Mobile Payment: A journey through existing procedures and standardization initiatives

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Abstract

It is predicted that mobile applications will become an integral part of our lives at personal and professional level. Mobile Payment (MP) is a promising and exciting domain that has been rapidly developing the last years, and although it can still be considered in its infancy, great hope is put on it. If MP efforts succeed, they will boost both e- and m-commerce and may be the killer service in 2.5G and beyond future ambient intelligence infrastructures. This paper introduces the mobile payment arena and depicts some of the most important mobile payment procedures and consortia that are relevant to the development of mobile payment services. The aim of this work is to introduce the reader to the mobile payments, present current concepts and the motivation behind it, and give an overview of past and current efforts as well as standardization initiatives that guide this rapidly evolving domain.

1 Introduction

The Internet has revolutionized the way business is done. eBusiness has slowly flourished and e-payments were introduced. However, the models, as well as the technology necessary to support eBusiness, is getting more complex day by day. mBusiness can be seen as the natural successor to eBusiness [1], exploiting the capabilities of wireless media for the development and provision of advanced business and citizen services. Payments are the locomotive behind the business domain and heavily depend on trust and security. Mobile payments are seen as the natural evolution of existing e-payment schemes that will complement them [2]. However, in eBusiness transactions occur between people who are often represented by multi-user machines; a task that eases anonymity and makes it difficult to provide services like identification, security and trust within the ePayments domain. On the mobile world this is different, as mobile devices are transformed to personal trust devices (PTD), which are generally considered to belong to, and be managed by a single user, i.e. the owner. Mobile payment is not seen as a simple mobilization of the e-payments (i.e. provide a mobile interface to an existing Internet payment procedure), as the context (e.g. business models, player relationships) and capabilities (e.g. end-device technology) are different. The context of mobile payments can be defined as follows:

Any payment where a mobile device is used in order to initiate, activate and/or confirm this payment can be considered as a mobile payment.

Contrary to popular belief mobile payments do not restrict themselves to payments via the mobile phone but virtually any mobile device such as:

- A tablet PC (which is a full function PC with limited mobility, usually used by one person)
- A PDA (truly mobile device with multimedia and connectivity capabilities)
- A smartphone (a consolidation of PDAs and legacy mobile phones)
- Any mobile payment terminal or device (merchant-operated terminals with built-in security) capable of initiating, activating and/or confirming a payment.

However, when we speak about mobile payment, we generally refer to the kind of payment where the mobile device has mobile phone capabilities (e.g. smartphones) and not general wireless capabilities (e.g. tablet PC). Within the rest of this paper we also foster this assumption, as all existing procedures assume this.

Since the domain of mobile payment is pretty new, there are often some misunderstandings about them. Some of the most popular include:

- It is often heard in the media that mobile payment will turn our mobile phones into “means of payment”. A mobile phone and in general a mobile device is not a mean of payment (unless you actually trade your device for goods). A mobile

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device is only a medium via which payments may be initiated, activated and/or confirmed.

- Many consider that mobile payment is about accessing an internet payment service from a mobile device. Although the same functionality may be realized by the mobile version of the service, generally designing and implementing payment procedures for the mobile world differs from the internet approaches due to the different context that these have to operate in.
- Finally, many consider that mobile banking and mobile payment are interchangeable descriptions when we refer to payment transactions via mobile devices. Although mobile banking services may allow mobile payments to happen, usually MP refers to services that are more general in scope, universally available, and can be realized by other financial service providers beyond banks. Therefore, mobile banking payment services can be considered as a sub-domain of all procedures that can be hosted under the mobile payment umbrella, as they are narrower in scope and usually tied up to the legacy bank procedures.

A lot of discussions are done in international fora and events among researchers, economists, technologists and other interested parties, and it is a common consensus that there exists a real need for a mobile payment service. Its impact will have a noticeable effect in electronic and mobile commerce, especially if it is coupled with digital rights management (DRM) technologies (mobile or internet based). Coupling content management with a global instant payment capability would result in a powerful combination. However, we have noted that very few have an overview of all mobile payment efforts that have been tested or deployed the last years. Therefore, a cartography of the mobile payment area focusing on standardization consortia that have emerged and try to master the heterogeneity by providing standardized interfaces, as well as the existing mobile payment services that have been launched, is the focus of this paper. Existing surveys and thoughts [3][4][5] can be seen as complementary to this work, which provides more extensive info on the consortia and services available. The motivation is to provide a handy overview of past and existing efforts on the domain, which can be used as a starting point by interested people while looking at this exciting area. We have tried also to refer to projects done all over the world and include the Internet URLs of the companies or the projects that have participated as well as indicative bibliography that one can follow in order to acquire further technical and conceptual details once interested to learn more.

The rest of the paper is organized as follows: We present an overview of the MP area, in order to introduce the reader to the main players, their expectations, the MP models, the MP consortia and the motivation and predictions about MP. Subsequently we refer to the major categories of MP as they exist today and comment on them. A discussion on the existing MP procedures, which are fully analyzed on the appendix of this paper, follows. Future MP technology directions that the author considers that will have an effect on the design and implementation of future MP procedure are also tackled.

2 An Insight on the MP Arena

2.1 The Players

A typical digital payment scenario is depicted in Figure 1. The customer is the party that is making the payment, the merchant is the party that accepts the payment, the acquirer is the third party that has a relation and interacts with the merchant and the issuer is a third party that has a relation and interacts with the customer. In any transaction, the goal is the value transfer from the customer to the merchant. A typical procedure that is followed by credit card companies is: the customer "pays" a merchant for goods/services. Subsequently the merchant sends the transaction details to the acquirer for clearing. The acquirer sends the transaction details to the financial network that it belongs (e.g. VISA) which then forwards the details to the issuer. The issuer is informed to make the necessary fund reservation at the customer side. The scheme settles/pays the acquirer, the acquirer settles/pays the merchant, the issuer settles/pays the scheme and the customer pays the issuer. However other schemes may directly exchange tokens (e.g. cash, e-tokens) between the customer and the merchant. In the mobile payment area, we have similar procedures, with the only difference that the customer and possibly the merchant use mobile devices in order to realize a transaction.

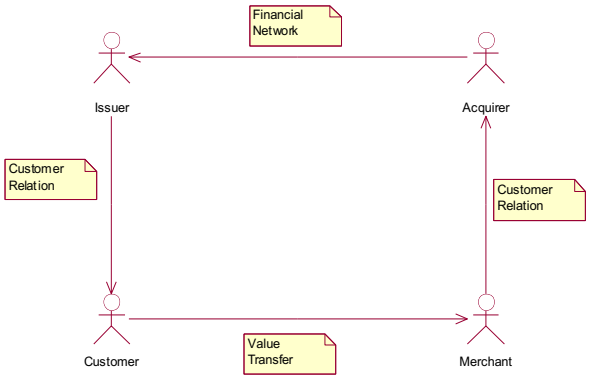

Figure 1 – Typical digital payment scenario

The main parties in the mobile payment are depicted in Figure 2 and are of course the customer (payer) and the merchant (payee). These transact with each other via the MP process whose main players include also the Mobile Network Operators (MNO), the financial sector institutions (e.g. banks, credit card companies, payment processors), the government (legislation and regulation constraints) and of course the device, software and service providers.

MNOs have a huge customer base and due to the fact that they control the Subscriber Identity Module (SIM) and/or the Wireless Identity Module (WIM) card of the mobile device, their influence and strategic impact in the MP model is great. However, they cannot fully handle an MP system as they have limited experience in payment services and the risks associated with them. However, the financial sector has been doing this for decades and can realize cross border payments. A successful cooperation of both sides is the key to empowering the MP era. The device manufacturers also play a significant role and although they have no payment experience, they control the technology and capabilities of the end-device, which without doubt affects the implementation, and deployment of an MP service. Cooperation of the manufacturers among them for a common approach on mobile device's capabilities and with the other MP players is therefore important. Finally software providers develop the means of implementing a MP infrastructure by producing standard compliant software that will glue the different parts of the MP process. The service providers will bring this service to the market and adapt it to user's needs. MNOs or banks can also play the role of the service provider and can offer limited MP services by their own.

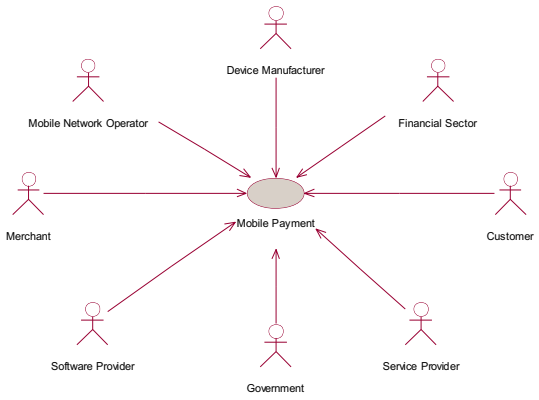

Figure 2 – The major mobile payment players

The cooperation of all MP players is the key into developing a global open solution and not a limited-scope closed system. Finally, all MP solutions are developed under constrains imposed by the government legislation and regulation at national or international level e.g. European Union. The basic attributes of the main players are depicted in Table 1. It is important to keep in mind that the mBusiness players reposition themselves constantly on the market, as they adjust to new opportunities and threats brought by rapid technological developments [6].

2.2 Expectations from MP

For global MP services to succeed a wide range of criteria will have to be met. The requirements are not technology nor business based only, but spawn several other domains such as social/cognitive science (domains that give feedback about the social regional characteristics where a MP service can be launched) and economics. However, the development of new business models is what will be mostly needed. The cooperation of the various players within such a framework is considered to be the key to success while standalone efforts may have only limited local success.

Table 1 - Existing attributes of the MP players

Player	Main Attributes
Financial Institutes	▪ customer base ▪ merchant base ▪ mini/macro payment infrastructure ▪ card operators
Mobile Network Operators	▪ customer base ▪ merchant base ▪ micro/mini payment infrastructure ▪ control of end-user device ▪ billing infrastructure (cross-border capable)
Independent MP Providers	▪ fast reaction ▪ no infrastructure ▪ no customer base
Other Providers	▪ provision of basic MP components, capabilities, services.

Mobile operators and banks express the highest interest in MP. These players are crucial for the proliferation and mass-market take-up of any MP service. But as MP is nothing else but an alternative payment form, it is the buyer and seller, i.e. the mobile phone subscriber and the merchant that seem to be the key links in the chain. A buyer needs to choose MP over cash, check, credit, or whatever form of payment he currently prefers, and it is the merchant who needs to be ready and willing to accept this new form of payment. A critical mass is needed on both ends of the chain to make this happen, and consumers and businesses will benefit from the proliferation of alternative payment methods. Merchants especially will enjoy a much lower

cost of doing business if the credit card network fees are eliminated. Since these costs are largely hidden from the consumer, other factors will have to motivate him to adopt alternative payment methods in the marketplace e.g. security, friendliness, customization etc. However, any alternative payment method will have to satisfy the needs of the consumer, the merchant and the financial institutions at the same time, for it to be widely adopted in the marketplace.

Different expectations exist among the main players of a MP service, of which the most important are depicted in Table 2. Some of the general requirements for the success of MP that have been identified include:

Simplicity and usability: Simplicity and usability largely determines whether users will use a service. This includes not only a user-friendly interface, but also, the whole range of goods and services one can purchase, the geographical availability of the service and the level of risk the user is taking while using it.

Universality: e-/m-commerce favors the logic of on-line universal payment services, integrating in a user-transparent fashion, person-to-person (P2P), business-to-consumer (B2C) and business-to-business (B2B), domestic, regional and global coverage, low and high value payments.

Table 2 - MP players' expectations

Player	Expectations
Merchant	▪ Faster transaction time ▪ Low or zero new investment & usage cost ▪ All in one open interoperable devices (e.g. POS) with backward and forward compatibility ▪ Integration/simplification of existing payment approaches ▪ High security and trust in the MP service ▪ Possibility of customizing the service (e.g. adding loyalty schemes) ▪ Real-time status of MP transactions
Customer	▪ Minimal learning curve ▪ Better and personalized service ▪ Trusted and secure solutions (at technical and social level) ▪ Wide availability of the new service ▪ Low or zero additional cost of usage ▪ Support for micro/mini and macro payments selectable per payment provider ▪ Interoperability between devices, MNOs and banks. ▪ The capability for anonymous payments (like cash) ▪ Minimization of service participation procedures ▪ Real-time transaction status overview ▪ Being able to pay "anywhere", "anytime" and at any currency ▪ Person-to-Person transactions
Mobile Network	▪ Potential to add value to existing services ▪ Increase customer loyalty ▪ New revenue channels
Operator	▪ Increase Average Revenue per User
Device Manufacturer	▪ Large market adoption of new embedded hardware/software features of the devices ▪ Open interoperable widely-used standards ▪ Low cost of new technologies/features to be integrated ▪ Low Time-to-market ▪ Multi-application capability. ▪ New relationships with banks/MNOs/application providers.
Bank	▪ Branding and customer loyalty ▪ New business cases ▪ Ownership or co-ownership of the new payment application ▪ Secure and trusted payment service / fraud-loss minimization ▪ Integration/use of existing infrastructure and payment methods.

Interoperability: In financial services, interoperability has always been a highly contentious topic and its progress has been uneven and in many cases rather slow. Standardization around the payment service should make interconnection of networks and systems technically easy and cost-effective. MP component development should be based on standards and open technologies that will allow any system to interact with another on a global scale at all levels (e.g. any mobile with any POS, any payment software should run on a wide range of mobiles etc.). The number of acceptance points is critical; therefore, standardized solutions that can be composed of plug-and-play components are a must.

Security, trust and privacy: Upon subscribing to a MP system, users are expected to place inherent trust on the system. Giving access to a checking or savings account to a software company is not the same thing—in most users' minds—as giving that same access to an already trusted entity such as a bank. Unless the basis for electronic payment systems is based on tried and true secure banking practices, it is unlikely that users will adopt it. Needless to say, that all steps should be secured/trusted from a technological [7] as well as social point of view. Furthermore, MP should minimize fraud losses and provide user-controlled transaction-specific privacy support. The last implies that anonymous payments should be possible (like cash today is). Furthermore, technologies like mPKI, biometrics, and mobile digital signatures will have to be further advanced in order to be easily integrated into MP architectures.

Cross-border payments: For a MP service to be widely acceptable, it should be possible to make cross-border payments almost as easy as local ones. Furthermore, this should be done regardless of the location of the user (i.e. whether he is roaming abroad or not). The European Union requires a cross-border electronic payment system to be available in all of its members and be as

efficient as any domestic system. Any global MP system should be able to handle cross-border payments in any currency and at any place.

Usability: The learning curve should be close to zero and easiness/convenience of the consumer should be enhanced. The customer should also have the ability to choose how each individual transaction should be processed e.g. from the bank or the MNO etc

Cost: the new systems should be at the end more cost effective than the legacy approaches e.g. the technology used may cost more but the fraud is minimized, so at the end of the day it is a cost saving solution. They should also create new revenue flows or tackle better existing ones in order to justify their existence.

