireless data transfer enhances the set of M-commerce services that can be used by the customers. Transmission speeds on individual channels will increase in both categories over time. A curious exception seems to be the telecom voice traffic, where the 4kHz bandwidth and 64 kbps uncompressed capacity requirement are expected to persist years. Wireless channel data transfer rates will have to grow but will in general be much smaller than wireline ones. Still, already GPRS offers transmission speeds that are essentially the same as typical wireline modems, and 3G should mean a considerable improvement in this respect. In overall traffic volume, wireless traffic will increase relatively and absolutely. Within the wireless access networks, voice traffic will form a smaller portion than currently and data traffic a greater portion. Still, the wireless voice traffic will grow many years to come, because the rapid proliferation of the wireless phone customer base increases the traffic volume.

Global Infrastructure will consist of hundreds or thousands of different networks, run by different operators. The terminal owner has a home network, and if that cannot service her while roaming, foreign networks have to offer wireless access and network services. The nasty problem is roaming heterogeneity that is encountered at each system level. The Open Mobile Architecture Initiative tries to tackle this problem at the M-commerce service level.

It remains to be seen how this will succeed, because it is not only a technical and organizational issue, but also a legal and business issue.

Another fundamental sphere is Enabling Technologies. Their development was a necessary condition for the mobile commerce to emerge. The Personal Trusted Devices are in a crucial position in this respect, because the technologies incorporated in them largely determine which M-commerce services can be offered. The advances in enabling technologies, such as integrated circuits, processor technology, wireless communication technologies, software technologies, cryptography, battery technologies, positioning technologies, etc., and their implementation in PTDs are a crucial condition for mobile commerce to advance qualitatively. Through increasing M-commerce functionality more sophisticated services are possible and, consequently, higher revenues become possible.

A further relatively independent sphere of concern is Business Models. For the concrete business models the Enabling Technologies and the Global Infrastructure are a necessary basis. Our modeling effort concentrates on the basic business actors and their interactions over the network that form the concrete instantiation of the mobile commerce. We exclude the infrastructure providers that do not explicitly take part in performing M-commerce transactions. The main source of revenues is the customer accessing the M-commerce services over the network infrastructure, but also advertisement or other similar sources are possible. The Business Models sphere also addresses the geographical validity region of a business model. This is important, as the business actors and the models applied always have a place or area on the earth where they are legal and/or accessible. How high can the revenues of individual actors be? What kind of business actors and models can exist? These kinds of questions are not answered at the level of our model, but they are interesting and must be tackled in the future. Our modeling incentive helps in focusing on the right issues.

Finally, we discuss Regulatory Frameworks. These include the legal bodies that issue legislation, as well as standardization bodies and interest groups. They all can be seen as global designers specifying a common interoperability area. Some standardization bodies, like ISO or ETSI have basically global coverage. They do not, however, have any legal means to enforce the standards into usage. A typical problem with the current truly global standardization bodies is that they are rather slow in developing the standards, in comparison to the emerging needs. This has led to the establishment of industry-led unofficial bodies that we call interest groups. For mobile commerce area the most important bodies are the WAP Forum, the Mobile Electronic Transactions Forum, and the Location Interoperability Forum. A still less cohesive conglomerate is the Open Mobile Architecture Initiative (OMA), but it has the most ambitious goal: "to create a nonfragmented, interoperable global market for the next generation of mobile services." Should this initiative be successful, it will have crucial impact on the future of M-commerce.

Common to mobile commerce and electronic commerce, as they exist currently, are technologies like HyperText Transfer Protocol (HTTP) for communication, HyperText Markup Language (HTML) or a member of the eXtensible Markup Language (XML) family for content, and the Java programming language for functionality. Regulatory bodies and especially interest groups also specify these. Furthermore, they play an important role also in business aspects. For instance, there are a couple of interest groups involved in setting up XML-based recommendations for business to business integration; the ebXML approach is put forward by OASIS and UN/CEFACT, a United Nations body. Naturally, there are a couple of differences in the Enabling Technology sphere between electronic commerce and mobile commerce. There is little need for defining specific devices and their properties, since electronic commerce applications are typically run by a computer connected to the Internet. Business aspects, however, are quite similar. There are electronic business companies, which offer services and business protocols to implement their business models. The Mobile Electronic Transaction Forum, for instance, is actually defining essential parts of the business model (services and protocols), but also lower-level technical specifications. Whether this is feasible, globally, remains to be seen.

In this chapter we propose a conceptual, object-oriented model to describe different spheres of concerns in mobile commerce environments. The framework seems promising. We are confident that the spheres of concern introduced here are fruitful in the forthcoming research. At the same time we are aware of the limitations of the work as concerns the analysis of the dynamics of the M-commerce field. This is for further study.

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REFERENCES

ANSI (2002). *American National Standards Institute* [online]. Accessible at http://www.ansi.org.

Booch, G., & Rumbaugh, J., & Jacobson, I. (2001). *The Unified Modeling Language User Guide*. Boston: Addison-Wesley.

Bluetooth Consortium [online]. Accessible at http://www.bluetooth.com.

Denning, D. E., & MacDoran, P. F. (1996). *Location-Based Authentication: Grounding Cyberspace for Better Security, Computer Fraud & Security*. Elsevier Science Ltd. Accessible at http://www.cosc.georgetown.edu/ denning/infosec/Grounding.txt.

Devine, A., & Holmqvist, S. (2001). *Mobile Internet Content Providers and Their Business Models*. Master’s thesis, Stockholm Kungl Tekniska Högskolan, January 2001. Accessible at http://www.japaninc.net/online/sc/master_thesis_as1.pdf.

Durchlacher Research, Ltd. (2000). *Mobile Commerce Report* [online]. Accessible at http://www.durchlacher.com.

