MOBILE BROKERAGE INFRASTRUCTURES – CAPABILITIES AND SECURITY REQUIREMENTS

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Abstract

This paper investigates the potential of integrated mobile financial information and transaction services which can help private investors in making time-critical investment decisions and portfolio transactions in time. The analysis of intraday stock price reactions following company announcements provides evidence regarding the added value of such services if abnormal price movements can be observed. As efficient capital markets react very quickly to new information available, private investors require combined mobile notification and transaction services. So far, existing concepts can not fulfill these requirements which results from inappropriate implementation of the security mechanisms in order to realize secure and trustworthy processing. After identifying potential weaknesses of current solutions we introduce an adequate system infrastructure which can realize secure information and transaction processing in time by permitting a smart integration of notification and transaction services.

Keywords: Mobile Brokerage, Security Requirements, Service Integration.

1 INTRODUCTION

In recent years, financial services were expected as one of the key commercial drivers for the mobile commerce market (Durlacher Research 1999, Roland Berger 2000, Frost & Sullivan 2002). As we know today, the market development of mobile financial services including mobile banking and brokerage services has not lived up to these expectations. Reconsidering the implementations of mobile financial services available, so far we can find that they are mostly reproductions of their (widely successful) web-based counterparts. This applies accordingly to the used security mechanisms. Consequently, they do not utilize their special features deriving from the mobility and infrastructural aspect. For example checking out the balance of accounts or requesting stock prices might be pastime but does normally not provide added value for customers and using transaction numbers for authorizing transactions while being on the way is inconvenient. As we can see from the success of equivalent online services, customers prefer doing their daily (time uncritical) transactions using online services. E.g. at the end of 2003 nearly eighty percent of all checking accounts at private banks in Germany were online accounts (Bundesverband Deutscher Banken 2004).

In this paper we focus on this missing market success of mobile financial services. Therefore, we analyze a promising application domain (mobile brokerage notification and transaction services) which can provide added value for customers and address the shortcomings of currently used security mechanisms. Watching out for an attractive and suitable application area we find that company announcements can have significant short term price effects on corresponding stock prices. If a private investor holds any stocks of the company, the portfolio value can be affected dramatically. As the resulting price effects can be very promptly and completed within a short time frame, investors should be notified and enabled to react immediately.

In contrast to most of the existing mobile banking services our proposed application domain can not be supported by traditional online services. This domain focuses on a time critical application scenario which should be supported in unexpected situations.

Therefore, we demonstrate the potential added value of the proposed application scenario in section 2 by analyzing intraday stock price reactions following company announcements. This is done by making an empirical analysis using voluminous historical intraday stock price series in order to prove the occurrence of relevant price effects and to demonstrate the time-critical speed of stock price adjustments.

Based on these findings we examine the potentials resulting from an integration of mobile notification and transaction services in section 3. In order to support private investors to react to an unexpected market event, it is necessary to integrate mobile notification and transaction services.

As current implementations seem to focus on security requirements of transaction services only and do not provide the postulated service integration, we analyze application and security requirements of suitable mobile services in section 4.

After introducing a typical implementation concept including typical shortcomings in section 5 we introduce an alternative approach in section 6, addressing the requirements defined.

Finally, in section 7, we summarize our findings and give an outlook regarding further research questions and additional implications concerning the proposed infrastructure.

2 INTRADAY PRICE REACTIONS AND REACTION TIME

In order to prove the application domain of mobile brokerage notification and transaction services we analyze intraday stock price reactions following company announcements. If significant intraday price reactions can be proven, investors should be notified promptly.

Therefore, we formulate a research hypothesis regarding the information content provided by company announcements in order to prove the application domain of mobile brokerage notification services.

