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Challenges in Mobile Electronic Commerce

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ABSTRACT

Advances in wireless network technology and the continuously increasing number of users of hand held terminals make the latter an ideal channel for offering personalized services to mobile users and give pace to the rapid development of Mobile Electronic Commerce (MEC). MEC operates partially in a different environment than Internet E-Commerce due to the special characteristics and constraints of mobile terminals and wireless networks and the context, situations and circumstances that people use their hand-held terminals. In this paper, we discuss challenges in electronic commerce transactions including designing new business models, applications and services.

I. INTRODUCTION

Advances in wireless network technology and the continuously increasing number of users of hand held terminals make the latter an ideal channel for offering personalized services to mobile users and give pace to the rapid development of e-commerce conducted with portal devices.

As a mobile e-commerce transaction, we define any type of transaction of an economic value that is conducted trough a mobile terminal that uses a wireless telecommunications network for communication with the e-commerce infrastructure. Mobile Electronic Commerce (MEC) refers to e-commerce activities relying solely or partially on mobile e-commerce transactions. MEC operates partially in a different environment than E-Commerce conducted in fixed Internet, due to the special characteristics and constraints of mobile terminals and wireless networks and the context, situations and circumstances in which people use their hand-held terminals. MEC has a number of business, technical and legal implications that are different from e-commerce in the fixed Internet setting. Most notably, location-based products and services is a completely new business, technical, and legal area that is typical of MEC.

MEC becomes interesting with the huge proliferation of the WWW-based business-to-consumer (b-to-c) E-commerce in Internet since 1995 and the simultaneous and huge proliferation of digital wireless telecom networks throughout the world (well, not so vividly in USA). Around 1995-1996, it became obvious for the telecom infrastructure providers, such as Nokia, Ericsson, Motorola, that bringing together the earlier separate digital telecom networks and Internet would offer very attractive business opportunities for the telecom infrastructure and handset manufacturers and increased value for the telecom customers. Why shall we use only PC for Internet and mobile terminal for voice traffic only, as the latter could be used for Internet, too? And maybe solely the mobile handset could be used to access Internet. The result of these considerations was the Wireless Application Protocol (WAP) on one hand and TCP/IP+HTTP supporting mobile handsets like the Nokia 9000 Communicator on the other hand. The latter came to the market in 1996-1997 (second generation Communicator Nokia 9110, which became WAP capable, in 1999) (Nokia Products 2000). WAP was developed by the Wapforum founded in 1997, aiming to develop the wireless Internet-like standards for digital wireless telecom networks. WAP can be understood as a kind of thin Web due to its simple Wireless Markup Language (WML) and simple browsers for the language, as well as a special protocol stack (WAP stack) that suits better to the wireless environment than the standard TCP/IP+HTTP stack.

WAP plays an important role in MEC by optimizing Internet standards for the constraints of the wireless environment and hand held terminals and thus bridging the gap between Internet and mobile world. Thus, it opens, at least in theory, also the existing e-commerce infrastructure in Internet for mobile handset users. Furthermore, WAP creates new business opportunities for players in the field, like device and infrastructure manufacturers, content and service providers, and for Mobile Network Operators. The latter can play a more active role and become more profitable and competitive while providing contents either solely in WML or both in HTML and WML. Also, the above mentioned location-based services and products become an attractive business opportunity for the Mobile Network Operators and contents providers when there is technology in sight that can support the services.

It is not yet sure how well WAP (or similar technology in Japan called I-mode) will be able to proliferate. From our point in this paper the fate of WAP is not essential, because there are already handsets like the Nokia 9110

Communicator that can be used perfectly well with or without WAP capabilities to perform mobile e-commerce transactions and more and more similar handset products are appearing on the market place. Thus, whether Web or WAP enabled devices are used for MEC, does not influence much our analysis below.

II. MOBILE WIRELESS COMPUTING

Wireless mobile computing faces many constraints (a) the characteristics of wireless communications, (b) device constraints and (c) mobility.

