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ADEPT III

Final Report

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FOREWORD

The ADEPT III project is a consortium of public transport operators who have joined their efforts to validate and evaluate available contact/contactless interface solutions in their real production systems with real users. The objective is to give public transport and other system operators support for their strategic decisions and choice of technology, when they plan to implement contact/contactless interface cards or devices in their existing environment.

The parties of the ADEPT III project (contract partners) and the pilot sites are the following:

- Ministry of Transport and Communications, Finland;
- Oy Matkahuolto Ab with Tampere regional transport as a pilot;
- Turku City Public Transport Office with Turku urban and regional transport as a pilot site;
- Department of the Environment, Transport and the Regions form the United Kingdom.

Chief Engineer Sepppo Öörni and later Inspector Harri Uusnäkki have on behalf of the Ministry of Transport and Communications supervised the work. Oy Matkahuolto Ab's pilot site has been managed by Project Manager Kari Nuolivirta and Turku City Public Transport Office's pilot site by Administrative Director Pertti Heinonen. Besides these contractors have Buscom Oy and Intermarketing Oy participated in the project as system suppliers. BSc Caj Holm and MSc Sanna Välimäki from Traficon Ltd have co-ordinated the project and MSc Mari Päätalo compiled the final report.

This final report includes the pilot reports and pilot technical reports produced by Matkahuolto and Turku Public Transport Office and the report of the Tampere regional transport user acceptance survey. Matkahuolto has not in time supplied their agreed report about the pilot and this chapter thus contains only a brief summary of the pilot.

Helsinki 30 April 2003

Harri Uusnäkki, Inspector

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SUMMARY

European public transport payment system operators and service providers have implemented at numerous sites both contact and contactless smart card fare payment systems. Urban transport systems mainly make use of contactless cards. Contact cards are used in inter-urban systems and when security has been seen as an important issue. Some operators, for instance in the Netherlands, have also made contracts of including their public transport module on cards issued by other operators, such as banks or telecommunication companies, who at the moment prefer contact cards.

Both card types have advantages and disadvantages in public transport use. Operators search for solutions giving them the maximal combined benefits of both interfaces. Contact card system operators need for urban transport the faster transaction times of the contactless interface. Contactless card system operators want a possibility to co-operate with such operators who prefer the contact interface.

Two technical solutions offering both contact and contactless interface are available. Solutions where a contact card is inserted in a separate "sleeve" which then provides the contactless interface are already in use and new planned. Cards with one chip and both interfaces, generally called combi-cards or dual interface cards[1], have been under development for some time and major European card producers have informed of commercial launch of such by the end of 1997.

The ADEPT III project is a consortium of public transport operators who have joined their efforts to validate and evaluate available contact/contactless interface solutions in their real production systems with real users. The objective is to give public transport and other system operators support for their strategic decisions and choice of technology, when they plan to implement contact/contactless interface cards or devices in their existing environment.

Project participants, besides the Ministry of Transport and Communications, were Oy Matkahuolto Ab, Turku City Public Transport Office and the UK Department of Transport. Buscom Oy and Intemarketing Oy participated as pilot site system suppliers. Adept III had also a technical group where in addition to the suppliers also representatives of Setec Oy and Automatia Oy participated. The work has on behalf of MTC been co-ordinated by Traficon Ltd. The combi card survey at the beginning of the project was carried out by TT-Valtionpalvelut Oy as MTC's subcontractor and DETR has sub-contracted for the project's dissemination tasks the University of Newcastle upon Tyne.

1. Cards with two chips, one with contact and one with contacless interface, so called "hybrid cards", are not included in the project.

The project stared with a survey on combi cards that were commercially available in 1998. The pilot sites Oy Matkahuolto Ab for Tampere regional transport and Turku Public Transport Office chose based on the survey the most suitable cards for their purposes. The Matkahuolto pilot proceeded according to plans quite rapidly to a test implementation and full-scale card rollout. The existing Matkahuolto ticket products were as such implemented on the new combi card. User acceptance surveys were completed in two phases, first with schoolchildren and later for a sample of normal cardholders. The experiences of Tampere regional transport were so positive that Matkahuolto has decided to gradually expand the combi card solution to covet the whole country.