Hypothesis I: *Company Announcements cause significant intraday stock price reactions (which uncovers the potential of added value provided by mobile brokerage notification services due to contemporary information supply).*

Furthermore, it is of utmost importance after which time frame the observed price reactions are completed as investors would have to react within this period. Therefore, an analysis of this time frame provides evidence regarding the window of opportunity which opens for a limited period of time only. If investors must react quickly to take the arising opportunity, an integration of mobile notification and transaction services is required. Consequently, we formulate a second research hypothesis.

Hypothesis II: *The observed price effects persist for a short time frame only (a few minutes, up to one hour).*

This finding would prove the demand for an integration of mobile notification and transaction services including prompt transaction authorization. In order to prove both research hypotheses we analyze the intraday stock price developments following the company announcements.

2.1 Price effect analysis

The analysis covers price effects following company announcements pursuant to §15 of the German Securities Trading Law. Our sample consists of 172 company announcements and covers the time frame between 2003-08-01 and 2004-03-31. The original data sample consists of 1694 company announcements which had to be reduced by several filter rules. First, as we want to observe intraday short-run price effects we discarded all announcements which were not published during stock exchange trading hours. Concentrating on the German capital market we eliminated all announcements of companies whose shares are listed at non-domestic stock exchanges only. To be able to analyze the price effect caused by the announcement we discarded announcements, if a company has published more than one announcement per day (confounding events) and if less than twenty price fixings were available after the announcement date. We begin with the calculation of discrete returns for company i at time t using intraday prices P.

$$R_{i,t} = \frac{P_{i,t+1} - P_{i,t}}{P_{i,t}} \quad \textbf{(1)}$$

Intraday return of company *i*

The intraday returns are calculated for all existing prices (and companies/announcements) between ten days before and until the announcement day. These calculated returns represent the intraday stock price development of company i over a 10 day period.

To isolate the price effect caused by the ad hoc disclosure, these returns have to be adjusted by general market developments, i.e. the corrected return series should only reflect price effects caused by the ad hoc disclosure.

In our work we calculate net-of-market-returns to isolate the announcement effect by applying a single index model (we use the CDAX index which contains all listed domestic companies representing the entire range of the German equity market). This is done for two reasons. First, this model generates better results compared to the mean adjusted returns procedure and secondly it is not outperformed by the (more complex) OLS market model (Klein and Rosenfeld 2002). These abnormal returns ($AR_{i,t}$) are worked out by subtracting the index (CDAX) returns from the stock returns $R_{i,t}$.

$$AR_{i,t} = R_{i,t} - R_{CDAX,t} \tag{2}$$

Abnormal returns (market-adjusted)

As we do not make ex ante announcement classifications, positive and negative announcement effects might neutralize. Consequently we use absolute values of the calculated abnormal returns ($AAR_{i,t}$). These returns can not be used for any statistical tests, because the sum of absolute values will always be significantly positive with high probability. For that reason we adjust these absolute returns by an average abnormal return which can be observed when no announcement is published. These average absolute abnormal returns ($AAAR_i$) cover the period between ten days before and two days before the announcement day. The day prior to the announcement is excluded as these prices might be affected by insider trading or anticipation effects.

$$AAAR_i = \frac{\sum_{t=1}^{T} \left|AR_{i,t}\right|}{T} \tag{3}$$

Average absolute abnormal returns

The absolute abnormal returns of the time intervals to be analyzed are corrected by these averages.

$$CAAR_{i,t} = \left|AR_{i,t}\right| - AAAR_i \tag{4}$$

Corrected absolute abnormal returns

In comparison to Carter and Soo (1999) this *CAAR* can be interpreted easily because we do not standardize equation 4. The *CAAR* is the part of the absolute abnormal returns lying above an average which can be observed when no announcement is published.

