

State of the Art Review of Mobile Payment Technology

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Introduction

Mobile payments will gain significant traction in the coming years as the mobile and payment technologies mature and become widely available. Various technologies are competing to become the established standards for physical and virtual mobile payments, yet it is ultimately the users who will determine the level of success of the technologies through their adoption. Only if it becomes easier and cheaper to transact business using mobile payment applications than by using conventional methods will they become popular, either with users or providers.

This document is a state of the art review of mobile payment technologies. It covers all of the technologies involved in a mobile payment solution, including mobile networks in section 2, mobile services in section 3, mobile platforms in section 4, mobile commerce in section 5 and different mobile payment solutions in sections 6 to 8.

Mobile Network Technologies

Mobile network [1] technologies have evolved from analog based systems to digital based systems and from circuit switching to packet switching technologies. This evolution can be described by different generations of mobile technologies, i.e. first-generation (1G), second-generation (2G), 2.5G and third-generation (3G) technologies. Only 1G is based on analog technology. Some of the main standards for each generation technology are:

- 1G: Advance Mobile Phone System (AMPS) in North America, Total Access Communication System (TACS) in UK, Nippon Telegraph & Telephone (NTT) in Japan, Code Division Multiple Access One (CDMAONE).
- 2G: Global System for Mobile Communication (GSM), Code Division Multiple Access 2000 (CDMA2000), High Speed Circuit Switched Data Technology (HSCSD).
- 2.5G: General Packet Radio System (GPRS), Enhanced Data Rate for GSM Evolution (EDGE).
- 3G: Universal Mobile Telephone Standard (UMTS).

GSM

Global System for Mobile Communication [1] is a second generation standard for mobile communication, developed by the European Telecommunications Standards Institute (ETSI) and now currently owned by the Third generation Partnership Project (3GPP). Operating in the 900 MHz and the 1800 MHz frequency band [2], GSM is the most widespread mobile standard currently in use across Europe and the Asia-Pacific region. Recently it is believed that GSM technology is in use by more than one in ten of the world's population [18] and it is estimated that at the end of 2002 there were 787 million GSM subscribers across the 190 countries of the world. By late 2003 or early 2004, it is forecast that the global GSM market will reach the one billion subscriber mark.

GSM was designed using digital techniques, unlike with previous analog cellular systems like AMPS in the US and TACS in the United Kingdom. The techniques [1] used are a combination of Time Division Multiple (TDMA) and Frequency Division Multiple Access, which are primarily for voice transmission and control. Since all users must share a limited radio spectrum, these techniques are used to divide the bandwidth among as many users as possible. Also, Space Division Multiple Access is used to provide a system based on a series of base stations each covering a limited area. FDMA [19] divides the radio frequency into several frequency carriers of 200 Hz, while TDMA enables 8 voice channels in each 200 Hz carrier by dividing each one in time.

GSM Services [19]:

- *Teleservices*: telecommunication services can be divided into bearer services, teleservices, and supplementary services. The most basic teleservice supported by GSM is telephony.
- *Data Services*:
 - Internet Services: GSM users can send and receive data, at rates up to 9.6K bps, to users on POTS (Plain Old Telephone Service), ISDN, Packet Switched Public Data Networks, and Circuit Switched Public Data Networks.
 - SMS (Short Messaging Service): unique to GSM technology, SMS is a bidirectional service for short alphanumeric (up to 160 bytes) messages. (will be discussed later in more detail)
 - Facsimile: Sending and receiving of fax messages, using a GSM phone and a laptop computer.
 - Secure Corporate LAN Access: secure access to e-mails, faxes, and file transfer via an encrypted link to a corporate LAN.
- *Supplementary Services*: [1] Such services include call forwarding, call barring, caller identification, call waiting and multiparty conversation. These services can be controlled via service applications using a GSM network API, such as those specified by the Parlay Group, allowing application developers to access GSM network capabilities.

GSM technologies are limited due to its low data transmission speed, therefore with the growth in data services the long term future of GSM is uncertain, unless it is changed to offer high bandwidth data services. Also, internet browsing using GSM phones is subject to charging of on-line duration and reconnection is necessary for each browsing session, as opposed to with GPRS (General Packet Radio Service), charging is based on the data received or viewed, with all time connectivity is available.

HSCSD

High Speed Circuit Switched Data [1, overview] is circuit switched protocol based on GSM, providing an enhancement of data services. HSCSD enables higher rates by using multiple channels as apposed to single voice channel with GSM. Transmissions rates can be up 57.6 Kbps by using 4 radio channels simultaneously. Typically, HSCSD [1] was directed at mobile PCs rather than smart phones, where a PCMCIA card is used with transmission speeds of 42.3 Kbps downstream and 28.8 Kbps upstream. HSCSD was intended as a temporary substitute for GPRS, to improve the transmission rates of existing mobile data applications.

GPRS

General Packet Radio Service [2] is packet switched wireless protocol providing non-voice value added services that allows information to be sent and received across a mobile telephone network. It is described as a 2.5G technology which supplements Circuit Switched technology such as GSM. Data transmissions speeds go from 9.6 kbps to a theoretical maximum speed of up to 171.2 kbps are achievable with GPRS using all eight timeslots at the same time. In addition to higher data rates, GPRS provides users with all time connectivity while only charged for the data viewed or received with a minimal on-line charge. GPRS is an evolutionary step towards 3G technologies, such as EDGE (Enhanced Data GSM Environment) and UMTS (Universal Mobile Telephone Service).

