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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 the personal and professional level. Mobile Payment (MP) is a promising and exciting domain that has been rapidly developing recently, 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 article introduces the mobile payment arena and describes 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 mobile payments, present current concepts and the motivation behind it, and provide an overview of past and current efforts as well as standardization initiatives that guide this rapidly evolving domain.

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, are 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 customer 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 such as identification, security, and trust within the ePayments domain. In 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-payment (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 a mobile payment.

Contrary to popular belief mobile payments do not restrict themselves to payments via the mobile phone, but are possible on virtually any mobile device, including:

- A tablet PC (which is a full-function PC with limited mobility, usually used by one person).
- A PDA (a 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). Throughout the rest of this article we also foster this assumption, as all existing procedures assume this.

Since the domain of mobile payment is relatively new, there are often misunderstandings. Some of the most common 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 means of payment (unless you actually trade your device for goods). A mobile device is only a medium by which payments may be initiated, activated, and/or confirmed.

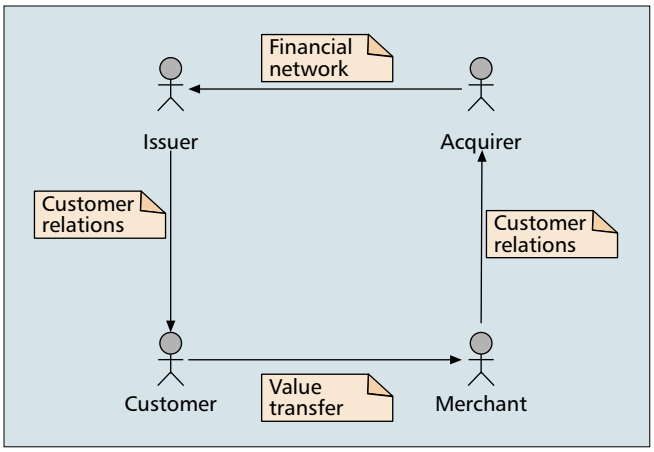

Figure 1. *Typical digital payment scenario.*

- 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, in general, designing and implementing payment procedures for the mobile world differs from the Internet applications due to the different contexts in which the two approaches operate.
- 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 which 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.

Many discussions occur 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 recently. Therefore, in this article we will provide an overview of the mobile payment area, focusing on standardization consortia that have emerged due to the attempt to master the heterogeneity by providing standardized interfaces, as well as the existing mobile payment services that have been launched. Existing surveys and thoughts [3–5] can be seen as complementary to this work, which provides more extensive information on the consortia and services available. The motivation is to provide a handy overview of past and existing efforts in the domain, which can be used as a starting point by those interested in this exciting area. We have also tried to refer to projects all over the world, including the Internet URLs of the companies or the projects that have participated, as well as a bibliography that one can follow in order to acquire further technical and conceptual details.

The rest of the article 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. This is followed by a discussion of the existing MP procedures, which are fully analyzed in the Appendix. Also discussed are future MP technology directions that the author believes will have an effect on the design and implementation of future MP procedures.

An Insight into the MP Arena

The Players

A typical digital payment scenario is depicted in Fig. 1. The customer is the party making the payment; the merchant is the party accepting the payment; the acquirer is the third party that has a relationship and interacts with the merchant; and the issuer is a third party that has a relationship and interacts with the customer. In any transaction the goal is the value transfer from the customer to the merchant. A typical procedure followed by credit card companies is as follows. 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 to which 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 arena we have similar procedures, with the only difference being that the customer and possibly the merchant use mobile devices in order to realize a transaction.

The main parties in the mobile payment scheme are depicted in Fig. 2: the customer (payer) and the merchant (payee). These transact with each other via the MP process, whose main players also include 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 because they control the subscriber identity module (SIM) and/or the wireless identity module (WIM) card of the mobile device, their influ-

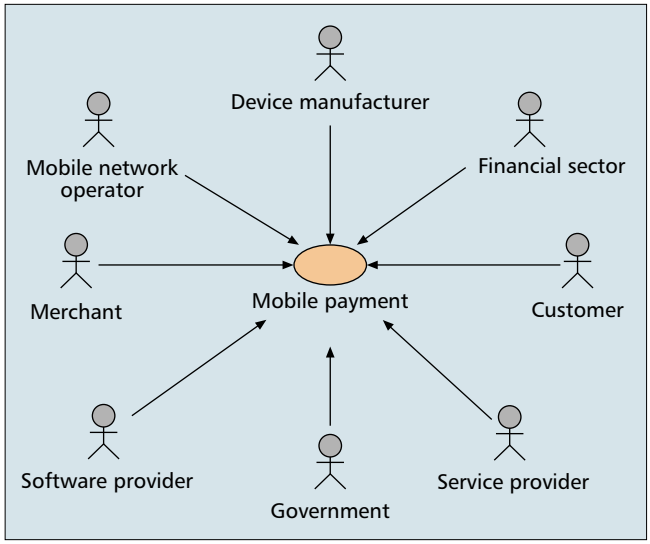

Figure 2. *The major mobile payment players.*

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

Table 1. *Existing attributes of the MP players.*

ence 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. On the contrary, the financial sector has been doing this for decades and can realize cross border payments. 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. Therefore it is important that the manufacturers cooperate with each other and with other MP players to develop a common approach to mobile device capabilities. Finally, software providers develop the means of implementing an MP infrastructure by producing standard compliant software that will connect 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 on their own.

