A Case-study on digiPROOF, a Fingerprint Based Payment System

Marcus Mayer
Unitec Institute of Technology
markus.u.mayer@accenture.com

Dr Noel Bridgeman
Unitec Institute of Technology
nbridgeman@unitec.ac.nc

Dr Logan Muller
Unitec Institute of Technology
lmuller@unitec.ac.nz

Abstract

A Case Study methodology is used to examine digiPROOF, a digital payment system (based on fingerprint technology) introduced by the German supermarket chain EDEKA. A framework of success factors which may influence the acceptance and success of new digital payment systems is used to evaluate whether the introduction of digiPROOF meets these success factors. Users are asked to identify advantages and disadvantages they see compared to other payment systems. The research showed that in the future, a fingerprint based payment system has the potential to be successful in the market, with new clients mainly being drawn from existing digital payment users rather than cash payers.

Keywords: Biometric payment systems, digiProof, EDEKA, fingerprint technology.

1 Introduction

The exchange of goods between human beings is one of the most natural things which dates back long before the beginning of recorded history and led to the invention of money as a means valuing goods. In the initial payment system money was represented by coins. Over a period of time, customers have been able to use payment systems which have adopted a number of non-coin based ways of representing money for example: Bank notes (cash), Promissory notes, cheques and, since the 1970s, credit cards. . The advent of the Internet and electronic commerce has spurred the invention of new digital payment systems but the market remains dominated by traditional payment systems. Despite experts predicting success for some, none of the 50 different cyber payment systems identified on the market in 2002 by Sietmann (2002) has been able to gain a significant market share. One exception is PayPal, used by EBay, however, this has only a very small share compared to traditional payment systems. When looking at the introduction of the established payment systems (such as the credit card) one can see that the key factor for the success of a payment systems lies with the customer. Although merchants tried to resist the introduction of the credit card, the fast adoption of credit cards among their customers forced them to accept credit cards (Kreyer, Pousttchi, & Turowski, 2002). In the existing body of knowledge there is some examination of the key factors which lead to user acceptance and which a payment system must fulfil in order to gain the critical mass of customers to establish itself in the market. (Pousttchi, 2003). This paper outlines a framework of factors (identified from existing literature) which influence the acceptance and success of new payment systems.

A case study of digiPROOF, a payment system which is based on fingerprint technology, evaluates whether it meets the success factors and what users think about the system and where they see advantages and disadvantages compared to other payment systems. The aim of the research was to find out if a fingerprint based payment system has the potential to be successful in the market and if it can complement or replace traditional payment systems in the future.

The EDEKA aktiv Markt Fitterer in Rülzheim started implementing the fingerprint payment system digiPROOF in November 2004 (Ziegler, 2005). Since then almost 200 users have registered for the system and the number of subscribers is still growing.

For the purpose of this paper, the term *payment system* is defined as the payment methods that the end-consumer and normal bank customer can use to pay for goods and services.

2 Theoretical foundations of payment systems

The first and most primitive form of payment involves barter. This means that people directly exchanged goods or services for other goods and services. Although this form of payment is still used today in primitive economies it suffers from a substantial problem called the "double coincidence of wants". This means that a person who is hungry and wants something to eat, but only has a TV to trade in for food must first find somebody who has some food to give away and at the same time wants to have a TV in return for the food. This problem led to the development of money. (O'Mahony, Peirce, & Tewari, 2001)

The first form of money that evolved was called commodity money. This form of payment made use of physical commodities (e.g. salt, corn, gold) whose value lay with the commodity, and was well known to everybody plus they had properties which allowed easy portability and divisibility. Gold and silver coins became

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the most used form of commodity money. The next step in the evolution of money was the introduction of tokens. The value of money was no longer incorporated in the money itself. Tokens, e.g. bank notes, were issued and the value of the token was backed by deposits of gold and silver by the money issuer, which was usually the state. (O'Mahony et al., 2001). What made them attractive was that they were easier to transport than the earlier commodity money.

The last step which led to the form of money we use today was the abolishment of the gold and silver standard in the 1930s. From then on, the state did not anymore guarantee the value of money by backing it with gold and silver but the money was only backed by the fiat of the state. That is why the present form of money is called fiat money. (Greenspan, 2002)

Cash is still the prevailing form of payment for private transactions. Even in the U.S. where credit cards and checks are a wide spread means of payment it is estimated that more than 50 per cent of transactions are still based on cash (Weiner, 1999). But as amounts get larger and due to security issues people tend to hold their wealth in form of bank accounts and not as cash. Bank accounts and also direct transfers between bank accounts and the use of checks however, is a very old idea. The idea of banks and bank accounts preceded even the invention of coins as a payment method. It is reported that banking systems already existed thousands of years ago in the ancient Mesopotamia and in Egypt (Davies, 2005).