Speed: The new payment method should decrease transaction time, automate transactions and of course in parallel satisfy the security requirements.

Local market understanding: Most of the customers are used to existing payment methods and need an incentive to use anything new. The ability to use the mobile device, as a payment tool, in itself might not be enough. Users and merchants should see additional benefits. Approaches that wish to be sustainable must either improve their functionality and usability, or be creative in making users and merchants perceive it as beneficial. Furthermore, the same success criteria may not apply to every country due to social local conditions. The last poses the requirement on market understanding as well as understanding of the idiosyncratic conditions on per region or even per country basis.

Integration of legacy approaches: It should be possible to reuse existing infrastructure and legacy billing systems, especially those that are difficult to change e.g. of the banks. Existing channels such as pre-/post-accounts, credit card infrastructure etc should be supported and the user should be free to choose the processing partner (e.g. bank, MNO, credit card) on per transaction basis (corresponding of course to the requirements of each processing partner).

2.3 Mobile payment models

Up to day there is no dominating mobile payment model in the market. We present here some models, but it looks like that cooperation and coexistence of the main players with complementary tasks in each model will be required for successful mobile payments. Some of them include:

Acquirer vs. Issuer centric model: In the acquirer centric model, the merchant and his agent are in charge of handling the interactions with the mobile device. Such approaches usually depend on a mobile specific protocol and require specific capabilities from the user (mobile device) and merchant side. Systems based on dual chip or dual slot fall within this category. In issuer centric models the customer and his agent are in charge of handling the interaction with the mobile device while the merchant may be totally unaware of the mobile nature of the payment. In this model, it is usual that the customer-issuer interaction is mobile, but the rest may be based on existing wired infrastructures and standardized e-payment protocols. For instance, mobile payment systems that use callback methods or a WIM-based digital signature validated by wallet server fall within this category.

Bank vs. MNO centric model: Banks have been in control of financial transactions for a long time, acting as issuing banks (owning customers' accounts), acquiring banks (owning merchants' accounts), and clearing houses (clearing and settling transactions between the issuing and acquiring banks). Mobile operators, are quite new to this business. Their billing systems have been used until today, for billing customers solely for the mobile services they offer within their network. That has been changing lately with pre-paid accounts and emerging data services, where content is produced and provided by third parties. In a bank dominated mobile payment model, the bank handles the mobile payments while the MNO provides only the air connection between the user and the bank. On the MNO dominated model the MNO is doing the billing either on the prepaid user account or later on the phone bill for their postpaid users. In some cases, revenue sharing agreements with multiple MNOs exist, in order to broaden the customer base.

Although the above models are dominating existing mobile payment efforts on markets, we are moving towards composite models where the main business partners cooperate, usually on a revenue sharing basis. Such a model is usually referred to as a **win-win model**, and is broader as it usually implies at least country-wide acceptance and cooperation among several partners from different domains. A large variety of MP services exists in the market already, some of which are operated by banks and MNOs, while others are operated by third parties. A key advantage of the independent players is that they enable every mobile user to use the service upon registration, regardless of their mobile service provider or bank. For a specific merchant intending to use an MP solution, teaming up with such a player is more efficient than teaming up with three or more separate mobile operators. An independent player will need to build a user base, usually from scratch, which is a non-trivial task. Mobile operators and banks, have already millions of customers who are potential MP users. Realistic models for a win-win situation should be developed where MNOs and banks harmonically co-operate in a non-exclusive scenario and each business

partner pursues core business and tries to increase revenue by providing core services. The best argument supporting the concept of banks and MNOs joining a co-operative business model, is, that for MNOs m-commerce will offset the reliance on prepaid mobile airtime/service (which tends to reduce Average Revenue per User - ARPU), and for banks that it is expensive to develop a common platform for m-payments from the scratch. A promising model integrates new technologies at the infrastructure level, which makes possible interoperable cooperation between multiple banks, MNOs and merchants. The last eases the task of establishing cross border MP functionality, the non-dependability of the MP service on specific banks or MNOs, and guarantees a high number of acceptance points which can help the MP service to reach the critical mass. Experience has shown that MP systems that have been implemented by non-bank consortia have either a very restrictive character (with regard to the number of acceptance points) or allow only low-value payments (micro-payments). Taking also into account that banks actually do not make much profit on the payment systems (infrastructure) themselves, but on the actual line of credit provided, they seem to be the suitable partners for the MNOs. This has been realized by the community, and for instance the SEMOPS project developed a model that is based on the cooperation between several banks, MNOs and other financial service providers [8].

2.4 Motivation and predictions for MP

Several interesting facts in the mobile payment domain, point out why MP is gaining momentum as well as why it should not be directly compared with ePayments nor considered as a simple mobilization of them. Some differentiating factors include:

- High penetration rate: Mobile phone penetration rate will be above 85 percent for Europe according to McKinsey Consulting (www.mckinsey.com) in 2005, while the PC rate is significantly lower. Furthermore, mobile Internet user penetration is expected to be higher than that of home or office Internet seats [9]. Therefore, mobile phone based solutions will have an effect on more people than the PC (traditional internet gateway) domain.
- Instant access: Mobile phones are transformed to personal trusted devices that most people carry around with them all the time, they are always on and one has direct contact with its owner. This simply means that via mobile phones anyone is reachable anytime anywhere, which fits-in perfectly into the vision of a mobile future.
- Continuous evolution of existing infrastructure and services. A high quality modern infrastructure (compared to the traditional bank one) is in place by the mobile network operators (MNOs) and new device models hit the market every two to six months addressing different end-user's requirements. That in conjunction with the usual tactic of MNOs to offer the handsets for free or at significantly reduced prices with a 12 or 24-month contract, results that the end-user devices will be able to integrate fast the latest standards and developments and increase the penetration rate (with an average update of the mobile device in a time period of 12 to 24 months for each MNO customer), which will allow the MP industry to use them for advanced MP solutions. Furthermore, other services such as roaming and inter-MNO billing are already in-place which may be used as basis for a global mobile payment service.
- Taking advantage of existing security and trust relationships: Mobile phones can deploy state of the art security (and are expected to do more in the future e.g. integrate biometric features) and do have advantages over the internet-models i.e. the mobile phone is more or less considered as PTD, which makes easier to identify the user e.g. via the MNO SIM owner.

Mobile Commerce and specifically mobile payments have a bright future ahead; at least this is what many research reports predict. For instance:

- According to research report of TowerGroup [10], 118 million Europeans, 145 million Asians and 22 million Americans intend to use their mobile phone for paying small purchases.
- The United Nations Conference on Trade and Development predicted (in 2002) that the volume of mobile business will reach $225 Billion by 2005 [11]. A more recent (July 2004) global study [12] by Arthur D. Little research firm estimates that tm-payment transaction revenues will increase from $3.2 billion in 2003, to $11.7 billion in 2005 and $37.1 billion in 2008 world-wide.
- A m-payment report [13] published by Wireless World Forum (www.w2forum.com), states that the size of the mobile Internet based mobile payment market will grow from around €5 billion in 2002 to nearly €55 billion in 2006.
- Forty-four percent of 5,600 mobile phone users on four continents surveyed in the February 2002 global Mobinet study [14] would like to use their mobile phones for small cash transactions.
- Global mobile commerce is predicted by Telecom Trends International (www.telecomtrends.net) to attract 1.7 billion users in 2008, who will use their

mobile phone handsets to make an anticipated $554 billion transactions [15].

It is clear that we are heading towards an infrastructure where e-services are transformed to m-services and cooperate or are unified. In such a context, the need for a universal payment system is there and its contribution is considered to be significant [16]. So, why aren't we all paying via our mobile devices? Today several mobile services in form of pilots or already commercial solutions appear in several countries and target different market segments [17]. However up to now no universal payment system exists and most efforts do not survive long. Mobile payment depends heavily on the successful collaboration between network operators, developers, content providers, enterprises and technology suppliers, which is difficult to achieve. Furthermore, there is still no global standard available that addresses the payment process or the programming platform offered within a mobile phone. The last may not hold true for the years to come as several efforts in the international community are underway to effectively tackle these problems.

2.5 MP Influencing Consortia

The mobile commerce space is a diverse composition of financial institutions, handset vendors, and technology companies, all knowing that they need the support of each other to gain market shares. Several consortia are active in the mobile payment domain. Since none of them is widely accepted and MP is still at is first steps, it is common that many companies participate in more than one consortia. Figure 3 depicts a taxonomy of the major existing standardization consortia in the domain of mobile payments, depending on the characteristics of each consortium. In general we can distinguish the following categories in existing consortia:

- MNO driven: Simpay, Starmap Mobile Alliance, GSM Association, European Telecommunications Standards Institute (ETSI), Universal Mobile Telecommunications System (UMTS) forum.
- Bank driven: Mobey Forum.
- Cross Industry driven: Mobile Payment Forum (MPF), Mobile Payment Association (MPA), Paycircle.
- Device Manufacturer driven: Mobile Electronic Transactions (MeT).
- Technology driven: Open Mobile Alliance (OMA), Infrared Data Association (IrDA).
- Identity driven: Radicchio, Liberty Alliance.

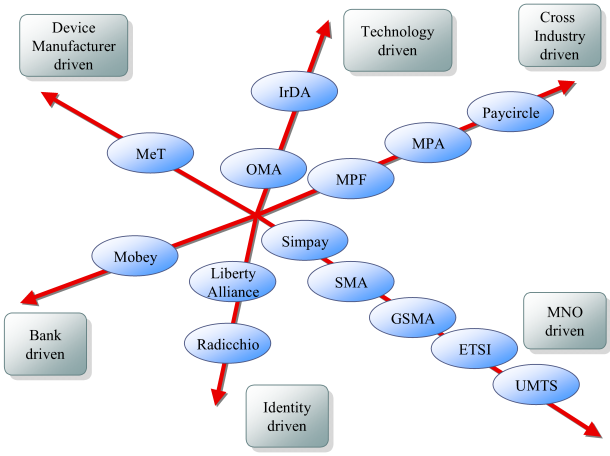

Figure 3 –Mobile Payment Consortia Taxonomy

Apart from these "pure" mobile payment consortia whose work directly affects the mobile payments, there are also other players that are indirectly evolved with the MP area, and come from the financial/banking sector. Such players are the:

- European Committee for Banking Standards (ECBS)
- Financial Services Technology Consortium (FSTC)
- Interactive Financial eXchange Forum (IFX)
- Association for Retail Technology (ARTS)

Of course, there are several other consortia dealing not only with the technologies used in mobile devices, but also the interfaces to the end-user devices. The Open Mobile Terminal Platform (OMTP – www.omtp.org) initiative that was formed in June 2004, aims at establishing a common framework for standardized application interfaces. A closer look to all aforementioned influencing consortia can be found on the appendix of this paper.

3 Mobile Payment Procedures

The long-term goal of mobile payments is to integrate all legacy payments (those possible with cash, bank transfers, credit cards etc) today and provide an alternative that uses the different channels in a homogeneous way. MP wants also to target the micro-payments area, especially the lower level as well as values lower than 1 ¢ (which is not possible via real cash). The last may be used in pay-per-view or pay-per-page schemas. There are several mobile payment systems and approaches today powered by different concepts and technologies. In the rest of the section we will try to group them based on some of their attributes.

The types of payments based on location can be categorized as:

- ***Remote Transactions****:* Here transactions are conducted independent of the user location. Examples include prepaid Top-UP services, delivery of digital services, mTickets, digital cash, peer-to-peer payments etc.
- ***Proximity/local Transactions:*** In this category fall transactions where the mobile device locally communicates (e.g. via Bluetooth, IrDA, RF, Near Field Communication) with a POS/ATM e.g. payments at unattended machines, mParking, payments at traditional POS or money withdrawal from bank's ATM.

The types of payments based on value include:

- ***Micro-payments:*** These are the lowest values, typically under $2. Micro-payments are expected to boost mobile commerce as well as pay-per-view/click charging schemas.
- ***Mini-Payments:*** These are payments between $2 and $20. These target the purchase of everyday's small things.
- ***Macro-payments:*** These payments are typically over $20.

It should be pointed out that the above limits e.g. $2 for micro-payments are indicative only, as there is no general official definition of where exactly the value limits among the different types of payments can be. However we give these indicative ranges here, in order to assist a better understanding on the magnitude of the transaction value.

The types of payments based on charging tactic include:

- ***Post-paid:*** This is the most usual method that is used in e-/m-commerce transactions today. Examples are:
  - *Phone-Bill based:* This is the charge method used usually from the mobile network operators and it is an internal charging method.
  - *Account based (bank/credit card):* This method is used by the banks, which a priori have an account of the user, or the credit card industry.
- ***Pre-paid****:* This is the most usual charging method for MNOs as well as third service providers in order to be able to evaluate with their means only that the user is capable of paying. The prepaid users is a significant part of current MNO customer base, as they represent 59 percent of the total global wireless market and are expected to reach 1.35 billion by 2009 according to Baskerville [18].
- ***Pay-now:*** In this method, the user pays in real-time or close to this (due to technical limits).
  - *Real-Time:* This includes solutions that charge in real-time the user of the service, and the funds are immediately available to the merchant (like cash) e.g. electronic wallets.
  - *Near "Real-Time":* This includes solutions that charge in a reasonable amount of time the user of the service. Typical example of this category is the debit card as well as systems that do real-time fund reservation, but the clearing and fund transfer happens later and typically at the end of the day. However, if this method (real-time fund reservation) is combined with real-time credit on the merchant side, the result is that the merchant will have immediate access to the funds, which makes the system real-time. The timeframe between the reservation and the clearing can be handled by the bank according to its risk management policy. For instance, SEMOPS [19] offers such a service with the capability to make it real time as described here.

Based on the validation of the tokens exchanged in a MP scenario we can have:

- ***Online MP:*** This assumes that in a MP procedure the tokens exchanged (e.g. electronic money) can be verified by contacting an external entity (typically an authorization server) that both transacting parties trust. This is the trivial case for almost all MP procedures.
- ***Offline MP:*** This implies that no third party is involved during the MP procedure and that the tokens that are exchanged between the two transacting parties can be verified without external help e.g. an authorization server. Typical examples are the e-coins transferred in mobile wallets. An indicative MP procedure of this category is Faircash.

The types of payments based on the number of chips or slots on the phone include:

- ***Single Chip****:* The phone uses a single chip card to which either the payment functionality has been integrated or is cooperating with it (e.g. via a Java applet). This approach favors the MNO as he controls the SIM card within the phone. Most new MP approaches that are based on the advanced capabilities of the mobile device fall within this category.