Wireless Communications

The necessary networking infrastructure for wireless mobile computing in general combines various wireless networks including cellular, wireless LAN, private and public radio, satellite services, and paging. In wireless networks, digital signals are modulated into electro-magnetic carriers that propagate through space with about at the speed of light. The carriers used are radio waves or infrared light. In wireless telecom networks, the carrier frequencies used are around 900 MHz (European GSM), 1.8 GHz (GSM in America, DECT in Europe). 2.4 GHz and 5.8 GHz are also allocated for wireless networks

There are numerous modulation techniques developed for digital signals that suit to different environment, including frequency and amplitude modulation, frequency shift modulation, as well as pulse coded modulation. The basic benefit of digital communications over analog ones is that there are only two different values (zero and one) to be modulated to the carrier and thus optimal schemes can be chosen. As a net result, bandwidth can be freed to other usage whenever analog wireless communications are replaced by digital ones.

The physical layer design of the wireless networks is not directly important in this context, although all the consequences are derived from the properties of the radio waves (infrared connections are not interesting in this context).

As compared with wireline networks, wireless radio communications add new challenges:

- C-autonomy. The handsets in the wireless radio networks are normally not always communicating with the network infrastructure, i.e. they are unreachable. There are numerous reasons for this behavior that can be described under Communication)-autonomy. First, disconnections may be voluntary, e.g., when the user deliberately avoids network access during nighttime, or while in a meeting, or in other places where the user does not want to be disturbed. In the case where the handset does not have voice capabilities, and thus disturbing is not a big issue, it is still often reasonable to cut the wireless communications with the network to reduce cost, power consumption, or bandwidth use. The break in on-going communication or incapability to set up any communication can also happen against the will of the user, e.g., when a user enters a physical area where there is not any or not enough field strength for a successful, battery becomes suddenly empty, or hand-over between base stations does not succeed and the connection is therefore lost.

When analyzing the different situations, one must differentiate between non-reachability of the device from the network because the user wants to exhibit her C-autonomy and non-reachability of the device against the will of the user. The latter can be called disconnection in the strong sense, if there was an ongoing connection between the terminal and the network when the device became unreachable for the network. But if the user just shut down the radio transmitter in the middle of a connection, then this is a disconnection only from the network point of view. It is a voluntary disconnection from the user's point of view.

Disconnections can be categorized in various ways from the point of view of the user, hand-held terminal, or the network infrastructure. Disconnections are either predictable or sudden from some point of view. For example, voluntary disconnections are predictable from the user point of view. From the device point of view they can be sudden. Clearly predictable disconnections from the device point of view include those that can be detected by changes in the signal strength, by predicting the battery lifetime, or by utilizing knowledge of the bandwidth distribution. They become predictable to the user only if the device informs her about them in advance. Sudden are the disconnections that cannot be predicted by any of the parties. In general, if the disconnection can be predicted by the device, it can usually inform the network infrastructure and the user of the immediate disconnection and then perform it properly. If it is sudden from the device point of view, there is no time or possibility to do anything before the connection breaks. Afterwards, the device can of course inform the user about loss of connection. These are the most difficult situations from the application point of view. From the communication infrastructure point of view, there is not much difference whether the connection just breaks or whether it knows about it just before it happens; sometime after the disconnection it will anyhow release the resources allocated for the connection if nothing happens anymore.

From the network and application architecture point of view, the major factor of non-reachability and disconnections of the hand-held sets is the C-autonomy of the hand-held devices. They are not always reachable (typically during the nighttime) and can become at any time unreachable if the user wants it, or for other reasons against the users' will. The better technology we will have, the less cases of non-reachability and disconnections we will have due to the technical problems and the more of the cases are directly a consequence of the C-autonomous behavior of the user against the network

Bandwidth restrictions and network topology: In the case of many wireless networks, such as in cellular or satellite networks, communication channels have much less transfer capacity than wireline network. This is caused by the fact that the used modulation and channel allocation schemes designed for voice traffic have rather modest upper bounds. Further, the wireless communications are much more error prone than the wireline communications and require much redundancy in the channel coding of the payload. In spite of the redundancy in the channel coding that makes correcting bit errors in large scale possible at the receiving end, retransmission of the data is required more often than in the wireline network.

Further, the protocol overhead (headers) requires certain amount of the channel capacity, as in any network. Therefore, the available nominal transfer capacity of a channel is used rather inefficiently. E.g. GSM network offers typically 9.6 or 14.4 kbits/s transfer capacity for both downlink and uplink directions for the application data over CSD, although the nominal capacity of a logical channel used is ca 30 kbits/s.

