

# Short-range Wireless Technologies with Mobile Payments Systems

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## ABSTRACT

Mobile devices and wireless technologies seem destined to make a large and continuing impact on our lives. Mobile devices especially have been widely used in the last few years, and recent developments in wireless technologies have provided some new solutions to problems of connectivity. Wireless technologies provide a new channel for implementation of mobile payments systems. The potential of short-range wireless technologies in commercial markets is enormous. Mobile payments is one such exciting application presently in development. Mobile payments systems offer great potential for both mobile and non-mobile products and services. However, in this early stage, mobile payments systems are facing some challenges. There are several available technologies for the applications and the mobile payments world is still waiting for standardization.

This paper examines several available short-range wireless technologies for mobile payments systems. The ways in which short-range wireless technologies support mobile payments systems are explored. This paper also evaluates the advantages and issues involved with using these technologies. Finally, this paper will discuss the future developments of mobile payments with wireless technologies and the challenges faced by the mobile payments industry.

## General Terms

Management, Measurement, Design, Economics, Standardization.

## Keywords

Wireless technologies, mobile payments, future development, challenges

## 1. INTRODUCTION

In recent years, mobile and wireless technologies have been a hot topic [1-3], and many mobile and wireless applications developments are going on [4;5]. The marketplace is enormous, dynamic and full of potential. For example, consumers and mobile industry representatives are looking forward to the third generation (3G) of mobile phones, one that promises higher quality services to consumers. There are already more than 1.2 billion mobile subscribers worldwide [6] and, with such rapid growth has come a demand for extra functions and services. Consumers are using their mobile phones not only as voice communication tools but also as multi-function tools that can send SMS, play games, and perform other functions.

Mobile payments represents another opportunity for the mobile industry and for financial service companies. Perhaps, in the near future, it will be a service that is demanded by consumers [7]. At present, mobile payments applications are limited and only a small number of markets enjoy high penetration [8]. Consumers, for example, can pay for items they download, such as music or games, by debiting their mobile phone monthly account. Clearly, there are already a variety of wireless technologies that should enable the development of new methods of mobile payments [9] such as Bluetooth and IrDA. As the numbers of mobile devices have embedded short-range with wireless technologies, for instance, there were about 80 million Bluetooth products shipped in 2003. Around 300 million Bluetooth-enabled devices will ship this year. About two-thirds of them will be mobile handsets [10]. This will provide a platform and opportunity to implement mobile payments systems and penetrate the commercial markets. We seem, at present, to be passing through another period of mergers and acquisitions. In the near future, the mobile phone is likely to become a "personal trust device" (PTD) and a powerful electronic wallet [11].

This paper will now examine the potential short-range wireless technologies for mobile payments systems. It will also explore two proximity mobile payments as examples to show how short-range wireless technologies connect with mobile payments systems. This paper will identify the opportunities and issues for mobile payments using short-range wireless technologies. Finally, this paper will conclude by discussing the future development of mobile payments using short-range wireless technologies.

## 2. OVERVIEW OF WIRELESS TECHNOLOGIES

Mobile devices, computers, and related electronic devices have become an important part of our digital life [9]. Wireless data transfer is highly preferred for personal and business purposes. It offers users flexibility and convenience. To meet the demand, various wireless technologies have been developed. Nowadays, there are different types of technologies in the world wireless market. Wireless communication is not a new technology; broadcast television and radio programs have been using wireless communication for a long period. As background knowledge, the following section examines and summarizes the possible short-range wireless technologies for mobile payments applications and for exploring technologies' main characteristics.

### 2.1 BLUETOOTH

Bluetooth research began in 1994, and the Bluetooth standard was developed by the Special Interest Group (SIG). The members of this group are the leading players in the computing and telecommunications industries; they are driving this technology forward to the market. Bluetooth operates at the 2.4 GHz industrial, scientific, and medical (ISM) frequency band. This band is unlicensed and is available worldwide [12].