It is also interesting to note that there exist different payment cultures in different countries. The payment culture helps predict which form of payment system prevails in a given country. Böhle, Rader and Riehm (1999) distinguish three types of payment cultures: cash oriented, check oriented and giro oriented cultures. Germany falls into the domain of giro oriented cultures as checks never played an important role in Germany and don't even exist anymore.

A big innovation of payment systems was the introduction of "plastic money" (credit cards) in the 1950s. The first credit card was issued in 1950 by Diner's club in the United States. American Express and the Bank of America (today the Visa Card) followed in 1958. This new form of payment was marketed as a method for time-saving in the payment process and became a big success in the United States (Bellis, 2004). In Europe however credit cards initially were not very successful, having only have become popular about 10-20 years ago. Till the late 1970s the penetration of credit cards was quite limited in Europe (Crede, 1995).

The next innovation was the introduction of debit cards. This type of payment cards is widely known as EFTPOS (Electronic Funds Transfer, Point of Sale) in the United States. In Germany they are called EC-Karte and were first introduced into the market in 1968. In the beginning debit cards were used to obtain cash from the bank and from ATM machines, as well as a verification mechanism for checks. Later on, the possibility of paying with those cards at the point of sale (POS) was introduced as well. When paying with a debit card at the POS, an online link to the bank is established and the money is directly debited from the customer's account and transferred to the merchant's account(EFT) . (ATM Locator, 2005)

Additionally to the normal EFTPOS payment procedure at the point of sale, which is offered through the card issuers, another "wild" system evolved in Germany: The Elektornisches Lastschriftverfahren (ELV). In comparison to EC-Cash, the original EFTPOS payment procedure, ELV does not establish a direct link to the bank and does not directly debit the account of the customer. With ELV only the account details of the customer are extracted from the payment card. Then the customer signs an agreement that the merchant can collect the money from the customer's bank account. Although this method is less secure, because there is no direct online check, it is widely used in Germany. (EURO Kartensysteme GmbH, 2005)

During the last two decades, Globalisation (and especially the internet) has lead to a dynamic evolution in the payment market which hasn't been seen before (Hartmann, 2002). One of the first approaches to replace money by "virtual money" is described by Chaum (1985), often called the father of "virtual money". In 1985 he described a system that is based on a small card computer which the user employs to perform all sorts of payments. In this scenario, the user does not need cash anymore, but all transactions would be performed virtually through the card computer.

Germany also introduced a smart card based payment solution. An additional chip was added to the EC-Karte where the user could upload money directly from his bank account and then use the stored money to pay at POS terminals. However, this payment method called GeldKarte never gained a wide acceptance in the market. (Sietmann, 1999)

Currently the hot topic in payment systems is mobile payment, which describes technologies that use the mobile phone as a payment instrument. "*Mobile payment is considered by many experts as the next 'big thing' [...]*" (Karnouskos, Vilmos, Hoepner, Ramfos, and Venetakis, 2003, p. 1). Nevertheless, Paybox, a German provider of mobile payment services, had to close down operations in 2003 as they were not able to acquire a sufficient amount of users in order to break even (Klaß, 2003). Besides mobile payment systems there are also approaches which use biometry to develop new and innovative payment systems. Van der Ploeg (1999) describes an ATM which uses iris scanning and voice recognition for authentication and Marshall (2003) reports, that there are already several supermarkets in the United States which use fingerprint based payment systems. Master Card recently announced the introduction of Master Card Pay Pass, a contactless credit card which is based on RFID technology (M2 Presswire, 2004) and American Express and Visa offer similar solutions (Sullivan, 2005).

Furthermore, there exist unusual approaches such as a method developed by Japanese researchers. They use a laser to engrave information into fingernails. This could

be used to store credit card information or account details and then use this information for payment transactions. The problem with that method however is that fingernails are growing, get cut off and then the information needs to be renewed. (Sietmann, 2005)

2.1 Payment Authentication Method

All electronic payment systems require some form of secure authentication method. Biometric authentication methods take advantage of the fact that every human being has distinct traits which are specific to only one person and differ in all other humans. Compared to traditional authentication methods such as PIN-Codes, magnet stripe cards or Smart Cards, biometric systems have an enormous advantage. Only biometric characteristics can reliably authenticate a person. Plastic Cards and passwords can get stolen, lost or forgotten. Biometric traits are always present and cannot be transferred to another person. (Schneider, Franke, & Nickolay, 2001)