The wireless IP network over GSM infrastructure, GPRSwill offer basically a variable capacity up to 172 kbits/s. In practice, it is expected that the transfer capacity remains around 100 kbits/s. UMTS has the promise to provide 2 Mbits/s for both uplink and downlink in a connection. Wireless LANs offer then 1- 10 Mbits/s. The fact is and seems to persist in the foreseeable future that the transfer capacity of the wireline networks is several orders of magnitude higher than that of the wireless network are of interest in this context.

Some wireless networks offer asymmetric transfer capacity for up- and downlink. Especially GPRS can in principle offer this, but in practice only when there is not too much voice traffic. The reason is that voice traffic needs the same number of uplink and downlink logical channels allocated. Thus, allocating e.g. two downlink logical channels for a data connection and one uplink channel for it prohibits one voice call to be set up, even if there is one uplink logical channel free. The asymmetry in channel allocation gives only then the full benefit, when there are both such applications that need more uplink capacity than downlink capacity and vice versa and the need of the applications for channels is in balance (within a cell).

The asymmetric transfer capacity on uplink and downlink can be applied in a reasonable way if the network offers broadcast facility. This is unfortunately not a strong side of the telecom networks, because they were designed for connection-oriented point-to-point communications. Wireless LANs are better in this respect, because they apply packet broadcast protocols anyhow. GSM networks have broadcast facility on the control channels, but the amount of application data that can be transferred on them is small. The currently very popular short messages (max 160 characters) are an example of such data that is transferred over control channels. If used e.g. to broadcast multimedia contents over the network, the network would collapse, because controlling the traffic would not be possible any more- and still certainly no videos could be watched at the handsets.

Still, the asymmetric transfer capacity is an important asset in cases where the wireless client usually sends a short request and gets a large data set as a response. We have envisioned this kind of behavior e.g. applications, where the mobile users request a local map to be transferred to the handset.

In particular, server machines should be provided with a relative high-bandwidth wireless broadcast channel to all clients located inside a specific geographical region. One should also note that, in general, it costs less to a client in terms of power consumption to receive than to send.

- **Variant bandwidth and bursty traffic**: Currently, multi-network terminals are emerging that can use several networks to communicate. Typical forerunners are the dual-band devices that are able to use 900 MHz and 1.8 GHz GSM networks. Soon, there will be products that are able to also use WLANs and possibly Bluetooth (Bluetooth, 2000), together with GSM, GPRS and soon also UMTS network infrastructure. Wireless technologies (e.g., BT, WLANs, cellular telephony) vary on the degree of bandwidth and reliability they provide. In this respect one can speak of variable bandwidth. Another phenomenon also observable in the wireless world is bursty traffic. As Norros and others have found out, in Internet-type networks, the traffic pattern is bursty, and this holds in different time scales (so it is "fractal" in a sense).

- **Variant Tariffs**: For some networks (e.g., in cellular telephones), network access is charged per connection-time, while for others (e.g., in packet radio), it is charged per message (packet). In the WAP environment there is a larger variety of tariffs, e.g. session-based, transaction-based, connection time-based while in Mobile E-Commerce the range of tariffs is even wider.

Device properties

Mobile devices that are of interest to MEC can be divided into four categories based on their processor, memory and battery capacity, application capabilities (SMS, WAP, Web), as well as physical size and weight. These categories are (from weakest to strongest): usual voice handsets with SMS capability, WAP phones, Communicators/PDA+wireless communication capability, and finally laptops with wireless communication facilities.

To be easily carried around, mobile devices must be physically light and small. Everybody, who has dragged a 3 kg laptop would say that it is not practical for anywhere anytime computing. On the other hand, a usual wireless phone weighing less than 100 g is easy to carry but cumbersome to write anything long due to the small multifunction keypad. PDA class is a compromise that has already the WAP and/or Web capabilities. Such considerations, in conjunction with a given cost and level of technology, will keep mobile elements having less resources than static elements. Thus, we can argue for the following invariants in these device classes:

- The physical size of the device should be such that it can be carried in a pocket and it should not weigh more than 100-200 grams. On the other hand, it should not be too small, because then it becomes impossible to use the keypad and also use the device into voice traffic. Going below 100 g is not necessary. Neither is it possible if the battery is expected to last a reasonable time between recharging (see below).