For the statistical tests we calculate cumulated corrected absolute abnormal returns $CCAAR_{t1,t2}$ for the price fixings following the announcement.

$$CCAAR_{t1,t2} = \sum_{t=t1}^{t2} CAAR_{i,t} \tag{5}$$

Cumulated corrected absolute abnormal returns

In order to prove our two hypotheses we calculate $CCAAR_{t1,t2}$ for the sequential time frames ($t1,t2$) = (1,2), (3,5), (6,10), (11,15) and (16,20). These $CCAAR_{t1,t2}$ were calculated for each time frame and ad hoc disclosure and are used for our statistical tests.

$$H_0 : E\left(CCAAR_{t1,t2}\right) = 0$$

vs.

$$H_1 : E\left(CCAAR_{t1,t2}\right) > 0$$

If we can reject H_0 for a time frame at a certain significance level we can show significant price reactions within this time frame.

2.2 Empirical results

In order to prove our first research hypothesis "Mobile brokerage notification services provide added value if significant intraday stock price reactions following by company announcements can be observed" we perform t-tests for each time frame.

	Mean	*t-value*
$CCAAR_{1,2}$	0.0359	5.34**
$CCAAR_{3,5}$	0.0100	1.88*
$CCAAR_{6,10}$	0.0077	0.93
$CCAAR_{11,15}$	0.0005	0.06
$CCAAR_{16,20}$	-0.0043	-0.58

** indicates significance on the 1% level; * on the 5% level

Table 1. Intraday price reaction following by company announcements

Table 1 illustrates that we can detect significant abnormal price reactions for the two sequential time frames (1,2) and (3,5). Consequently, we can corroborate hypothesis 1 as this price reaction asks for notification of the investors.

Furthermore, we can show that the price reaction is completed within the first 5 price fixings following the publication. Depending on the trading volume of each stock these five price fixings occur within different time frames (measured in minutes). Figure 1 presents the distribution regarding how many minutes correspond with the first five price fixings.

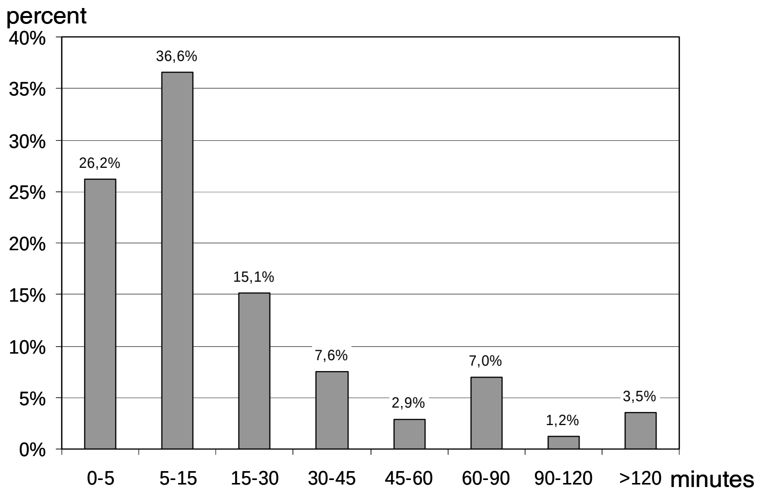

Figure 1. Time conversion of the first five price fixings (n=172)

Figure 1 illustrates that nearly 80% of the first five price fixings can be observed within the first 30 minutes following the publication (arithmetic mean of 23.2 minutes). As this period of time opens a short window of opportunity for investors we can corroborate our second hypothesis "An integration of mobile notification and transaction services, including prompt transaction authorization, is required if observed price effects persist for a short period of time only".

Consequently, an intelligent integration of the notification services with the transaction services is required or the investor will not be able to benefit from the notification service.

Furthermore, an investment decision has to be made when the investor decides that the announcement requires portfolio transactions. The analysis of intraday price reactions has shown that there is a maximum of approximately a few minutes up to half an hour time to react after which the price reaction is completed. Consequently, notification and transaction services have to be integrated services enabling investors to react promptly as the available time is required for the evaluation of the investment decision to be made by the investor.