The objectives of the Turku Public Transport Office were initially much more ambitious. They looked for a solution that would enable charging of public transport tickets at bank ATMs. A new periodic pass type was developed for this purpose. Simultaneously Turku searched for a card reader that could read both A and B type cards. There were early problems with the delivery of the chosen card that delayed the pilot. Also the search for the A+B type reader module delayed the Turku pilot. The delivery of the reader module did not meet the timetables, the development work of the once chosen module was stopped and even the development of an own module was considered. Due to such external reasons the whole Turku pilot was delayed so much that no user acceptance surveys were possible during the project.

As a summary of the whole project it can be said that taking the combi card in use in the existing production systems has been realised smoothly without any significant technical or institutional problems. The pilot of Turku has because its more challenging objectives been delayed due to reasons depending on the card and equipment suppliers. Cardholders of Tampere regional transport have been very satisfied with the new card. The combi card can based on the project be estimated to be technically mature for implementation and supporting such multi-application systems in which the service providers have various types of contact and contactless card readers.

1 CONCLUSIONS

1.1 Turku conclusions

1.1.1 General

It is still difficult to do a comprehensive evaluation of the project as it still is running and the real implementation of the project will be done during year 2003. However, the combi cards and especially the reader devices purchased for them are mainly ready to use. When evaluating the project before its full-scale inauguration the understanding of it can be based only on experiences from its preparation laboratory tests.

IT seems very realistic that Turku will reach the goals that are defined in the beginning of this report. Although the system is still only in its first phase has the card solution based on the services and automation been created and co-operation between the various involved companies proven to be possible. The technical development has in addition clearly shown it possible for the City to develop in its service production a multi-application card for a means of payment for the different service providers.

1.1.2 Progress of the project

The defined goal schedule was far too optimistic compared with the reality. This is as such nothing new when discussing smart card based payment applications. Delays in the development of such systems are very common even worldwide. Realism, even a bit exaggerated, arose already in the beginning of the project when the availability of combi cards was studied and it was clear that cards were already available or at least close to production however, this proved not to be the case. The technical and interoperability requirements together with the multi-application requirement that were defined for the system created throughout the project more or less problems. However, one must conclude that ticket has done its task even in this case because the general interest in card systems with A+B reading possibilities have grown, even world-widely. Following the discussion in professional journals and conferences one can understand that there is interest in combi card systems and there is also willingness to implement such. Also the device and card manufacturers are ready to deliver such solutions.

The hardest task for Turku in the project proved to be the lack of industrial production of the A+B type reader module that was included in the contactless card reader. This also caused the longest delays of the project. The new card type, its contents and the external requirements it defined required completely new features of the card reader, without which a comprehensive product development was impossible. This meant in the case of Turku that new card readers were acquired from Buscom Oy to every bus. As comes to the card itself and the Avant electronic purse on it, some compromises concerning their usage time will still be necessary. Such a long age as the present contactless Turku cards have, cannot be defined for the combi cards. The contact/contactless card is also more

vulnerable compared to the sole contactless card. Turku concluded that besides the new combi card system also cheaper contactless travel cards would be introduced.

During autumn 2002 about 100 such cards were acquired for test use from the French company Schlumberger.

The common final report of the ADEPT III project will more in detail describe how the project as a whole has succeeded. This gives the other parties also to complete the Turku report with their own experiences of Turku.

1.1.3 Legal obstacles

No plans or realisation of the project were necessary to be revised due to legal obstacles. The Turku pilot site had clarify the use of the social security codes, the use of register data (personal data and card number ore not allowed to be connected), distribution of information to each household and problems concerning VAT. A positive solution was found to all these questions.

1.2 Tampere conclusions

The project was implemented as planned during 1998. Matkahuolto's Tampere Combi pilot was developed, tested and implemented with very good results. All the target goals were reached.

A 4000 Easyflex combi cards enabling both proximity and contact handling was selected and tested for travelling in a production environment in Tampere starting the end of year 1998. The test purpose was to verify the technical and functional applicability of the combi card and its maturity before implementing it in full-scale production use

The major challenge was to implement existing Matkahuolto contact card ticketing system into the selected Easyflex Combi card by maintaining the security and speed needed for a contactless ticketing. These goals where reached due to the Multitasking capability of the MTS system and due the well proven contactless ISO14443A - Mifare technology.