- As a consequence of the above, the optimal portable devices have small screens and small, multifunction keypads; the former fact necessitates the development of appropriate visual user interfaces, different from the PC or laptop. The visual interfaces can use colours; voice-based interfaces can be also used in a natural way. For the latter, the physical size of the device is not so important, whereas for the former it is. The keypad must have a minimal physical size in order to be usable. Unless clever new technologies are invented to replace the keypad, it and the screen determine the lower bound for the size of the devices.

- Portable or embedded devices have less resources than static elements, including memory, disk capacity (usually absent from the three lower classes) and computational power than traditional computing devices. This is, however, only relative. The processor capacity of the current PDAs is at the level of a PC five years ago, and probably in a few years the 1 GHz clock speed processors will have reached the handsets. With memory the development is similar, because the memory chips also will contain more bits in the same physical space. The only problem is that the more speed the processor has, the more energy it tends to consume, because the voltage used in the circuitry tends to be higher in fast processors.

- Portable devices rely for their operation on the finite energy provided by batteries. Even with advances in battery technology, this energy concern will not cease to exist. This is because the conserved energy depends primarily on the weight volume of the battery. Different technologies have in this respect different coefficients, but the law is the same. Thus, the tendency might be that larger and larger part of the device's weight and volume consists of the battery and smaller part of the circuitry in the future.

- There are higher risks to data stored and transactions performed in mobile devices, since it is easier for mobile devices to be accidentally damaged, stolen, or lost than for fixed devices.

Mobility

The big promise of wireless networks is the mobility that is offered to users. Apart from C-autonomy, mobility is the other main factor that determines the network architecture. GSM infrastructure allows roaming all over the world, i.e. the user can get access to voice and data services basically in any other GSM network (in practice of course the operators must have roaming contract). Further, GSM technology guarantees that voice calls and data services are available while moving, irrespective of the cell borders. That is, user can drive through several cells and be able to continue a phone call or data connection without interruption, even if the base station servicing the device is changed maybe several times. This is facilitated by the so-called hand-over mechanism. Similar mechanisms exist for WLANs. The network infrastructure keeps track of the location of the devices automatically. They need only to register at one base station.

Mobility causes diverse phenomena. First, while visiting a foreign country, the services offered by the telecom network used might differ from those at home. This might have drastic consequences for MEC, if the e-commerce infrastructure used needs them. Maybe the user cannot recharge the battery in the country. Then, in a smaller scale, the bandwidth might vary, if a mobile terminal rely on low bandwidth networks outdoor, while inside a building it may be offered reliable high-bandwidth connectivity or even operate connected via wire line connections. Moreover, there may be areas with no adequate coverage resulting in disconnections while on the move. There may be also variability in the provision of specific services, such as in the type of available printers or local weather reports. Finally, the resources available to a mobile element vary, for example, a docked computer or PDA has more memory or is equipped with a larger screen.

Mobility also raises very important security and authentication issues. Is this device that registers stolen? Is it certainly the device it claims to be? Is the user really that one who he/she claims to be? These issues are handled more closely in.

III. APPLICATIONS AND SERVICES IN MOBILE E-COMMERCE (MEC)

Factors affecting MEC applications and services

Hand held terminals can be considered as access devices to Internet. As such, they don't change the nature of Internet applications. However, services and applications successfully being offered over the Internet (e.g. financial or travel services), in order to have similar success in MEC, they need to take into account the peculiarities of mobile wireless computing and wireless devices analysed before as well as the different needs of mobile users and the different usage of hand held devices: users need location-based services (e.g. maps, nearby restaurants) as well as personalized information and services, e.g. time management facilities and access to personal information in an easy and secure way. Furthermore, the use of mobile terminals makes them an ideal candidate for becoming an electronic wallet. Security issues are essential and compromises have to be made between the provided security and functionality. Figure 1 shows the impact of various factors on MEC applications and services.