3 POTENTIALS OF MOBILE BROKERAGE SERVICE INTEGRATION

The potentials of mobile notification services are quite obvious considering the price effects analyzed in section 2. Using mobile notification services enables private investors to be informed permanently about relevant market events without observing the market development continuously. The addressed notification services can improve the level of information of private investors significantly and can put them on level playing field with their institutional counterparts who observe all portfolio relevant market news continuously.

Solely increasing the level of information by mobile notification services will not lead to prompt investment success. Furthermore, investors must be empowered to perform necessary transactions in time or they will not be able to take advantage of the better information situation. Consequently, a stringent service integration of mobile notification and transaction services is required which can not be fulfilled by existing concepts. This constraint arises from the fact that security requirements are addressed in a wrong way. These existing implementations are designed to achieve security but not application requirements. Therefore we analyze general security and application requirements for the proposed notification and transaction services in the next section to be able to derive an alternative approach in order to bring these security requirements in line with the application requirements (stringent integration of notification and transaction services).

4 SECURITY AND APPLICATION REQUIREMENTS

It is essential for the investor that the whole process, starting with the notification and leading to a possible transaction, is as little time consuming and as much convenient as possible. This would enable the investor to spend most of the available time for the decision making. Therefore, we formulate an application requirement.

Requirement I: *The complete process of notification and transaction services has to be as little time consuming and as much convenient as possible.*

Since investors use a great variety of different mobile devices the service provider should have an interest to design the service as compatible as possible to most devices. Therefore, we formulate another application requirement.

Requirement II: *The notification and transaction services should be useable with (almost) any mobile phone on the market.*

Because of the short time span in which the investor has to react to the notification it is not possible to crosscheck the received information. Therefore, the notification service has to provide a way to ensure the integrity and authenticity of the notifications. Otherwise, a potential attacker could alter notification messages or create false notification messages that could lead to false decisions by the investor. It is also important that the notification does not get lost or delayed (availability is the corresponding property). Consequently, we formulate a third requirement which should be fulfilled by the notification service. Obviously, the notification service on its own cannot guarantee fulfillment of any of these requirements (e.g. when communications are interrupted or tampered within parts of the network outside of its control), but it is important that the user knows about the state of the message he gets.

Requirement III: *The notification service has to provide means to ensure that violations of the integrity or authenticity of the notification message can be detected by the receiver and to ensure that the message reaches the investor in time.*

The linked transaction services should also provide integrity and accountability of the process. In addition, the communication between the investor and the online broker should be confidential. Consequently, we formulate a security requirement for the transaction service.

Requirement IV: *The transaction service should provide availability, integrity, accountability and confidentiality.*

Based on these requirements we formulate a research hypothesis regarding the security of the system infrastructure.

Hypothesis III: *A solution using a smart card (e.g. SIM) with electronic signature functionality will be at least as secure as current approaches*

With regard to service integration and service convenience we formulate a fourth research hypothesis.

Hypothesis IV *A smart card based approach can provide better integration of mobile notification and transaction services than current approaches and is consequently more adequate for the introduced application domain.*

In the following section we will analyze current approaches of mobile brokerage information and transaction services with regard to our requirements. We will then propose an infrastructure with the aim of corroborating our hypotheses.

5 CURRENT APPROACHES

Current mobile brokerage services are usually implemented like traditional online brokerage services. Figure 2 illustrates such a system.