Especially in payment systems biometry can provide a higher level of convenience and additional security. An example is a fingerprint based payment system (e.g. digiPROOF), the payment system which is reported on in this paper. Banks and credit card companies are also very interested in biometry to enhance the security of payment systems. "*MasterCard estimates that adding smart-card-based biometric authentication to a POS credit card payment will decrease fraud by 80%*" (Zhang & Yu, 2003, p. 81). A disadvantage which is directly linked to biometrics is privacy. This issue is of concern to a number of the public with people often indicating they are reluctant to give away their fingerprint or other personal identification characteristics, because they fear they will lose their privacy and become traceable wherever they go and whatever they do. On first sight this fear seems justified, but some data protection and privacy experts argue that biometry may even help to increase privacy. Biometric payment systems can be designed in a way such that they can only be used to authenticate a person during the payment process. At all other times, it would not be possible to reconstruct the fingerprint or identify a person from the stored data. Furthermore, there must be strict regulations in place as to who has access to the data and for what reason access is granted. Experts admit that the path between biometry as a surveillance technology and biometry as a privacy keeper technology is very narrow, but when designed in the right way, biometry can work without compromising privacy. (Walters, 2001)

Another disadvantage of biometric authentication systems is that there is never an exact match as with PIN-codes.

When scanning (for example) a fingerprint, one never gets exactly the same picture of the finger each time. This can be due to dirt on the finger, little injuries, different positioning on the fingerprint scanner or inaccuracies during the scanning process. Consequently, the fingerprint is not matched exactly, but only with a certain probability. The quality of biometric systems is therefore measured by two characteristics: The False Rejection Rate (FRR) and the False Acceptance Rate (FAR). The FRR tells how many per cent of the authorised users are rejected and the FAR states how many unauthorised users are accepted in error. The more secure a system needs to be, the lower the FAR has to be. This naturally means that the FRR will go up. So in biometric systems one usually has to find an equilibrium between an acceptable FAR and an acceptable FRR. This point is usually where the FRR and the FAR are equally high and it is called Equal Error Rate (ERR). (Brückbauer, 2005)

2.2 Classification of Payments

Payments can be classified into different groups having different requirements of their payment system.

The first differentiation is the amount of the transaction – subdivided into micro and macro payments. Micro payments have a low value, say below 5 to 10 Euro (Henkel, 2001; Mallat, Rossi, and Tuunainen, 2004). Here transaction costs need to be low, as for lower amounts, especially fixed transaction costs have a much higher weight than for high sums. Some authors differentiate additionally between micro and pico payments (Balzer, 2005). Pico payments are in the range of several cents and are especially important in the context of downloads in the internet and on mobile phones (e.g. content, music, ring tones …).

Another classification is the time of payment: solutions may be pre-paid, pay-now and pay-later (Abad Peiro, Asokan, Steiner, & Waidner, 1998). In pre-paid systems the user pays in advance for some sort of coupon which is traded against the goods. A classical example is mobile phone pre-paid cards. The most popular pay-now solution is cash, but also include systems like EFTPOS which directly carry out the transaction on-line. In pay-later systems, commonly met as cheques, credit cards and invoices, the customer pays after having received the goods. Lastly there is the "location" or the circumstances of the payment. Is the purchase and the payment transaction conducted online (as in over the internet or over the mobile phone) or done in a real environment, directly at the point of sale. In the latter case the customer and the merchant have direct physical contact and can directly interact with each other, whereas on the internet the customer and the merchant usually do not know each other. This normally increases the level of uncertainty and hence the need for higher security measures. A third category which can be distinguished is the customer to customer (C2C) transaction. This transaction differs as customers do not necessarily possess the facilitors (e.g. a credit card terminal) as do merchants. (Pousttchi, 2003).

Th ese are summarised in Figure one

Classification of payment Scenarios			
Amount	Pico payments (< 1€)	Micro Payments (1-10€)	Macro payments (> 10€)
Time	Pre-paid	Pay now	Pay later
Location	Point of sale	Internet/Mobile	C2C

Figure 1: Classification of payment systems

Source: Author's illustration

2.3 Framework of success factors

When analysing the development of payment systems in the past, one can see that the key success factor for a payment system are the customers. According to Wichmann (2002), most online stores follow the payment preferences of their customers although they often would prefer to use different payment methods.

This framework of success factors draws on previous research in this area and by analysing the success of already established payment systems in the market.

The main factors customers consider, which influence their acceptance of a payment system are identified as:

- cost
- convenience
- security and
- privacy

Whereas the interests in the first three factors are similar for merchants and customers, the interests of those two groups differ essentially for the privacy factor. Both groups want to have cost efficient payment systems with a high level of convenience and security, but when considering privacy, merchants usually prefer to collect as much data as possible whereas customers tend to want to protect their privacy as much as they can, by minimising the data they are required to provide.

Another factor is marketing. However, marketing is independent of the design characteristics of a payment system and can be performed in the same way for all payment systems. It is therefore, not included as a criterion in this framework.