As it can be seen, most of the arrows are bi-directional. This is because there is influence on both sides. More specifically, limitations of Mobile Networks (e.g. relatively low bandwidth) or of hand held terminals (e.g. small screens) impose certain requirements on MEC applications and services and, at the same time, limitations of existing applications demand further improvements from networks and hand held terminals. The arrow from mobile network infrastructure on hand held terminals denotes that hand held terminals, in order to exploit the advantages offered by advanced network technologies (e.g. WAP) have to change accordingly.

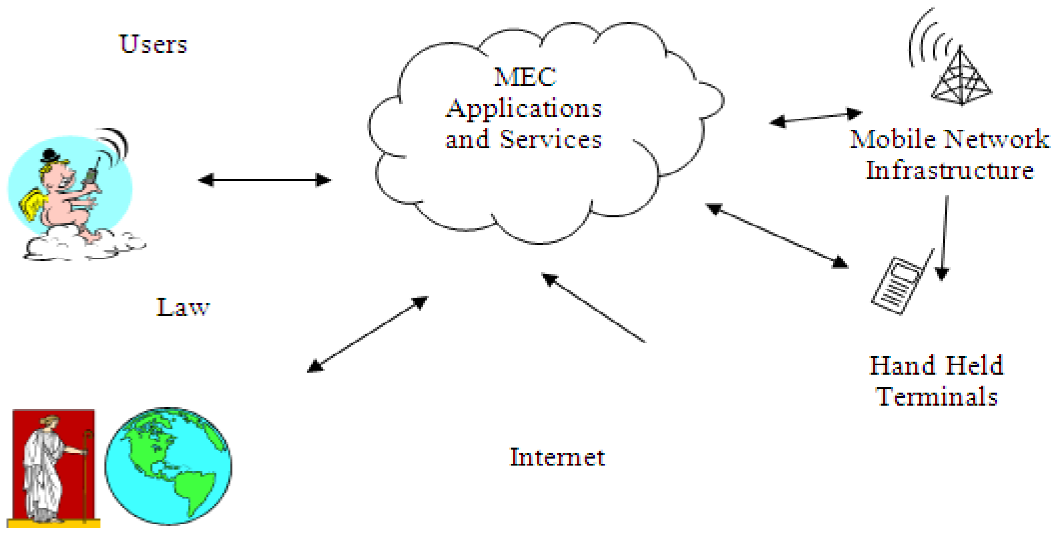

Figure 1: Factors affecting MEC applications and Services

Existing legislation imposes constraints on certain aspects in MEC. For example, in some countries privacy protection doesn't allow the users' location to be given to service providers. On the other hand, the peculiarities of MEC (e.g. the fact that the user can close a contract very easily and in any country) require certain legislation to be defined in order to support e-commerce (e.g. out-of-court dispute settlements or electronic cancellation of contracts). And, of course, user's needs influence the development of MEC applications and services. At the same time, the offered applications and services have an impact on users' needs, e.g. since the user enjoys the benefits of location-based services and can, for instance request guiding instructions to reach a place, s/he will also demand to have location-based services in his/her language when s/he is abroad that can be accessed in a familiar way.

Distinctive Features of MEC Applications and Services

MEC applications take advantage of mobile communications to offer to consumers and businesses additional benefits as opposed to traditional e-commerce applications.

Location-awareness. In mobile computing, knowledge of the physical location of a user at any particular moment is central to offering relevant services. The location of a mobile device is available to the mobile network operator but it can also be found using sensor devices or technologies such as the Global Positioning System (GPS). GPS uses a number of satellite stations to calculate with great accuracy the location of devices equipped with GPS receivers. There are many examples of location based electronic commerce applications including: geographically targeted advertising (everyone near a fast-food restaurant gets free (electronic) coupons for the new burger), fleet management, vehicle tracking for security, traffic control, telemetry, emergency services, etc.

Adaptivity: Mobile e-commerce applications should be adapted to the environment of their clients. Adaptability is possible along various dimensions including the type of the device in use, the currently available communication bandwidth as well as location and time.

Ubiquity: Mobile communications enhance electronic commerce by making electronic commerce services and applications available anywhere and at any time. Through hand-held devices such as mobile phones, users can be reached at any time, independent of their location. Mobile computing makes possible that users are immediately notified about particular events. It also enables the delivery of time-sensitive information whose value depends on its timely use.