Bluetooth provides the opportunity for *ad hoc* connections between wide ranges of personal electronic devices such as mobile phones, laptops and so on. It also has been implemented in home automation systems [13]. Bluetooth operates at a short distance—up to 10 meters. By increasing the transmission power to 100 mW, the range can theoretically be extended to 100 meters [12].

Bluetooth can be implemented in mobile payments systems because it offers low power consumption [12]. This is a key benefit for the mobile devices. Also, as the semiconductor industry has managed to produce Bluetooth chips at low prices, by 2005 there may be as many as 700–1200 million Bluetooth devices in the worldwide markets [14]. This has provided a unique opportunity for Bluetooth devices to penetrate and be accepted in the market. It also creates a unique market position for mobile payments. Moreover, Bluetooth used the Frequency Hopping Spread Spectrum (FHSS) method to avoid interference. It helps payment systems to provide a reliable service.

In 2001, Ericsson cooperated with Eurocard AB in Sweden to test the Bluetooth-based mobile payments system. The Bluetooth-enabled mobile phones were equipped with a virtual “Eurocard”, and consumers used their phones at a terminal as they passed through the retail check out [15].

On the other hand, Bluetooth security is huge concern for wireless applications [16;17], and it is relatively difficult to configure [18].

### 2.2 INFRARED DATA ASSOCIATION

IR uses infrared light to set up a wireless communication channel. To standardize the infrared communication, the IrDA was established in 1993 [19]. IrDA is one of most mature and established players for cable replacements applications. This point-to-point method of communication between devices has

been widely used. Many electronic appliances, such as electronic-device remote controls, PDAs, and laptops, use infrared [19]. It offers a high throughput, 1.152 Mb/S, 4.0Mb/s and 16 Mb/S respectively [20].

Infrared is another competitive player for mobile payments systems. There are two reasons for this. First, infrared provides low power consumption [20], and battery life is a critical design factor for mobile devices. Second, infrared is already well known in the industry. Around 100 million infrared devices have been installed [19]. Clearly, it provides a new mechanism to implement mobile payments systems. Moreover, infrared is relatively easy to use and configure.

In South Korea, the Harex InfoTech provides a mobile payments system called “ZOOP”. It combines mobile devices and a wireless technology to create a mobile wallet that allows consumers to make payments via IrDA mobile devices [21].

On the other hand, infrared has limitations. It cannot penetrate objects such as walls. Infrared devices have to operate in the line-of-sight and at short range in order to set up the communication channel [12]. It limits the performance of the applications.

### 2.3 RADIO FREQUENCY IDENTIFICATIONS

RFID has been around since the Second World War [22]. RFID is a technology that uses electromagnetic fields that are coupled with the radio frequency [23]. The basic RFID system has three components: an antenna, a transceiver, and an RF [24]. The antenna is the “bridge” between the tag and the transceiver. RFID works at different frequencies ranges, including 125 KHz, 13.56 MHz, 2.45 GHz and 5.8 GHz, and 860–950 MHz [25]. It also offers read ranges from a few centimeters to 5 meters, depending on the frequency of the devices.

RFID is one of the potential players for mobile payments systems. Nokia and MasterCard each have tested new retail payments using mobile payments based on mobile phones in the U.S. [26]. RFID can be fitted in mobile payments systems, because it requires no contact and also no line-of-sight conditions. RFID is automated ready and easy to use [23]. If RFID is deployed in mobile payments systems, the systems will be simple, operated by consumers. Moreover, RFID can operate under a variety of conditions such as ice, fog, and so on [23]. In addition, it also provides the high-speed reading and writing of data. The demand for RFID is growing [25] which contributes to RFID becoming more popular in the market. This provides a platform for RFID to implement mobile payments systems.