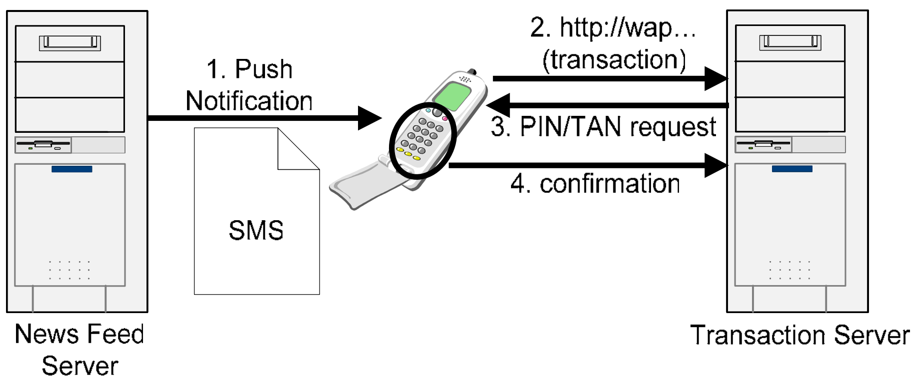

Figure 2. Notification and transaction system infrastructure (current)

After the publication of the company announcement the investor receives a SMS notification with the relevant information. The investor will then use the browser of his mobile device to connect to the transaction server and enters the login data (e.g. account number) and a personal identification number (PIN). Now the investor is able to perform transactions but has to confirm every single one with a transaction number (TAN).

This solution does not fulfill Requirement III. The SMS message containing a relevant notification does not provide any protection of integrity or authenticity. A potential attacker will be able to pose as the news feed server sending false notifications (GSMBox 2004). Since the notification is sent via SMS there is no guaranteed delivery (Schiller 2003).

It is very inconvenient for the investor to enter a transaction number while being pressed for time. Furthermore, the investor has to carry a list of TANs at all times in order to be able to react to incoming notifications. This increases the risk of potential theft or loss of the TAN list.

Therefore, we conclude that despite being time efficient as possible it does not fulfill Requirement I. The German bank Postbank AG offers a service called mobile TAN (mTAN) that offers the investor the possibility to request a TAN online that will be send to the investor via SMS (Deutsche Postbank AG 2004).

Using this solution the investor is able to react to incoming notification messages even if the TAN list is at a different location than the investor. However, this solution remains to be rather inconvenient since the investor has to order the mTAN online and after receiving the corresponding SMS has to switch from the brokerage application (most likely a WAP browser) to the SMS client. Then after memorizing the mTAN the investor has to switch back to the brokerage application, wasting valuable amounts of time. Furthermore, this service adds a new security risk. The SMS containing the mTAN could be intercepted by a potential attacker (because it is a plain text message) and could be used to damage the investor’s portfolio status or perform unwanted transactions. However, the PIN/TAN solution does fulfill Requirement II, because no additional software has to be used. Only a browser is needed and almost all current mobile phones offer at least a WAP-browser (Forrester Research 2003).

Most of the current mobile brokerage providers use Wireless Transport Layer Security (WTLS) and/or Secure Socket Layer (SSL) to encrypt the data transfer between customers and their transaction servers. These standard encryption protocols are commonly used and should provide the necessary amount of data confidentiality. The PIN/TAN authentication method ensures that someone with knowledge of the PIN and one of the TANs has ordered the transaction made. The investor is supposed to keep the PIN and all TANs confidential. Therefore, the PIN and TANs should only be known by the investor and the online broker. One could argue that this is sufficient support of accountability, but the investor has to trust the service provider. An attacker located inside the service provider with access to the TANs could initiate unwanted transactions. There is also no way of ensuring the integrity of the ordered transaction. A rogue employee of the service provider could be able to alter the order made by the investor. Other problems can arise from the stateless interaction paradigm of the web (Shegalov, Weikum, Barga and Lomet 2002). Therefore, we conclude that Requirement IV is only partially met by current mobile brokerage services.

6 PROPOSED INFRASTRUCTURE

The infrastructure we are going to propose is based on the assumption that the investor is using a SIM card that is capable of creating electronic signatures. The technology for such SIM cards exists but has not gained much market penetration so far. The WiTness project (European IST Project 2004) sponsored by the European Union has developed such a SIM card that is capable of creating RSA signatures (Rivest, Shamir and Adleman 1978) and also provides 3DES encryption. Using such a SIM card the investor can register his public key at the online broker and can obtain a copy of the public key of the notification service provider. Having defined the necessary premises we can now propose the following infrastructure that is illustrated in Figure 3.