GPRS [1] may be considered as an overlay network on the GSM networks, using the GSM resources to the fullest potential. To enable this, extra network elements are required for this packet based mobile network. Certain hardware elements are added to provide the IP infrastructure needed for packet based services. The SGSN (Serving GPRS Support Node) and GGSN (Gateway GPRS Support node) are the mobile network equivalents of routers and gateways. Other main additions are the upgrading with new software to existing cellular infrastructure.

GPRS [19] only uses its radio resources when users are actually sending or receiving data, therefore the available radio resource can be concurrently shared between several

mobile data users, rather than dedicating a radio channel to a single user for a fixed period of time. This efficient use of scarce radio resources means that large numbers of GPRS users can potentially share the same bandwidth and be served from a single cell. GPRS [1] uses the same radio channel as voice calls, a channel that is 200 kHz wide and which carries a raw digital radio stream of 271 kbps. For voice calls this channel is divided into 8 separate data streams, each carrying about 34 kbps. After protocol and error correction overhead, 13 kbps is left for each voice connection or about 14 kbps for data. Packet-switched data can use several channels where as circuit-switched data uses one voice channel. GPRS can combine up to 8 of these channels, and with 14 kbps of data throughput each, the delivered bandwidth can be up to 100 Kbps. Most economical phones will be ones that are limited to 56 kbps, as not all eight voice channels have to be used. A mobile station can request the amount of bandwidth it desires at the time it establishes a data session.

GPRS applications includes Intranet access, Internet access, E-Mail, Fax, and Unified messaging, using a single mailbox for all messages, including voice mail, faxes, e-mail, short message service (SMS), and pager messages.

Limitations of GPRS [1, 19]:

- The limited cell capacity during voice and GPRS transmission calls. The use of a bearer for a different type of radio resource, such as SMS, would better utilize the cell capacity.
- Achieving the theoretical maximum GPRS data transmission speed of 172.2 kbps would require a single user taking over all eight timeslots which is unlikely that a network operator will allow all timeslots to be used by a single GPRS user. The bandwidth available to a GPRS user will therefore be severely limited.
- Suboptimal Modulation - GPRS employs a modulation technique called Gaussian minimum-shift keying (GMSK) while the EGDE uses a new modulation technique to allow a much higher bit rate across an air interface, called eight-phase-shift keying (8PSK) modulation. This type of modulation is used for 3G systems, so upgrading to 3G technology seems inevitable for a network operator.
- Transit Delays - GPRS sends data packets through different channels to reach a destination, therefore data corruption or data loss may occur. Data integrity and retransmission capabilities are used to avoid this, but the result is that potential delays can occur.
- No Store and Forward - Unlike SMS technology, GPRS doesn't provide a store and forward mechanism for data transmission, therefore SMS may be need to enable sending and receiving of short messages.

EDGE

Enhanced Data for Global Evolution [2] is a higher bandwidth version of GPRS permitting transmission speeds of up to 384 Kbps. It is compatible with the GSM protocol, but it requires higher quality radio signals to reach the increased speed.

Deploying EDGE will allow mobile network operators to offer high-speed, mobile multimedia applications. It allows a migration path from GPRS to UMTS, because the modulation changes that will be necessary for UMTS at a later stage will already be implemented. A number of mobile operators are considering implementing EDGE as an interim data technology between GPRS and UMTS, but no investments have been made in this technology as yet. The opportunity window for EDGE may be very short, unless major delays occur during UMTS deployment.

3G

3rd generation [2] is the generic term for the next big step in mobile technology development. The formal standard for 3G is the IMT-2000 (International Mobile Telecommunications 2000). There are three optional modes as part of the 3G standard. W-CDMA (Wireless Code Division Multiple Access) is for Europe and for the Asian GSM countries, CDMA (Code Division Multiple Access) is for North America, and then TDD/CDMA (Time Division Duplex/CDMA) for China.

UMTS

Universal Mobile Telephone System [1] is designed to provide for 3G mobile data services. Realistic expectations suggest a maximum capacity in metropolitan areas of 384 Kbps, at least until 2005. The same transmission rate can be achieved much earlier with EDGE. This third generation mobile phone system is already available in Japan [2]. The system enables the transmission of video, data and voice communication at a high speed and low cost.

CDMA

Code Division Multiple Access [1] is a proprietary standard for mobile communication, where GSM is an open standard. CDMA was pioneered by Qualcomm and enhanced by Ericsson. Both standards are in competition for dominance in the cellular world. CDMA is adopted mostly in US where it has a large subscription base. CDMA is a spread spectrum technology, which means that it spreads the information contained in a particular signal of interest over a much greater bandwidth than the original signal. A CDMA call starts with a standard rate of 9.6 kbps, which is then spread to a transmitted rate of about 1.23 Mbps.

Mobile Service Technologies

SMS

Short Messaging Service [1] was created as a part of the GSM Phase 1 standard to send and receive short text messages, of 70-160 alphanumeric characters in length, to and from mobile phones. The number of characters which can be sent is dependent on the language in use, with language support limited to the European Languages, Chinese and Arabic. This service is widely popular in Europe and Asia while in the US it is practically non-existent. SMS requires digital wireless interface standard (GSM) which is slowly being adopted in the US. In the US the 'mobile-party-pays' pricing model is commonly used, so mobile users pay for incoming as well as outgoing calls. Similarly this is the case with text messaging, so paying for messages received will not help the adoption of SMS in the US.