Nokia and MasterCard launched the mobile payments trial in the U.S. in 2003. The Nokia handset's cover is embedded with a RFID chip. This chip contains MasterCard payment account information. When consumers wave their handsets at the RFID enabled point of sale, payments will transmitted to the terminal [26]. This service offers the convenience of using mobile phones as wallets for consumers.

However, there are some concerns about using RFID in payments applications. Privacy, especially, is the key issue [27]. Privacy advocates have been worried about losing their personal

information during payments transactions. Chip set cost is another issue for RFID, and some companies and vendors believe that RFID is still expensive [27].

## 2.4 NEAR FIELD COMMUNICATIONS

NFC is an open global infrastructure for easy access to wireless services and data anywhere and at any time. NFC offers a convenient connection for all types of electronic devices. A built-in security mechanism makes it ideal for payment/financial applications [28].

NFC works in 13.56 MHz frequency band. It can provide 3 to 30 cm working range and is compatible with RFID technology [29]. The NFC offers a less costly solution for the implementation of wireless products. It supports file transfer and data transfer [30].

NFC can be implemented in mobile payments systems as well as RFID for three reasons. First, it provides very low power consumption. Second, it offers a great security mechanism for applications. Finally, the NFC device is easy to use and it is easy to establish the connection. This enables rapid and easy communications, and it is an ideal solution for controlling data environment such as mobile payments systems.

In January 2004, Philips and VISA presented a NFC based mobile payments application. Mobile phones can pay for items simply by holding the phone next to the terminal. The NFC chip in the phone transfers the payment details to the terminal. It also deploys an authentication service based on the standard 3D secure to provide a secure service for consumers [31].

NFC has limitations. It only works at very short distances. Moreover, it simply supports peer-to-peer communication. These are the drawbacks for NFC implementing mobile payments systems.

## 2.5 SUMMARY

The above short-range technologies are competitive and they are potential players in the mobile payments industry. Some technologies have already implemented the payments systems and the system is up and running. One example is IrDA in ZOOP. The others intend to move in this industry as soon as possible. NFC is one example. The following table summarizes the main characteristics and specifications of the above short-range wireless technologies. These characteristics are relevant to mobile payments systems.

Clearly, many short-range wireless technologies intend to take part in the exciting mobile payments applications. Therefore, this is a highly competitive area, and the application may seek the convergence of wireless technologies. There are several factors to consider in choosing a suitable wireless technology. Standard is one of important factors, particularly whether or not mobile payments are supportable. For example, the IrDA has defined a special profile for mobile payments application – Infrared Financial Messaging (IrFM) in order to penetrate and secure the mobile payments market. This profile aims to cut transaction costs and provide a simpler and more secure environment for mobile payments [32].

**Table 1. Main characteristic of wireless technologies**

	Standard	Throughput	Range	Radio frequency (Infrared light)	Price	Power consumptions	Key players	Application areas
Infrared	IrDA	1.152 kbps – 4 mbps	1 – 5 meters		\$2	Very low	Agilent, Microsoft, Motorola and Sony Ericsson Mobile	Data exchange, devices remote control, payment systems.
Bluetooth	IEEE 802.15.1	720 Kbps – 1 Mbps	10-100 meters	2.45 GHz	\$5	Low	Ericsson, IBM, Intel, Nokia Toshiba	Data exchange, electronic devices remote control, payment systems.
RFID	ISO/IEC 14443	4-128 Kbps	10 feet	120-140 KHz	\$3-\$10	Very low	Honeywell, Texas and Philips	Access control, Inventory control
RFID			10 feet	13.56 MHz	\$0.5 - \$5			Access control
RFID			40 feet	869-956 MHz	\$0.75			Smart cards, Railroad car monitoring, Toll collection systems
NFC	ECMA, 340, ISO/IEC 18092	424 Kbps	Up to 20 cm	13.56MHz	20 cents	Very low	Philips & Sony	Data exchange, contact less smart card