- ***Dual Chip:*** The dual chip phones have two cards i.e. one SIM card and a payment chip card that remain permanently within the phone. Since both cards are of the same size, the phone is relative small and the payment card can be exchanged when needed. The financial institutions favor this approach as they can fully control the payment chip and therefore the whole MP process. Mobey Forum (www.mobeyforum.org) supports exactly this method of doing MP. EMPS is such an MP procedure.
- ***Dual slot:*** Some mobile phones are equipped with a second card reader slot; therefore have the functionalities of a standard chip-card terminal. In order to authorize the payment the customer has to insert the payment card into the slot and confirm the transaction with a PIN. The approach is more secure as except from the mobile phone the payment card is needed in order to make the transaction. The drawback is that the phones are heavier, more expensive, larger and not widespread. The "Paiement CB sur mobile" and Payline approaches in France are examples of this concept.

While trying to be as closely as possible to cash, two directions are evident, namely the one where tokens symbolizing money are exchanged, and the wallet-like approach where these tokens can be money tokens or the credentials of the user (which can then be used for the final transaction charging). Examples of these approaches include:

- **e-coin based**: Typical are tokens like e-coins which have ratio relationship with real money e.g. 100 e-coins equal to 100 cents. Other ratios can also be used that map to smaller divisions of real money and can be suitable for micropayments. Furthermore, e-coins (which are intangible tokens) can be anonymous, which effectively is the closest that we can have to cash. This approach can also be used with offline authorization, where users simply exchange the tokens, and online authorization (check for double-spending or invalid tokens). However differently with the cash, there is no central authority producing e-coins, since each company controls their creation, ratio to real money, their circulation among their partners and the checks with regard to their spending (e.g. prevent double spending). FairCash and Meest (M-Token) are such approaches.
- **Account based**: Here the customer is associated with an account (MNO/bank/credit card etc) and all charges are done on this account (prepaid or postpaid). Traditional account-based systems (and here the bank or credit card accounts are mostly implied) are generally not suited for micropayments (especially their lower end).

Some existing MP procedures can be hosted under the umbrella of more general categories, such as:

- **Wireless Wallet:** A payment application is placed in the mobile phone of the user with all of his data entered once (and not on every transaction), which allows the customer to make mobile payments. The wallet can be local (the application relies on the chip of the mobile phone) or remote (the wallet relies on the payment provider and is accessed via a standard interface). Remote wallets require always a connection with the server-side therefore an always-on connection is needed, a complex infrastructure at the server side must exist and all user data are centralized. However they are easy to implement since the server is controlled by the provider and there is no software upgrade necessity at the customer side. Wallet-like approaches are followed for example in the Macalla, MoxMo and Nokia's m-wallet "Verified by VISA".
- **IrFM based**: Based on the IrFM Point and Pay profile standard of IrDA, several MP procedures have been developed. This approach seems to be more popular in Japan and Korea, but also in USA there have been trials. It is worth noting that VISA participates actively in many of them. Some of the efforts in this category are done by South Korea Telecom (Moneta), NTT DoCoMo, KDDI, ViVOTech, Verizon Wireless and Zoop.
- **RFID based (Smart Phone Covers):** This approach is also known as "contactless Chip Cards" or "RF-tag" and aims at smooth migration of existing infrastructure. A contactless chip or a RF-ID tag on the mobile side (usually on the phone cover but may be an integral part of the phone in the future) is combined with a user authorization on POS (PIN entry). In this way the consumers just have to place the phone close to the POS or ATM in order to initiate the payment. The mobile phone is used as a token to replace existing approaches e.g. magnetic cards. Celent Communications (www.celent.com) predicts that in 2007, RFID technology will capture at least eight percent of the payment volume at quick service restaurants, movie theatres, and movie and video game rental stores. Nokia/MasterCard, QuickWave and ExpressPay are some examples in this category.
- **Top-UP:** Electronic prepaid reload applications are a major weapon in operator's mission to maximize ARPU and increase profit. Since the majority of all MNO customers are prepaid users, and a significant percentage of revenue comes from them also, the

minimization of cost and expansion of Top-UP service points is critical for MNOs. According to Yankee and Baskerville analysts, prepaid mobile recharge is over $100 billion worth, and the value of servicing these payments at a 2.5 percent premium amounts to $2.5 billion per year. Europe's prepaid market penetration is estimated at 63 percent, or 170 million subscribers, which is more than double that in the US. The mobile Top-UP services are relative easy to deploy and the existing method of selling the Top-UP cards is costly and inefficient. According to Baskerville research most of MNOs spend up to $15 billion per year on prepaid vouchers and paper based recharging, in which 15 to 20 percent of their annual revenues are reinvested. Since there are numerous efforts in several countries, only some representative ones i.e. ATM based, SMS-based and Over The Air (OTA) based Top-UPs are further analyzed on the appendix of this paper.

Finally, there have been some "inventive" approaches on the market, that use the mobile phone not only as an authorization token e.g. RFID approach but also take advantage of its extra capabilities. Some examples include:

- **Mobile Cash Card:** Here the SIM card is used for authentication purposes e.g. on the bank's ATM. For instance NTT DoCoMo in Japan offers the ability to withdraw money from an automatic teller machine (ATM) with the use of a mobile phone i.e DoCoMo's 504i Series handsets. The phones are equipped with a chip onto which account information can be stored and via infrared light access ATMs.
- **Barcode paperless receipt:** Another unusual usage of the mobile phone is to use it as a medium that will uniquely identify a certain payment. The approach that makes online purchases possible without the use of a credit card or other deposit guarantee, is developed by Japan's major Telcos including NTT DoCoMo, KDDI and J-Phone, and is a single payment system that enables mobile phone users to pay for goods at convenience stores such as am/pm, Lawson and Ministop. When a consumer makes an online purchase, the system, sends a two-dimensional bar code with billing information to their phone handset. This is used to prove that a transaction has been initiated and in parallel as a digital receipt after the end of transaction; therefore, there is no need for a paper one. At a local convenience store, the consumer confirms the billing data (therefore finalizing the online initiated transaction) by waving the phone, which displays the two-dimensional bar code received earlier, at a special bar code reader, before paying by cash and picking up the goods. It is expected that consumers without a credit card or those who are not comfortable using a credit card online to pay for goods, will show interest in this approach. Bar codes are easy to be read using existing optical devices and therefore such procedure can be easily applied to most mobile phones.
- **PhotoPay:** A modern camera enabled phone captures the payment data from the merchant's terminal screen and proceeds with the actual transaction.

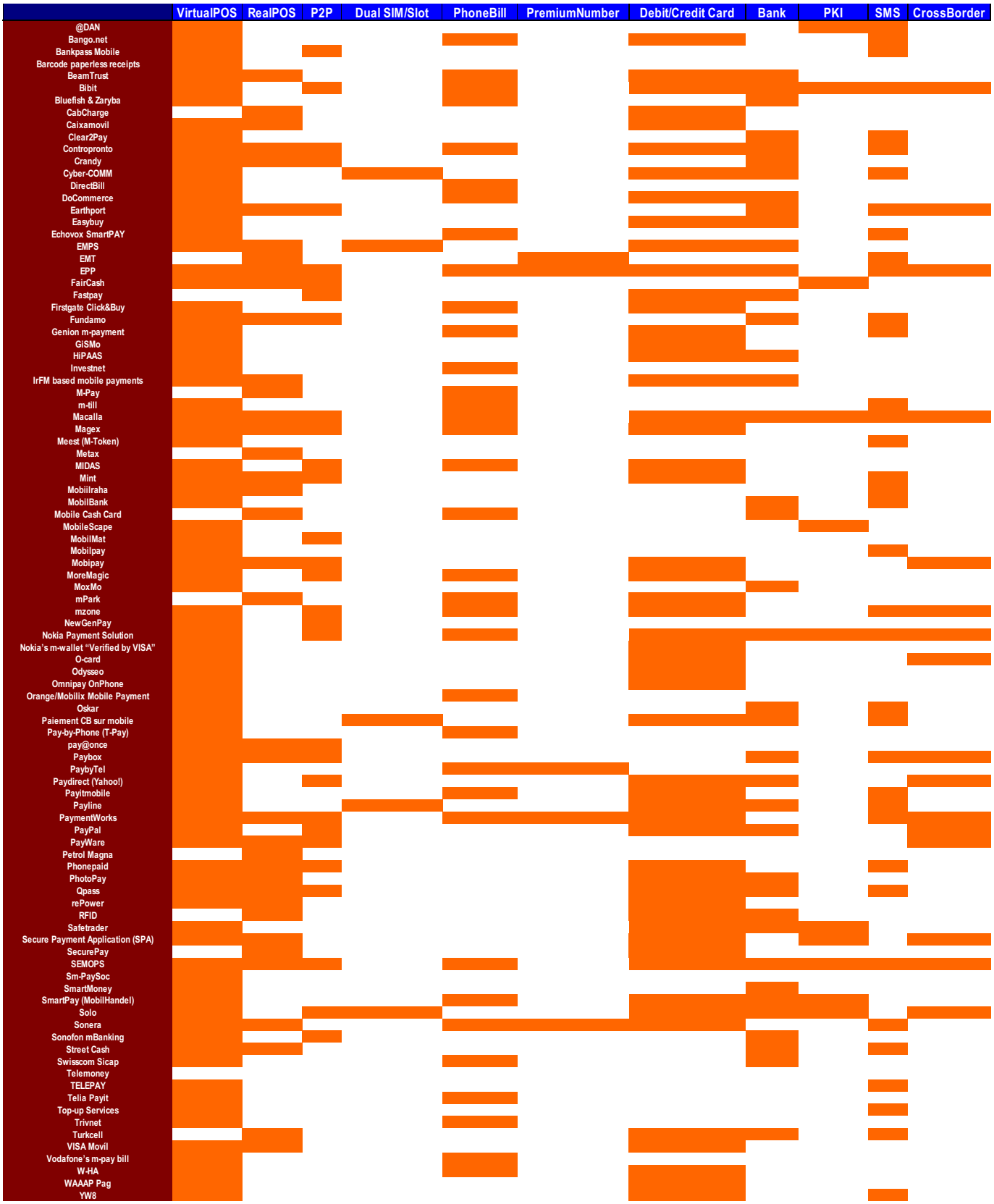

Figure 4 - Overview of mobile payment procedures

4 Discussion

As it has been shown, the interest on MP is evident, the standardization efforts are ongoing, and the search for the right business models as well as the successful approaches gets one step further day by day. This proves that the area is active and of great interest, but also indicate that we are still at the beginning of a long way that lies ahead. In Figure 4 we have made an initial comparison of the existing systems based on some of their characteristics. Please have in mind that the area is very dynamic and new services are put on trial or are going commercial day-by-day, therefore some of the features depicted in Figure 4 might have changed. The shaded areas in the comparison table show some existing characteristics of the system e.g. usage of a technology or approach, and the absence of a shaded area indicates that the service doesn't support this at the time of writing or it is not known to the author. Since many sites are in local language and not in a wide spoken one such as English, German, French etc, or do not provide adequate info, the task of identifying precisely each service's capabilities was challenging.

As depicted in Figure 4, most of the developed services are aiming at Virtual POS (also known as remote payments) in order to cover the needs of Internet purchases mainly. However enough MP services address also the RealPOS (also known as proximity payments) i.e. a real cashier interaction and some of them even allow person-to-person transactions. Most of the systems tried to use the existing business processes and to push them in the mobile payment layer, therefore it is quite common to charge the customer via: a credit/debit card, his bank account, his phone bill or even make him call a premium phone number (or send a premium SMS/MMS) that has a special cost. Common examples include newspapers such as the Johannensburg Sunday Times (www.sundaytimes.co.za), London's Sun (www.thesun.com.uk), Estonia's Postimees (www.postimees.ee) and Aripaev (www.aripaev.ee), that have integrated mobile payment schemes based on SMS/USSD or phone bill charges. Top-UPs are also a rapidly developing area that MNOs focus on, mainly due to the low costs when comparing with alternatives (e.g. distribution via real POS). Top-UPs not only cut the intermediates between MNOs and user, but also if coupled with a bank account provide the flexibility to be used anytime, anywhere and with no limits.

Most systems use standard 2G phones without any technical modification for fast adoption. Only some of them are designed with future infrastructures (3G and beyond) in mind, such as SEMOPS and MobileScape. In such 2G-2.5G systems the SMS as a method of notification and transport of transaction data including authentication is very common. WAP access to "mobilize" an Internet solution as well as IVR (interactive voice response) are other methods used to provide basic MP services. Since many systems were designed to be used over Internet, many solutions considered using PKI at least on the Internet-based part, while some others did actually use or intent to use PKI within the mobile handset as proposed within Radicchio. It is worth noting that only a few current efforts allow or have the potential to permit cross-border payments.

Most systems tried to handle micro and mini payments alone or in cooperation with a limited number of MNOs or banks. One can argue that the whole palette of payments (micro, mini and macro) can be provided by a single player e.g. a bank or an MNO. In reality, however the provision of this kind of payments is directly connected with risk management activities as well as technical capabilities. Therefore, today MNOs seem to be able to handle effectively micro and mini payments, while banks concentrate more on mini and macro payments. MNOs could also handle macro-payments, however legislation procedures in some countries will require a banking license from them. To handle the whole MP spectrum the bank infrastructure must be updated in order to allow handling of micro-payments, and this may not even be a cost-effective approach. Both big players can offer mini-payments and this is the domain where it is expected that both of them will provide antagonistic offers to the consumer, who at the end will select if a payment will be carried out via a bank, a MNO or a third-party service provider.

Most of the services tried to pursue the "all size fits all" solution by developing a mobile-end-point-capability agnostic approach i.e. addressing mobile phones as an end-user communication device without any advanced features while others experimented with SIM toolkit applications and Java. Finally, a small number of approaches focused on the "dual" approach (promoted also by the Mobey forum) i.e. "dual SIM" or "dual slot" in which the mobile device is equipped with two physical SIM cards, one for identifying the customer to the MNO and the other is used as a payment card to the payment provider. SIM chips today exist in all phones; however, it is questionable if an approach where only one chip combines it all and hosts multiple applications from different providers will establish itself. Currently many payment associations prevent banks from placing payment applications on a non-bank issued platform such as an MNO controlled SIM chip. Furthermore, by doing so the bank must trust the MNO platform and this in turn requires a heavy logistical cooperation, which is usually not the case. Payment applications are personalized before being used by the bank and SIM chips are pre-personalized by the MNO. As in each chip (controlled by MNO) there could be different payment applications (controlled by different banks), the approach of

controlling personalization might not prove feasible due to its high overhead. However, with the design of open platforms and software applications running on the phone (the aim of the newly created OMTP initiative), there might be hope for this approach as banks could (with the cooperation of MNO) update and personalize already deployed SIMs via online/offline software upgrades or the Over the Air interface of MNO.