SMS is a smart service, as it can store messages when the target mobile device is switched off and forwards the messages when the unit is again in use. SMS applications are voicemail/fax notifications, delivery of replacement ring-tones, operator logos and group graphics, unified messaging, personal communication (text messaging), and information services. Basically, any information that fits into a short text message can be delivered by SMS.

In 2002, there were about 24 billion SMS messages sent per month within the Global GSM world, according to a European SMS Guide, by Netsize [20]. The majority of these were peer-to-peer (mobile-to-mobile) text messages at around 90% of SMS traffic, and the remaining 10%, were mobile transaction services such as news, stock prices, weather, horoscope, etc. SMS continues to grow more as a payment medium, e.g. reverse SMS billing, premium SMS numbering, and as a combination with advanced messaging solutions built around instant messaging via GPRS or e-mail.

WAP

Wireless Application Protocol [1] is a technology which provides a mechanism for displaying internet information on a mobile phone or any wireless device. This is done by translating internet information in to a format which can be displayed within the constraints of a mobile device. WAP is an open standard, developed by the WAP Forum, which has over 500 members. Its founder members include the major wireless vendors of Nokia, Ericsson and Motorola, plus the US software company, Phone.com (formerly Unwired Planet).

To obtain Internet access on a mobile device, the device should be WAP-enabled and the web site information should be described in WML (Wireless Markup Language) format.

WML is the mobile equivalent to HTML for web pages. A WAP gateway is also necessary between the client mobile device and the WML host server, to translate the WAP request. The response from the host server is translated into a WAP response by the WAP gateway, which can be displayed on the mobile device. An application environment, called WAE (WAP Application Environment), is defined by the WAP standard to enabling the development of advanced services and applications. These include micro-browsers, scripting facilities, e-mail, www-to-mobile messaging, and mobile to telefax access.

There has being difficulties with the launch of WAP, especially in Europe, due to the slow speed and high charges when using WAP on GSM technology. The increase use of GPRS will see an increase popularity of WAP usage. WAP has been very popular in Asia, except in Japan where I-mode is dominate in this market. WAP is an open standard in contrast to I-mode, which is a proprietary standard. Also, there are difficulties with the configuration of a WAP phone for new WAP services. 20 or so different parameters are needed to be entered to gain access to the WAP service, which may discourage users.

I-Mode

I-mode (I stand for information) [1] is a wireless technology developed by a Japanese company called NTT DoCoMo, which enables users to access Internet services via their cellular phones. I-Mode can be used to exchange e-mail with computers, personal digital assistants (PDAs) and other I-Mode cellular phones. I-Mode has already dominated the Japanese market and is being considered a success story in the world of M-Commerce.

I-Mode's underlying technology is uncomplicated, which makes it easy for content providers to create new I-Mode services and easy for customers to find and use them. The service is based on the Asian cellular standard PDC and uses Compact HTML (cHTML) markup language [3]. cHTML [2] is basically a scaled down version of HTML. It is relatively easy and it takes little time to rewrite HTML into cHTML. I-Mode's transmission speed is just 9.6kbps, but fast enough for its services. DoCoMo operates a packet-switched network, which means that customers pay not for time elapsed but for the packets of data they download. Packet switching also means that I-Mode is always on, so customers don't have to log into the service or wait for a connection, but have immediate access to services, similarly with GPRS.

USSD

Unstructured Supplementary Services Data [1] is a mechanism of transmitting information via a GSM network. Similar to SMS, but it is only basically a store and forward service. USSD offers a real-time connection during a session. It is said that USSD will grow with the further market penetration of WAP. Its main uses will be for mobile financial services, shopping and payment.

Cell Broadcast

Cell broadcast [1] is a technology that is designed for simultaneous delivery of short messages to multiple mobile users within a specified region or nation-wide. Cell broadcast is similar to SMS, but it is a one-to-many service rather than a one-to-one or one-to-few. It is a mass distribution media mainly for news and generic information. Usually, cell broadcast services are distributed to the consumer on a no cost basis. The network operator charges the content provider for sending the messages and the content provider will try to make money on follow-up services.

SIM Toolkit

SIM Toolkit [4] is an ETSI/SMG standard for value added services and e-commerce using GSM phones to perform the transactions. SIM Toolkit programmed into the special GSM SIM card enables the SIM card, using the GSM handset, to build up an interactive exchange between a network application and the end user and access or control access to the network. Therefore, it provides the SIM card with a proactive role in the handset. This means that the SIM initiates commands independently of the handset and the network. SIM Toolkit [1] is targeted at phones that do not yet fall into the smart phone category. Although SIM Toolkit was being heavily pushed by the smartcard industry, it will be an interim technology and will not be able to survive once GPRS terminals take over the market, since WAP is the GPRS-supported protocol.

Web Clipping

The Web Clipping [1] service for 3Com's Palm handheld device has been very successful, utilizing Palm's 75% market share of PDA market in the US. Web clipping is a Palm proprietary format for delivery of web-based information to Palm devices via synchronization or wireless communication to the Palm platform. Web clipping may co-exist with WAP in the fragmented US market. However, in Europe it is likely to be superseded, even on the Palm platform, by WAP based services.

MExE

The Mobile Station Application Execution Environment [1] is the incorporation of a Java virtual machine into the mobile phone, allowing full application programming. The protocol is integrating location services, sophisticated intelligent customer menus and a variety of interfaces, such as voice recognition. MExE will incorporate WAP, but also provides additional services exceeding the WAP functionality.