The cooperation of all MP players is the key to developing a global open solution instead of a closed system with limited scope. Finally, all MP solutions are developed under constrains imposed by government legislation and regulation at the national or international level (e.g. the 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 in the market, as they adjust to new opportunities and threats brought about by rapid technological developments [6].

Expectations from MP

For global MP services to succeed a wide range of criteria will have to be met. The requirements are not only technology-based or business-based. There are also economics-based requirements, and requirements that have their origin in the social/cognitive sciences (domains that give feedback about the social regional characteristics where an MP service can be launched). However, the development of new business models will be needed the most. 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.

Mobile operators and banks express the highest interest in MP. These players are crucial for the proliferation and mass-market acceptance of any MP service. But because MP is nothing more than an alternative payment mechanism, 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 some other form of payment currently preferred, 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 as the expected operational cost of a global MP service is expected to be lower than existing ones, for example, credit card schemes. 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, to be widely adopted in the marketplace any alternative payment method will have to satisfy the needs of the consumer, the merchant, and the financial institutions at the same time.

Different expectations exist among the main players of an 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 determine 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. The learning curve should be close to zero and ease of use/convenience to the consumer should be enhanced. The customer should also have the ability to highly personalize the service in order to easily integrate it to his everyday payment activities.

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-value and high-value payments.

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 system 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 an MP system, users are expected to place inherent trust in 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, all steps should be secured/trusted from a technological [7] as well as social perspective. Furthermore, MP should minimize fraud losses and provide user-controlled transaction-specific privacy support. The last implies that anonymous payments should be possible (as with cash today). Furthermore, technologies such as mPKI, biometrics, and mobile digital signatures will have to be further advanced in order to be easily integrated into MP architectures.

Player	Expectations
Merchant	• Faster transaction time • Low or zero new investment and 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 in any currency • Person-to-person transactions
Mobile network operator	• Potential to add value to existing services • Increase customer loyalty • New revenue channels • 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

Table 2. *MP players' expectations.*

Cross-Border Payments: For an MP service to be widely acceptable, it should be possible to make cross-border payments almost as easily as local payments. 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 to 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.

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

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

Local Market Understanding: Most 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 need to 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 local social conditions. The last factor leads to the requirement for an understanding of the local market, as well as an understanding of unique conditions on a 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. bank systems). Existing channels, such as pre-/post-accounts, credit card infrastructures, etc., should be supported, and the user should be free to choose the processing partner (e.g. bank, MNO, credit card) on a per transaction basis (corresponding to the requirements of each processing partner).

Mobile Payment Models

Although several MP efforts exist, still today there is no dominating mobile payment model in the market. We present here a number of models, but it appears as if cooperation and coexistence of the main players with complementary tasks will be required for successful mobile payments. Some of them are described in the following sections.

Acquirer-Centric vs. Issuer-Centric: 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-Centric vs. MNO-Centric: 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. In 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 dominate existing mobile payment efforts in market, we are moving toward composite models where the main business partners cooperate, usually on a revenue-sharing basis. Such a cooperative 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 not a trivial task. Mobile operators and banks already have millions of customers who are potential MP users. Realistic models for a win-win situation should be developed in which MNOs and banks harmoniously co-operate in a non-exclusive scenario, and each business partner pursues core businesses and tries to increase revenue by providing core services. For MNOs the best argument supporting the concept of banks and MNOs joining in 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)). For banks the best argument is 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 factor 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 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). Also taking 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 recognized by the community. For example, the SEMOPS project developed a model that is based on the cooperation between several banks, MNOs, and other financial service providers [8].

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. Following is a discussion of several differentiating factors.

High Penetration Rate: In 2005 the mobile phone penetration rate will be above 85 percent in Europe, according to McKinsey Consulting (www.mckinsey.com), while the percentage of PC ownership 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 (the traditional Internet gateway) domain.

Instant Access: Mobile phones are transformed into personal trusted devices that most people carry around with them all the time. They are always on and enable direct contact with the owner. This simply means that via mobile phones anyone is reachable anytime, anywhere, which fits 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 model) has been put in place by the mobile network operators (MNOs), and new device models hit the market every two to six months addressing different end-user requirements. That, in conjunction with the usual tactic of MNOs to offer the handsets free or at significantly reduced prices with a 12- or 24-month contract, results in end-user devices that will be able to quickly integrate 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). This 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 the 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 a PTD, which makes it easier to identify the user, for example via the MNO SIM owner.