All goals where reached without compromising security. Transaction speed and performance was enabling faster transactions. Comparing 2 – 3 second contact ticketing transactions, contactless ticket transactions are 0,5 – 1.0 second including card-presenting time.

Reliability and security was maintained at the present system level due to fast and secure Mifare contactless card system.

The pilot as such did not provide any new ticket products. The target goal was to enable the use of all the Matkahuolto ticket products that are accepted as means for payment on the buses of the transport operators

Matkahuolto Tampere pilot was successful due to the experience of Mifare technology and as a result of good security planning. Pilot results have proven that with goal setting of the existing contact card ticketing compatibility, it was possible to reach a reasonable performance.

2 PROJECT GOALS

The main objectives of the ADEPT III project were:

- to carry out a survey among European smart card producers in order to find at least two commercially available combi cards out of which the sites can choose their cards for the project;

- to validate and evaluate the use of combi card technology and possibly other new technologies in existing public transport systems, in taxi systems, in their chained services and the co-operation with the Banks and

- to disseminate the results of the project among public transport and other card system operators in order to support them in choosing the right implementation strategy and the appropriate technology.

2.1 Project Participants and Test Sites

The participants and test sites of the ADEPT III project were the following:

- Ministry of Transport and Communications, Finland;

- Oy Matkahuolto Ab, Finland, with a main test site in the Region of Tampere;

- Turku City Public Transport Office, Finland, with a test site in and Turku urban and regional transport;

- The Department of Environment, Transport and the Regions, UK.

Local project groups are set up at both sites based on local agreements. These groups include in addition to the above mentioned contractual partners the following parties:

At test site Tampere:

- Regional transport operators of the Tampere region

- Social Office of the City of Tampere

- Tampere City Transport

- Tampere Taxi Association

- Inter Marketing Oy

At test site Turku:

- Automatia Rahakortit Oy

- Turku Taxi Association
- Matkahuolto Turku Office
- City of Turku Planning Office
- Buscom Oy
- Traficon Ltd

The Parties appoint Traficon Ltd for project management tasks and for producing the project's validation and Evaluation Plan. John Polak from Imperial College of London is sub-contracted as an advisor for the latter work. The project further appoints the Transport Operations Research Group of the University of Newcastle upon Tyne for dissemination tasks.

2.2 Main Objectives of the Finnish Site

The main objective of the Finnish site is to validate and evaluate the use of combi card technology in existing public transport payment systems, in taxi systems, in their chained services and in the co-operation with the Banks. The main tasks by which the goal is achieved are:

- to survey the marketplace in order to find at least two commercially available combi cards out of which one is selected for the project
- to validate and evaluate the use of the selected combi card in existing public transport applications with a sample of real users at both sites
- to validate and evaluate the use of combi cards for charging value on them at ATMs of the Banks with a sample of real users in Turku.

The Finnish sites will implement their systems in such way that they make the use of the regional tickets possible on all buses at both sites in the whole regional transport area. The card readers of the sites read both ISO Standard 14 443 A and B type cards.

2.3 Main Objectives and Participant Sectors of the Turku Site

The objective of the project is to study and test in a real environment and with real users new smart card technology and the next generation of smart cards, the so called combi cards. The combi card is expected to be a reliable, practical and economical multi-purpose card.

Another objective is to gather experience and knowledge of the pilot test to be able to extend the geographical area in which the card can be used. All the experience and know-how can be exploited in other European cities.

Participant Sectors:

1. Public transport within Turku and regional traffic

2. Reloading at ATMs of the Banks

3. Museum and sports department

4. Parking

5. Taxi systems

2.4 Objectives of the City of Turku

The goals of Turku in the ADEPT -project were:

- Interoperability of the card with priority to urban and regional public transport
- In addition it must be later possible to pay with the card for parking, taxi services and entrance fees to museums plus some leisure time activities
- The card system has to enable the user to recharge the card as flexibly as possible and that enough recharging points must be available taking into consideration the whole geographical area of card use.
- The smart card which will be implemented must be a reliable, practical and feasible multi-application card.
- The price of the card and the card system must be such that investments in the system and its maintenance are economically reasonable.
- It must be possible to expand the card system operation into a city card and later also elsewhere in Europe once the technical development and pilot tests have been success-fully carried out.