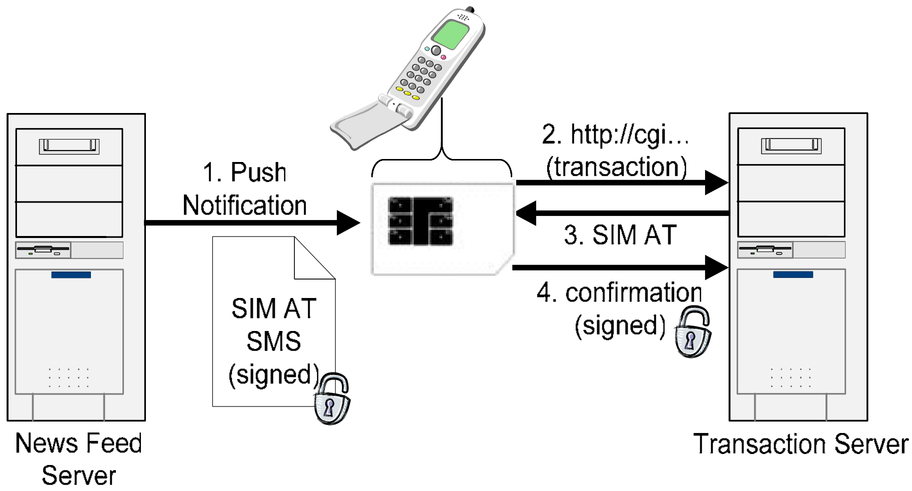

Figure 3. Notification and transaction system infrastructure (proposed)

Our goal is to achieve as many of the application and security requirements defined in section 4 as possible. Therefore, we propose an implementation using the SIM Application Toolkit (SIM AT) which also ensures compatibility to almost all mobile phones. Using SIM AT for supporting secure transaction services has been proposed in the past (Guthery and Cronin 2002) but these existing application scenarios do not provide added value which can be achieved by focusing on promising application domains (e.g. enabling investors to react to relevant events in time) and smart integration of mobile notification and transaction services.

When a company makes an announcement during stock exchange trading hours the news feed server creates a notification SMS and sends it to the SIM AT application running on the mobile device of the investor (European Telecommunications Standards Institute 1992). The SMS is electronically signed with the private key of the service provider. After receiving the signed push notification the application can check the integrity and authenticity of the notification by verifying the signature. If the signature is valid the investor starts his brokerage client. After making an investment decision the investor connects to the transaction server and enters a PIN for user authentication. If required, the investor performs a stock order which is electronically signed by the SIM AT application using the digital signature functionality of the SIM AT application (European Telecommunications Standards Institute 1999). In order to confirm this signature the investor has to enter a signature PIN. The transaction server verifies the signature and completes the transaction if the signature is valid.

As the used SMS service does not provide acknowledgements for delivered messages, availability can not be guaranteed. Therefore, additional steps are necessary to make sure the investor receives the needed information in time.

If the investor does not react at all to an incoming notification, the notification service resends the SMS 2 times after 10 and 20 minutes. Notifying 3 times provides a balance between availability and convenience. Another option is to let the investor configure the number and frequency of notification retransmissions.

This solution seems to be pretty convenient and very time efficient. After receiving the notification the investor has direct access to the transaction services after entering the authorization PIN. The transaction process is completed when the transaction is confirmed with a second signature PIN. In contrast to current solutions this second PIN does not change, eliminating the need to carry around a TAN list. Therefore, we can state that Requirement I has been met. Since most current mobile phones support SIM AT we can also conclude that Requirement II has been fulfilled. By checking the validity of the electronically signed notification message the SIM AT application is able to check the authenticity (only the service provider can make a valid signature) and the integrity of the notification message automatically. Moreover, notifications are resent if the investor shows no reaction. So we conclude that Requirement III has almost been fulfilled, as delivery can not be guaranteed.