Mobile commerce, and specifically mobile payments, have a bright future, as predicted by many research reports. For instance:

- According to a research report from TowerGroup [10], 118 million Europeans, 145 million Asians, and 22 million Americans intend to use their mobile phone to pay for 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 global study (July 2004) by the Arthur D. Little research firm [12] estimates that global m-payment transaction revenues will increase from $3.2 billion in 2003 to $11.7 billion in 2005 and $37.1 billion in 2008.
- An 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

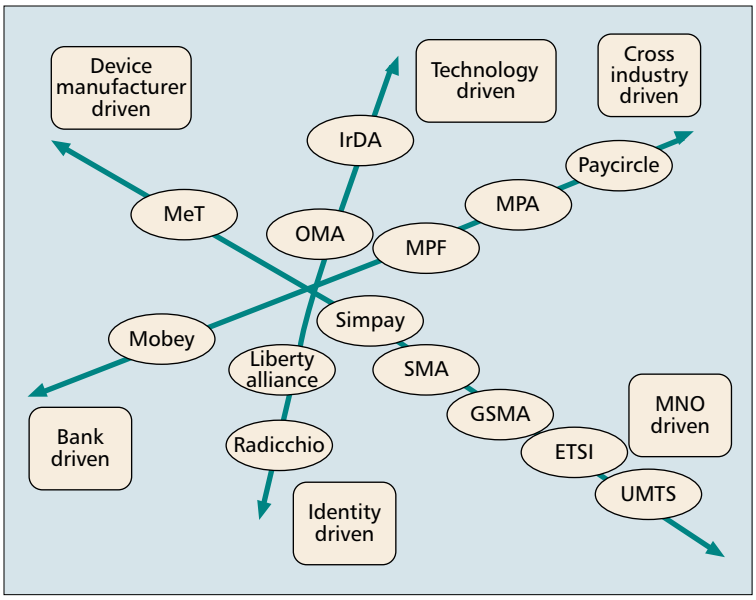

Figure 3. *Mobile payment consortia taxonomy.*

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 in transactions [15].

It is clear that we are heading toward an infrastructure in which e-services are transformed into m-services, and the respective services will cooperate or be unified. In such a context the need for a universal payment system exists, 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 the form of pilot programs or already available commercial solutions have appeared in several countries and target different market segments [17]. However, until recently no universal payment system has been deployed and most efforts do not survive for 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.

Influential MP 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 share. Several consortia are active in the mobile payment domain. Since none of them is widely accepted and MP is still in its first stages of development, 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, grouped by 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.

Apart from these "pure" mobile payment consortia whose work directly affects mobile payments, there are also other players who are indirectly affiliated with the MP sector, and are based in the financial/banking sector. These include:

- 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 with the technologies used in mobile devices as well as with 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 at all the aforementioned consortia can be found in the appendix.

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.) and provide an alternative that uses the different channels in a homogeneous way. MP also targets 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 currently powered by different concepts and technologies. In the rest of this 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's 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 withdrawals from a 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, targeting commonly purchased small items.
- Macro-Payments: These payments are typically more than $20.

It should be pointed out that the above limits, e.g. $2 for micro-payments, are illustrative only, as there is no generally accepted exact definition of the value limits of the different types of payments. However, we give these ranges here in

order to provide a better understanding of the magnitude of the transaction value.

The types of payments based on charging method include:

Post-paid: This is the most common method used in e-/m-commerce transactions today. Examples are:

- Phone-bill based: This is the charge method most commonly used by mobile network operators, and it is an internal charging method.
- Account-based (bank/credit card): This method is used by banks, which *a priori* have an account of the user, or the credit card industry.

Pre-paid: This is the most common charging method for MNOs as well as third-party service providers in order to be able to evaluate only that the user is capable of paying. The prepaid user is a significant part of the 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 real-time (based on technical limits).

- Real-time: This method includes solutions that charge the user of the service in real-time, with the funds immediately available to the merchant (same as cash). Electronic wallets are an example.
- Near "real-time": This method includes solutions that charge the user of the service in a reasonable amount of time. A 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 ability 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 example MP procedure in 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 relatively small and the payment card can be exchanged when needed. 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 executing MP. EMPS is such an MP procedure.

Dual Slot: Some mobile phones are equipped with a second card reader slot; therefore, they have the functionality 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. This 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 commonly used. The "Paiement CB sur mobile" and Payline approaches in France are examples of this concept.

While trying to be as close 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 such as e-coins which have ratio relationship with real money, e.g., 100 e-coins is 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, on contrast to 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. to 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 always require 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 necessary 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 there have also been trials in the U.S. 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 it 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 the 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 is generated from them, the minimization of cost and expansion of Top-UP service points is critical for MNOs. According to Yankee and Baskerville analysts, the market for prepaid mobile recharge is more than $100 billion, and the value of servicing these payments at a 2.5 percent premium amounts to more than $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 U.S. The mobile Top-UP services are relatively easy to deploy, and the existing method of selling the Top-UP cards is costly and inefficient. According to Baskerville research most 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 examples, i.e. ATM-based, SMS-based, and Over The Air (OTA)-based Top-UPs, are further analyzed on the appendix of this article.