2.5 Tampere Objectives

The Tampere ADEPT III combi card project is an important domestic test project for collecting experiences of the practical interoperability of public transport fare payment systems and interoperability with other card applications.

Matkahuolto’s Tampere region combicard test will exploit the interoperability of the contact card equipment, which is in national use to test the existing ticket products with the faster contactless technology of the combicard.

The pilot will later be geographically expanded and new interoperable applications for which the combicard is an ideal solution will be implemented.

Pilot financing and state subsidy will be applied for within the ADEPT III project.

3 PROGRESS OF THE PROJECT

3.1 Background

The Finnish ADEPT III site includes two public transport sub-sites: Oy Matkahuolto Ab's inter-urban fare payment system and Turku City Public Transport Office's urban transport fare payment system. Both sub-sites have existing smart card based fare payment systems in use. Matkahuolto makes use of a contact card and Turku urban transport of a contactless card.

Oy Matkahuolto Ab is a ticket sales and clearing company for 400 private bus companies serving inter-urban transport all over Finland and urban transport in some cities. Matkahuolto and its shareholder companies operate about 40 000 daily bus departures on an accumulated route length of 66,000 kilometres. Matkahuolto's fare payment system has today about 300 000 cardholders and about 5 000 vehicles equipped with OBEs.

Turku City Public Transport Office has implemented their urban transport fare payment system during 1996. The system covers 210 vehicles and has today over 80 000 active cardholders. Turku City Public Transport Office purchases the urban transport services from three service providers. The total route length is 920 kilometres, annual passenger volume over 20 million passengers and annual vehicle mileage over 10 million kilometres. Private bus companies serve regional lines.

3.2 Combi Card Survey

ADEPT III started with surveying the markets in order to find at least two combi cards, which are commercially available for the project. The commercial availability estimations were based on following criteria:

- quantity of cards in regular industrial production;
- fault frequency of the produced cards and
- price.

The sites chose each their card out of the acceptable ones. Matkahuolto chose their card for the Tampere site in autumn 1998 and Turku decided about their card in May 1999. The sites then validated and evaluated the chosen cards in real public transport applications with samples of real users.

3.3 General description of the pilots

The Region of Tampere, the test site of Matkahuolto's system, is located in central Finland about 170 kilometres north from Helsinki. The city of Tampere has 185 000 inhabitants and the region altogether 250 000 inhabitants. Matkahuolto is the system operator and clearinghouse of Tampere regional transport. Urban

transport in Tampere is served by Tampere City Transport, having a fleet of 165 buses and a contactless card fare payment system with 110 000 cardholders. TCT, regional transport operators and Matkahuolto have signed a regional transport contract.

The City of Turku is located about 160 kilometres west from Helsinki. The city has a population of 170000 inhabitants. The total population of the region, containing the city and three adjacent cities Kaarina, Raisio and Naantali and the municipality of Lieto, is 250 000.

Both system operators, Oy Matkahuolto Ab and Turku City Public Transport Office, planned to develop their systems to make use of combi cards when such were commercially available.

Matkahuolto wants a combi card:

- for regional contract transport use;
- for faster transactions in urban transport sites.

Turku wants a combi card:

- for regional transport use;
- to give a possibility to charge new value on the card at bank ATMs;
- to enable sales of special ticket products at sales points equipped only with contact interfaces and
- to realise a multi-application system where services are making use of both contact and contactless interface.

System implementation, validation and evaluation were planned to be carried out at both sub-sites after a necessary adaptation and testing phase according to the ADEPT III Validation and Evaluation Plan. Turku could not due to delays complete its surveys in time for this report.

3.4 Turku

3.4.1 Background

Turku has about 170000 inhabitants. The Board of Public Transport and the Public transport Office are responsible of planning and operating the local public transport in Turku. All transport in Turku City Area is subsidised by the City of Turku. The subsidy the city paid in year 1998 was 38% of the office's turnover. The city buys the traffic operations from the operators and keeps the ticket income. Tendering was started in phases from year 1998 and all transport was

subject to tendering by the end of year 2000. The share of purchased services was in year 1998 127,7 million FIM.

A smart card based public transport ticketing system was implemented during years 1996-97. Validators and readers have been installed in 210 urban transport vehicles. Both the City of Turku and private operators operate urban transport. Until year 2000 a joint venture company of Turku bus operators took care of the interests of the private operators. The smart card is accepted in every operator's vehicles.