Personalization: The information, services and applications available in the Internet today are enormous. It is thus important that the user receives information that is of relevance. Furthermore, customization is a key issue in using mobile devices because of the limitations of the user interface in terms of size, resolution and surfability. Studies (Durlacher Research, 2000) show that every additional click reduces the transaction probability by 50%. Thus, MEC applications must be personalized enough to represent information in compact and attractive forms and to optimize the interaction path, enabling the user to reach the desired services with as few clicks as possible.

Broadcasting. Some wireless infrastructures, such as cellular architectures and satellite networks, support broadcasting (i.e., the simultaneous delivery) of data to all mobile users inside a specific geographical region. Broadcasting offers an efficient means to disseminate information to a large consumer population. This mode of operation can be used to deliver information of common interest to many users such as stock prices, weather information or for advertising.

IV. BUSINESS MODELS IN MOBILE E-COMMERCE

There are many definitions of a business model. We use the definition by (Timmers, 1999), where a business model is defined as:

- An architecture for Product, Service and Information Flows,
- A description of Business Actors and their Roles,
- A description of Potential Benefits of the various Business Actors,
- A description of the Sources of Revenue.

A business model by itself is not enough to provide an understanding of how the model contributes in realising the business mission and objectives. It also cannot answer to questions like: how competitive advantage is being built, what the positioning of the business is, what the marketing mix is and which product-market strategy is being followed. These questions need a Marketing Model to be answered. A marketing model is defined as a Business Model in combination with the Marketing Strategy of the Business Actor under consideration.

The above definition can form the basis of a detailed analysis of the business models emerging in MEC. However, this is outside the scope of this paper, therefore we will concentrate on some of the above issues starting from a description of the main players in the Mobile Business Value chain who are.

- technology platform vendors that offer operating systems, e.g., Windows CE and Palm OS, as well as micro browsers, e.g., Phone.com,
- infrastructure and equipment vendors that provide the network infrastructure, e.g., Nokia,
- application platform vendors who offer middleware and standards,
- application developers,
- content providers and aggregators,
- mobile portal providers for application aggregation,
- mobile network operators,
- mobile service providers that offer added value services, and
- handset vendors and retailers.

Businesses can play a number of different roles in this value chain and make profitable alliances with other partners by adopting the right business model. Business models used in Internet e-commerce, e.g. e-shops, e-auctions, value-chain providers, information brokerage etc. provide a good basis for investigating the opportunities for new business models in MEC. The underlying business model defines the role of each player in the value chain. For example, in Internet e-commerce, if the business model is an e-shop, e.g. amazon.com, the customer interacts directly with the merchant or service provider, while in other business models, the intermediaries/brokers or portals, play an active role in the value chain.

An interesting and profitable business model in MEC is the mobile portal. The conditions, under which the hand-held terminals are used, make it rather impossible for users to extensively browse the Internet in order to acquire the desired information or service. Mobile portals can help users in this respect by offering personalized and localized services, taking into account the user's preferences, language, previous behavior and so on. Portals like www.yourwap.com are along these lines; the more personalized functionality they provide the tighter the relationship they built with customers and the higher the profit.

A business should take into account its core competence before adopting a new business model. Thus, the Mobile Network Operators (MNO) have a competitive advantage over other players in the field as they already have a billing relationship with the customer, they maintain customer's personal data and they can easily identify the customer's geographic location. It is therefore natural for operators to adopt new business models that exploit these advantages and enter new markets and provide new services in order to increase their profits. Thus, they can be strategically positioned between mobile users and content/service providers and provide for example mobile portal services or play the role of intermediaries, i.e. collect, package and resell information of 3rd parties or trusted third parties and so on. It is obvious that the role of the MNO, depending on the adopted business model, can vary from very simple and passive to strategic and dynamic. We have to mention here that the role that the operator can play depends a lot on the current legislation. For example, in Finland, operators can not charge services more than 60FIM.