Mobile Platforms

Mobile Operating Systems

Symbian [5] was formed from Psion (UK PDA manufacturer) Software by Nokia, Motorola, Psion and Ericsson in June 1998. In 1999 Matsushita (Panasonic) and in April 2002 Siemens joined the Symbian group. It was based on Psion's earlier software, EPOC operating system. It was a modular 32-bit multitasking operating system especially designed for two types of mobile devices: smart phones and communicators. After EPOC release 5, the operating system was renamed 'Symbian OS'. Symbian is a joint venture between leading phone manufacturers formed to develop a common operating system suitable for mobile communication devices. The operating system is quite simple: Symbian develops and licenses Symbian OS containing the base (microkernel and device drivers), middleware (system servers, such as the window server), a large set of communication protocols, and a test user interface for the application engines of the operating system.

The **Series 60 Platform** [5] (Smartphone Platform), designed for Symbian OS, supports mobile browsing, multimedia messaging service (MMS) and content downloading, as well many personal information management and telephony applications. The Series 60 Platform 1.0 provides communication technologies needed in smartphones such as e-mail, WAP 1.2.1 stack, SyncML, MMS, Bluetooth and GPRS. This platform creates a larger developer base and thus creates more content for use on smartphones.

Microsoft has developed a lighter version of its Windows operating system, called **Windows CE** that has been created especially for small palm-size, hand-held PCs and other consumer electronics devices. A large number of handheld computer/PDA manufacturers mostly coming from the PC industry, such as HP, Casio, Philips and Compaq, have developed their devices around CE. However, CE has faced problems surrounding ease of use, robustness, synchronization and memory requirements. Windows CE is now renamed as **Windows Pocket PC**.

3COM is the smallest player for mobile terminal operating systems, but it is the global market leader in the PDA market (72% according to IDC in 1998) with the Palm Pilot product and its proprietary OS [1]. The operating system is regarded to be inferior to its competitors', but the Palm is much simpler to use in both software and hardware terms. 3COM has spun-off its Palm division (Palm Inc.) in 2000. The **Palm OS** has a particular wide acceptance in the US, where the Palm VII with its wireless connectivity and web clipping technology has hit the market already.

Wysdom has recently developed a mobile network operating system called **Wysdom MAP-OS** [10]. It is the mobile industry's first complete service delivery platform designed exclusively to meet the challenges mobile operators face in delivering feature and margin-rich mobile data services to their consumer and enterprise customers, according to Wysdom.

Mobile Commerce

The increase in mobile commerce [6] services and demand for these services is affected by the current mobile networks in existence. 2G networks are not designed to support data services, therefore providing slow connection speeds and limited choice of applications. With the increase deployment of 2.5G packet-switched networks and the imminent deployment of 3G networks, users will have access to an internet experience as good as PC-based access with the added benefit of their mobility. This provides an ideal environment for payment of content (digital and physical goods) and services.

Mobile payment can be divided into three areas: Mobile Operator Payment, Out-of-Band Payment and Proximity Payment. These will be discussed in sections to follow.

Mobile Payment Principles

The mobile payment value chain has various roles which need to be managed [18]. Such roles may be service or product providing, consumer authentication, payment authorization and payment settlement. In a general sense these roles can be assigned to four actors of the payment system; the consumer, the content provider/merchant, the payment service provider (PSP) and the trust third party (TTP).

The consumer is the person owning the mobile device and is willing to use it to pay for a service or product. In this report I refer to the consumer as the mobile user. The product or service, maybe are physical content (products or services) or downloadable digital content. The mobile user's roles may involve initializing the mobile purchase, registering with the PSP and authorizing the payment.

The content provider or merchant, depending on whether digital content or physical goods and services are being purchased, is someone or some organization that sells products to the consumer. Their roles may involve forwarding purchase requests to the PSP, relaying authorization requests back to the consumer and delivery the content. In this report I refer to this actor always as the content provider.

The payment service provider is the party responsible for the payment process. They control the flow of transaction between the mobile consumer, the content provider and the TTP. A consumer may be register with the PSP to avoid repetition of keying payment details into the mobile device, such as credit card details or a mobile phone post-paid account. A PSP could be a network operator, a bank, a credit card company or an independent payment vendor.

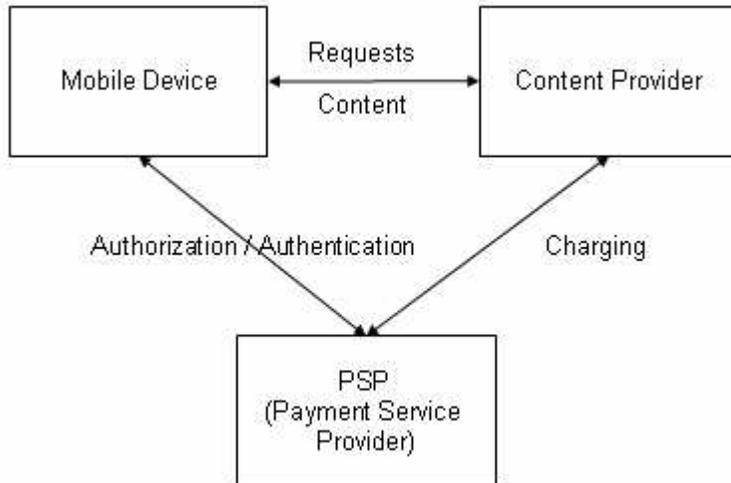


Figure 1: A Mobile Payment System

The trusted third party is a company used to perform the authentication and the authorization of transaction parties and the payment settlement. These could be network operators, banks and credit card companies. Therefore, their main role is authentication and authorization of payment requests. A network operator or bank could be positioned at the same time as the PSP, the TTP, and the content provider. In this report I do not refer to the TTP, and I assume that the PSP is responsible for all its roles, as it may be in many cases.