The smart card in use is a proximity card. Cards are distributed and charged at the service point of the city and at a sales point at the Wiklund department store and at four sales points of Veikkausrasti (lottery company). Recharging is also possible on board every urban transport vehicle. The ticket products are different value and season tickets and different special tickets. The regional ticket was introduced at the end of year 1999. Turku Public Transport Office (JLT) is the clearinghouse, and the operators send their transactions data to JLT from their depots.

3.4.2 Project implementation

The objectives of the project could according to the Public Transport Office (JLT) be best implemented the by making use of the existing network of ATMs.

The expansion of the ATM network guarantees that a cardholder finds easily a charging place. Simultaneously there is a possibility to link smartcard loading and other possible bank activities.

This means that the implemented system has to support recharging of the card at bank ATMs and later maybe at home PCs. In the first phase of the pilot test charging at ATMs is realised in such a way that the client, by making use of a bank chipcard as evidence, can charge from his bank account value to his combi-card inserted in the ATM.

In the first phase of the pilot the card is used only for paying for urban transport journeys and later also regional trips. Other possible expansion of card use will be implemented if the earlier mentioned phases are successful.

3.4.3 The City of Turku joins to ADEPT III

Following the chosen strategy Turku had been searching the optional solutions and co-operation partners to develop a system, that enables the realisation of an automatic multi-application city card.

One studied alternative was a so-called hybrid-card. This solution was rejected quite quickly, because it was understood that it was not the card for the future as more advanced cards were available at the smart card markets. Later, the combi-card or Dual Interface card proved to be the most rational solutions for the City of Turku.

The Ministry of Transport and Communications (MINTC) studied the possibility to continue the ADEPT II project as a European Union funded project, but wen the application was rejected the nationally funded option was brought to he discussion.

The final solution for Turku pilot project was found from the ADEPT III project co-ordinated by Ministry of Transport and Communications. Oy Matkahuolto Ab with a pilot site in Tampere regional transport and Turku Public Transport Office with a pilot site comprising urban and regional transport of Turku plus the UK Department of Environment, Transport and the Regions (DETR) with the evaluation and dissemination task joined the MINTC driven project.

3.4.4 Project preparation

Preparations for participating in the ADEPT III-project were started on 6th of November 1997 in a meeting convened by the Ministry of Transport and Communications. The meeting decided that besides the Ministry of Transport and Communications also the pilot sites appoint their representatives to the management board of ADEPT III. A representative of the UK Department of the Environment, Transport and the Regions has the right to participate in the management board meetings. Traficon Oy is working as a consultant of the project.

The first study essential for the project was ordered from TT-Valtionpalvelut OY and it dealt with the availability of combi-card technology. The study was completed during the first quarter of 1998.

Pertti Heinonen participated in the Kontiki conference on 24 – 26 June 1998 where he gave a paper on the subject ”The contactless card based fare payment system Turku and its future in the ADEPT III project.

The Public Transport Board of Turku decided on the 22nd of October 1998 to accept the ADEPT III project start in Turku and also to apply state subsidy for it. The state subsidy was granted on the 24th of February 1999.

In November 1998 the ADEPT III management board was unanimous that the pilot systems of the project shall be interoperable. The interoperability requirement was recorded also to the working program.

Later the technical group together with the representative of the consultant and the device manufacturers defined the principle of interoperability as follows:

“Interoperability in ADEPT III is implemented in the expansion phase, when the regional ticket of Tampere shall be accepted as a means for payment in Buscom Oy’s devices in the region of Tampere and the Turku Avant card based combi card shall be accepted as means for payment in Inter Marketing’s devices in the region of Turku.”

3.4.5 Choice of the card deliverer

Turku Public Transport Board delegated the Public Transport Office to make a pre-contract of making use of the Avant electronic purse and combi-card in public transport in Turku.

The security features of the system were discussed both in the project management board and in the technical group.

In January 1999 the management board came to the understanding that a common security module could not at least in this phase be used in Turku and Tampere. However, the goal was that an interoperable security module would in future be used at both pilot sites.

Turku Public Transport Office started a bidding process for acquiring the combi cards in January 1999.

There were two essential requirements for the card:

- The smart card that will be implemented has to be a reliable, practical and feasible multi-application card.
- The card and the card system prices must be such that investments in the system and its maintenance are feasible.