3 Methodology

According to Myers (1997), a case study is a recognised research method employed within Information Systems and is especially suited to this piece of research. A case study is used to reach an understanding of complex issues or objects within real life situations. A definition commonly referred to in the literature is from Robert K. Yin who defines a case study as "*an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident*" (Yin, 1984, p. 23)

As biometric payment systems are a new, contemporary issue and as the acceptance and success of payment systems depends highly on people's perceptions of the system within the real-life context, a case study seems especially suitable to the topic. Furthermore, the existing literature and past experience has revealed, that general surveys about the potential willingness of customers to use innovative payment systems do not translate into actual usage (e.g. with mobile payment). For people it is often hard to imagine how they would accept and like a product, or in this case a payment system, if they never have used it. Even more so, if the payment system is based on a technology which they have never used as well, such as fingerprint technology. Therefore it seems sensible to use a research method where the opinion and behaviour of actual users in a real-life environment can be observed.

3.1 Summary of the Process

Interviews were conducted with the store manager and the owner of the EDEKA store as well as with the CEO of the company which implemented the digiPROOF system. The store manager of the EDEKA store was able to provide information on the operation of the system and how the users reacted to the system. The owner of the EDEKA store (a member of the board of the EDEKA supermarket chain and responsible for IT within the group) was able to give a more detailed insight into the financial and strategic advantages of biometric payments for EDEKA, while the CEO of the company that invented and implemented digiPROOF was able to give a detailed overview of how the digiPROOF system worked. Additionally to the open questions about the functionality of digiPROOF some targeted questions on security, reliability and data protection issues were asked.

A questionnaire was mailed out to all 182 digiPROOF users and a survey was conducted on site at the EDEKA store where those customers who had not used the system when making their purchase were questioned as they exited the store.

The data collected was then analysed using a mySQL database to discover any trends and clusters. In the last part of this paper, data and findings are interpreted and digiPROOF is matched against the framework of success factors as well as against other current and established payment systems.

3.2 Questionnaires

Different questionnaires were developed for the user and non-user groups. Whereas users were asked to judge the system and make comments about negative as well as positive aspects of the system, non-users were asked about their reasons for not using the system. Both groups were asked to judge the system against the success factors which had been previously identified. They also were asked to mention which points are important for them in a fingerprint based payment system and how they evaluate future chances of such a system.

3.3 Data Analysis

The main aim was to gather as much information as possible and to find patterns and tendencies which emerged from the data.

Besides the qualitative data, some quantitative data was collected through the questionnaires. Quantitative data was mainly used to compare established payment methods and the digiPROOF fingerprint system according to the identified success factors.

4 The case study

The digiPROOF payment system was invented and is marketed by it-Werke Lahr, a German IT company which specialises in biometric applications for marketing and customer retention. Besides the digiPROOF payment system it-Werke also offers a fingerprint based time recording and access control solution for employees and a virtual customer retention solution which is also based on fingerprint technology and works similar to a customer store card. (it-Werke, 2005a, 2005b)

The digiPROOF system consists of two main components, a high quality fingerprint scanner and the digiPROOF software which can be connected to a standard LINUX or Windows based cash register. The digiPROOF system is connected to the cash register through a standard network interface (LAN) and communicates with the cash register using the TCP/IP protocol. This means, for the cash register, the digiPROOF terminal is not any different than a standard EC or credit card terminal.

Before a customer can use digiPROOF they have to register for the system giving their personal details and their account and payment information. Additionally their finger is scanned to create a template of their fingerprint. When scanning the finger, digiPROOF extracts 24 typical reference points of the fingerprint which will later be used to identify the finger. 24 reference points are more than what is usually required to unambiguously identify a person. Normally only ten to twelve typical reference points are required to identify a person (Abdalla & Abschinski, 2002). The 24 points are directly encrypted in the hardware of the fingerprint scanner, then the encrypted fingerprint is saved onto the server on which the digiPROOF software runs. To further enhance the security, the fingerprint scanner uses a hash algorithm to encrypt the fingerprint. A hash algorithm is an algorithm which only works unidirectional and only allows for the encryption (but not decryption) of the information. This means that it would be technically very challenging to try to reconstruct a fingerprint from the encrypted information which has been saved onto the digiPROOF server.

Once registered, at the cash register, the customer only has to put their finger onto the fingerprint scanner in order to approve the payment transaction. The scanner extracts the typical reference points again, encrypts the information with the hash algorithm and compares it to the stored template on the digiPROOF server. When the fingerprint can be matched, the system will approve the payment and the payment details will be stored on the digiPROOF server. Which data will be stored and how the actual settlement process is designed depends on the preferences of the user. As for the cash register the digiPROOF system is just another payment method equivalent to a standard EC-Karte or credit card terminal, the existing settlement providers and infrastructure can be used to settle the payment. Alternatively, it-Werke also offers the service of administering the settlement process for small customers who do not already possess their own settlement infrastructure.