The frequency spectrum is an important factor, for example, particularly whether it is unlicensed or not. Some wireless technologies operate in a license-free band. Bluetooth, which uses the 2.45 GHz ISM band, is an example. This feature is attractive for both manufactures and customers because they do not need to pay a license fee for using this frequency band. Battery life is a critical design factor for mobile devices. Potential consumers

would not want to charge mobile devices more often because they use mobile payments services. The range of wireless data transmission and throughput constitute additional factors to consider. Making a decision about which technology is the most appropriate for mobile payments depends on the type and size of a system and application. Some applications require only short-range data handling, for example, Philips and VISA presented a NFC based mobile payments application. Mobile phones can pay for items simply by holding the phone next to the terminal. It means that this system only requires very short distances data handling.

Cost is one decisive factor for a new wireless technology when it comes to penetrating and dominating the market. For instance, in the mobile communication market, GSM is the current dominant standard in the European wireless market in the world today [33]. There are more than 1.2 billion mobile subscribers worldwide [6]. The mobile phone usages have dramatically increased in the past few years. Due to reduced hardware costs, for example, mobile handsets are getting cheaper and cheaper compared to first generation phones. Bluetooth has reduced the chip set cost from \$50 to \$5 because of the improvement in productivity. It helps Bluetooth to easily penetrate the mobile payments market.

The key players in wireless technologies have important roles to play in the development of mobile payment systems, because they are more influential companies in the computers and communications industries. It is likely that they will select the most profitable technology for mobile payments applications.

### 3. TWO MOBILE PAYMENTS SYSTEMS

Obviously, People are attached to their mobile phones, carrying them all the time [11]. Mobile payments allows consumers to make purchases more easily, more quickly, and more conveniently than some existing payment methods do. Mobile payments holds much commercial promise: W2F research shows the estimated mobile payments market to be worth €5 billion by 2006 in the key markets of Japan, USA, UK and Germany. This compares with approximately € billion in 2002 [34]. Clearly, there are huge opportunities for wireless technologies to take part in mobile payments, and there are obvious benefits to financial services companies, merchants, and consumers. Especially in the case of proximity payments, consumers can send transaction data between devices within a short distance without physical contact. Selecting suitable wireless technologies to implement mobile payments systems will be one of the important factors in developing a system. This section explores two existing mobile payments systems that adopted short-range wireless technologies in payments applications.

Two mobile payments applications are now explored in more detail, Bluetooth based application and IrDA based application. This is done to provide a view of how short-range wireless technologies interacted in mobile payments development. These two payments applications are examples of mobile proximity payments. Mobile proximity payments are using mobile devices to pay at point-of-sale, vending machine, parking, motorway tolls, and so on. ZOOP is the one up-and-running payments system in South Korea. This is the largest scale mobile payments system using Infrared. ZOOP has a very successful business record in

South Korea, and it is important to explore how the system works. Eurocard wireless payments provide similar services as ZOOP. However, this system used Bluetooth to implement it. It was also the first Bluetooth-based mobile payments in the market.

### 3.1 ZOOP

At present, the Harex InfoTech provides a “proximity payment” system in South Korea. The first trial began in April 2002 in Seongnam city. Now, several cities have been equipped with this mobile payments system, based on using infrared technology [21]. ZOOP used infrared in the payments system, because IrDA offers high speed transmission without interference. Also, the IrDA is economical and the chip sets cost around \$1 [35]. This is the first large-scale application of infrared-based mobile payments in the world. Large-scale mobile payments applications using wireless technology in the commercial market are still rare. The idea of this proximity payment combines mobile devices and a short-range wireless technology. This offers a new payment method for consumers.

ZOOP provides a flexible payment service for consumers. It allows consumers to use mobile devices to make purchases anywhere and at any time via infrared technology. ZOOP aims to provide convenient, fast, and secure payment methods for consumers [21]. Figure 1 shows procedures concerning how to use the application.