Additionally, some economical and technical requirements were defined; one of the most important of which was that the Avant electronic purse functionality is an essential part of the combi card system.

There were technology, application and security requirements from Automatia Oy, Buscom OY and Ministry of Transport and Communication Finland that had to be taken into consideration besides those of the ADEPT III participants.

5 000 cards had to be delivered for the pilot. Invitations to tender were sent to the following card producers

- ST Microelectronics
- Siemens
- ASK
- Schlumberger
- GemPlus and
- Setec Oy

Tenders meeting the invitation were received from Setec Oy, Siemens, ASK and ST Microelectronics. Gemplus did not send any tender but announced that they

would be interested in further discussion.

The tenders were processed in co-operation between the Ministry of Transport and Communications, Automatia, Buscom and the City of Turku. Based on a unanimous process the decision was delegated to the Turku Public Transport Board.

The Public Transport Board decided on the 3rd of June 1999 to make up a delivery contract of the Dual Interface cards with Setec Oy. The contract was signed in Vantaa in December the same year.

The offered card was a Set Card Dual Interface smart card with a Siemens SLE66CL160S chip. The essential features of the card are 32Kbyte ROM, 1280 bytes RAM and 16Kbyte EEPROM (application memory).

3.4.6 Creation of the system

The ADEPT III co-operation contract was signed in year 1999 between the four participants:

- Ministry of Transport and Communications,
- Oy Matkahuolto Ab,
- Turku Public Transport Office and
- The Department of the Environment, Transport and Regions.

Contract was undersigned in last year half 1999. Turku Public Transport Board undersigned the contract on the 2nd of August 1999.

On 16th August 1999 the Public Transport Board decided that Dual Interface card system contract will be signed with Buscom Oy.

The implementation of the contract required device deliveries. Buscom Oy and urban transport operators in Turku will make a delivery contract of the reader modules and the Public Transport Office will pay the investments back to the operators according to the real need and taking into consideration considering the refunding for the earlier reader modules.

The Public Transport Board decided at its meeting on the 9th of March 2000 to sign a co-operation contract with Leonia Bank.

The target of the co-operation was a card product that Automatia Rahakortit Oy and Leonia Bank had developed together. Charging of this so-called co-branded card requires always a chip card bonded to Leonia's or another Automatia owner bank's account. Leonia and the city of Turku own their applications at the chip.

With this co-operation contract Leonia gives to the City of Turku the right to distribute the cards to the citizens of Turku and Turku region, according to the current conditions that Turku has defined for the contactless card. The City of Turku is responsible of card distribution costs and also of the security of their application management.

In connection to this project Turku will still make an e-purse service contract with Leonia. This contract will be comparable to the contract that the Public Transport Office has with Automatia Oy.

3.4.7 Pricing

When implementing the Avant card, Automatia as the Leonia service provider is responsible for the e-purse application and the money on the card, the e-purse charging network and the clearing of the card money.

Turku Public Transport Office confirmed the charge of the combi card pilot test on the 27th of April 200l. As a public transport application the combi card is a combination of a value ticket and season ticket. In the value card section the prices are same as in the current student, teenager, children's and adult ticket. Correspondingly the same user group's current season ticket prices are the maximum prices. 40 FIM was confirmed as a card deposit.

The ADEPT III management board established in the 15th of August2000, that the question of an interoperable security module remain open because Setec Oy has informed that they are not interested to move the multi-usable security module of the Ministry of Transport and communications to the new component.

Additionally the management board meeting established that the contract between Automatia Oy and Turku Public Transport Office concerning the ATMs and use of its co-branded system would be included in the contract with Leonia Bank Oy.

3.4.8 Security and interoperability

In November 14th 2000 the ADEPT III management board discussed the principles of interoperability and how these will be recorded in the co-operation contract. Interoperability has been one of the main objects of the ADEPT III-project. Independence of devices has been one of the key words, the possibility to cross-use the cards of both pilot cities was not required in the final co-operation contract.

According to the co-operation contract interoperability means, that every device in the Turku regardless of the supplier accepts the Turku Dual Interface card. Interoperability between the pilot sites was no required. Turku regional card does not have to accept in the region of Tampere or the Tampere card in the region of Turku.