Many operators have already adopted the “mobile portal” business model but most portals run by MNOs, like Sonera or Radiolinja (Finland), Telia (Sweden), Telenor Mobil (Norway) have access limited to their own subscribers. This is mainly due to billing issues that have not been resolved yet. Billing is also a problem for the provision of MEC services to 'roaming customers' and requires cooperation between Telecom Operators. A more detailed description of various scenarios depicting the role of the operator in the MEC value chain and respective legal and technical implications can be found

V. INFRASTRUCTURE AND SYSTEM SUPPORT FOR MEC

For MEC applications to be successfully deployed, there is a need for appropriate system architectures to be advanced, useful standards to be designed and accepted, and specific system properties to be guaranteed.

Mobile Agent Architectures for MEC applications

To deal with the characteristics of mobile computing, especially with C-autonomy and small devices, various extensions of the client/server model have been proposed. Such extensions advocate the use of proxies or middleware components. Proxies of the mobile host residing at the fixed network, called server-side proxies, perform various optimizations to alleviate the effects of non-reachability and scarce bandwidth, such as message compression and re-ordering. Server-side proxies may also perform computations in lieu of their mobile client. Proxies at the mobile client undertake the part of the client protocol that relates to mobile computing thus providing transparent adaptation to mobility. They also support client caching and communication optimizations for the messages sent from the client to the fixed server.

Mobile agents have been used with client/server models and their extensions to build MEC applications (Samaras, et. al., 2000). Such agents are initiated at the mobile host, launched at the fixed network to perform a specified task, and return to the mobile host with the results. Agents in MEC transactions include search agents to locate the appropriate service, supplier’s and buyer’s agents.

The WAP Standard

The Wireless Application Protocol (WAP) is a set of standards for developing applications that extend Internet services to the mobile telephony environment that includes, mobile phones, pagers and PDAs. Part of the protocol is WML (Wireless Markup Language) - WAP's equivalent to HTML. A standard web server, appropriately configured, can deliver WML files. WAP defines a microbrowser that displays content pages in WML-format that get transmitted to the mobile device using the WAP communications protocol over a broad range of mobile data channels.

WAP addresses both the low bandwidth, high latency and C-autonomy of wireless networks and the resource constraints of the mobile devices. The network issues are addressed at both the transport and higher layers of the protocol. In the transport level, a WAP gateway is inserted between the wireless network and the client that acts as a proxy: encodes the WAP data into compact formats to reduce the size and number of packets traveling over the wireless network. In addition, the WAP gateway typically takes over most of the computing tasks from the mobile device, permitting the device to be simple and inexpensive. The device-constraints issues are also dealt with directly by WML. WML provides a small (telephony aware) set of markup tags. WML documents are divided into a set of well-defined units of user interactions, called cards. A card is usually defined by a single action or operation, typically able to be displayed on a small screen. Services, called decks, are created by letting the user navigate back and forth between cards from one or several WML documents. A deck of cards providing a complete service is downloaded at the mobile device at one time, eliminating the need for a constant network connection.

MEC Transaction Properties

Transactions in mobile electronic commerce involve a number of players, typically customers, merchants and often banks, mobile network operators and other authorities. Traditionally, in database systems, transactions are used to encapsulate operations and provide Atomicity, Consistency, Isolation and Durability (the ACID properties). Ensuring the ACID or similar properties for electronic commerce transactions while preserving additional requirements such as security and anonymity remains an open problem. A main obstacle is the fact that the participants in an electronic commerce transaction may be dishonest or malicious. In the MEC environment, the problem is further complicated due to device limitations and frequent network disconnections. An initial requirement analysis is presented in (Veijalainen, 1999). We list below some preliminary definitions for the properties.

Atomicity. A transaction is atomic if either all operations necessary for preserving e-commerce atomicity are executed or all executed operations will become compensated. Atomicity is an important property; however, many electronic commerce protocols do not provide atomic transactions. Tygar (Tygar, 1996) defines three levels of atomicity to properly characterize electronic commerce protocols: money atomicity, goods atomicity and certified delivery. With money atomic protocols, funds are transferred from one party to another without the possibility of the creation or destruction of money. Money atomicity is a basic level of atomicity that all electronic commerce protocols must satisfy. Goods-atomic protocols are money atomic, and also effect an exact transfer of goods for money. That is, with goods-atomic protocols, a good is received if and only if the money is transferred. Certified delivery protocols are money atomic and goods-atomic protocols that also allow both a merchant and a customer to prove exactly which goods were delivered. Such protocols are helpful for scenarios where merchants or customers may be malicious. They are analyzed further in (Tang, Veijalainen 2000).