Finally, there have been some "inventive" approaches in the market that use the mobile phone not only as an authorization token, e.g. the 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 ATMs accessed via infrared light.

Barcode Paperless Receipt: Another unusual application of the mobile phone is to use it as a medium that will uniquely identify a certain payment. The approach, which makes online purchases possible without the use of a credit card or other deposit guarantee, has been 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. Thus, there is no need for a paper receipt. 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 read using existing optical devices, and therefore such a 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.

DISCUSSION

As it has been shown, the interest in MP is evident, the standardization efforts are ongoing, and the search for the right business models as well as the successful approaches is ongoing. This proves that the area is active and of great interest, but also indicates that we are still at the beginning of a long road. In Fig. 4 we present an initial comparison of the existing systems based on some of their characteristics. Note that the area is very dynamic and new services are put into trial or are going commercial day-by-day, therefore some of the features depicted in Fig. 4 might have changed. The shaded areas in the 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 the local language and not in an international language such as English, German, French, Japanese, etc, or do not provide adequate information, the task of identifying precisely each service's capabilities was challenging.

As depicted in Fig. 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 also address 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 into mobile payment applications, 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), all of which have integrated mobile payment schemes based on SMS/USSD or phone bill charges. Top-UPs are also a rapidly developing area on which MNOs focus, mainly due to the low costs when compared with alternatives (e.g., distribution via real POS). Top-UPs not only cut out the intermediaries between MNOs and users, 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 to facilitate 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 the Internet, many solutions considered using PKI at least in the Internet-based portion of the transaction, while others did actually use or intend 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