EU Information Society portal (2002). Accessible at http://europa.eu.int/information_society/services/sitemap/index_en.htm.

EU E-Commerce legislation portal (2001). Accessible (archived) at http://

europa.eu.int/ISPO/ecommerce/legal/legal.html.

ETSI (2002), European Telecommunications Standards Institute (ETSI) [online]. Accessible at http://www.etsi.org.

Oasis, UN/CEFACT: *Electronic Business Exchange Jointly Sponsored by OASIS and United Nations Centre for Trade Facilitation and Electronic Business* [online]. Technical Documentation accessible at http://www.ebxml.org.

Helal, A., Haskell, B., Carter, J. L., Brice, R., Woelk, D., & Rusinkiewicz, M. (1999). *Any Time, Anywhere Computing; Mobile Computing Concepts and Technology*. Kluwer Academic Publishers.

IEEE (2002). The Institute of Electrical and Electronics Engineers, Inc. [online]. Accessible at http://www.ieee.org.

IEEE LAN/MAN Standards (2002). LAN/MAN Standards Committee 802 [online]. Standards available at http://grouper.ieee.org/groups/802/.

ISO (2002). *International Organization for Standardization (ISO)* [online]. Accessible at http://www.iso.org.

ITU (2002). International Telecommunication Union [online]. Accessible at http://www.itu.int/home/index.html.

Kaario (2000). A wearable project presentation [online]. Accessible at www.uta.fi/hyper/projektit/iti/esitykset/kaario_clothes.pdf.

Kahney & Leander (2002). *Video Clothes: "Brand" New Idea*. [online]. Accessible at http://www.wired.com/news/technology/0,1282,36698,00.html.

Location Interoperability Forum (LIF) (2002). Accessible at http://www.locationforum.org.

MeT (2001). *MeT overview White Paper: The MeT Initiative—Enabling Mobile E-Commerce* version 2.0, January 2001 [online]. Accessible at http://www.mobiletransaction.org.

MeT (2002). Mobile electronic transactions forum [online]. Accessible at http://www.mobiletransaction.org.

MIT (2002). The MIT wearable computing Web page [online]. Accessible at http://wearcam.org/computing/.

Nordea Bank (2002). *See Especially Solo Services* [online]. Accessible at http://www.nordea.com.

NTT DoCoMo (2002). FOMA Services/V-LIVE [online]. Accessible at http://foma.nttdocomo.co.jp/english/.

OMA (2001). *Open Mobile Architecture Initiative* [online]. Press releases available at http://press.nokia.com/PR/200111/840158_5.html, http://www.hp.com/communications/nokia_mobile.html.

OMA (2002). *Open Mobile Architecture Initiative* [online]. Accessible at http://www.nokia.com/oma/.

Siau, K., & Lim, E. (2001). Mobile commerce: Promises, challenges, and research agenda. *Journal of Data Management*, *12* (3).

Tanenbaum, A. S. (1996). *Computer Networks*, 3rd ed. Englewood Cliffs: Prentice Hall.

Tang, J., & Veijalainen, J. (2000). On e-commerce transaction protocols that support atomicity based dispute handling with untrustworthy players. *Proceedings of the 3rd International Conference on Telecommunications and Electronic Commerce* (ICTEC 2000), Dallas, TX, USA, Nov. 16-19, 2000, pp. 299-314.

Tang, J., Terziyan, V., and Veijalainen, J. Distributed PIN verification scheme for improvement security of mobile devices. *ACM MONET*, Special issue on security in mobile computing environments (forthcoming).

Telecommunications Policy (2002). 26 (3-4). List of contents accessible at http://www.elsevier.com/cdweb/journals/03085961/viewer.htt?vol=26&viewtype=issue&iss=3-4.

Timmers, P. (2002). Business models for electronic markets. Accessible at http://www.electronicmarkets.org.

UMTS forum (2002). Accessible at http://www.umtsforum.org.

Varshney, U., & Vetter, R. (2001). A framework for emerging mobile commerce applications. In R. Sprague (ed.): *Proceedings of the 34th Hawaii International Conference on System Sciences.*

Veijalainen, J. (1990). *Transaction concepts in autonomous database environments.* Ph.D. thesis. Berichte der GMD Nr. 183, Oldenbourg Verlag, 1990.

Veijalainen, J., Eliassen, F., & Holtkamp, B. (1992). The S-transaction model. In A. Elmagarmid (ed.), *Database transaction models for advanced database applications*. San Mateo: Morgan Kaufmann.

Veijalainen, J. (1992). Issues in Open EDI. In P. Ng, C. Ramamoorthy, L. Seifert, & R. Yeh (eds.), *Proceedings of the Second International Conference on Systems Integration* (ICSI'92), Morristown, NJ, June 15-18, 1992, pp. 401-412.

Veijalainen, J., & Tsalgatidou, A. (2000). Electronic commerce transactions in mobile computing environment. In Q. Jin, J. Li, N. Zhang, J. Cheng, C. Yu, S. Nogushi (eds.), *Proceedings of IS2000 Conference*, Fukushima, Japan, November 5-8, 2000, (pp. 37-45). (Best Paper Award). Accessible at http://www.cs.jyu.fi/~mmm.

Veijalainen, J., & Tsalgatidou, A. (2001). Electronic commerce transactions in a mobile computing environment. In Q. Jin, J. Li, N. Zhang, J. Cheng, C. Yu, & S. Noguchi (eds.), *Enabling Society with Information Technology* (pp. 131-140). Springer Verlag.

WAP forum (2002). Wireless Application Protocol Forum [online]. Accessible at http://www.wapforum.org.

W3C (2002). The World Wide Web Consortium [online]. Accessible at http://w3c.org.