In biometric systems there might occur inaccuracies in the scanning process caused by dirt, injuries, etc. For the digiPROOF system the FAR is scalable on a scale between one and ten. The standard setting is eight. With this setting, the FAR of digiPROOF is 10^{-7}. This means that one in ten million users will be accepted falsely. For the FRR it-Werke cannot tell exact numbers as they do not measure the FRR. For them the FRR is not vital, as when a customer is falsely rejected they can simply put their finger on the scanner again and repeat the procedure.

Another interesting point to look at is the number of users a payment system can handle. At the moment digiPROOF can handle a database containing 20,000 users with a recognition time under one second. If the number of users in the database grows over 20,000 the recognition time will increase. At the current stage digiPROOF is still far away from having 20,000 users in its database,. However, (according to the CEO of it-Werke), there is still room for response time improvement in the system (through faster hardware and improved database algorithms such as e.g. regional clustering of customer groups) to meet the demands on the system in the future, which will be brought about when user numbers grow.

4.1 Rationale for the introduction of a new payment system

All of the common payment methods have certain disadvantages for EDEKA. Cash is labour intensive and expensive to handle and it is a high risk to have large amounts of cash in a store. EC-Cash resolves these problems of cash as customers only need to insert their EC-Karte and enter their pin code. The downside of EC-Cash is, that the merchant has to pay a processing fee for each transaction. ELV resolves the problem of transaction costs, as no direct link to the bank is established and therefore no online processing fee has to be paid. As no online credit check is performed with ELV, the biggest problem is return debit notes (Rücklastschriften). Especially at the end of the month, bank accounts tend to be empty and when EDEKA tries to debit the bank accounts of their customers the debit note fails. This incurs high costs for EDEKA as well as for the customers. To find out name and address of a customer who did not pay incurs costs of 20€ to 30€. Additionally there are bank fees for the return debit note and costs for the collection procedure.

One of the main reasons for EDEKA to introduce digiPROOF was to eliminate the downsides of existing payment methods and save costs in the payment process. At EDEKA, digiPROOF is based on the ELV method, but in comparison to ELV, EDEKA knows the name and

the address of the customer who is paying. Furthermore, the payment and collection process lies in the hands of EDEKA and, in the case of return debit notes (Rücklastschrift), EDEKA can directly contact the customer and collect the money on its own. This makes the process much cheaper for EDEKA and the customer, as no banks and collection agencies (Inkasso Büros) are involved.

Another reason for introducing digiPROOF is a higher level of convenience for the customer. The customer only has to put their finger on the fingerprint scanner and thereby confirm the payment. They do not have to carry any cash or plastic cards and do not have to remember a PIN code. This also helps to increase the efficiency and the speed of the payment process.

4.2 Evaluation by EDEKA

EDEKA views the introduction of digiPROOF as a success. The system was introduced in the E aktiv markt Fitterer in November 2004 as a pilot project. Since then almost 200 users have subscribed to the system and already about 12% of all payments are processed using the digiPROOF system. Comments from users of the system have been universally positive. The implementation of the system proceeded with few problems. The operation of the system has also been very smooth and there has not been a single major error or wrong recognition of a fingerprint since the introduction of the system. The savings in the payment process which were the main reason for introducing digiPROOF have also been realised. Since the introduction and with growing number of users, a decline in return debit notes (Rücklastschriften) and non-payments has been achieved. According to the owner of the E aktiv markt fitterer, the amortisation of the investment to equip a cash register with the digiPROOF system was about four to five months.

4.3 Customer Survey results

Responses were received from 31 of the 182 (17%) of digiPROOF users that questionnaires were sent out to by mail, while a further 155 non-users were prepared to answer the survey, when approached while they were doing their shopping. This survey of non-users was carried out on a Monday and Tuesday during different times in the day and on Friday afternoon and evening as well as on Saturday to get exposure to a wide a range of customers as possible.

When looking at the payment behaviour of users and non-users one can see a clear difference in both groups. Users were asked for their payment behaviour before and after the introduction of digiPROOF. When examining the payment preferences of digiPROOF users before they had the possibility to pay with digiPROOF, they already showed a high preference for card based payments (with most people who used their EC-Karte before the introduction of digiPROOF switching from the EC-Karte to digiPROOF). On the other hand, digiPROOF non-users had a strong preference for cash payment, which they continue to use. In fact, there still exists a large group of people who are happy to stick with cash payment and are not interested in using any form of electronic payment methods.