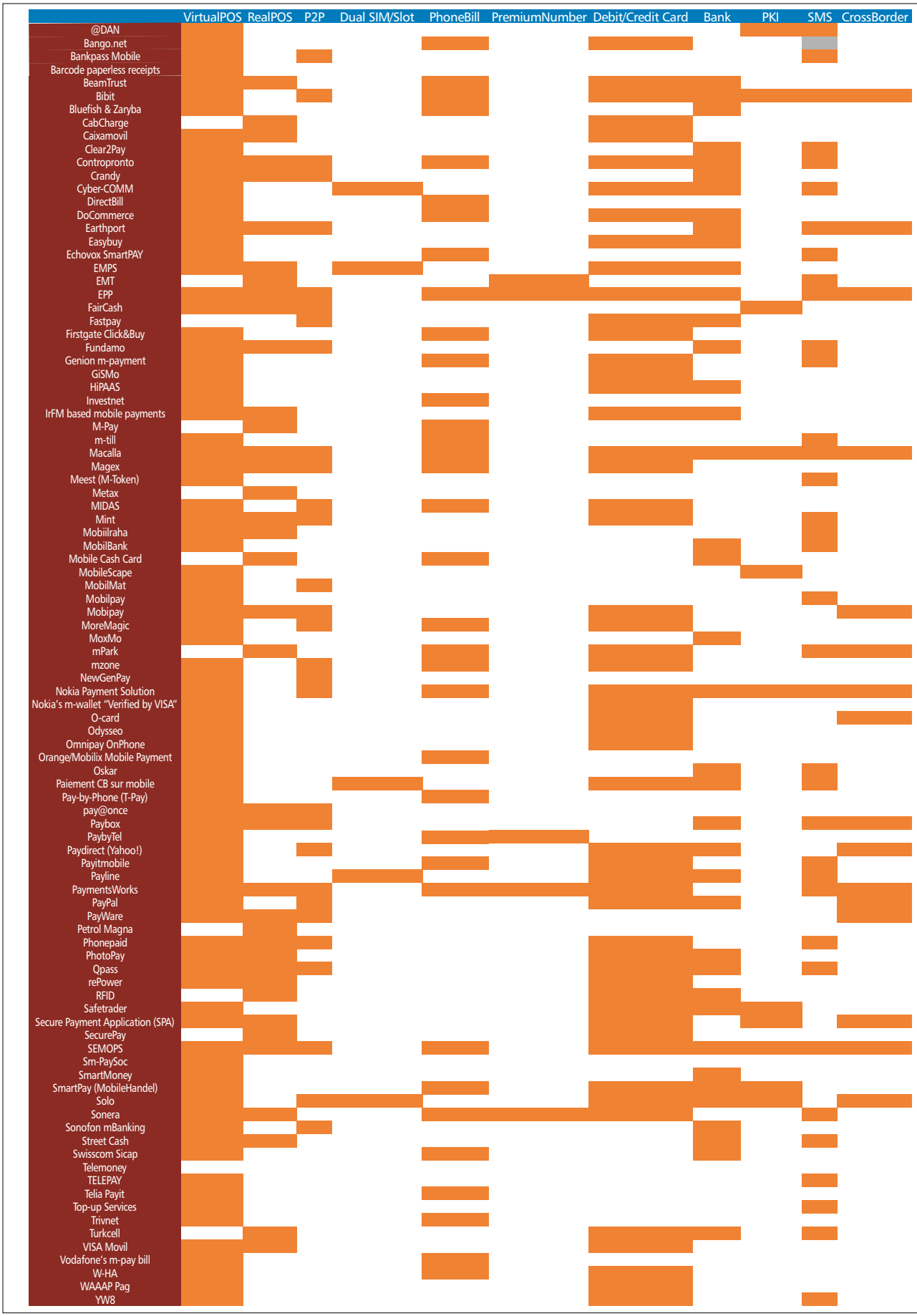

Figure 4. *Overview of mobile payment procedures.*

this kind of payment is directly connected with risk management activities as well as technical capabilities. Therefore, today MNOs seem to be able to effectively handle micro and mini payments, while banks concentrate more on mini and macro payments. MNOs could also handle macro-payments, but legislative 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 decide 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 (also promoted 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 to be used as a payment card to the payment provider. SIM chips today exist in all phones, but 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 the 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 in the MP domain limited alliances between the MNOs and between the banks and their efforts to bring various MP procedures to the market. However, as 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 e-Commerce while the MNO alliances handle limited m-commerce scenarios. Lately we have also seen bank and MNO cooperation, but again on a limited basis. The last implies the cooperation of one or two banks with one MNO. Although this is a step in 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 it should be flexible and extensible enough to accommodate evolving business models. This is the only foreseeable way today to 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, such as Mobipay, SEMOPS, or prepaid approaches such as StreetCash. Most MP procedures ask their users to register and provide private data, an act that limits the control the user has over this data. Nowadays this 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 customers' trust and establish a base where other value-added services that require personal context-sensitive information can also flourish.

Future MP Technology Directions

As indicated throughout this article, 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 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, continue to enter 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 reduce 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 are security, trust, and privacy. Furthermore, 3G and beyond infrastructures provide advanced capabilities as they introduce the capability of execution environments for third-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 market competitive offers to the end-user, who selects the suitable option according to his preferences.

The device manufacturers continue to bring to market mobile phone models that have advanced capabilities [22] and host their own execution environment. It is only a matter of time before advanced cryptographic services will be integrated into the devices that will make possible secure voice and data communication. The security on most existing MP schemes is very weak, and it is not widely exploited only because MP is not mainstream. If MPs reach critical mass, and the 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 information 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, always in balance with 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 are working toward federated identity in the virtual world. Many current limitations exist because identity management issues were not built into the networks at inception, but were added in later on. This did not work, and no-one wants to make the same mistake again. If such efforts are successful, they will have a catalytic effect on MP development and acceptance, as they will provide a homogeneous identity framework capable of bridging universally the real and virtual world. Therefore, efforts in this direction, such as the newly announced (March 2004) cooperation between NAC, OMA, OSE, PayCircle, SIMalliance, and the WLAN Smart Card consortium with the Liberty Alliance in order to demonstrate that federated identity is one of the key enablers in mobile payments, are hints at future trends.

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 a mobile Internet connection, lately a new trend was identified. The banks (who have an interest in deploying applications and further customizing the SIM cards) use their chip-card readers available on the streets (e.g. the bank's ATM) to interact with the chip cards the user carries. 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 protocols such as IrDA and Bluetooth for P2P payment transmission. Apart from these, also interesting for MP are emerging technologies such as 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). 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 such 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 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 reading a tag only 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 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 loosing a credit card today.

Much effort has been invested lately in Digital Rights Management for mobile devices (mDRM). OMA is working toward 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 legitimately access 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 in the eGovernment domain and the vision of a mobile Europe pose the need for 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 user requirements and in parallel not restrict business side creativity.

CONCLUSIONS

In currently dominating 2G to 2.75G networks, the voice application (simple voice transfer) and "accidentally developed" services such as SMS are the killer applications. This however will not last long. Soon such basic messaging services, including simple voice, 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 in 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. com-

posed 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 the hardware and software levels 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 another challenging domain where the "one size fits all" rule does not apply. For instance small-value payments (micropayments) require a different approach than other payments due to their different risk level, and therefore a general MP architecture may not be suitable for all transactions. Furthermore, many people see MP only as an additional access channel in the palette of existing payment services (such as interactive TV via the Multimedia Home Platform — www.mhp.org). Therefore we might experience efforts for a consistent homogeneous approach in all these channels. 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 must be as simple as possible, as simplicity is one of the major MP characteristics [26] that will allow it to be adopted by customers quickly and reach the much desired 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, to be able to extend themselves in order to cover future needs and accommodate technological development.

Mobile payment has sparked much interest in the research and commerce communities and is viewed as an integral part of the future. Mobile payment is not a simple stand-alone application for m-commerce; it is a key-enabler whose success will empower both the m-commerce and e-Commerce domains. As mentioned before, 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 article) 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 noted that apart from the technology factors, the right legislative framework must be in place to encourage development, 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 the per-country level still remains a challenging task [27]. Finally, following the general trend where mobile and fixed-line services converge (the goal of the July 2004 formed initiative named Fixed Mobile Convergence Alliance — FMCA), we will soon be 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, from both the research and business perspectives.