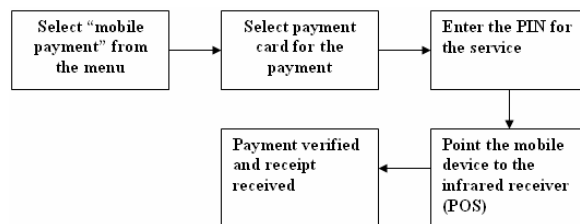


Figure 1. ZOOP mobile payments

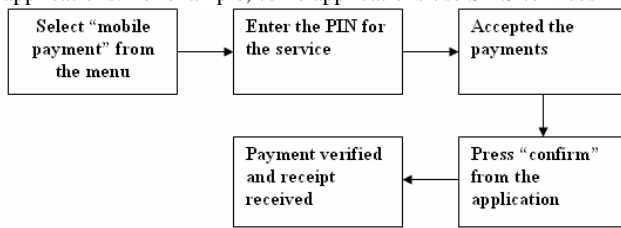
### 3.2 EUROCARD BLUETOOTH BASED WIRELESS PAYMENT

In the summer of 2001, there were 100 selected Swedish Eurocard customers who were testing Eurocard mobile payments via Bluetooth-enabled mobile phones in three weeks. This is the first time that this payment form has been used in such a trial.

This service offers transmitting wireless data in short-range distances. It does so quickly and free of charge [15]. Consumers can benefit from passing through the store check-out much faster, and even there is a queue [15]. The payments application operates procedures shows in figure 2. Bluetooth has deployed the system because it offers more flexibility than other wireless technologies [36], and because consumers do not have to point the mobile devices in a straight line.

The service provider tried to determine the consumers' experience. Did they view payment via mobile phone as easier, faster and more convenient than the other payment methods? Moreover, the system demonstrates how the new wireless technology can be used for financial applications. Both mobile

payments applications are unlike other mobile payments applications. For example, some applications use SMS services



**Figure 2. Eurocard Bluetooth mobile payments**

that create extra costs for consumers. Clearly, the above two mobile payments have provided a new payment method for consumers because the method offers flexibility and convenience. Moreover, it reduces costs as well. In these two examples, both wireless technologies fit well in the payment applications. In contrast, there are some differences between these two short-range wireless technologies. In the ZOO system, consumers have to point mobile devices in a straight line to the terminals, because of the infrared line-of-sight. However, IrDA has its own mobile payments profile IrFM to support the payments application. It helps to build a robust system. Bluetooth offers more flexibility to consumers compared to infrared, and consumers do not have to point mobile devices in a straight line to the terminals. However, there is no financial profile in Bluetooth protocol involving payment transactions.

To summarize, short-range wireless technologies can offer some benefits for mobile payments applications. These benefits can be summarized as: convenience, simplicity, and flexibility.

#### **4. PROBLEMS FOR MOBILE PAYMENTS AND SHORT-RANGE WIRELESS TECHNOLOGIES**

There are a number of issues occurring during the development of mobile payments. One of the challenges to be faced by the operators of mobile payments systems is how to handle the conflicting interests of the varied and powerful parties involved. Another is how to construct a standard and interoperable payment model [1]. These factors will affect users' confidence in the mobile payments concepts [37]. Interoperability is always an important issue. When mobile subscribers were able to send and receive text messages to and from all mobile networks around the world, for example, the use of SMS dramatically increased [38]. From both the users' and the service providers' perspective, the market needs a universal solution. Consumers and mobile service providers are likely to hold back, choosing a mobile payments system until there is a dominant system in the marketplace.

Short-range wireless technologies provide a massive opportunity for implementing mobile payments systems. However, some new technologies are not mature enough, and it takes times for commercial markets to accept the new technologies [39]. Clearly, there are some key issues that need to be addressed before system implementation [1]. These issues include interoperability, security, reliability, and availability.