Something notable is that we have seen on the MP domain limited alliances between the MNOs and between the banks and their efforts to bring various MP procedures on the market. However, as it was expected these approaches did not flourish. These alliances solve partially the critical mass problem, but are limited in the scope where they can be applied e.g. macro and the upper limits of mini payments are supported for bank alliances and respectively micro and the lower end of mini payments are supported by MNO alliances. Therefore, bank alliances are more suitable for eCommerce while the MNO alliances handle limited m-commerce scenarios. Lately we have seen also bank and MNO cooperation, but again on limited level. The last implies the cooperation of one or two banks with one MNO. Although this is a step to the right direction, this approach is still feared by many banks and MNOs who still see each other as competitors in a war to win the most customers and merchants. An MP procedure supported by many MNOs and many banks, will have a catalytic effect as all customers and merchants belonging to all participating banks and MNOs will be able to transact with each other. This MP procedure should be based on state of the art technologies, with open possibly standardized interfaces, and be flexible and extensible enough to accommodate evolving business models. This is the only foreseeable way today, to really establish a global mobile payment service (GMPS). This is what cross-industry standardization consortia aim at. MP procedures that will be able to accommodate all these requirements, will soon establish themselves as global players. SEMOPS is such a MP procedure, which proves that such a symbiotic cooperation is possible.

Finally, privacy issues are not adequately addressed in most procedures, with the exception of few of them such as Mobipay, SEMOPS, or prepaid approaches such as StreetCash. Most MP procedures ask from their users to register and provide private data, an act that limits the control the user has over these data. Nowadays these private data are moving away from centralized storage points and are kept in data centers distributed all over the world. Furthermore, the number of access points to these data is constantly increasing, since they have to be partially shared with all transacting and collaborating parties. Privacy is rarely or not at all addressed in any of the above systems. However, privacy is crucial for the future success of a payment solution that will inevitably replace paper money, as we know it today. Privacy and anonymity are fundamental in order to gain customer's trust and establish a base where also other value-added services, that require personal context-sensitive info, can flourish.

5 Future MP technology directions

As indicated throughout the paper, MP is still in its infancy. What is more striking though is that almost all existing approaches focus on 2G or 2.5G infrastructures and do not take into account emerging technologies. This can be understood, as most try to reach the critical mass by lowering their requirements at the user's handset, however the telecommunication and technology domain are also rapidly changing. New powerful devices, verifying Moore's Law, keep on coming to the market. The infrastructure itself is also quickly evolving. The debut of UMTS, wireless LAN, WiMAX and other 3G and beyond technologies will provide new capabilities [9] that will free MP from some its limitations and allow more sophisticated approaches to be developed. The mobile phone industry embraced 3G because it promised better quality voice calls, similar to fixed-line calls, alongside faster data connections for multimedia services such as video, e-mail downloads, music and interactive games. WiMAX (www.wimaxforum.org), a new promising technology is designed for data only. The latest simply confirms the already existing trends for migrating all services including voice calls completely onto the Internet, using the Voice over Internet Protocol (VoIP) technology, in an attempt to dramatically cut-down costs. In the near future of ambient intelligent environments, the mobile citizen will roam between different infrastructures and providers. Several issues arise from this, the most profound of which is security, trust and privacy. Furthermore, 3G and beyond infrastructures provide advanced capabilities as they introduce the capability of execution environments for 3rd-party service providers, and the rise of virtual MNOs (an operator without a physical network but with the ability to switch his own traffic and to issue his own USIM/SIM cards) will have an effect on existing processes and models. Future MP services, that do not confine themselves to simple MNO billing [20], will have to take into account the new security capabilities [21] offered by the 3G and beyond, and integrate dynamicity in their business models that may even lead to a marketplace of MP services for specific contexts where the MP providers provide antagonistic offers to the end-user who selects the suitable one according to his preferences.

The device manufacturers continue to bring on the market mobile phone models that have advanced capabilities [22] and host their own execution environment. It is a matter of time for advanced

cryptographic services to be integrated in the devices that will make possible secure voice and data communication. The security on most MP existing schemes is very weak, and that it is not widely exploited is only because MP is not mainstream. If MPs reach the critical mass, and manipulation of such services results in economic benefit, there will be efforts to compromise them. As an example, many systems offer SMS based authentication. However, any SMS can be forged, and it would be very risky to transfer any MP critical info via this medium. Furthermore, other attack scenarios are also possible [23]. MobilePKI, mobile digital signatures, encryption, and biometric authentication are expected to be widely available in the near future, so MPs should examine these methods for providing strong security and privacy whenever it is required, and always in balance with the other requirements such as usability. As an example in the biometrics section, JCB (www.jcb-global.com) in Japan has introduced the world's first finger blood vessel pattern authentication system that combines payment authentication with access control. In addition, Fujitsu's F900iC 3G handset not only supports the mobile wallet function available to the 46.6 million customers of NTT DoCoMo, but also can be locked and accessed securely via a fingerprint scanner. Furthermore, Identity Management efforts are ongoing in the Internet community and several standardization consortia such as Radicchio and Liberty Alliance work towards federated identity in virtual world. Many current limitations exist because identity management issues were not built in the networks at first place, but it was tried to put it later as an add-on. This didn't work, and no-one wants to make the same mistake again. If such efforts are successful, they will have a catalytic effect on MP domain, as they will provide a homogeneous identity framework capable of bridging universally the real and virtual world. Therefore, efforts towards this direction, like the newly announced (March 2004) cooperation of NAC, OMA, OSE, PayCircle, SIMalliance and WLAN Smart Card consortium with the Liberty Alliance in order to demonstrate that federated identity is among others a key enabler in mobile payments is a hint towards the trends of time.

While future mobile devices are expected to have a general-purpose execution environment, the problem that arises is how applications (including MP applications) can be securely loaded in a SIM card. While this can be done OTA or via mobile Internet connection, lately a new trend was identified. The banks (that have interest on deploying applications and further customizing the SIM cards) use their chip-card readers available on the streets (e.g. bank's ATM) to interact with the chip cards the user caries. A scenario where a bank's ATM machine is used for securely downloading applications to EMV cards or even updating the SIM applications via a bank-trusted terminal seems promising and will provide possibly new services and a new revenue-generating source.

We have seen that some systems use for P2P payment transmission protocols like IrDA and Bluetooth. Apart from these, interesting for MP are also emerging technologies like ZigBee (www.zigbee.org) that can offer an alternative over WiFi or Bluetooth networks. Even more promising are Instant Messaging (IM) and Near Field Communications (NFC). The IM will not only allow bridging the Internet and mobile services and payments, but also will permit P2P payments where the transacting parties are not in the same physical space. Recently NTT DATA and SEMOPS demonstrated at CEBIT 2004 (www.cebit.de), that such an approach is viable and promising. NFC [24] is a very short-range wireless technology (distances measured in centimeters) that is optimized for intuitive, easy and secure communications between various devices without user configuration. In order to make two devices communicate, users bring them close together or even make them touch. The devices' NFC interfaces will automatically connect and configure themselves to form a secure peer-to-peer network. NFC can also bootstrap other protocols like Bluetooth or wireless technologies by exchanging the configuration and session data. As NFC is an open standardized platform technology, it is interesting to deploy it in a several MP scenarios and develop secure "touch and pay" approaches. Contrary to RFID where usually the tags are mobile and the readers are stationary, NFC supports exactly the opposite more interesting model, where the tags are stationary and the readers are mobile. NFC allows only reading a tag when it is pressed against the phone, therefore eliminating the possibility of accidental scanning and preserving valuable system resources such as battery life, which will remain a limiting factor, at least until fuel cell powered mobile phones become a commodity. Adopting NFC based MP will mean that the device can authenticate on behalf of the user, which will eliminate the need for PIN numbers and passwords, and boost user friendliness. According to a recent ABI Research study [25], handsets with embedded NFC chips will be available in 2005, and exceed the 50 percent of market share by 2009. The open question that remains is what happens if the phone gets stolen, but as VISA points out, this is no different than losing a credit card today.

A lot of effort is invested lately on Digital Rights Management for mobile devices (mDRM). OMA is working towards this direction with a new standard (OMA DRM 2.0) that adds the ability to support richer content business models, such as stateful rights (e.g., play a tone *n* times) and, more significantly, the ability to copy content to other devices that a person owns, including backup storage. Business models are expressed in OMA DRM 2.0 rights expression language (REL), which could ease the coupling of DRM and MP. Coupling mDRM

with mobile payments results in a very powerful combination, where the mobile user any time anywhere can access legitimately content and instantly pay for it. This undoubtedly will boost content generation, which will also promote MP. In general, all mobile and Internet services will benefit from MP, since as an old telecom saying points out: nothing can be considered really as a service unless there is a way to charge for it. Furthermore, developments on the eGovernment domain and the vision of a mobile Europe pose the need a Europe-wide payment capability that will be seamlessly available to its citizens via a high penetration channel such as mobile phones, in an open cross-country form that will respect the user requirements and in parallel not restrict the business side creativity.

6 Conclusions

In current dominating 2G to 2.75G networks, the voice application (simple voice transfer) and "accidentally developed" services like SMS are the killer applications. This however will not last long. Soon such basic messaging services including the simple voice one, will be offered for a very low cost - if not for free - and the MNOs will rely on revenues coming from increased data traffic (the traditional way) and from their participation to value-added services (e.g. rich voice, location based services etc) developed not necessarily by themselves. These value-added IP-based services will be wireless by default, and the future citizen will be using them while roaming between heterogeneous infrastructures e.g. composed of UMTS, Wireless LAN and WiMAX networks. Mobile Payment is such a service, and its future impact is of key importance. In this work, we have created a cartography of the mobile payment area by presenting current efforts in standardization consortia as well as past/current MP procedures. Companies coming from different competitive areas are cooperating in order to set the roadmap for development of common capabilities at hardware and software level that would enable the introduction of global interoperable payment systems. These efforts are still not mature and none of them is widely accepted, at least not yet.

MP is a challenging domain where also the "one size fits all" rule doesn't apply. For instance, small value payments (micropayments) require a different approach than the other payments due to their different risk level and therefore a general MP architecture may not be suitable for all transactions. Furthermore, by many people MP is seen only as an additional access channel in the palette of existing payment services (like interactive TV via the Multimedia Home Platform - www.mhp.org) therefore we might experience efforts for a consistent homogeneous approach in all these channels as a total. For instance, MP and general card wireless payments can be merged, e.g. KDDI and NTT DoCoMo in Japan are integrating contact and contactless card (Sony's FeliCa - http://www.sony.net/Products/felica/) technologies in a single handset. Standardization is the key to accelerate mobile payments and, as we have presented, there are several consortia contributing to this common goal. Standardization does not necessarily have to be formal but just be endorsed by a subset of key players and should be extended by harmonizing the MNO system interfaces (both for authorization and clearing) to allow the development of open interoperable global services. Other challenges that MP will have to successfully tackle include security, usability, consumer behavior, new business models and country-specific regulation. Finally whatever MP approaches will be developed, they have to be as simple as possible, as simplicity is one of the major MP characteristics [26] that will allow itself to be adopted by the customers quickly and reach the so much wanted critical mass. Future MP architectures should not be designed with technology specific goals, as technology changes, but it should be possible to use a wide range of approaches available and more important, be able to extend themselves in order to cover future needs and accommodate technology evolvement.

Mobile payment has sparked a lot of interest in research and commerce communities and is viewed as an integral part of our future life. Mobile payment is not a simple stand-alone application for m-commerce; it is a key-enabler whose success will empower not only the m-commerce but also eCommerce domains. As mentioned above, there are still different business models, technologies, and approaches, a fact that clearly points out that mobile payments are still in their infancy. The right coordination of the existing MP fora (as presented in this paper) and relevant technology consortia (e.g. 3GPP, IETF, ITU, OMA etc.), the development of new business models, the successful integration of technology and of course the right balance between security, privacy, openness, user-friendliness and the other aforementioned requirements will determine the success of a global mobile payment service. It should also be always kept in mind, that apart from the technology part, the right legislation framework must be in place and ease approaches, especially when we refer to a global payment service. Experience has shown that even when a common directive exists (for instance within the European Union), its full interoperable implementation at per country level still remains a challenging task [27]. Finally following the general trend where mobile and fixed-line services converge (the aim of the July 2004 formed initiative named Fixed Mobile Convergence Alliance – FMCA), we will be soon realizing universal/ubiquitous payments (uPay), where the payment service is available on a global scale and the underlying infrastructure is completely hidden from the end-user. The payment area is expected

to be one of the most exciting ones within the next five to eight years not only from the research point of view but also from the business one.

7 Appendix

7.1 Index of MP standardization and other influencing consortia

7.1.1 Mobile Network Operator driven consortia

SimPay: In February 2003 T-Mobile (www.t-mobile.com), Orange (www.t-mobile.com), Telefónica Móviles (www.telefonicamoviles.com) and Vodafone (www.vodafone.com) formed a new "Mobile Payment Services Association" (MPSA) with the goal to deliver an open, interoperable and commonly branded solution for payments via mobile phones, designed to work across all operator networks. In June 2003 the consortium has re-branded itself as SimPay (www.simpay.com). Other operators including Elisa (previously Radiolinja), Mobilkom, Optimus, SFR,TeliaSonera, 3, debitel, KPN Mobile, O2 and TMN have expressed interest in joining the association which only by its initial four members has today a customer base of 280 million worldwide. Simpay focuses at the moment to payments under the 10 € (micro/mini payments) mark, with the goal enable over 1billion € of extra transactions for the mobile phone industry by 2007. Simpay mobile payment solution will have its technical launch by the end of 2004 and be commercially available in early 2005. Simpay will use the transaction-processing technology from Encorus (www.encorus.com), a company that is also offering its own MP, i.e. PaymentWorks Mobile.

Starmap Mobile Alliance: Nine leading independent small and medium-sized mobile operators formed on 1st of October 2003 a "Mobile Alliance", which was re-branded to "Starmap Mobile Alliance" (SMA) in February 2004, in order to provide seamless, enhanced voice and data solutions for business and consumer customers across Europe. The members include: Amena (Spain), O2 (Germany, UK and Ireland), One (Austria), Pannon GSM (Hungary), sunrise (Switzerland), Telenor Mobil (Norway) and Wind (Italy). This new alliance spawns initially European countries and can reach more than 41 million subscribers. It aims to be quick to market with new, innovative cross-border products and services, as well as co-operate on initiatives, including technology, sourcing and sales. Although mobile payments are not explicitly mentioned in their preliminary statement, these are included under the "innovative cross-border products and services" theme, and in the near future plan is to provide international Top-UP services for the prepaid accounts.

GSM Association: The GSM Association (GSMA - www.gsmworld.com) is a global trade association that represents the interests of more than 620 GSM mobile operators that have more than 1 Billion customers across more than 200 countries and regions around the world. Within the GSMA is active the Mobile Commerce group, which focuses on mobile payments i.e. aims at transforming the mobile phone into a 'mobile wallet'.

ETSI: The European Telecommunications Standards institute (www.etsi.org), is a non profit organization with 912 members from 54 countries inside and outside Europe. Its M-commerce (M-COMM) focuses on monitoring activities of various active fora on the field and analyzing the business needs of users/content providers/banks and other payment organizations for the security of mobile systems. The information gathered is then fed into appropriate organizations and activities. M-COMM work was finished in July 2003 and the results include requirements for payment methods for m-commerce, as well as work on mobile digital signatures that can be used for mobile payments [28].