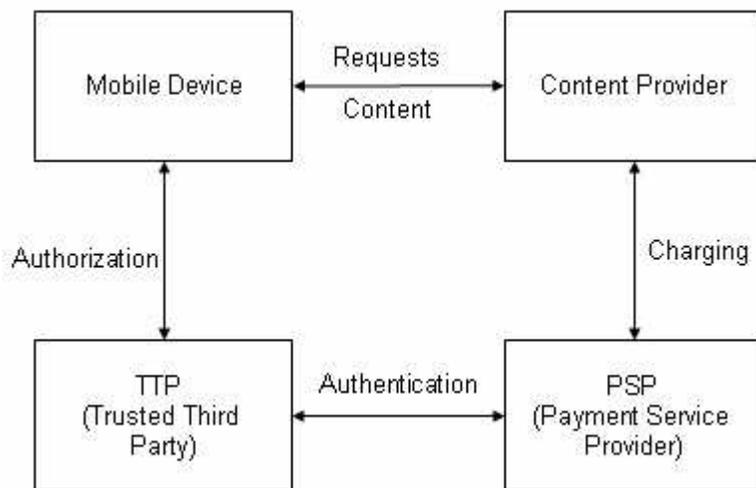


Figure 2: A Mobile Payment System with participation from a TTP

Mobile payment may be characterized into various categories, such as transaction type, transaction settlement method, content type, and content value.

Transaction Type:

- *Pay Per View* – the mobile user pays for each view, or increment, of the desired content. For example downloadable MP3 files or video clips.
- *Pay Per Unit* – the mobile user pays for each unit of content provided by the content provider. Units can be based on volume or duration of content, such as per byte or per minute. The amount of units used for each session will be billed to the consumer. Such examples of this type could be used in downloadable games or streaming video content.
- *Flat Rate* – the mobile user pays a recurring periodic amount to access the content on an unlimited basis during the period. For example unlimited access to online newspaper articles.

Transaction Settlement Type:

- *Pre-paid* – mobile users pay in advance of obtaining the content with pre-paid accounts which are deducted after each payment session.
- *Post-paid* – mobile users receive and use the content before they paid for it. The consumer is billed after the access to the content is obtained, for example on a phone bill.

Content Type:

- *Digital goods* – e.g. downloadable music or video content, value-added information
- *Physical goods and services*
- *Voting* - e.g. TV voting polls
- *Ticketing* – e.g. booking plane tickets

Content Value:

- *Micropayments* – describes same purchases usually less the 10 Euro, for example pay parking and ring tones.
- *Marcopayments* – usually large purchases over 10 Euro, for example purchasing plane tickets.

Payment Scenarios

Content Download

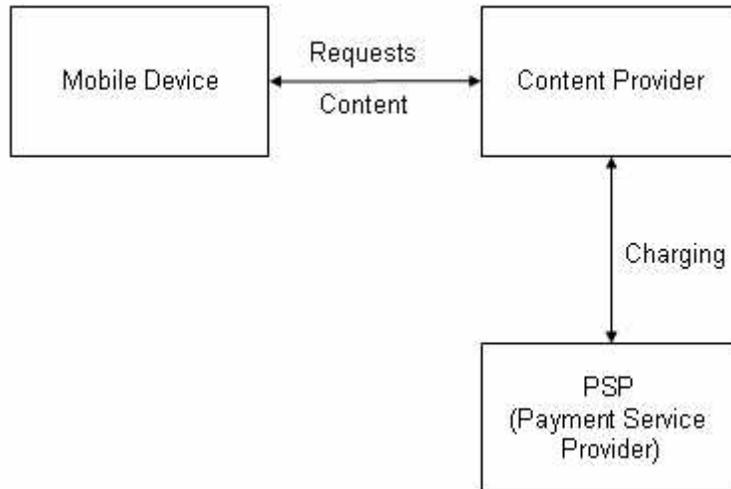


Figure 3: Payment System for Content Download

In this payment scenario, the content provider offers digital content to mobile users. The content can be purchased by either a metered or event pricing model.

Metered content may be a streaming service, such as a video, a radio channel or an on-demand game service. The payment of the transaction is dependent on a metered quantity of the provided service, such as the duration of the service, the data volume delivered, or type of gaming sessions (e.g. different levels).

Event content may involve the full download of digital content, in which the consumer pays a predefined price per item downloaded. The transaction is dependent on a successful download, as the content is worth the purchase price only when it is complete downloaded. This pricing mode may also cover recurring charge agreements or subscriptions, e.g. to a monthly online magazine subscription.

The content may also be purchased via a PC internet connection, where the mobile device will be used to authorize the payment transaction and authentication the content recipient as the mobile user.

Once a service request is made by the mobile user to the content provider, then the content provider will initiate a charging session with the PSP. The PSP will seek authorization from and authentication of the mobile user to complete the payment transaction, using either a post-paid or prepaid method.