Techniques that are used to guarantee transaction atomicity in database systems (e.g., two-phase commitment) are not suitable to guarantee transaction atomicity in electronic commerce because of autonomy and dishonest participants. The main reason is that in electronic commerce, a set of dishonest or malicious participants may cause arbitrary failures. For instance, a customer may deny receipt of electronic goods by pretending a system failure or command commits and aborts for participants in the same transaction.

In MEC, ensuring atomicity is further complicated. Mobile devices may be unreachable and unable to participate in a distributed protocol. Furthermore, due to device limitations, the part of the protocol executed on a mobile device should be lightweight. Finally, the fact that a mobile device may be easily stolen or lost must be taken into account and transactional mechanisms combined with security.

Consistency. EC transactions must preserve consistency at various levels. For instance, if database systems are involved in the transaction, database consistency, that is preservations of the database integrity constraints, must be maintained. For instance, a customer should not be allowed to draw funds from an account if this would result into a negative balance. In general, if more than one system is involved in the EC transaction, distributed constraints may need to be enforced; for instance a positive balance among various credit institutions may need to be preserved.

Isolation. Isolation ensures that the various steps of a MEC transaction do not interfere with steps of other MEC transactions. For example, if a customer buys a product through its mobile phone, this purchase should not affect other transactions being made at the device or at the merchant server.

Durability. The durability property guarantees that once a MEC transaction completes its execution, its results become permanent even in the presence of failures. For example, after the completion of an electronic purchase, the corresponding funds transfer from a bank is permanent even if the network fails.

Anonymity. Some customers do not want their identity to be disclosed. Anonymity is often preserved by adopting a token-based model. Tokens are used as a form of currency: similar to coins, they are used to purchase a good but they do not reveal the identity of the holder. The requirement for anonymity complicates the development of protocols that also provide ACID transactions.

Security. Security is a key issue in MEC transactions. In general, security and trust in e-commerce transactions can be achieved with the following security functions:

- Authentication and non-repudiation: each party needs to be able to authenticate its counterpart, i.e. to make sure that the counterpart is the one s/he claims to be and that s/he doesn't deny later on agreements s/he has approved earlier
- Integrity: each party needs to make sure that received messages are not altered or fabricated by other than their counterpart
- Confidentiality: each party wants to keep the content of their communication secret
- Message Authentication: each party wants to make sure that the received messages do really come from his counterpart

Techniques like the asymmetric cryptographic algorithm (also called Public Key algorithm) are used to achieve these results, with a Certification Authority (CA) which issues certificates and a Public Key Infrastructure (PKI) for generating, revoking, updating, recovering etc. certificates and keys.

Three different security techniques are currently used for hand-held devices: (a) Smart trust type solution cards (offered by Sonera), where the PKI private key is on the SIM card and it is used for authentication and non-repudiation, (b) the solution offered by Nokia, Merita, Visa where authentication and other security mechanisms are incorporated into the software and hardware of the hand-held device in such a way that the device has a credit card capability and (c) the solution provided by Motorola andMasterCard which offer hand-held devices equipped with a credit card reader.

CONCLUSIONS

Mobile E-Commerce is a challenging area as it creates opportunities for many players in the field, like Mobile Network Operators or Content and Service providers. MEC is a dynamically changing area and so are the applications and requirements due to the many interdependencies with user needs, wireless technology and legislation. It is thus essential that related business and legal issues are resolved and follow advances in technology.

At the moment there is a small number of applications and content available, the WAP phones are not widely available and the call set-up time is too long. However, there is a lot of work going on by legislators, industries, network operators and software providers and, it is estimated that, at the beginning of 2002, as GPRS will become more widespread, MEC will start to take off on a larger scal. It is worth mentioning here the importance of Bluetooth technology (Bluetooth, 2000) and its expected impact on MEC as it would be possible to conduct e-commerce transactions without a heavy network infrastructure, e.g. handheld devices could talk directly with cash registers.

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