The technical group appointed by the ADEPT III management board has completed a study on smart card system security solutions. The report is dated No-

vember 15th 2000 and Sanna Välimäki and Caj Holm from Traficon Ltd prepared it.

In February 2001 it was still problematic to acquire A+B reader modules. The interoperability requirements are now met on the minimum level that the ADEPT III project required, but through the A+B reading possibilities it will be implemented even wider than the contract required.

The problems in the reader module delivery were mainly caused by GemPlus stopping the development program of the A+B-reader. In December 2000 they delivered a sample, with has mainly enabled evaluation of the module's technique. Buscom continues looking for a reader module and has discussed subject with Idesco Ltd. Buscom has also done measurements with such as the Mifare-technology. The card reading transaction was still too slow. In table tests 0,3 seconds was achieved, but when measured with the reader module it was almost two seconds. However, the main goal has to be that the new card is not slower than the present one.

It is not feasible to implement the Turku pilot by force but better to wait a reasonable reader module. However, the project had to be started as soon as possible because the Public Transport Office had other plans that may have suffered because of a delay with the pilot.

As no other security module was available than Avant's own one, the additional secure solutions were done with programming. Larger actors may later get together and negotiate about the security module.

In October 24th 2001 the ADEPTIII management board of noted, that the City of Turku and Buscom Oy had been looking for an A+B-reader module for the Turku pilot for a half year. Interest to manufacture such modules has increased and several options of manufacturers could be expected within a half a year.

In spite of the problems with components, the planning of the information contents of the card and the software design has advanced. The multi-application environment and the design of security measures are still going on.

It was also concluded, that in the tests done by Buscom Oy have shown that the internal transaction speed of the card limits its external transaction speed.

3.4.9 Finalising the project

In its meeting held in spring 2002 the management board of ADEPTIII stated, that

- The Turku Card meets the ISO 14443-4 standard
- The standard is ready and this has enabled progress in Turku
- The goal of Turku is a multi-application card

Buscom Ltd has said that the testing of the card and the card readers will be successfully finished in such way that the readers can be delivered to Turku still during autumn 2002.

The Ministry on Transport and Communications prolonged on the 7th of March 2002 the earlier state subsidy until 31st December in 2002. The state subsidy was prolonged because the project had been delayed due to the availability problems of the reader modules.

The Ministry on Transport and Communications presumes that the City of Turku will deliver a final report of the project to the Ministry by the end of year 2002. The main phases and achievements of the project have to be recorded in the report. The final report of the project will be available at the Ministry's Internet pages during spring 2003.

The test sites will produce a common final report. This includes compiling the material the test sites have produced into a single logical report according to the visual instructions of the Ministry and proof reading of the report. The test sites shall deliver their texts and illustrations in the Finnish and English languages. The report shall be completed by the end of March. The report will also be available on the Ministry’s Internet pages. The report of Turku is complete by the 20th of December 2002 and Matkahuolto will deliver its own report by the 20th of January 2003.

In the ADEPT III management board meeting on the19th September 2002 in Oslo the board established that according to measurements by Buscom Oy the new reader devices have now the features that the Turku system requires. Prototypes are ready and the production will start so that the reader devices can be delivered to Turku in week 46.

3.4.10 Next steps

Due to the technical problems with the Setec cards the first phase testing will be carried out with cards delivered by Schlumberger. About 100 cards will be acquired for the test and will be tested mainly with the staff of JLT. A study of the experiences of the staff will be done for the report.

The upgrading of the Turku card system will be done step by step. The old card system will be used parallel with the new one for about two years. The future goal is also to purchase cards together with other public transport organisers and operators in Finland. The interoperability of the systems and as wide use as possible of the card are essential for the common card purchases.

The possible user surveys of Turku will be delayed until the new ticketing system is fully in use. The user surveys will deal with the passengers' experiences and opinions about the new tariff system, ATM charging and city card applications.

3.5 Matkahuolto Test Site Description at Tampere

The Tampere region has about 280000 inhabitants. Tampere City Transport (TCT) is responsible for planning and developing Tampere urban transport and is also the provider of urban transport services. The city subsidised public transport in year 1998 with 46 million FIM that is about 30% of the annual turnover of TCT. The subsidy is used for bought services and tariff discounts. Only a small share of the urban transport is bought.