The customers who do not use the digiPROOF system were asked for the reasons why they are not using it. 23 out of the 155 survey participants did not know of the system and therefore hadn't registered. 13 people stated that they had not had the time yet to register or that they had not thought about registering and 10 people said that they did not shop frequently enough in the store to warrant registering.

The reason stated most frequently (for not registering for digiPROOF) by customers was their strong preference for cash payment (31 people). The main reason for the strong preference for cash was that using cash provides them with a much better overview of what they are spending and how much money they have left. This strong preference for cash and traditional payment systems was further supported by 19 people who stated that existing payment methods were sufficient and therefore digiPROOF was unnecessary. Also frequently stated reasons for rejecting the system were security and data protection concerns. 15 people did not want to give away their finger prints and feared surveillance and abuse of their data. Another 6 people had security concerns and did not trust the system. A general mistrust and rejection of technology were named by 8 people as the reason for not registering with digiPROOF. Another group identified, was people who thought that the technology is not ready yet (7 people) and who want to wait first and see how the system develops (6 people).

When looking at the reasons for not registering with digiPROOF, survey participants can be clustered into 4 groups.

- Group One are people who did not know digiPROOF, haven't thought about registering yet or do not shop frequently enough.
- Group Two are people who reject digiPROOF because they have a strong preference for cash and think that traditional payment systems are sufficient.
- Group Three are people who have data protection and security concerns and
- Group Four is made up of people who think that the technology is not ready yet and who want to wait and see how the system develops.

Besides those four groups there existed other individual reasons e.g. somebody who uses a company EC-Card to pay or a woman who works in a window factory and therefore always has glue on her fingertips. Those people could not be assigned to one of the four groups.

Non-users were also asked to evaluate the security and user-friendliness of digiPROOF against cash, EC-Karte and credit cards. What was interesting to see, was that both groups, (users who are considering registering in the future as well as user who will not register in the future) think that digiPROOF is safer than traditional payment methods. The main difference between those two groups lies again in their use of cash. As already seen, users who

do not want to register in the future, have a strong preference for cash. But despite their strong preference for cash, even people who do not want to register in the future, still attribute a higher level of security to digiPROOF than to cash. Non-users evaluate the user-friendliness of digiPROOF similarly to the user friendliness of cash and the EC-Karte. Only credit cards score significantly worse than digiPROOF.

4.4 The future

The last part of the questionnaire asked survey participants to evaluate the future prospects of finger print based payment systems. 72% of all non-users think that finger print based payment systems will be wide-spread in the future and only 17% thought that this kind of payment systems will not have a great future. Even in the group of people who do not want to register for digiPROOF in the future 65% think that fingerprint based payment systems will be important and widespread in the future, compared to only 24% who do not see good chances for fingerprint based payments.

This shows that even though people still might have concerns about biometric payment systems they attribute a high future value to those kinds of systems. The only difference between users and non-users is, that digiPROOF users give a very high importance to marketing and information (9 people)

4.5 Success factors

The last question of the survey asked which factors respondents thought were most important for the success of a fingerprint based payment system. With 38 different criteria nominated, security was the most important identified by survey participants. They thought that the system must be absolutely secure and that there must not be any possibility of being able to reproduce a fingerprint and use that reproduction to cheat the system. Connected to the security of the system was also the demand for data protection mechanisms and regulations, which is seen as important.(9 people). The second most important criterion for the success of a fingerprint based payment system (13 people) was a high diffusion of the system, so that people can not only pay at EDEKA with their fingerprint, but also in many different places. The claim for security is closely followed by the claim for good recognition of the fingerprint without failures (11 people). An easy registration process and comfortable and fast handling of the system are seen as important by 9 people. During the survey it became obvious that there was a strong preference for cash among the non-users, as cash allows a better control on what one has spent and how much money is still left. Therefore it is not surprising that 10 non-users stated that a control mechanism, to see how much one has spent and how much money is left, is a vital function for the success of a payment system. Some of those people remarked, that it would be great if one could have a direct online check with digiPROOF to see how much money was left in their bank account. Some participants also named a good marketing (3 people) and a test phase (2 people) as important success factors.

4.6 Assessment of the system by users

The registered users of digiPROOF were asked to state their motives for registering with digiPROOF. For the great majority of users a comfortable, easy and fast payment process was stated as the main reason to use digiPROOF as a payment method (27 people). Also an important factor which led to a registration with digiPROOF was the fact, that people do not have to carry cash or other payment instruments with them. 14 people stated that they registered for digiPROOF because they do not need to carry any payment devices with them and that they always have their finger with them and could not forget it. 4 survey participants registered with digiPROOF because they thought it provided a high level of security and 3 people just thought that the system was very practical.