By signing the transaction request the investor ensures the integrity of this request. It also guarantees that only the investor could have requested this transaction enabling accountability. Confidentiality can be provided by ciphering the data transfer between the brokerage client and the transaction server using WTLS, SSL or 3DES. As the server is the general server for web transactions, availability is comparable to the non-mobile case. So we can state that Requirement IV has been met.

The proposed solution has almost fulfilled the requirements that we defined in section 4. Therefore, we can corroborate our hypotheses 3 and 4, because the proposed solution provides better security and better integration of services than current solutions.

However, we must admit that the proposed solution only works with SIM-cards that have not entered the market yet. Consequently one could argue that mobile operators will not have any interest in providing more expensive SIM-cards equipped with a cryptographic coprocessor. On the other hand the mobile operator can expect an increase in traffic caused by notification and transaction services that possibly creates enough new revenue to finance the additional costs. Also the mobile operator could sell signature enabled SIM cards to early adopters at a higher price than normal SIMs and thereby pass on the additional costs to the investor. Furthermore, the mobile operator controls which applications can be run on the SIM. This enables him to charge the financial service provider for the mobile notification and transaction services providing a new source of revenue. This of course raises the question why the financial service providers should let the mobile operator participate on their revenue stream. By providing mobile information services and by also enabling the investor to make transactions based on these notifications they can expect an increase of financial transactions. Therefore, they can expect an increase of revenue that can be shared with other parties.

7 CONCLUSION AND OUTLOOK

In this paper we focused on application domains of promising mobile brokerage services. Starting from the current range of mobile brokerage services we criticized the missing added value from these services ascribed to the fact that most of these services are reproductions of web-based online banking services. In consequence, these services do not utilize from their mobile ubiquity.

Therefore, we proposed to support private investors by notifying them about relevant market events which might have impact on their portfolios. In order to demonstrate these potentials we analyzed intraday stock price reactions which were caused by company announcements. We found out that these price reactions occur promptly and are completed within a time frame of several minutes. Our findings confirm the potential of the respective mobile notification services which provide relevant information supply that can not be accomplished by traditional online services in time. As investors would want to be able to react by performing portfolio transactions in time, we recommended an integration of mobile notification and transaction services. This integration can not be found in available concepts which seem to just concentrate on security requirements and neglect application requirements.

Therefore, we formulated security and application requirements which should be fulfilled by appropriate mobile brokerage services. After comparing these requirements with typical infrastructures available today, we found out that they are met only partly. Therefore, we proposed an alternative infrastructure concept using mobile signatures supported by the GSM Subscriber Identity Module (SIM) and the SIM Application Toolkit. We can show that our concept meets most of the postulated application and security requirements and definitely more than existing infrastructure concepts.

Furthermore, we showed that the proposed application infrastructure provides benefits for private investors, service providers and mobile network operators. This proposed infrastructure could also be used for legally binding electronic signatures based on the EC-Directive on a community framework for electronic signatures (European Community 1999). As pointed out in Roßnagel (2004) it would be possible for financial service providers to act as trust providers for advanced electronic signatures issuing qualified certificates. This of course would require a certification of the SIM card as well as the SIM AT application against common criteria.

The proposed architecture shows that highly specialized and integrated mobile brokerage services can add value to all parties involved and can be a component for future services requiring binding electronic signatures.

Acknowledgements

The authors thank Deutsche Börse Group and DPA-AFX for providing the used data sources. Furthermore, we would like to thank IS.Teledata AG on whose server infrastructure the event study has been performed. This work of Jan Muntermann and Heiko Roßnagel is supported by grants from T-Mobile International. We gratefully acknowledge the support.

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