Point of Sale

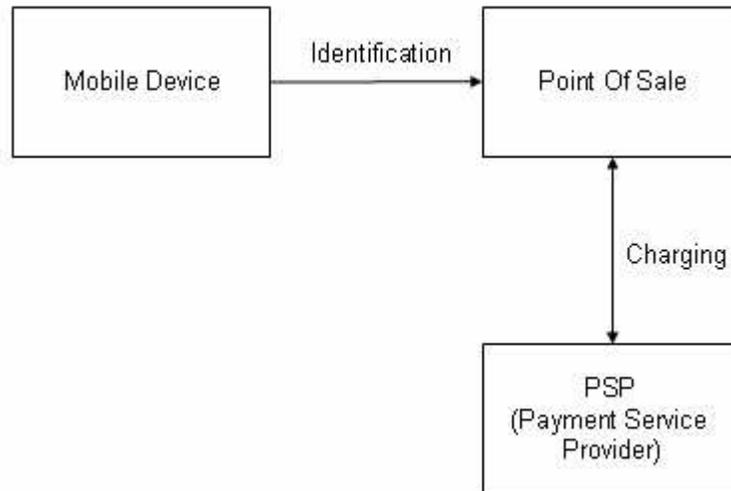


Figure 4: Payment System for Point of Sale

In this payment scenario, the content provider or merchant will offer services or the sale of goods to the mobile user, at a point of sale, e.g. paying for a taxi service or purchasing a physical good in a shop. The payment will be initiated at the point of sale by the content provider. The PSP may request authorization from the mobile user either directly, such as a sms pin request, or indirectly via the content provider, such as using a wireless Bluetooth link.

Also vending machine scenarios apply here. A mobile user can pay for goods and services at a machine, such as buying public transport tickets or paying for parking. Identification of the mobile user may also involve using a wireless link such as Bluetooth or Infra Red. A sms pin request may also be involve for authentication

Content on Device

In this payment scenario, the content may already exist on the mobile device, in which the use of this content may involve obtain a license. The license may be based on usage, duration or number of users. Such content using this scenario will be an on-demand gaming service. In this scenario, the license is a form of content which payment is required to obtain it.

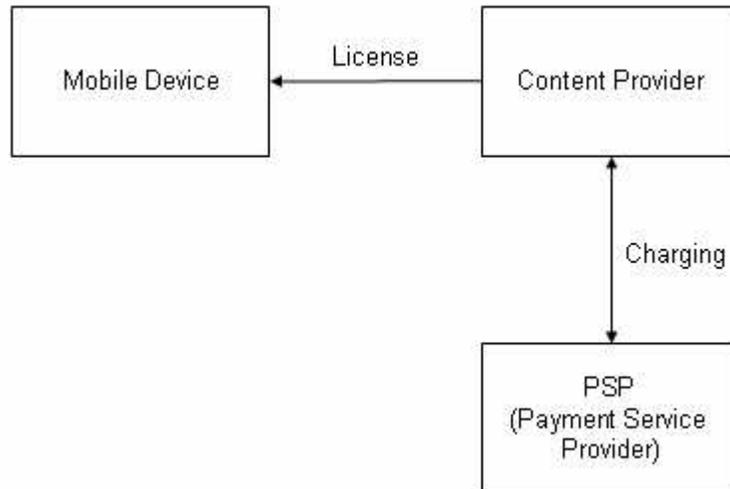


Figure 5: Payment System for Content on Device

Mobile Payment: Mobile Operator Payment

Network Operators are suited to deliver payment services for mobile content due to their expertise in the area of billing. This type of payment is sometimes referred to as “in-band” [6], where the content and the payment channel are the same, e.g. a chargeable WAP service over GPRS. Mobile users will either be offered subscription or per usage payment models, with the amount of payment usually being small, i.e. micropayments. Applications that could be covered by in-band transactions included video streaming of sports highlights or video messaging. An example of this is: Bob is on holiday, and uses his smartphone to take a photo, adds audio comment, and sends it via MMS (Multimedia Messaging Service) to Tom. He is charged 1 Euro to her prepaid account. This would use MMS and 2.5G technologies, involving a mediation system integrated with real-time stored value micropayment system.

Network Operator Payment Systems

Mediation systems provide the systems to manage the charging models and integrate with various payment methods, such as billing systems and prepay systems [6]. Operators are generally not interested in providing a standalone payment application because charging and payment are at the centre of their wireless data systems and form part of the network operator’s infrastructure.

Operators deploying these systems will take on the role of the payment broker. They want to control the relationship between the user and the content providers, but also they are faced with investing heavily in payment systems that can support these complex models. They can choose to outsource transaction processing to an ASP (Application

Service Provider) that is an expert in aggregating micropayment, or they could upgrade their systems to support data services billing. The second option is usually the better option to maintain trust and security confidence with the mobile users.

Mobile Payment Standards

The wireless and financial services industries aren't ignoring the issue of standards for mobile payment systems. Recently, Orange, Telefonica Moviles, Deutsche Telekom, unit T-Mobile International and Vodafone formed the Mobile Payment Services Association to foster development of an open, commonly branded system designed to work across all mobile networks [8]. A second group, PayCircle, recently released its reference implementation for the first version of its payment service specification.

PayCircle [9, 11] was formed recently by Internet and telecom network technology vendors CSG Systems, Hewlett Packard, LogicaCMG, Lucent Technologies, Oracle, Siemens and Sun Microsystems to develop uniform application programming interfaces (APIs) for payment systems based on Internet languages. The companies realize they have more to gain by contributing to a standard than by competing with proprietary offerings. With a proprietary-segmented market, mobile commerce activity would be a fraction of what it can be with standard APIs.