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BIOGRAPHY

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APPENDIX

INDEX OF MP STANDARDIZATION AND OTHER INFLUENTIAL CONSORTIA

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 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 through its initial four members alone has today a customer base of 280 million worldwide. Simpay focuses at the moment on payments under the €10 marks (micro/mini payments), with the goal to enable more than one billion € of extra transactions for the mobile phone industry by 2007. At the time of this writing the Simpay mobile payment solution technical launch was planned for the end of 2004, with commercial availability planned for early 2005. Simpay will use the transaction-processing technology from Encorus (www.encorus.com), a company that is also offering its own MP, called PaymentWorks Mobile.

Starmap Mobile Alliance — On 1 October 2003 nine leading independent small and medium-sized mobile operators formed a "Mobile Alliance," which was re-branded as the "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 initially covers 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 to 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 their plan is to provide international Top-UP services for 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 with more than one billion customers across more than 200 countries and regions around the world. Active within the GSMA is the Mobile Commerce group, which focuses on mobile payments with the goal of 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) efforts focus on monitoring activities of various active fora in 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 that promotes the global adoption 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 a form of mobile payments where the MNO has the control (pre- or post-paid).

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 (a 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: 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.

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 goal 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 the standardization of specific areas. Up to now they have released two documents: a white paper and 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, 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. In 2003 Paycircle released 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 also tackle 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.

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 among its 50 members (the six original members were Ericsson, NEC, Matsushita, Nokia, Siemens, and Sony), MeT is working toward 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."

Technology-Driven

OMA — The Open Mobile Alliance (OMA — www.openmobilealliance.org) was formed in June 2002 by nearly 200 companies representing the world's leading mobile operators, device and 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 (April 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 — 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 fosters 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, and 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.

*Identity-Drive*n

Radicchio — Radicchio (www.radicchio.org) was founded in 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 t^2r (Trusted Transaction Roaming) project was launched in January 2002 to establish a global cross-industry platform to enable secure, trusted wireless transactions. The t^2r 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 Project (www.projectliberty.org) is an alliance of more than 150 companies, non-profits, 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, the Network Applications Consortium (NAC), the Open Mobile Alliance (OMA), Open Security Exchange (OSE), PayCircle, the SIMalliance, and the 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.

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. Its 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 the 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 services 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. In February 2004 the IFX Forum published 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 (an m-payment method), 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 the m-payment era, mobiles are expected to interact with any POS, so an extensible POS is seen as an important integrated part of m-commerce.

Other Technology Influencing Consortia — Finally, because m-payment brings together companies with different backgrounds, 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)

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, as did the mSign and Radicchio consortia. MoSign had as a requirement the existence of a smartcard, which hosts the private key and the certificates according to the Identrus scheme (www.identrus.com). The MoSign solution was not bound to the mobile phone but was a universal one, and was based on open standards such as 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 in 1999 as a non-profit group that promotes the development of mobile commerce services around the world, including mobile payments. Its main activities included the organization or sponsoring of conferences and other events concerning m-commerce. It seems that GMCF has ceased to exist.

Mobile Wireless Internet Forum — The Mobile Wireless Internet Forum (MWIF — www.mwif.org) was an international non-profit industry association with a mission to drive acceptance and adoption of a single mobile wireless and Internet architecture that is independent of the access technology. MWIF 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 a 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.

INDEX OF MP EFFORTS

In recent years we have witnessed the rise and fall of several mobile payment efforts. The World Wide Web features a great number of companies mentioned 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 MP efforts. While the author does not claim this listing is complete, to the author's knowledge no such archive exists for those interested in the history and current state 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 that 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 also be done 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 toward the standards outlined by the 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 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 center 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) specializes in international Internet payments, allowing the consumer to pay a foreign Internet retailer using a payment method that 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 such as i-Mode and "Vodafone Live."

6. **Bluefish and 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 by 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 U.S. The aim is to provide 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 are automatically paid into a driver's bank account.

8. **Caixamovil**: The Spanish bank Caixa offered the "Caixamovil" payment system to its customers who have a credit or debit card. Mobile phone numbers are linked with a credit/debit card. On the Internet the user provides his phone number, while in a real POS the merchant dials the customer's number from an ad hoc 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 that offers payment 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**: Contopronto (www.contopronto.com) is a MP procedure in Norway that realizes 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**: This 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 has offered 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 Sony's FeliCa smartcard.