Users were also asked to make suggestions for improvement and to state what they did not like about digiPROOF. 14 out of 31 survey participants stated that they are satisfied with the system and would not improve anything. The biggest room for improvement seems to be in a better recognition rate for the finger print. 10 people stated that they would improve the recognition mechanism of the fingerprint scanner. People stated that they feel very embarrassed if they stand in line at the cashier and the recognition of their finger does not work correctly. This shows that for users a high recognition rate is very important. The only other improvements mentioned was that digiPROOF is not widespread enough (3 people) and some other individual issues such as a person who would like to register several fingers and persons on one account.

With users, digiPROOF scored significantly better than all other tested payment systems for security as well as user-friendliness. Users were also asked how easy and fast the registration process for the system is. 17 out of 31 (57%) users stated that the registration process is very fast and easy, 9 persons (30%) though that the registration process is easy and only 4 users (13%) found that the registration process takes some time, but that it was still OK. None of the questioned users had the opinion that the registration process was complicated or very complicated.

In the last part of the questionnaire users were questioned about their estimation of the future prospects of digiPROOF. They were asked if they would welcome it if they had the possibility to pay with their fingerprint in other stores and places. 62% would welcome it very much if they could use their fingerprint as a payment device in other places as well, 26% would welcome it and 12% do not care. None of the questioned users stated that they did not want to pay by fingerprint in other places. When being asked for the future prospects of fingerprint based payment systems, both digiPROOF users and non-users are similarly optimistic. 35% absolutely think that finger print based payment systems will be widespread in the future. 52% attribute good chances to fingerprint based payment systems and only 13% think that fingerprint based payment systems will not be widespread in the future.

5 Comparisons with other payment systems

When comparing the privacy level of digiPROOF to that of traditional payment systems, digiPROOF is very similar to card based payment systems. Only cash provides a higher level of privacy. Cash is the most anonymous form of payment and nobody can trace payments with cash. Only with cash, is no paper trail left behind. But it is doubtful if cash will still provide this high level of privacy in the future. The European Central Bank has already announced plans to equip bank notes with RFID chips in order to make them traceable (Juels & Pappu, 2003).

Cost wise, at the moment digiPROOF is an interesting alternative for both the customer as well as the merchant. The only payment method which may in the future be even more cost efficient than digiPROOF are mobile payment services. That will depend on the actual cost structure chosen for mobile payment services and who will have the control over the payment process and the payment data.

When looking at the survey results of the digiPROOF survey, almost one third of the users especially liked the fact that they do not have to carry any device with them and can't forget passwords or payment devices. This advantage is unique to digiPROOF as with smart cards and mobile payment systems one has to carry a payment device which one can forget, lose, etc. Therefore, one could argue that digiPROOF could provide a slightly higher level of user-friendliness than other innovative payment systems.

A tracing function, where customers obtain an overview of how much money is left and what they have spent, can be implemented in mobile payment systems more easily and efficiently. Another advantage lies in the existing mobile communications network and the high diffusion rate of mobile phones. Mobile payment systems may be used not only in the stationary payment scenario in stores, but also e.g. for payments over the internet or payments for mobile content. For digiPROOF, the customer would need to acquire a fingerprint scanner first and connect it to the computer in order to effect internet payments. As prices for fingerprint scanners are decreasing (Ulfelder, 2005) and some computer manufacturers already integrate fingerprint scanners to protect computers from unauthorized access (Lenovo, 2005), internet payments could become a possible scenario for digiPROOF. But at the moment, mobile payment systems have a clear advantage in this area.

Credit card companies up to now have mainly experimented with RFID based payment solutions. These attempts were not very successful and it seems very doubtful if a credit card which works in exactly the same way as a regular credit card, except that one can pass the card contactlessly in front of the card terminal (rather than swiping it through), would provide huge advantages. But banks also show a high level of interest in biometry to increase the security of their services. Master Card estimates that they could decrease the level of fraud by 80% when adding biometric authentication to their credit cards (Zhang & Yu, 2003). The approach of banks and credit card companies however differs from the architecture of digiPROOF. When they talk about using biometry to improve the security of payment solutions they mostly think of smart card based biometric systems (Zhang & Yu, 2003). These kinds of systems have two advantages over digiPROOF. Firstly people do not have to give away their fingerprints, but their fingerprint template is directly stored on their smart card and at payment, their fingerprint is directly verified on the smart card. This naturally increases the level of privacy. The second big advantage of smart card base biometric systems is that they resolve the problem of the limited number of users. As each user carries his fingerprint template with himself, the finger only has to be compared to that specific template and it is not necessary to search a database of users, (which would be an advantage, because as the number of fingerprints in a given database increases, it has the potential to lengthen the recognition time, and hence from a practical point of view, limit the number of fingerprints in the given database). On the other hand, almost 30% of the digiPROOF users stated that what they especially like about digiPROOF, is that they do not have to carry any payment device and cannot forget it. In the smart card based scenario, they would have to carry their smart card, just as with traditional card based payment systems.