UMTS Forum: The UMTS Forum (www.umts-forum.org) is an open, international body for promoting the global uptake of UMTS third generation (3G) mobile systems and services. In that context work is done for billing and charging models in a 3G and beyond infrastructure, which is form of mobile payments where the MNO has the control (pre or post-paid).

7.1.2 Bank driven consortia

Mobey Forum: The Mobey forum (www.mobeyforum.org) is a financial industry-driven global forum, founded in May 2000 with the mission of encouraging the use of mobile technology in financial services. In the meantime it has more than 30 members and has published documents related to the "preferred payment architecture for local payments" which is a solution (prototype implementation exists) based on a bank-issued EMV card (in the customer's dual chip phone) with the payment method embedded in or programmed on it. The roadmap for fully realizing mobile payments foresees a three-phase integration process i.e. a) RFID tags and PIN entry at the POS, b) dual-interface chip and PIN entry at the mobile phone and c) a full EMV-based solution optimized for use with mobile devices.

7.1.3 Cross-industry driven consortia

Mobile Payment Forum: The Mobile Payment Forum (MPF - mobilepaymentforum.org) is a cross-industry organization with several high profile members such as VISA, MasterCard, American Express, JCB, Chase, Compaq, Interpay, Mobileway, NTT DoCoMo, Scotiabank, Schlumberger, TIM and T-Mobile. It was

launched in November 2001 with the aim to create a framework for standardized, secure and authenticated mobile payments, based on payment card accounts. MPF wants to complement the work of other existing consortia by focusing on standardization of specific areas. Up to now they have released two documents a) a white paper and b) a risks and threats analysis and security best practices for two-way messaging [23].

PayCircle: PayCircle (www.paycircle.org) is a vendor-independent, non-profit and computer-company dominated (Hewlett Packard, Lucent, Oracle, Siemens and Sun Microsystems) organization that was founded in January 2002. Its main focus is to accelerate the use of payment technology and to develop or adopt open payment APIs (uniform Application Programming Interfaces) based on XML, SOAP and Java. Paycircle released in 2003 the ParlayX Web Service Specification that has integrated the Paycircle API, as well as a reference implementation and sample software. Paycircle focuses on a mobile payment infrastructure based on mobile web services. In order to tackle also more effectively authentication and identity management, Paycircle teamed up in Jan 2004 with the Liberty Alliance Project (www.projectliberty.org).

Mobile Payment Association: The three main mobile operators and the five most important banks in the Czech Republic have founded the Mobile Payment Association (MPA - mpa.ami.cz). The aim is to develop and support a unified system for mobile phone payments. MPA is an open association, and other banks and mobile operators present in the Czech Republic may join.

7.1.4 Device Manufacturer driven

MeT: Mobile electronic Transactions (MeT - www.mobiletransaction.org) aims at establishing a framework for secure mobile transactions, ensuring a consistent user experience independent of device, service and network. With many global players in its 50 members (the six initial were Ericsson, NEC, Matsushita, Nokia, Siemens, Sony), MeT is working towards developing technology and concepts that will further strengthen the framework for secure interoperable mobile transactions over heterogeneous environments. MeT claims that it will not start standardization efforts on its own and does not intend to compete with any existing initiatives. In 2003 MeT released its second set of mobile e-commerce specifications, a white paper on a "Secure Services Architecture for Mobile Commerce" and a description of a "Wallet Concept".

7.1.5 Technology driven

OMA: Open Mobile Alliance (OMA - www.openmobilealliance.org) was formed in June 2002 by nearly 200 companies representing the world's leading mobile operators, device & network suppliers, information technology companies and content providers. OMA's mission is to facilitate global user adoption of mobile data services by specifying market driven mobile service enablers that ensure service interoperability across devices, geographies, service providers, operators, and networks, while allowing businesses to compete through innovation and differentiation. Within OMA the m-commerce and Charging Charter (OMA MCC) was formed (Apr 2003) to identify the requirements of the m-commerce market, taking into account the needs of the entire value chain including - but not limited to - the global financial payment systems and operators. The group will work closely with the existing forums focused on mobile payment to ensure buy-in from all the players in this market.

IrDA: The Infra-red Data Association (IrDa - www.irda.org) aims at promoting an infrared standard that provides convenient cordless connectivity and foster application interoperability over a broad range of platforms and devices. Among other specification IrDA has released a Universal Wireless Payment Standard, the IrFM Point & Pay Profile. The specification contains detailed consumer usage models, terminal and mobile client implementation guidelines, architectural definitions for sending and receiving payment and transaction record information between mobile devices, such as handheld phones or PDAs and a financial terminal such as a Point-of-Sales (POS) device.

7.1.6 Identity driven

Radicchio: Radicchio (www.radicchio.org) was founded 1999 as a global body of companies, organizations, manufacturers and groups, with an interest in building a global infrastructure by promoting common standards to unleash the potential of secure wireless commerce globally. The t²r (Trusted Transaction Roaming) project was launched in January 2002 in order to establish a global cross-industry platform to enable secure, trusted wireless transactions. The t²r framework will enable secure identification of all end-users in a wireless network therefore enabling services outside the home operator network to securely identify end-users as they roam. PayCircle and Radicchio have signed a liaison agreement (October 2002).

Liberty Alliance: The Liberty Alliance (www.projectliberty.org) Project is an alliance of more than 150 companies, non-profit and government organizations from around the globe. The consortium is committed to developing an open standard for federated network identity that supports all current and emerging network devices. Federated identity offers a more convenient and secure way to control identity information in today's digital economy, and is of key importance to any mobile payment scenario. This has been realized by

the major mobile payment consortia who are working closely with Liberty Alliance. As announced in March 2004, Network Applications Consortium (NAC), Open Mobile Alliance (OMA), Open Security Exchange (OSE), PayCircle, SIMalliance and WLAN Smart Card consortium are working collaboratively with the Liberty Alliance, demonstrating that federated identity is a key enabler in everything from mobile payments and on-demand networking to integrating electronic and physical security systems.

7.1.7 Financial Services consortia

ECBS: The European Committee for Banking Standards (ECBS - www.ecbs.org) was formed in December 1992 by Europe's three credit sector associations, the banking federation of the European Union, the European association of co-operative banks, and the European savings banks group. Primary aim is to enhance the European technical banking infrastructure by developing standards when a clear business and commercial interest has been identified. ECBS also produces technical reports and standard implementation guidelines that are relevant to mobile payment and further assist the European banking sector's application of relevant standards. The internal active group on MP is WG4 (Work Item 6.4): Mobile Payments.

FSTC: The Financial Services Technology Consortium (FSTC - www.fstc.org) was founded in 1993 and is a consortium of North American-based banks, financial service firms, industry partners, laboratories, universities and government agencies that sponsors collaborative research and development on technical projects affecting the financial services industry. Well-known past projects are eCheck (www.echeck.org) and Bank Internet Payment System (BIPS). FSTC has two initiatives on wireless security and interoperability of wireless and other mobile technologies in the financial services industry.

IFX: The Interactive Financial eXchange Forum (IFX - www.ifxforum.org) was formed in 1997 to create a messaging standard for financial services. The forum is designing a next generation XML standard that would be usable in many types of environments and extensible to cover many types of financial transactions. The IFX Forum published in February 2004 the latest IFX specification (Version 1.5), which provides an Extensible Markup Language (XML) based communication protocol that enables the exchange of information between financial institutions and their customers, their service providers, and other financial institutions. A direct debit payment process (one of m-payment methods), which is used by business banking to draw funds from payers, is also included.

ARTS: The Association for Retail Technology Standards (ARTS - www.nrf-arts.org) of the national retail federation is a retailer-driven membership organization, established in 1993 and dedicated to creating an international, barrier-free technology environment for retailers. ARTS has developed two standards of significance: the retail data model and Unified Point of Service (UnifiedPOS). The standard data model contains all the data definitions required to develop the computer applications required to operate a modern retailing business. The UnifiedPOS (which links JavaPOS (www.javapos.com) and OlePOS (OPOS) under one common API specification) is a device interface standard that allows retailers to add new devices to sales floor terminals with minimal, if any, program change. As in m-payment era mobiles are expected to interact with any POS, an extensible POS is seen as an important integrated part of m-commerce.

7.1.8 Other technology influencing consortia

Finally, due to the fact that m-payment brings together companies with different background, several other consortia affect indirectly a mobile payment system. Some of these are:

- OMTP (www.omtp.org),
- TIA (www.tiaonline.org),
- 3GPP (www.3gpp.org),
- SWIFT (www.swift.com),
- EMVCo (www.emvco.com),
- Identrus (www.identrus.com),
- ISO TC68 (www.tc68.org),
- CEPSCO (www.cepsco.com),
- The SIM Alliance (www.simalliance.org),
- Bluetooth (www.bluetooth.com).

7.1.9 The Merged and "frozen" mobile payment related consortia

MoSign: MoSign (www.mosign.de) was a consortium initiated by Deutsche Bank, Emagine, Ericsson, Materna, Microsoft, Sema Group, Siemens and TC TrustCenter aiming also at the introduction of digital signatures like mSign and Radicchio consortia. MoSign had as requirement the existence of a smartcard, which hosts the private key and the certificates according to Identrus scheme (www.identrus.com). The MoSign solution didn't not bound to the mobile phone but was a universal one, and was based on open standards like WAP, HTTP etc. In general, the aim was to develop multi-infrastructure flexible smartcards for m/e-commerce and easy integration with existing POS. It is highly unlikely that the consortium will continue its work.

Global Mobile Commerce Forum: The Global Mobile Commerce Forum (GMCF - www.gmcforum.com) was created 1999 as a non-profit making body that promotes development of mobile commerce services around the world, including mobile payments. Main activities included organization or sponsoring of conferences and other events concerning m-commerce. It seems that GMCF has ceased to exist.

Mobile Wireless Internet Forum: Mobile Wireless Internet Forum (MWIF - www.mwif.org) was an international non-profit industry association with mission to drive acceptance and adoption of a single mobile wireless and Internet architecture that is independent of the access technology. MWIF has folded all operations as of December 31, 2002 and will continue most of its technical work in the Open Mobile Alliance (OMA).

Mobile Electronic Signature Consortium: The Mobile Electronic Signature Consortium (mSign www.msign.org), was created in 1999 and is an association of companies and organizations from the mobile phone and Internet sectors, with the objective to establish and develop a secure cross-application infrastructure for the deployment of mobile digital signatures. MSign specified the mSign Protocol, which is a standardized interface defining communication between mobile operator and a service provider. In February 2001 Radicchio and mSign announced plans to formally merge their international activities, therefore any future activity will be done within the Radicchio.

7.2 Index of MP efforts

The rise and fall of several mobile payment efforts has been witnessed in the last years. The World Wide Web features a great number of companies referred in press announcements, technology web sites etc that planned to introduce m-payment services. Due to the economic meltdown and the decrease in willingness to finance high-risk technology-based activities many of them have ceased to exist or have frozen their activities until new financial support is acquired. Here we offer an index of the MP efforts, which is not claimed to be complete, but according to the author's knowledge no such archive exists, for those interested on the history and present of MP efforts.

1. **@DAN:** @DAN stands for "@DvANced and high secure mobile platform to support the digital economy" and is another European Union project (IST-2001-32634). The project develops a PC-based platform for applications based on digital signatures and secure payment over UMTS handsets.

2. **Bango.net:** Bango.net (www.bango.net) is a mobile services provider, which acts as a payment gateway for operators across Europe for the purchase of mobile content. Mobile credit/debit card payments are possible and the funds are subsequently transferred to the content provider's account. The payment can be done also by using a prepaid account, premium SMS or operator billing. Lately Bango has been integrating the Simpay mobile payment standard into its payment platform.

3. **Bankpass Mobile:** Bankpass Mobile (www.bankpass.it) is a server-based mobile payment solution. It will be an SMS based service capable of handling peer-to-peer fund transfer.

4. **BeamTrust:** BeamTrust (www.beamtrust.com) is a mobile solution deployed in Denmark that has a wireless account-to-account payment system and aims at migrating its solution towards the standards outlined by Mobile Payment Forum. BeamTrust's solution requires a mobile telephone with a special SIM card, a traditional cash register, and a newly developed payment terminal The customer accepts his purchases by pointing the infra-red beam of his mobile phone at the payment terminal and by entering his digital signature. When the payment has been accepted, the customer receives an electronic receipt on his mobile telephone. The approach allows to the payer to freely choose from which of his accounts he wishes the amount to be withdrawn. The transactions are stored on a server in the shop and can be cleared later or simultaneously with the transaction at the data centre of each individual bank. All electronic receipts are stored in a database to which the customer has access via the Internet, and detailed information about all the mobile purchases can be found.

5. **Bibit:** Bibit (www.bibit.com) is specialized in international Internet payments, allowing the consumer to pay a foreign Internet retailer using a payment method, which is common in his own country. Among other payment types, Bibit offers mobile, WAP and peer-to-peer payments by introducing country-specific m-payment existing services. Mobile Payments are possible via their "Mobile Payment Suite" which uses platforms like i-Mode and "Vodafone Live".

6. **Bluefish & Zaryba:** Bluefish (www.bluefish.com) and Zaryba (www.zaryba.com) offered at the begin of 2003 a mobile post-paid bill payment solution. The application uses the SIMToolkit / SIM browser technology to create a menu-driven interface via which users can view and pay their bills and also receive transaction confirmations. Payments are made through a direct connection between the banks and clearing houses, the Zaryba transaction server and the network operator's billing system.

7. **CabCharge:** Wireless payment terminals are being installed in cabs in several countries, including the UK, Australia, Dubai, Japan and the US. The aim is to provide the legacy credit card payments via mobile POS in cabs. The most widely known is the Australian CabCharge (www.cabcharge.com.au), which validates Mobile POS Payments over a GPRS network. The POS simply connects to the acquiring bank via the mobile network operator, and fares and tips automatically paid into a driver's bank account.

8. **Caixamovil:** The Spanish bank Caixa offered the "Caixamovil" payment system to its customers that have a credit or debit card. Mobile phone numbers are linked with a credit/debit card. In Internet the user provides his phone number while in real POS the merchant dials the customer's number from an adhoc terminal. The procedure ends with the user authorizing the transaction via his PIN when "Caixamovil" calls back. The system is substituted by VISAmovil (since May 2001).

9. **Clear2Pay:** Clear2Pay (www.clear2pay.com) is a Brussels-based company, offering payments solutions for the international financial industry. They enable banks to offer account-based payments to their customers via wireless channels (SMS-based messages, call centers, 3G interfaces) and mobile network operators to join in via their eWallet Solution. The user has a pre-paid account where all charges are made.

10. Contopronto: This (www.contopronto.com) is a MP procedure in Norway, realizing a server based mobile wallet linked to a GSM mobile number. Users can make P2P and Internet payments and withdraw cash. It is SMS based.

11. Crandy: The company (www.crandy.de) offers to registered users real time payments for goods. They have an IVR and a Java interface. It is a typical prepay service with online account management.