15. **Earthport**: Earthport (www.earthport.com) offers worldwide (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, which differentiates Earthport from the standard pre-pay models. Furthermore, charging to the V-account can be done at the 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 must 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 an iTIM WAP phone,

whereby the 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 third 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 is 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 the 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 bank card 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 has again been 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 must 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 an m-account. The customer must make an agreement at an 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 capabilities 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 latter 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 through which fairCash can be used cover a variety of existing technologies and devices, including mobile devices.The user receives (against a deposit, an accout, 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 is reached, 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 regard to counterfeiting 'money'. The analysis of that log requires the cooperation of the owner, 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 the 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 are aggregated and charged later in the 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 performed via dedicated lines and private networks, and encryption is again required. Mobile phone-based transfers are authorized by the user with their PIN. Even if the user initiates the transaction on the 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 latter and when shopping in a VirtualPOS, the user is redirected to the Genion m-pay-

ment 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 will be added as a 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, 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 the GiSMo Web site, where they supply their mobile phone number and receive a use name 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 receives 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 receive a notification, and the merchant notifies the GiSMo server that the goods have been delivered. Finally, the GiSMo customer can access at 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 a transaction. Millicom withdrew its product, and is working on a simpler alternative to GISMo.

27. **HiPAAS**: HiPAAS is a service offered by Upaid (www.upaid.net) that is 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 the 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 that delivers a number of payment services, including mobile payment. They offer prepaid and postpaid accounts, direct fund transfer, and clearing services for easy integration. MasterCard International has selected (in 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, and IVR.

31. **Meest (M-Token)**: Mobile e-commerce and eWork Secured Transactions (MEEST — www.meest-ist.org) is a European Union-financed project that focuses on e-commerce transactions via SIM, SMS, GPRS, and UMTS mobile technologies. MEEST's solution, m-Token, facilitates anonymous purchases of digital content from a mobile subscriber's prepaid account, or payments for goods at real-world stores, and also targets 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 (a patented concept) in Denmark. The mobile phone is used as a replacement for a METAX credit card, therefore the customer still receives a monthly invoice from Metax even though a mobile phone is used. The user calls a free phone number and is invited to enter their PIN (provided by Metax), after which they 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, and 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 that will enable payment for services by SMS. Users can download money between € 5 and € 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 the first stage, as well as 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 checking of available funds is possible. A SIM toolkit allowed encryption of SMS. The project started in January 2001 but was stopped in May 2002 due to limited interest from the customer 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 on the recipient and the 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. After the payer selects Mobilpay as the payment method, a

one-time PIN is announced to the user's mobile phone via a voice service. By sending the PIN via SMS to the Mobilpay system the user authorizes the payment. Currently the activities of Mobilpay are, due to the global economic situation, "frozen" while 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 or macro payment transaction in a 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 a 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 the Mobipay system. Then the consumer receives information 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 to both the user and the 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 has been 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 such as 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 a 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. Transfers from mobile purse to mobile purse are possible.

43. **MPark**: mpark (www.mpark.ie) is a 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 the mobile phone'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 the 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 (ECC). Data integrity is via digital signatures. End-to-end encryption is available for third parties, such as banks. The system has also been 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 the UK. It is available on all four MNOs in the 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 was merged with iPIN in 2003 and offers 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 method to pay, using a wide range of payment methods in a secured environment. Furthermore, Nokia has implemented an m-wallet in many of its phones, 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"**: In 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 from Nokia enables users to store personal data such as user names and passwords, VISA card details, and delivery addresses, on their phones. Since VISA cardholders can use the same password on 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 Web site 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 that 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 the user's choice, no matter which 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 an m-payment service that allows Omnitel cus-

tomers owning a VISA card to pay for Internet purchases using their mobile phone. To make a payment the user 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.orange-mobilbetaling.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 access 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), provides pre- and post-paid subscribers with m-payment services. All payments are credited to the customer's account, who 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**: This mobile payment service is offered France. The service uses a dual-slot phone, SIM Toolkit-based cards, and SMS messaging. The payer provides his mobile phone number to the merchant, an SMS notifies him about the transaction details, and then the smart card is inserted into 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 also receives 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 the national or international level (money streams are routed via PayBox — no direct payments are made). 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 free phone number, enters it into the PayBox system together with the price. Then PayBox calls the payer announcing to him via a 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 instructs Deutsche Bank to settle the transaction via "Lastschrifteinzugsverfahren," a sort 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 the 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 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 discontinue 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 Persian 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 such as purchases of real-world goods, tickets, and lottery games are included. In Germany the same concept is marked under the 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 the Internet aggregated on the user's phone bill. When a user must pay something online, the Web site informs him of 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 to complete the transaction.

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 a pilot in 2001 in Germany. The system separated the payment process from the VirtualPOS, which did not receive the 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 a breakthrough and was dropped by its partners.

62. **Payline**: Payline (www.payline.com) offers, among other services, mobile payment services. 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 toward kick-starting general mobile payment initiatives in the U.S. The aim is to have a virtual wallet where several different 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 the customer 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 suite developed by Trinitech (www.trintech.com) that contains all the necessary elements associated with the transfer 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 the customer's Magna account, while a fee will be paid to Mobitel for the service.

67. **Phonepaid**: Phonepaid (www.phonepaid.com) provides mobile payment services to users who register with them. Users 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 also must be entered. When the transaction is completed, payer and payee receive an SMS notification.

68. **PhotoPay**: Fun communications (www.fun.de) has developed fun PhotoPay, an MP procedure for the 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 transaction.