The way digiPROOF is designed and marketed at the moment however, it seems to be rather doubtful that it can reach a critical mass and become widespread and accepted throughout Germany – or even worldwide as a payment instrument. It is true, that with EDEKA, one of Europe's leading food retailers, digiPOROOF has a very strong partner and a good starting position to become widespread, but at the moment digiPROOF is designed and marketed as a closed system. Each merchant has its own database and digiPROOF server. This means that if a customer registers with one specific merchant he cannot automatically pay in other places which also offer digiPROOF as a method of payment without going through the same registration process.

Smart cards can provide a variety of different functions and when they are combined with fingerprint technology, they can also offer a high level of security and at the same time help to protect the privacy of customers. As banks have a profound knowledge in the payment industry, are in close contact to the customers and possess the largest market power, there is a high probability that they will in the end have the greatest influence when shaping the future landscape in payment systems. And that this future will involve biometry is very probable. The opinion that mobile payment systems will only win in the short term and that banks will upgrade the traditional payment systems to defend their market, is also supported by literature (Heng, 2004).

6 Conclusions

The question which this paper addressed was whether fingerprint based payment systems do have the potential to supplement or replace existing payment systems in the future. When looking at the results of the digiPROOF survey, people are mostly positive about the system and

also think that it is very probable that fingerprint based payment systems will be widespread in the future. The success factors for payment systems are also mostly met by digiPROOF. The high level of perceived security by users as well as non-users is seen as a special strength of digiPROOF. Compared to traditional payment systems, the convenience of digiPROOF was also judged to be higher by users of the system and from a cost point of view digiPROOF seems to be an interesting alternative for a merchant as well as customers. This shows that fingerprint based payment systems have a good starting point for being successful in the future. But there remain still some shortcomings which have to be overcome. One is the recognition rate. Almost one third of the questioned users stated that the recognition rate should be improved. This however is mainly a technical problem and there seems to be no reason why this issue should not be resolved with a further maturing and development of the technology. The second is the low diffusion of fingerprint based payment systems at the moment. This is normal for new payment systems and it is mainly an issue of marketing and sales politics to quickly increase the number of users in order to reach the critical mass and profit from network effects. However, the need for customers to register for the digi-Proof system with each merchant provides a barrier to widespread adoption. The other big issue with digiPROOF is speed. At the moment digiPROOF can only handle a database of up to 20,000 fingerprints(users) and still provide a recognition time of less than one second. The number of fingerprints(users) in a database can still be increased (while still maintining a recognition rate of less than 1 second) given faster and better hardware or more elaborate database algorithms. But if one assumes that digiPROOF should be accepted as a method of payment Germany wide, with 80 million inhabitants, the number of users could hardly be supported by the current architecture of digiPROOF.

Especially when it comes to diffusion, mobile payment systems have a strong advantage over other new and innovative payment systems. In developed countries mobile phone penetration is very high and the mobile phone infrastructure is in place. This could support a fast diffusion of mobile payment services and there should not occur any restrictions concerning the number of users. Another advantage of mobile phone based payment systems is, that they are strongly pushed forward by the big players in the mobile phone industry. This is especially important as with the backing of large companies, huge resources for marketing are available and it is easier to push a product into the market. This is also the main reason why most industry experts and scientists see mobile payments as the future payment system with the highest chances of success in the short term.

In the mid-term however it seems to be more likely, that banks and credit card companies will try to defend their market share and upgrade existing payment methods to meet the needs of their customers. From the current point of development there seems to be a high probability that banks and credit card companies will try to bring smart card based biometric solutions to the market which are based on fingerprint technology.

In conclusion, one can assert that biometric payment systems are likely to play an important role in the future. Within the field of biometrics, fingerprint technology is the most developed and best accepted technology. Therefore, it is likely that the direction will go towards fingerprint based smart card solutions. When looking at the question of whether fingerprint based payment solutions will replace existing payment systems or whether they will supplement them, one can get a first indication from the digiPROOF user survey. While most of the customers who have registered for digiPROOF replaced payments by the EC-Karte with payments by digiPROOF, the share of cash payments stayed relatively constant. This means that new and innovative payment systems will be competing with the traditional card based payment systems, whereas cash is likely to remain less affected by the new payment systems. The view that cash will still co-exist with new and innovative payment systems is also supported by Freedman (2000). This leads to the assessment that fingerprint based payment systems have a good chance to replace card based payment systems and co-exist with cash and maybe even other innovative payment methods in the future.

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