12. **Cyber-COMM:** Cyber-COMM (www.cyber-comm.com) is a SET-compatible solution for payment on the Internet, via bank smartcard readers. Its functionality has been extended to include mobile payment via the "Paiement sur mobile" approach. The service probably stopped being operational in 2001.

13. **DirectBill:** Cingular (www.cingular.com) is the first company to offer wireless micropayment services in the United States via its DirectBill product. It is a MNO-assisted microbilling solution where the user can make purchases that appear on the monthly MNO bill.

14. **DoCommerce:** Japan's major mobile operator, NTT DoCoMo (www.nttdocomo.co.jp), is offering 'DoCommerce', a secure mobile payment service, to its i-mode [29] subscribers. Currently the service is offered in cooperation with Mizuho bank (www.mizuhobank.co.jp) in Japan, but several other providers integrate this as an alternative solution to their services. Lately NTT DoCoMo offers to subscribers with 2G and 3G SSL-compliant handsets, the capability to pay online with VISA or JCB credit cards. The 'DoCommerce' aggregation service has already attracted thousands of customers, who can use a single password and screen to check their account balances with the 18 banks and credit card companies participating in the initiative. In July 2004 NTT DoCoMo launched a mobile-wallet system within the i-mode handsets that is based on the Sony's FeliCa smartcard.

15. **Earthport:** Earthport (www.earthport.com) offers world-wide (70 countries) cash transfer via several channels including SMS, Java2 Micro Edition, WEB and WAP. Payments are carried out between two parties who are registered to the system and have linked their bank accounts/credit card or have made a cash transfer to an Earthport account (V-account). The user can retransfer back the money to his bank account if he wishes; therefore this differentiates Earthport from the standard pre-pay models. Furthermore charging to the V-account can be done at micro level, which enables micro-payments and at multiple currencies. Earthport has a bank-centric business model, whereby the money never leaves the banking system.

16. **Easybuy:** Easybuy is a m-payment solution for the Internet offered in Italy by i-TIM (www.tim.it). The payer has to provide his credit or debit card to any Automatic Teller Machine (ATM) of an EasyBuy participating bank in order to enable future EasyBuy transactions to take place. In the merchant's site the payer's phone is provided and a SMS notification invites him to authorize the transaction via his PIN. The solution requires a SIM card with 32 Kbyte of memory, and one can optionally use the service with iTIM WAP phone, whereby Internet transaction and payment are both carried out over the same mobile phone.

17. **Echovox SmartPAY:** SmartPAY of Echovox (www.echovox.com) is a mobile micro-billing system for Microsoft Windows powered smartphones that enables mobile software developers to bill usage of their application through a simple pay per use mechanism. The user downloads an application to his mobile device and he can then test the application once or twice. On the 3rd trial the application prompts him for payment to unlock the application. The user accepts the transaction and sends the

required information. The SmartPAY platform queries the developer license server for the unlock sequence and sends it to the phone therefore allowing the user to access the application. The user gets billed on his phone bill for his software usage. Via its ICON (Inter-Carrier Open Network) coverage, application developers can distribute applications with this model throughout Europe (more than 36 mobile operators in 10 countries).

18. **EMPS:** The Electronic Mobile Payment Service (EMPS [30]) is a mobile-commerce pilot of Nokia, VISA and Nordea (www.nordea.com), using dual chip WAP phones (SIM+WIM), an EMV WIM card issued and the VISA Open Platform. Over the first half of 2001, the pilot offered remote payment (also via Internet) and log-on to electronic-banking. Real POS payment was also planned. In its second phase, the pilot used local communication technology such as Infrared and Bluetooth, and targeted the wireless download of applications onto a bankcard using VISA Open Platform. EMPS is associated with the technological choice of separating SIM and WIM chip cards (as also supported by Mobey Forum) and the resulting business model of bank/MNO collaboration, keeping separate the payment function (via the WIM card controlled by the bank) and the network function (via the SIM card controlled by the network operator). In 2003 the EMPS pilot is again started in the Helsinki metropolitan area in Finland.

19. **EMT:** EMT (www.emt.ee) and Radiolinja (www.radiolinja.ee) offer m-payment services in Estonia. In order to pay for a service, the payer has to call a special number or send an SMS. Mobile parking (m-parking.emt.ee) is a successful service launched in Estonia and lately in Norway, and has also been one of the finalists in the 2002 Stockholm challenge award (www.challenge.stockholm.se) in the category "e-business". Other featured services include buying goods and charging them to a m-account. The customer has to make an agreement at Internet-bank (hanza.net and U-Net) by specifying the amount to be deposited to his personal m-account.

20. **EPP:** Enterprise Payment Platform (EPP) is a product of iPIN (www.ipin.com) that features an agnostic architecture and extensive functionality, which supports all types of mobile payment methods across a variety of access channels. EPP has been chosen by Ovum (www.ovum.com) as "the most comprehensive suite of payment capability on the market". iPIN joined the Mobile Payment Forum in February 2003.

21. **FairCash:** FairCash (www.e-faircash.com) is a prepaid payment system solution that can accommodate micro and macro payments. Cash is represented by encrypted tokens stored on a reloadable and secure "Safe Valuta Storage" device" (SVS), based on the fairCash-PAY-Chip, acting as a local storage personal payment server. In peer-to-peer transactions, fairCash value tokens flow directly from one fairCash chip to another fairCash chip and no third-party intermediary clearance takes place except of the holders of the two fairCash chips. The later really enables payments as with cash today, and with less fraud risk due to a double spending database maintained by the fairCash issuer. The platforms via which fairCash can be used covers a variety of existing technologies and devices including mobile devices. The user receives (against a deposit, an account or credit card debit) a set of tokens transferred to his SVS device and the encrypted serial number of the fairCash tokens is entered in the double spending DB owned by the issuer. These tokens can be passed on to any other SVS device until their maximum hop-count is exhausted or when their expiration date has come, after which tokens can only be transferred back to the initiator for clearing. All SVS will maintain a local log of tokens received together with the ID of the transmitting SVS which provides the user with a means to prove his innocence with regards to counterfeiting 'money'. The analysis of that log, requires the owner cooperation, as centralized log data bases are not supported. FairCash uses PKI certificates, various encryptions algorithms, double spending DB, zero-knowledge proof/authentication, and enhanced modified blind signature issuing protocol to provide a secure solution.

22. **Fastpay:** FastPay (www.fastpay.com) is a system that integrated Magex and offers person-to-person fund transfers via email and mobile phone. The charges are made on user's credit/debit card or UK-based bank account.

23. **Firstgate Click&Buy:** Firstgate Click&Buy (www.firstgate.de) is a microbilling system for digital content on the Internet and on mobile platforms. Several billing models are supported e.g. payment per click, per item, per time, per view, subscriptions etc. The purchases are not debited directly but aggregated and charged later in payer's bank account, credit/debit card or MNO bill. This approach is used by more than 2000 providers worldwide including RTL, bild.de, Spiegel.net AG, Deutsche Post, UNICEF, BT (www.btclickandbuy.com) and ePaymentsnews (www.epaymentsnews.com).

24. **Fundamo:** Fundamo (www.fundamo.com) is a mobile payment system that realizes real-time transactions primarily in Africa. It enables its users to make payments, with value stored on a server, from mobile-to-mobile, mobile-to-POS and mobile to Internet. Inter-Fundamo payments do not require a clearance

period and these funds are immediately available. Fundamo Payment Gateways (FPG) can be operated by a bank in order to have its legacy accounts Fundamo-enabled. For non-banking institutions that operate an FPG it is possible to offer peer-to-peer payments between Fundamo users. Fundamo has undertaken several measures to provide a secure environment. All links between FPG-to-FPG and FPG to third party applications are based on secure links e.g. shared symmetric keys (3DES for GSM or SSL for Internet) between FPGs and Fundamo enabled handsets and POS devices enable encryption of information between and authentication of these devices. Security mechanisms have been designed for both SAT (SIM Application Toolkit) and WIG (Wireless Internet Gateway) handset implementations. To partners using its technology, Fundamo provides a certification system including a set of rules and principles with which they are required to comply. Transfers between the various parties are done via dedicated lines, private networks and encryption is again required. Mobile phone based transfers are authorized by the user with the PIN. Even if the user initiates the transaction on Internet, the notification is still sent to the mobile phone of the payer for authorization.

25. **Genion m-payment:** Genion m-payment is a mobile payment service developed by VIRBUS (www.virbus.de) and offered by O2 (www.o2online.de) in Germany. There is a choice between WAP (PIN authorization) and SMS (TAN - one time authorization code). In the later and when shopping in a VirtualPOS, the user is redirected to the Genion m-payment server where he logs in. The server sends via SMS a TAN to the customer in order to authorize the Internet purchase. Both parties (merchant and customer) are notified for the success of the transaction. The Internet part is SSL secured and it is planned that digital signatures are added as capability to the SIM and to extend to real POS. Processing is done by Telecash (www.telecash.de), a clearing house subsidiary.

26. **GiSMo:** GiSMo's name is a combination of the initials GSM with G i(nternet) S M o(pen) and is a m-payment approach developed by Millicom (www.millicom.com). Gismo allows account-based payments for Internet shopping, but using a GSM phone to verify the buyer's identity and authorize the transaction. Customers must first register and open a credit account (electronic wallet) on GiSMo Web site where they supply their mobile phone number and get a username and password. GiSMo can handle both micro-payments and macro-payments. Again the pattern is the same i.e. the user gives his mobile phone number to the merchant and gets back an SMS with a transaction-specific PIN. The user reports the PIN back on the web site or the merchant's POS and the transaction is authorized. Both payer and merchant get a notification and the merchant notifies the GiSMO server that the goods have been delivered. Finally the GiSMO customer can access any time payment, billing, and shipping information on Gismo servers. Again this is a legacy system that uses the mobile phone as a complementary tool for extra security in an transaction. Millicom withdrew its product, and is working on a simpler alternative to GISMO.

27. **HiPAAS:** HiPAAS is a service offering from Upaid (www.upaid.net), based on proprietary payment processing software. The approach enables multiple parties such as banks, mobile operators and merchants to connect to centralized payment authentication, and service delivery centers to allow anywhere-to-anywhere handset-authorized payments. At the moment prepaid Top-UP services via SMS, ATM, Web or POS are supported and charging is done at user's bank account or credit/debit card.

28. Investnet: MPS is a mobile payment system designed by Investnet (www.investnetinc.com). It is WAP based, and offers three different approaches with different levels of security. The charging is done on user's phone bill.

29. **Macalla:** The Macalla Mobile Payments Platform (www.macalla.com) is a MP solution that provides an extensive range of wallet and payment related services orchestrating the interaction between a consumer, their preferred payment mechanism, a merchant and payment processors.

30. **Magex:** Magex (www.magex.com) offers a managed payments platform delivers a number of payment services including mobile payment. They offer pre- and postpaid accounts, direct fund transfer and clearing services for easy integration. MasterCard International has selected (June 2003) Magex's Managed Payments Platform as its chosen technology for its new European cross-border P2P payments service to be known as MasterCard MoneySend. The approach supports traditional and mobile channels e.g. SMS, WAP, IVR.

31. Meest (M-Token): The Mobile eCommerce and eWork Secured Transactions (MEEST - www.meest-ist.org) is an European Union financed project that focuses on eCommerce transactions via SIM, SMS, GPRS and UMTS mobile technologies. MEEST's solution, m-Token, facilitates anonymous purchase of digital content from mobile subscriber's prepaid account, or payments for goods at real-world stores and targets also micropayments. M-Token users making micropayments from a prepaid account enter their phone number at an e-tailer, for SMS-based validation by the operator, which

settles with the merchant after the user has typed the validation code into the e-tailer's web site.

32. **Metax:** Metax (www.metax.dk) offers petrol payment via mobile phones (patented concept) in Denmark. The mobile phone is used as a replacement for a METAX credit card, therefore the customer still gets a monthly invoice from Metax even though a mobile phone is used. The user calls a free phone number and is invited to enter his/her PIN (provided by Metax), after which he can use the station's pump.

33. **MIDAS:** MIDAS is a pilot MP service of NetCom (www.netcom.no) in Norway that is based on MoreMagic's payment transaction software MBroker. Credit cards (VISA/Eurocard) as well as the NetCom phone bill and mWallet, a server-side wallet comparable to a pre-paid card, were the supported payment methods.

34. **Mint:** Mint (www.mint.nu) is providing m-payment services in Sweden via their m-payment platform [31]. Mint can accommodate Internet, in-store, billboard payments, session, person-to-person. Mint uses CLI (calling line identifier) for the identification of customers wishing to conduct a transaction and PIN codes for transaction authorization. The platform accepts DTMF as well as voice recognition. Other mobile interfaces include SMS and WAP. The scheme has attracted more than 11.000 users and 160 POS.

35. Mobiilraha: In Finland, operator Radiolinja and banks Nordea and Sampo will introduce a service, which will enable paying for services by SMS. The users can download money, between EUR 5 and EUR 400, to the mobile purse at Nordea's and Sampo's Internet banks. When paying, the user sends an SMS to the number provided by the retailer. The system checks whether there is enough money in the purse and sends an approval for the payment to the retailer. The retailer has to pay a commission for the system.

36. **MobilBank:** Mobilcom (www.mobilcom.de) and Landesbank Baden-Württemberg (LBBW - www.lbbw.de) joined forces and created MobilBank (www.mobilbank.de), which offers mobile payment services via WAP and SMS at first stage and more advanced services with the introduction of UMTS infrastructure. As the customers of the mobile payment service have a bank account with MobilBank real time check of available funds is possible. A SIM toolkit allowed encryption of SMS. The project started January 2001 but was stopped in May 2002 due to limited interest from the customer's side (according to their press release).

37. **MobileScape:** Sprint (www.sprint.com) and Novatel Wireless (www.novatelwireless.com) are working on a wireless 3G payment processing system (MobileScape) for the enterprise market. MobileScape is envisioned as a platform that can be easily integrated as a wireless business process application and payment processing system for use by mobile workforces. MobileScape is equipped with the MobileScape M2 handheld device, signature capture capabilities, an integrated printer, encryption, security and a Web-based interface called POSware.

38. **MobilMat:** MobilMat (www.mobilmat.it) is a mobile payment service offered in Italy. The user is able to make Internet purchases and send money to other MobilMat users. The user is calling a toll-free number and interacts with a voice-based service via DTMF codes. After authorizing the transaction via a PIN the results are immediately displayed on the mobile phone's screen (both in recipient and sender). The whole process takes only a few seconds to complete.

39. **Mobilpay:** Mobilpay (www.mobilpay.com) is a patented mobile payment service for VirtualPOS purchases in Austria. Once the payer selects the Mobilpay as a payment method, an one-time PIN is announced to the user's mobile phone via a voice service. By sending the PIN via SMS to the Mobipay system the user authorizes the payment. Currently the activities of Mobilpay are, due to global economic situation, "frozen" while the management is searching for new investors.