69. **Qpass**: Qpass (www.qpass.com) offers a solution for generating and managing revenue from mobile commerce initiatives, e.g. the 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 with 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; when they receive money from the consumer the funds are transferred from the consumer's account to the content provider's 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 party responsible for balancing accounts). Consumers can be charged according to whichever 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), which enables credit card connectivity via mobile phones (mobile POS) for 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 [8, 19]. The project brings together banks and MNOs, and handles Internet as well as mobile payment transactions (including peer-to-peer). Privacy, security, trust, openness, and flexibility are driving forces behind this approach. Within SEMOPS each transacting party communicates with its trusted 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 (prepaid 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 the 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 offered in Norway by Telenor (www.telenor.no) that uses PKI. MobilHandel (www.mobilhandel.no) is the first application of SmartPay. PKI is used for authentication of the payer and the signing of the payment, and the bank account, credit card, or mobile phone bill is charged. This solution requires the replacement of the SIM card with a new PKI-enabled card. As of February 2003 credit card-based mobile payments to all VISA holders are also 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 also accessible via a WAP phone (since October 1999) that facilitates bank transfers, bill payments, investments in equity, mutual funds and bonds, electronically signed credit facilities, crossborder payments, and shopping at the 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 use of dual-chip phones.

78. **Sonera**: Sonera (www.sonera.com) has launched a mobile payment system that can be used with the existing generation of telephones (2G) and can be applied in attended and unattended POS. The payment can be done in three dif-

ferent 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 must sign a contract with Sonera and register the payment method(s), e.g. credit card, direct credit. In the case of an 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 six-digit payment code that he shows to the cashier. The customer can make text message inquiries about recent 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 1990s.

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 (among the participating banks). The service uses end-to-end encryption based on the 3DES between the SIM Card and the banking data centre (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, smartcards, and more. SPA is a multi-platform service, i.e. it accommodates payment transactions conducted via smartcards, 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 account holder 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 must 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 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 confirmation, Inatec (www.inatec.com), in cooperation with Paysafecard (www.paysafecard.com), provides a mobile prepaid anonymous solution by charging the prepaid account. In the latter case the user authorizes the transaction with his Paysafecard numeric 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), since August 2002 has been offering 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 have existed for 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**: In this MP service (www.telemoneyworld.com) the user must register and select a preferred payment method such as credit card, debit card, direct debit to bank account, or stored value. With Internet payments the user must provide his telephone number, and confirm via PIN the transaction after a system-generated call. A confirmation, via voice on the mobile and on the screen of the computer, is presented, while a receipt is also emailed to the user. In other cases, e.g. TeleCab, the user must call a number and manually enter the cab driver's Telemoney ID and amount of fare to be paid. Other services such as 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 that allows transport service payments using mobile devices (for example, public transport, tolling for motorways, etc.). Virtual "e-tickets" in mobile phones and e-tolling using SMS, WAP, and short-range communication technologies are the project's goals.

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

86. **Trivnet**: Trivnet (www.trivnet.com) introduced in 2001 a pilot in which users could use their mobile phones to surf and purchase products via WAP. The charging was done in the 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). 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 phone 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 bill. In order for the service to be used, the user must register and choose a user name, 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 the user's monthly postpaid account or in real-time on the prepaid account. The user can pay online by entering his login/password or via WAP by simply entering his PIN.

90. **WAAAP Pag**: This (www.waaap.com.br) is a mobile payment service offered in Brazil. The users must 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 an 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 extends 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 machines, and generally anything that has a way to a) establish the identity of the user (e.g. bank's ATM), or b) accept cash or credit card from the user (e.g. any card reader POS). For instance, BVG (www.bvg.de) in Berlin 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, including:

- **Top-UP via the bank's ATM**: As example, Euronet Worldwide has gone live with its ATM-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) is piloting an 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 the Philippines is 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 sent from mobile telephone handsets to upgraded merchant terminal POS, and includes a VISA payment application. Charging is done on the 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, a user can settle all payments with a single mobile phone as well as provide proof of identity, making wallets obsolete. A trial was done at 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 is promoting their 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 allow payment via pre-stored card information, as specified by IrMF.
- **Verizon Wireless**, VISA, Cross Check, and Bank of America have also started an Infrared payment pilot program at the University of Southern California.
- **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 late 2004.
- **KDDI**: The Japanese cellular carrier KDDI Corp (www.kddi.com) is also conducting trials of 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 smartcard and the Infrared for Financial Messaging (IrFM) Point and Pay profile.

95. **RFID based**:

- **Nokia/MasterCard**: Nokia (www.nokia.com) is conducting a trial in Dallas and Orlando in U.S. in which a specially designed 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. In this way MasterCard hopes to add an advertisement channel based on customer bases of each merchant.
- **QuickWave**: In October 2002 Bank of America started piloting a "QuickWave" system in Charlotte, N.C.. They equipped 24 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 to 30 percent more on their purchases while they were served 30 to 40 percent faster than those customers using real cash.