PayCircle is a vendor-independent non-profit organization. Its main focus is to accelerate the use of payment technology and develop or adopt open payment APIs based on XML, SOAP, Java and other Internet languages.

The **OSA/Parlay** standard [12] is a merged standard derived from OSA and Parlay. OSA is developed by the 3GPP organization and Parlay is developed by the Parlay Industry Consortium. The objective of OSA and Parlay was to simplify application development for fixed and mobile networks and open up to a larger development community than what traditionally existed for telecom networks. Via standardized OSA/Parlay interfaces, the Application Server interconnects with the operator's network to use functionality in the network. For charging the application server interfaces the billing system via a charging gateway. Figure 2 illustrates a combined OSA/Parlay and charging gateway.

The alternatives to OSA/Parlay are solutions based on vendor proprietary interfaces between the application server and the billing systems. The disadvantage with proprietary solutions is the scalability, i.e. proprietary solutions are more expensive to maintain since each new application server needs to implement the proprietary interface.

Vendor Billing Solutions

The current vendors for providing mobile billing solutions for GPRS and 3G services are Amdocs, Cerillion Technologies, Convergys, EHPT, Geneva Technology, Kenan

Systems, Portal, Sema, and TelesensKSCL [12]. Some of the services provided are content billing management and CRM (Customer Relationship Management) services.

Mobile Payment: Out-of-Band Payment

Out of band payment [6] refers to the fact that the payment channel is separate to that used for a shopping phase, e.g. a credit card holder may use their mobile device to authenticate and pay for a service they consume on the fixed line Internet or interactive TV. This type of payment usually involves a system controlled by a financial institution, maybe in partnership with a mobile operator. In order to make the wireless device suitable for authenticating payments, financial institutions are especially interested in wireless PKI, shared secret (or symmetrical key) schemes, or merging with their chip card programs via dual slot or dual chip devices.

An example of Out-of-Band payment: An SMS notifies Anna that U2 concert tickets have just gone on sale. From an Internet Café she browses to the ticket vendor site, books her tickets and pays with her Visa card. The payment authentication request appears on her mobile phone via SMS, and she authenticates using a personal PIN, digitally signing the order. A receipt is sent to her phone. Here wallet server technology with SMS and PKI support and an acquiring gateway is needed.

Financial Institutions

Banks are already seeing the opportunity for using mobile phones as a personal secure payment terminal [6]. Different payment schemes exist where a bank will deduct payment from a mobile user's account to pay for a service or virtual product. The payments involved here are usually of higher value than micropayments. Various methods are used to authenticate the payment transaction, such as using a dual slot phone for credit card payments, PIN authentication via a SIM toolkit application and also with the use of digital signature based on a public key infrastructure (PKI) mechanism. The adoption of a PKI system requires at least 2.5G technology, so therefore this type of system has been slow to reach the markets.

At the moment, there are schemes where the security is based on the mobile user being in possession of a registered mobile device and authentication is obtained via a PIN. The mobile user is required to register their mobile phone with the payment service provider, allowing the payment transaction to be authenticated using a variety of technologies. Such examples of these systems are offered by Paybox and MobiPay (described later on).

Reverse-Charge/Billed SMS

Reverse-billed premium rate SMS deliver content to mobile telephone handsets for a charge [14]. Customers typically subscribe to a service and are then charged a premium

for the messages they receive. The payment model enables consumers to use SMS text messaging to anonymously pay for access to digital entertainment and content. Reverse SMS billing means that the owner of the recipient phone rather than the message sender is charged for the cost of the SMS message received. There are various vendors offering reverse-charge SMS services to content providers, providing an alternative payment option not connected to mobile network operators' infrastructure.

Vodafone m-pay

Vodafone m-pay allows you to bill users directly on their mobile phone bill. There is no need to send them an SMS each time you wish to bill a user. Instead, users are billed when they enter their username and password details on the web or WAP site where they are buying content from.

MobiPay

MobiPay (formerly Movilpago) is a Spanish company, which launch a pilot scheme for mobile payments [8]. Based on a cooperative model between mobile telephone operators and financial institutions, MobiPay is owned by Banco Bilbao Vizcaya Argentaria and Santander Central Hispano, as well as all Spanish mobile telephone operators (which include Vodafone but not O2). MobiPay's payment system [7] can work in several ways. In a traditional merchant environment, the customer either tells the sales assistant their mobile phone number or (in larger retailers) allows the sales assistant to scan their phone using a special barcode reader. The POS (Point of Sale) terminal sends the phone number, a description of the goods and the payment amount to MobiPay.

MobiPay makes an Unstructured Supplementary Services Data (USSD: essentially a transactional version of SMS) call [8] to the customers handset and sends the "invoice" and amount. The customer authorizes the transaction by punching in their PIN code. All of this takes a few seconds.

The service costs the customers nothing and the charge to merchants (apart from the special POS interface if they choose to have one) is "comparable" to credit cards. The system currently offers two payment options to customers:

- A pre-paid network wallet (separate from the operators' pre-paid wallet) that can be loaded manually or automatically.
- A post-pay (against a bank account) option.

There is an IVR alternative for handsets incapable of placing USSD calls, where the customer calls MobiPay on receipt of a payment instruction and confirms the payment by a voice call. There is no doubt that MobiPay have the ambition to become a payment brand on par with Visa or MasterCard.