40. Mobipay: Mobipay (www.mobipay.com) is a system introduced in Spain (but patented in 66 countries for future expansion) that can handle micro a macro payment transaction in real and virtual POS as well as peer-to-peer. The system allows users to recharge their purchases with their bank-issued credit and debit cards, or with e-cash drawn from prepaid accounts. In real POS payment the merchant enters in his terminal the code of the product to be purchased and the phone number of the consumer or scans the barcode sticker given to the user with its registration on mobipay system. Then the consumer receives info on his screen about the purchased product and its price. With his PIN code he authorizes the transaction and the Mobipay system sends a confirmation message both to user and merchant. In Internet purchases the payer receives a reference number, which he enters on his phone together with his PIN. Both the payer and the merchant receive confirmation of the payment. Since November 2003, Mobipay is available in cabs in several cities in Spain. The cab driver enters the amount of the fare and the customer's mobile phone number. The customer receives a message with the charge and he has simply to enter his credit card PIN to validate the

transaction. It is worth mentioning what differentiates Mobipay; the Internet transactions are user-initiated (a virtual shop generated reference number and the PIN are entered on the mobile phone) and no personal data are revealed (e.g. name, telephone number etc) therefore it is enhancing privacy and preventing problems like misuse of the mobile phone number e.g. via commercial SMS. Authentication is again provided via the SIM card, the PIN is sent over USSD (Unstructured Supplementary Services), which guarantees message delivery and communication is encrypted via GSM-secure network (which is only effective on the Over the Air interface). All transactions are controlled by the Mobipay server and the processing is routed on the respective financial institution.

41. **MoreMagic:** MoreMagic (www.moremagic.com) was founded in 1997 and provides a mobile transaction platform that is an open, standards-based solution with a modular generic architecture, that can accommodate mPayments including prepaid and postpaid electronic wallet.

42. **MoxMo:** MoxMo (www.moxmo.com) is a mobile payment solution introduced in the Netherlands. The user is offered a mobile purse that is bound to a bank account. Mobile purse to mobile purse transfers are possible.

43. **MPark:** mpark (www.mpark.ie) is wireless parking payment system, launched in Dublin, Ireland. Customers are able to pay for on-street parking using their mobile phones. The user has to call a special number, follow the pre-recorded instructions and input the requested information (on mobile's keypad) in order to activate the ticketing machine. The authentication is based on the called-ID (mobile telephone number) and charging is done on user's credit card or phone bill.

44. **M-Pay:** M-Pay (www.m-pay.com) is a mobile payment system developed by Ultra (www.ultra.si) in Slovenia. The patented payment process is using voice to transfer the information necessary for the purchase. The user's identity is defined on a SIM card in the mobile phone and is further secured by entering a special PIN either on a phone or payment terminal. The payment terminal and payment center authenticate themselves with a digital signature based on an Elliptic Curve Cryptography based system. Data encryption is performed according to a validated digital signature and end-to-end encryption is available for third-parties, such as banks. The system is also introduced in Croatia.

45. **m-till:** M-till (www.m-till.com) is a mobile phone micro-payment service aimed at publishers that want to sell digital content on an ad-hoc basis in UK. It is available on all four MNOs in UK and the charging is done on the phone bill. The customer selects the m-till method of payment by simply clicking on the m-till 'Buy' button, and then he receives an SMS with the code that grants access to the content he wishes to view.

46. **Mzone:** mzone is a complete mobile payment and service delivery solution from Network365 (www.network365.com) that addresses all the elements of the mobile Internet value chain from secure, personalized payments and identification to advanced messaging and optimization of content. Network365 has been merged with iPIN in 2003 and offer a common product named ValistaPlus.

47. **NewGenPay:** NewGenPay (www.newgenpay.com) has taken the IBM micro-payment technology and developed it so that it can be used for a number of different payment methods. NewGenPay offers payment systems to a wide variety of payment service providers including financial institutions, Telcos and Internet service providers. The main product of NewGenPay is the Valuto System, which is easily customizable and can be used to build multiple payment applications, including wireless payments, person-to-person payments and micropayments. NewGenPay microPayments implements W3C's common markup for micropayment per-fee-links specification [32].

48. **Nokia Payment Solution:** Nokia (www.nokia.com) has been developing a MP solution (the Nokia Payment Solution) that is a server software product that enables mobile network operators and other service providers to position themselves as a payment mediator, offering consumers a way to pay, using a wide range of payment methods in a secured environment. Furthermore Nokia has in many of its phones implemented a m-wallet, a password-protected area in the phone, where one can store personal information such as credit card numbers or loyalty card details.

49. **Nokia's m-wallet "verified by VISA":** On Sept 2003, VISA EU and Nokia agreed to enable mobile subscribers to make secure payments from their phone handsets by using Nokia's m-wallet application with "verified by VISA" authentication functions. The m-wallet of Nokia enables users to store personal data such as usernames and passwords, VISA card details, and delivery addresses, on their phones. Since VISA cardholders can use the same password in the Internet and the mobile channels, VISA is effectively extending the transparency of its 3D-Secure protocol to mobile payments.

50. **O-card:** O-card is a e/m-payment solution from Orbiscom (www.orbiscom.com) that allows cardholders to shop online without having to transmit their actual card details over the Internet or mobile phones (WAP). A unique generated number (O-number) is used for each transaction. Customers can access the O-card application directly from their issuing bank's website and can communicate with their bank via the O-card every time they shop online. Mobile users can use the WAP.

51. **Odysseo:** Odysseo (www.odysseo.com) offered a virtual wallet, which allowed safe purchases on the Internet on all merchant sites certified by Blue Line International (www.bluelineinternational.com). The purchases could be international in the currency of user's choice, no matter what payment cards he had. The services were accessible via WAP and PDA. The pilot was discontinued in 2001.

52. **Omnipay OnPhone:** Omnipay OnPhone (www.omnipay.190.it) is a m-payment service that allows Omnitel customers owning a VISA card to pay for Internet purchases using their mobile phone. To pay the payer must call a free phone number and follow the voice-based menu eventually authorizing the transaction by entering his PIN.

53. **Orange/Mobilix Mobile Payment:** Orange (www.orange.dk) in cooperation with PBS (www.pbs.dk) is offering a mobile payment service in Denmark (www.orangemobilbetaling.dk) also known in its first steps as "Mobilix" or "m-Pay". A credit/debit card is associated with a mobile phone number. In order to get access to the payment function of the mobile phone, the payer uses the individually assigned PIN code, which is attached to the SIM card of the mobile phone. When the user accepts a payment, a transaction certificate is created which makes sure that the information may not be changed later. The payment transaction itself takes less than 10 seconds.

54. **Oskar:** The Czech Republic operator Oskar (www.oskar.cz) in cooperation with Komercní Banka (www.kb.cz) provide pre- and post-paid subscribers with m-payment services. All payments are credited to the customer's account that is informed of the transaction result immediately by SMS. The service is based on SIM Toolkit and every transaction requires authorizations by both the provider and the partner bank.

55. **Paiement CB sur mobile:** It is a mobile payment service offered in France. The approach uses a dual slot phone, SIM Toolkit based cards and SMS messaging. The payer provides his mobile phone number to the merchant, an SMS is notifying him about the details and then the smartcard is inserted in the dual-slot phone and the PIN is typed. When the transaction is authorized by the bank, a confirmation message is sent by the bank via SMS to the payer and the merchant receives also a payment confirmation.

56. **pay@once:** pay@once (http://www.siemens.com/payment/) is a real-time payment solution from Siemens that brings together the advantages of real-time charging, highly flexible payment logic as practiced in the prepaid card business, and extensive interfaces to existing payment methods and processes used in the financial services industry.

57. **PayBox:** PayBox (www.PayBox.net) was a mobile payment system launched in Germany in May 2000. It enabled payment via mobile phone for virtual and real world POS as well as peer-to-peer payments between PayBox users at national or international level (money streams are routed via PayBox – no direct payments). The user registers with PayBox, which provides him with a PIN to be used for authorization of future transactions. Existing phones can be used and the system in general works as follows: The payer shares his phone number with the merchant who, via a freephone number, enters it to the PayBox system together with the price. Then PayBox calls the payer announcing him via voice-based system the merchant's name and the amount to be paid. Finally the user authorizes this transaction with his PayBox PIN and the PayBox system informs Deutsche Bank to settle the transaction via "Lastschrifteinzugsverfahren", a kind of direct debit approach used in Germany that is cheaper to process than credit card payments. PayBox can also be used for purchases on the Internet. The only difference with the above-described procedure is that the transaction data is typed by the payer on the web site. In Internet transactions the payer can also send money to payee's bank account even if the later is not a PayBox customer. For mobile to mobile (P2P) transactions the payer sends the money directly to a mobile number of another registered user, even in another country. PayBox as a service was offered in Germany in several real and virtual POS ranging from cabs to online transactions at ebay.de. PayBox acts as a neutral payment intermediary aiming at the independence from telecom operators through a recognized brand and does not require any special mobile phone characteristics. However the approach is not cost effective (SMS and voice based communication) and the PIN is transmitted via normal DTMF (Dual Tone Modulation Frequency) procedure. PayBox announced in January 2003 that it will restructure itself and therefore discontinues its service in all countries except Austria, where PayBox in 2004 reported having more than 100.000 customers. The problems that forced PayBox to this decision include the slow development of the m-

payment market, the prolonged poor investment climate, and industry's unreadiness and lack of cooperation, particularly among banks and telecommunication providers, and the potential providers of a mass-market m-payment system. In July 2003 PayBox and British Telecom have formed an alliance to create a system for authentication and management of m-payment services, while efforts to expand in the Middle-East (initially in Kuwait and then the Gulf region) are underway.

58. **Pay-by-Phone (T-Pay):** „Pay by phone" (formerly known as banko.mat) is a service offered by T-mobile (www.t-mobile.at) in Austria. The user has to register and get a PIN for transaction authorization. Services like purchase of real world goods, tickets and lottery games are included. In Germany the same concept is marked under T-Pay brand (www.t-pay.de) which is a mobile wallet that can also accommodate other payment instruments such as credit cards.

59. PaybyTel: PaybyTel (www.paybytel.net) is a mobile payment micro-billing solution for Internet aggregated on the user's phone bill. When a user must pay something online, the web site informs him on the premium number that he must call via mobile or a fixed line. The voice system gives the user the necessary access codes, which the user enters on the web site of the merchant and the transaction is completed.

60. **Paydirect (Yahoo!):** PayDirect (paydirect.yahoo.com) is a service that allows users to send and collect money online or over an Internet-enabled mobile phone by linking their credit/debit cards or bank accounts to their secure Yahoo! PayDirect account at HSBC (www.hsbc.com).

61. **Payitmobile:** Payitmobile (www.payitmobile.de) was a mobile payment service launched as pilot in 2001 in Germany. The system separated the payment process from the VirtualPOS, which didn't get customer's mobile number, and used a procedure similar to PayBox with the difference that the authorization was via SMS and not via voice. The system failed to make the breakthrough and was dropped by its partners.

62. **Payline:** Payline (www.payline.com) offers among other, also mobile payment services to its customers. The mobile payment process is the same as in "paiement CB sur mobile", except that Payline manages the authorization process and the SMS authorization message.

63. **PaymentWorks:** Encorus (www.encorus.com) offers PaymentWorks, which is a secure, flexible and scalable application software for enabling payment transactions from cellular phones, the Internet, WAP-enabled mobile devices and PDAs. PaymentWorks Mobile can also be deployed at real world Point-of-Sales facilities and supports peer-to-peer transactions. Sprint (www.sprint.com) and eONE (www.eoneglobal.com) (mother company of Encorus) are working towards kick-starting general mobile payment initiatives in USA. The aim is to have a virtual wallet where different several payment methods can be supported including credit/debit cards and stored value.

64. **PayPal:** PayPal (www.paypal.com) is a popular online payment service that was recently acquired by eBay (www.ebay.com). Via WAP enabled phones one can use PayPal's wireless interface to accommodate MP. Payment recipients receive instant notification directly to their mobile phone. Peer-to-peer payments as well as international payments and bank transfers are possible.

65. **PayWare:** PayWare is an ePayment product range developed by Trinitech (www.trintech.com) that contains all the necessary elements associated with the transferring of monetary value from a buyer to a seller electronically - in the physical, virtual and wireless environments.

66. Petrol Magna: In Slovenia, Petrol Magna and Mobitel users can activate a virtual Magna account, which lets them pay for petrol bought at petrol stations via their mobile phones. After filling up, a customer will be able to dial a special number, which will record the charge on customer's Magna account, while a fee will be paid to Mobitel for the service.

67. **Phonepaid:** Phonepaid (www.phonepaid.com) provides to users that register with them, mobile payment services. One can send and receive money and pay for goods and services via regular GSM mobile phones. The service is SMS based as well as voice based and the charging is done on a prepaid account. Payments can be made after putting funds in the account by credit/debit card (online), credit transfer or check. Transactions are possible via the dial of a GSM phone number by using touch-tone (or voice) commands. The merchant's Phonepaid ID and product code have also to be entered. When the transaction completes, payer and payee receive an SMS notification.

68. PhotoPay: Fun communications (www.fun.de) has developed fun PhotoPay, an MP procedure for Internet and virtualPOS, which requires a camera-enabled mobile phone. When the customer makes a payment, all the relevant data is displayed on a monitor. The customer then starts the PhotoPay application and takes a

photograph of the screen contents, which is composed of special symbols or barcodes. The application decodes these contents, and lets the customer select the preferred method of payment (e.g. credit card, online bank transfer or direct debit). The application stored on the mobile phone builds up a connection to the payment service provider's server and transmits the relevant data. The server receives the payment order from the fun PhotoPay application, carries it out (e.g. by sending the card details to the credit card company, performing an online bank transfer or by submitting a direct debit order), and then notifies the customer and the shop about the status of the procedure.

69. **Qpass:** Qpass (www.qpass.com) offers a solution for generating and managing revenue from mobile commerce initiatives e.g. purchase of digital goods and services. Qpass is mostly a B2B solution that is used by several of its partners to provide m-payment services.

70. rePower: This MP procedure (www.MasterCardrePower.com) developed by MasterCard, is available in South Africa. Cardholders register with their participating financial institution in the U.S. or their wireless carrier in South Africa, and provide their contact and payment information, their mobile phone number(s) and then select a rePower code or password for future authentication. The payment details are stored in a secure, password-protected account for them to access whenever they'd like to replenish their prepaid accounts using their registered debit or credit card.

71. **Safetrader:** Safetrader realizes a mobile payment B2B solution based on the Jalda [33] which is, beyond an old Scandinavian word for pay, an Internet method payment system. EHTP (www.ehpt.com), which is now owned completely by Ericsson, has developed a system based on Jalda that is branded as Safetrader, and is a hub connecting content providers, a payment provider and consumers. The players have a Jalda account hosted on the Safetrader server and when they receive money from the consumer these are transferred from the consumer's account to the content provider account. The Jalda account can be loaded via money transfer from a bank account, a scratch card or a credit card. The payer is billed by the payment provider who deducts its fee and forwards the payment to the content provider (the final responsible for balancing accounts). Consumers can be charged according to whatever parameter the service or product content provider chooses, e.g. elapsed time, quantities, items, mouse clicks, data files, searches, online gaming, streamed music, etc. Safetrader uses PKI, SSL/RSA for authentication, 3DES for symmetric encryption, and Digital certificates (retrieved from the computer or a smartcard).