Various companies are producing their own electronic products that are embedded with wireless technologies. But, interoperability is an issue with these electronic products. For instance, different IrDA electronic devices may not communicate with each other because they are manufactured by different companies. This has happened to Bluetooth devices in the early stage of development. It is important that devices are compatible with each other even though they are produced by different manufacturers. The industry has already realized this issue. Some technologies have their own standardizations. Moreover, they have set up the special task groups in order to test the products' compatibility. For example, Bluetooth SIG has provided guidelines and a platform for members to test Bluetooth products' interoperability [40].

Not surprisingly, security is a huge issue for wireless technology [41;42]. Moreover, wireless network security is very different from wired security [43] for example, some wireless technologies' security architecture did not define a threat model by a standards body [44]. This issue has to be resolved before the system development. For instance, some researchers and industry players have discovered security loopholes in Bluetooth devices [45]. At this moment, however, the Bluetooth vulnerabilities are due to system implementation mistakes and software errors. It is likely that the attackers will exploit the weakness in Bluetooth protocol in the near future [46]. Security is a very sensitive topic for the payments industry. The payments industry is reluctant to accept new technologies and applications. The technologies need improved security protocols. Typically, it needs to focus on the financial transaction environment. IrDA has developed a special profile IrFM for mobile payments applications [32].

Finally, reliability and availability are key factors of wireless network performances. These have been proven to be very important in wireless applications developments [47]. In mobile payments systems, application has to perform a set of functions under certain conditions and at any given moment. These are vital for any payment transaction applications.

The above issues need to be addressed before these short-range wireless technologies can be successful enough to penetrate the mobile payments markets.

#### **5. SUMMARY AND CONCLUSIONS**

Mobile payments applications still lack the proper regulations and standardization. At present, the mobile network operators' billing solution is unregulated and incompatible with banks and financial services. Customer billing systems, for instance, are either based on monthly payments with limited credit checks or they are pre-paid. No standard has been set yet although some organizations have been set up to investigate the best infrastructure for the mobile payments systems. It will not help to construct a standard and interoperable payment model because the most influential players - banks, mobile network operators, and handset manufacturers - want to be the centre of the system in order to realize maximum profits. There are numerous challenges to be overcome. Governments should publish the guidelines and regulations for the mobile payments as soon as possible. This will assist the mobile payments markets to make significant progress. It seemed that there would be a battle to control mobile payments.

This involves financial institutions, mobile network operators, and start-up payment service providers.

The mobile payments market offers much potential, and the mobile payments systems are still being developed although there are many challenges. At present, there are numerous available technologies that might be applied to these systems, and there are a variety of options for building the system infrastructure. Making a decision about which technology is the most appropriate for mobile payments is not an easy task. Of course, it depends on the type and size of a system and application. It may also be significantly influenced by the company and business sector that is developing the technology and by bureaucratic and political influence. The “winning” system may not offer the best technology or the one most convenient for consumers.

This paper has identified some possible short-range wireless technologies, including Bluetooth, IrDA, RFID and NFC, attempting to summarize these technologies. This paper has also selected two mobile payments applications as examples, and it has discovered how wireless technology interacted with mobile payments systems. Bluetooth and IrDA use totally different wireless technologies to implement the systems.

The new wireless technology is driving mobile payments systems forward. The convergence of wireless technologies provides a potential opportunity and platform for the growth of mobile payments. It clearly indicates that wireless technologies have an important role to play in this application.

Mobile payments services provide an attractive, simple and rapid payment channel for users. The battle for control of the mobile payments infrastructure and market is likely to be very fierce, and it has just started. There are many challenges and hurdles that need to be overcome. The “winner” is likely to be the one who can command the biggest support from the powerful sectors such as financial institutions, companies, governments, and of course, consumers. It may not be the best technology and the cheapest option for consumers since the mobile payments application is a potential commoditized market where services are differentiated by marketing rather than technology. The next few years will be vital for these short-range wireless technologies and mobile payments applications.

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