Iti Achat

France Télécom launched a service whereby consumers can pay for goods (which they have ordered using a voice service) by inserting their bank card into the external slot in their mobile handset [8]. The pilot was called “Iti Achat”, a name that may still be in use, although the operational service is now called CB Payments on Mobile.

PayBox

PayBox [2] was established EKS, Oracle, Compaq, Lufthansa Service and Deutsche Bank, where Deutsche Bank has the largest share in the company and deals with the client databases, clearing and settlement. This system allows for the debiting of bank accounts to pay for services via a PayBox voice message requesting payment confirmation and the customer using their mobile phone to authorize the payment with a PIN code.

Mobile Payment: Proximity

A payment system with good potential for mobile commerce is proximity transactions, such as using a mobile device to pay at a point of sale, vending machine, ticket machine, tolls, parking, etc. By using wireless technologies, such as Bluetooth and 802.11, mobile devices can be transformed into sophisticated payment devices that can process both micro and macro payments [6].

A proximity payment example: Bob is at his photo and imaging shop. He transfers his holiday photos from his digital camera to the store computer over a Bluetooth link. The payment request is sent to his mobile phone, also over a Bluetooth link, where he accepts it, and his credit card information is returned to the store point of sale device. The technologies used here are Bluetooth, or some other wireless technology, and a payment java applet on the mobile phone and the point of sale device.

Smartcards

Smartcards, i.e. chip cards with a small microprocessor such as GeldKarte, Proton or Mondex, can have credit/debit functionality as well as digital signature or electronic wallet functionality [1]. The SIM cards used within the GSM phone are smartcards as well. Their size and compatibility with the magnetic stripe card theoretically makes the smartcard an ideal carrier for personal information, such as secret keys, passwords, customization profiles and medical emergency information. Although many smartcards have been delivered to customers for other reasons, such as ATM cards, and not as a debit card for direct payments, there is ongoing speculation about the success of smartcards as a mobile wallet.

A common standard for smartcards is still absent. The 20 member strong OpenCard organization grouped around IBM, Sun, Visa, Gemplus and Schlumberger have tried to push for interoperable smartcard solutions based on Java across many hardware and software platforms that are based on Java, but they do not seem to be overly committed to make it fly. Visa, for example, has also developed a proprietary solution, called Open-Platform that it is pushing independently into the market.

EMV

In a relatively short time almost all European consumers, and many others around the world, may have a bank-issued smart electronic payment card [8]. These cards will be based on EMV: the Europay-MasterCard-Visa standard. Most schemes for moving existing 'dumb' credit, debit and charge cards over to smartcards have declared EMV compliance to be one of their goals. Even France, where smart payment cards have been in use for many years, has decided to switch from proprietary standards to EMV.

The current plan is for all European payments cards to be replaced by smart cards by 2005. This mass issuing of EMV cards is relevant to mobile commerce. A smart credit card can be used with a two-slot mobile phone to pay for a theatre ticket, for example, quickly and conveniently. Since the banks are issuing the cards anyway, many of them will choose to issue cards that have both EMV and mobile wallet applications on them.

Mobile Wallet - Micropayments

The use of the mobile handset as a payment device for impulse purchases at unattended POS may become very significant [8]. The Sonera Coke machine demonstrates how such a system might work and there are already other suppliers working to develop infrastructure. It isn't only operators, but third-party service providers who are pushing forward in this area. Coca-Cola and its' local bottling partners, to give an important example, are to invest \$100m in bringing 500,000 vending machines online. The technology will allow customers to make cashless purchases and give bottlers greater flexibility in managing inventory. About 60,000 machines in the US, Australia and New Zealand are already on line.

The use of the handset as a payment device is spreading. Scandinavians pay for their car parking using their phones in several cities. In Ireland in 2003, O2 and Vodafone are involved with a public parking scheme run by Dublin City Council where drivers can pay for parking using their mobile phones [7]. Hundreds of thousands of French pre-paid users top up their accounts by slotting their bank card into their phones and Japanese consumers buy from vending machines by dialing them.

Mobile Wallet - Wireless Technologies

Due to the increasing emergence of m-commerce, mobile applications could become an important and widely adopted tool for use in financial transactions. However, at present, one of the outstanding problems is that certain resources limit mobile devices, most notably memory and communication facilities, battery power and security.

Improvements in wireless networks in terms of protocols, standards, infrastructure and user acceptance, have been significant in the last few years. Two of the widely adopted wireless technologies, Bluetooth and IEEE 802.11, are seen as the future communication solution for mobile payment mediums. Both standards have their inherent benefits and drawbacks, but neither has proven more suitable than the other for an application in the mobile payment domain.

Although Bluetooth can co-exist with IEEE 802.11 [16], they interfere with one another in close proximity. In the context of a mobile payment trade offs exist, with the two standards providing different properties that suit this payment environment in contrasting ways.

One of the main issues with a mobile wallet system using these wireless technologies is the lack of security for payment transactions. It is believed that additional application level security is needed, such as cryptographic mechanisms provided by DES and PGP algorithms or a Public Key Infrastructure (PKI) mechanism. These may be embedded on to a SIM card, possibly using the Dual-SIM technique, where two SIM cards exist in a mobile phone.

Conclusion

Up to now, mobile payment has not been adopted on a scale large enough to make it viable, but it will arrive when the handset, network operator and vendor infrastructure is in place. Before mobile payment infrastructure can be rolled out on a large scale, much work must still be done in the areas of wireless network security, standardization of protocols, and user interface design. In this paper we have discussed many of the technologies required for mobile payment and the state of the art in mobile payment solutions.

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