72. SecurePay: Pipeline (www.pipelinedata.com) is offering SecurePay (www.securepaywireless.com), that enables credit card connectivity via mobile phones (mobile POS) for the merchants.

73. **SEMOPS:** SEMOPS (www.semops.com) is a European Union project that aims at developing a universal, standard-compliant open mobile payment system that will be able to handle national and international, micro and macro payments [19][8]. The project brings together banks and MNOs and will handle Internet as well as mobile payment transactions (including peer-to-peer). Privacy, security, trust, openness and flexibility are driving forces of this approach. Within SEMOPS each party communicates with its bank or MNO, and the payer has the option not to provide his personal data to the merchant (therefore enabling anonymous payment). The service is expected to be offered by the banks and/or the MNOs (pre- and postpaid accounts) to their customers.

74. **SmartMoney:** This is a mobile payment method introduced by Smart Communications (www.smart.com.ph), the biggest GSM operator in Philippines. A reloadable electronic cash card is linked to a cellular phone. The electronic wallet can be linked to its user's current account in participating banks, through mobile banking.

75. **SmartPay (MobilHandel):** SmartPay is an electronic payment system using PKI offered by Telenor (www.telenor.no) in Norway. MobilHandel (www.mobilhandel.no) is the first application of SmartPay. PKI is used for authentication of the payer and signing of payment, and the bank account, credit card, or mobile phone bills is charged. This solution requires the replacement of the SIM card with a new PKI-enabled one. As of February 2003, also credit card based mobile payments to all VISA holders are possible.

76. **Sm-PaySoc:** Sm-PaySoc (www.smPaymentsoc.org) stands for Secure Mobile PAYments and Services On Chip and is a European Union project (IST-2001-32526). Sm-PaySoc aims at realizing a mobile and trusted secure access to information services by developing a novel smartcard-based service platform that allows the mobile fruition of information services (including mobile payment).

77. **Solo:** Solo (solo.merita.fi) is an e-banking service accessible also via a WAP phone (since Oct.1999), that facilitates bank transfers, bill payments,

investments in equity, mutual funds and bonds, electronically signed credit facilities, crossborder payments and shopping at Solo electronic mall. Crossborder payments are possible if the merchant participating in Solo has a Nordea bank account in every country. Mobile payment is done with the usage of dual-chip phones.

78. **Sonera:** Sonera (www.sonera.com) has launched a mobile payment system that can be used with existing generation telephones (2G) and can be applied in attended and unattended POS. The payment can be done in three different variations a) payment via a credit card, b) payment via direct debit and c) by calling a premium rate number. In the latter case each individual product price is associated with a number and the charge is on the user's MNO bill or another account if a prefix is used (for Finland 152) that allows account selection. In any case the user has to sign a contract with Sonera and register the payment method(s) e.g. credit card direct credit. In case of MNO charge (mobile phone bill) the existing MNO registration is used and the amounts are aggregated on that bill. The latest mobile payment service launched by Sonera is named "Shopper" (www.sonera.net/shopper) and is available in the metropolitan area only. The customer sends the search word MAKSU followed by his personal security code to number 13130 and he receives a reply text message with a a six-digit payment code that he shows to the cashier and the transaction finishes. The customer can make text message enquiries about his last payments and account transactions. It is worth mentioning that Sonera (now merged with Telia – www.teliasonera.com) has been developing mobile payment related solutions since the early '90s.

79. **Sonofon mBanking:** Sonofon (www.sonofon.dk) is providing a mBanking service to its customers. A web browser stored on the modified SIM card is used. The customers can check balances, trade stocks, pay bills and make fund transfers (within the participating banks). The service uses end-to-end encryption based on the 3DES between SIM Card and banking data centre (http://www.bankdata.dk). Virtual POS support is also planned.

80. **SPA:** Secure Payment Application (SPA) [34] is an issuer-based authentication mechanism that uses MasterCard's (www.MasterCardintl.com) Universal Cardholder Authentication Field (UCAF) infrastructure. UCAF is a multipurpose data transport mechanism implemented by merchants and acquirers for collecting authentication information generated by issuers and cardholders. Once collected, this information is communicated to the issuer in the payment authorization request and provides evidence that the transaction was originated by a legitimate cardholder. UCAF supports a variety of issuer security and authentication approaches including SPA, smart cards and more. SPA is multi-platform i.e. accommodates payment transactions conducted via smart cards, PDAs, mobile phones and other wireless devices. SPA makes use of public key infrastructure (PKI) and is designed to reduce the incidence of chargebacks in which the accountholder disputes having authorized a transaction.

81. **Street Cash:** StreetCash (www.streetcash.de) is a m-payment system that uses SMS as the basis of communication. The merchant sends an SMS with the payer's mobile phone number and transaction details to Streetcash, which via SMS again notifies the payer. The authorization of the transaction is done by sending back the PIN code via SMS to Streetcash. In Internet transactions, the procedure is the same with the difference that the payer enters his mobile phone number on the web site or WAP page. The user has to be registered with StreetCash and the amount is charged on a bank account or a credit card. StreetCash makes it possible to pay for tickets via SMS and also receive the paid tickets on the mobile (again in the form of SMS). For a non-StreetCash user who receives an SMS requesting a payment conformation Inatec (www.inatec.com) in cooperation with Paysafecard (www.paysafecard.com) provide a mobile prepaid anonymous solution by charging the prepaid account. In the later case the user authorizes the transaction with his Paysafecard numerical code. The solution is insecure, not cost-effective, and not reliable as it is based on SMS.

82. **Swisscom Sicap:** Swisscom (www.swisscom-mobile.ch) in cooperation with Sicap (www.sicap.com) offers since Aug. 2002 to its customers in Switzerland the capability of purchasing beverages from vending machines. The payer has only to dial the special USSD number written on each machine. The purchased items are paid either by charging the payer's bank account or the MNO's bill. The USSD method was selected because it is faster than SMS. Swisscom uses a similar service ("Quick and More") with Consultas in order to allow customers to pay for online articles via their phone. Similar services exist several years now in other European Nordic countries allowing mobile phone users to purchase golf balls, beverages etc. from vending machines or fast food by dialing a phone number or a USSD command on the product.

83. **Telemoney:** This (www.telemoneyworld.com) is a service offering mobile payment. The user has to register and select a preferred payment method such as credit card, debit card, direct debit to bank account or stored value. On Internet payments the user has to provide

his telephone number, and confirm via PIN the transaction after as system generated call. A confirmation, via voice on the mobile and on screen of the computer is presented, while a receipt is also emailed to you. In other cases e.g. TeleCab, the user has to call a number and manually enter the cab driver's Telemoney ID and fare to be paid. Other services like Telepay and TeleParking have similar concepts.

84. **TELEPAY:** Telepay [35] stands for the "Telepayment system for Multimodal Transport Services using Portable Phones" and is a European Union project (IST-2000-28269). The TELEPAY project is developing a payment system allowing transport service payments using mobile devices (for example, public transport, tolling for motorways, and the like). Virtual "e-tickets" in mobile phones and e-tolling using SMS, WAP and short-range communication technologies are project's goals.

85. **Telia Payit:** PayIT was a mobile payment service of Telia (www.telia.se) in Sweden. They used the Jalda platform offering micropayments for Internet purchases. The digital goods were billed either on phone bill or in a pre-paid account.

86. **Trivnet:** Trivnet (www.trivnet.com) introduced in 2001 a pilot where users could use their mobile phones to surf and purchase products via WAP. The charging was done in user's mobile phone bill.

87. **Turkcell:** Turkcell (www.turkcell.com.tr), which has a customer base of approximately 15.7 million postpaid and prepaid users, offers a credit card-based mobile payment service by teaming with Yapi Kredi bank (www.ykb.com). The subscribers with a valid bank account send a string of USSD-based encrypted code, including the code of the bank, and the product details, to the cash register. Then, the subscriber receives a secure confirmation code, which the merchant enters into his system to conclude the payment. All initiated mobile payments are charged to a subscriber's predefined Yapi Kredi credit card, and are free to subscribers, apart from the text message for the payment.

88. **VISA Movíl:** VISA (www.VISA.es) in Spain offers a mobile payment system where the charge is done via VISA cards. The mobile number is associated with a VISA card. In Internet purchases the user provides his mobile phone number, and in real POS the merchant enters the payer's phone number via an ad-hoc terminal. VISAMovil calls back the user who authorizes the transaction with his PIN. On May 31, 2001, Caixa Movil joined the scheme, therefore VISAmovil substituted the former Caixamovil standalone solution. It is worth mentioning that the system is less sophisticated but also less expensive than Mobipay.

89. **Vodafone's m-pay bill:** Vodafone offers to its customers a microbilling solution (MP-bill.vodafone.co.uk) whereby online purchases are charged on the mobile phone. In order for the service to be used, one must register and choose a username, a password and a 4-digit PIN. The solution uses iPIN's (www.ipin.com) e-Payment Platform. The XML-based user interface gives consumers a consistent look and feel when making purchases in different environments. The charging is done on user's monthly postpaid account or in real-time on the prepaid account. The user can pay online by entering his login/pass or via WAP by just entering his PIN.

90. **WAAAP Pag:** This (www.waaap.com.br) is a mobile payment service offered in Brazil. The users have to register and the purchases made are debited to the user's MasterCard. The users enter the merchant's ID, the amount of money and their PIN code in order to authorize the payment. The service uses WAP and a platform developed by EverSystems (www.eversystems.com.br).

91. **W-HA:** W-HA (www.w-ha.com) is a microbilling solution based on iPIN's (www.ipin.com) platform. Goods can be purchased, and the charges are made on the MNO bill or in the credit/debit card (if the user has an iPIN account).

92. **YW8:** "Why Wait?" (YW8 - www.yw8.com.sg) is a m-payment service that was commercially launched in February 2003 in Singapore. The user links his virtual account with VISA or an eNETS VCard (www.nets.com.sg) stored value account and the payments are charged there. The service is based on SMS and WAP. The service will extend the exiting Bankpas web service for mobile users.

93. **Top-UP:** Top-UP services allow prepaid users to refill their MNO account balance. In general Top-UP services can be provided in virtual POS or vending machine and generally anything that has a way a) to establish the identity of the user (e.g. bank's ATM), or b) to accept cash or credit card from the user (e.g. any card reader POS). For instance BVG (www.bvg.de) in Berlin, Germany uses its network of bus/metro ticketing machines to provide Top-UP services for all MNOs in Germany. Many MNOs offer Top-UPs, via different channels e.g.:

- **Top-UP via bank's ATM**: e.g. Euronet Worldwide has gone live with its ATM (Automatic Teller Machine) based Top-UP services for Hutchison Max

Telecom, which operates under the Orange brand in Mumbai, India. Similarly LINK, the interbank group that manages the UK's ATM network, will enable mobile phone Top-UPs at the country's 43000 cash machines.

- **SMS-based Top-UP:** VISA EMEA (Europe, Middle East and Africa) pilots a SMS-based prepaid mobile phone Top-UP service in partnership with a bank that is to act as both the acquirer and issuer. In VISA's vision, a full roll-out of the service will enable participating VISA member banks and mobile carriers to offer a VISA-branded service for their customers to use credit or debit cards to Top-UP prepaid phones.
- **OTA Prepaid Reload Service:** Smart Communications (www.smart.com.ph) in Philippines is offering an offering an 'over-the-air' (OTA) prepaid reloading service. The retailers instead of accumulating excess scratch-card inventory for prepaid Top-UPs, use their cell phone to load airtime over-the-air directly to a subscriber's phone.

94. IrFM based:

- **Moneta:** Moneta is a card launched by SK Telecom (http://www.sktelecom.com/english/services/m_commerce/), a mobile telecommunication service provider in South Korea. The Moneta card works with an IR beam or signal sent from mobile telephone handsets to upgraded merchant terminals POS and includes a VISA payment application. The charging is done on user's VISA card.
- **ZOOP** (Harex) International (www.mzoop.com), the U.S. subsidiary of Korean Telco Harex InfoTech offers the UMPS (Universal Mobile Payment Service) an IrFM-based solution that stores all types of personal payment information e.g. credit/debit/pre-paid cards and personal identification and security access cards in a mobile phone's memory or a chip. As a result one can settle all payments with a single mobile phone as well as provide proof of identity, making wallets obsolete. A trial was done in University of Southern California (March 2002). The mobile payment domain in South Korea is hampered by a dispute between the mobile carriers and service providers. SKT, KTF and Harex InfoTech use IrFM to facilitate mobile payments, but SKT's and KTF's card-based m-payments rely on integrated chips built into the handsets, while Harex InfoTech stores credit card data on the chips within a mobile handset. Therefore everyone promotes its own solution, which is not good for the market.
- **ViVOTech** (www.vivotech.com) provides a proximity payment solution that allows customers to pay by waving their contactless cards or by pointing and clicking their cell phones. The ViVOPay and ViVOwallet products allows the payment via pre-stored card info, as specified by IrMF.
- **Verizon Wireless,** VISA, Cross Check and bank of America have also started an Infrared payment pilot program at Univ. of Southern California/USA.
- **NTT DoCoMo:** VISA International, Nippon Shinpan, OMC Card and AEON Credit are testing (June 2003) an infrared credit card payment service. The pilot leverages a DoCoMo "i-appli" application for payments based on the "VISA Proximity Payments Messaging Specification". The service is expected to be commercially available in 2004.
- **KDDI:** The Japanese cellular carrier KDDI Corp (www.kddi.com) is also making trials a system that allows cell phone users to make credit card purchases online or in stores using their mobile handsets. The system is based on a credit card Java applet stored on the telephone's smart card and the Infrared for Financial Messaging (IrFM) Point and Pay profile.

95. RFID based:

- **Nokia/MasterCard:** Nokia (www.nokia.com) is running a trial in Dallas and Orlando in USA where a specially contactless chip is integrated into the Nokia phones and associated with a pre-registered MasterCard account. The user pays by waving his mobile phone into a specially equipped PayPass (www.paypass.com) reader at the POS. This new method however hardly adds anything to the standard method of swiping the credit card. MasterCard hopes to add in this way an advertisement channel based on customer bases of each merchant.
- **QuickWave:** On October 2002, bank of America started piloting a "QuickWave" system in Charlotte, NC in US. They equipped two dozens of restaurants and shops with RFID technologies at the POS, and issued 2,000 bank of America employees with special cards. The cardholders could simply wave their cards to make a payment.
- **ExpressPay:** American Express introduced the ExpressPay service based on RFID and concluded that customers spent an average of 20-30 percent more on their purchases while they were served 30-40 percent faster than those using real cash.

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