Tampere implemented a smart card based fare payment system step by step during years 1995-97. Ticketing equipment and card readers are installed in about 430 urban transport buses. TCT and six private bus companies operate the urban transport. In year 1996 started a common tariff transport according to which the private operators make use of the same flat fare as TCT. The smart card is accepted on board all buses of all companies operating urban transport.

The smart card is a contactless one. Cards are distributed and configured at TCT's service point. Recharging can be done at 52 sales points around the city but not on board the buses. The ticket products include various value and periodic cards plus the regional ticket and Matkahuolto's products. TCT is the clearinghouse and the operators send the transactions to TCT from their own depots.

Combicard use started in the Region of Tampere the 4th of March 1999. The card is before the production use piloted with a small sample of users. Combi clients will in the first phase be a few hundred. The pilot will based on experienced be gradually expanded to a feasible number of users after which the pilot will directly continue as a production system. It is important for a successful implementation that the private bus companies operating in Tampere are involved from the first phase of the pilot. Inter marketing is ready to carry out the necessary card validator software upgrades.

4 SUMMARY OF THE MATKAHUOLTO COMBI CARD PILOT SURVEY

4.1 Introduction

Oy Matkahuolto Ab participates in the ADEPT III project that is supported financially by the Ministry of Transport and Communications and studies the use of combi card technology in existing public transport fare payment systems. Matkahuolto has already for several years had a smart card based ticketing system, which is constantly improved to better meet the user requirements. A combi card, combining the features of both contact and contactless smart card, has been tested for almost a year in Tampere regional transport. Public transport fares are paid making use of the contactless interface of the card and additional value is stored through the contact interface. Only a pilot group of about 300 users have so far had the combi card in use. All earlier Matkahuolto Travel Cards have been contact cards.

At the time of the survey, the combi-card could only be used on board the buses of such bus companies that had on-board equipment supplied by Inter Marketing Oy. There were also on-board equipment supplied by the other producer, in which the combi-card did not work during the survey period. This may have been the reason to some negative comments, as the combi-card could not be used as a means of payment on board all regional transport buses. From the 1st of July 2000 all regional transport buses have accepted the combi-card and a full-scale rollout of the card to all users could be started.

One of the objectives of ADEPT III is to study how travellers and drivers accept the combi card as a means of fare payment. The surveys are carried out according to a common evaluation plan. Survey results are presented at domestic and international conferences.

The objective of this survey has been to find out with a few questions the pilot group's attitudes towards the new combi card. The pilot group consisted of upper grade schoolchildren who had been using the combi card. The questionnaires were sent on 23 May 2000 to the schools where teachers distributed them and collected the answers. Answers were returned to Matkahuolto's Tampere office by 16 June. The results can not be regarded as statistically reliable but rather as indicative because the survey was done on a test group of ”forced users”. The results also give guidance for planning a later survey with ”real” users.

4.2 Survey Population

Answers were received from altogether 88 persons of which 47% were female and 53% male. Age groups under 15 and between 15 to 25 were almost equally represented (45% and 51%) as the population consisted of schoolchildren of the ages between 13 to 16. However, two said that they were over 65 and pensioners. All of the participants have earlier used Matkahuolto's contact card. The results are in spite of the narrow population group of importance to Matkahuolto, because main part of Matkahuolto's card users are schoolchildren.

4.3 Questions about the public transport use

Main part of the answers came from regular public transport users. 67% were daily users of regional transport services and 25% weekly users. They made use of Tampere urban transport services weekly or less. Public transport elsewhere in the country was used more seldom. 3% used monthly public transport elsewhere in the country, others less than that or never. The frequencies of regional and urban transport use are given in figures 1 and 2.

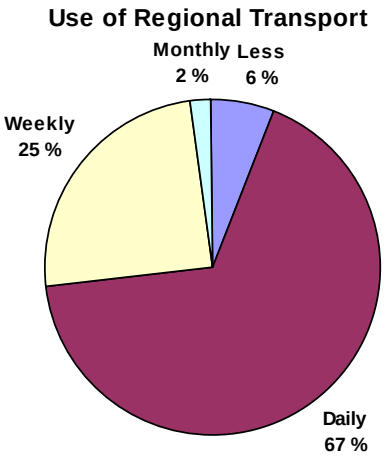

Figure 1. Frequency of regional transport use.

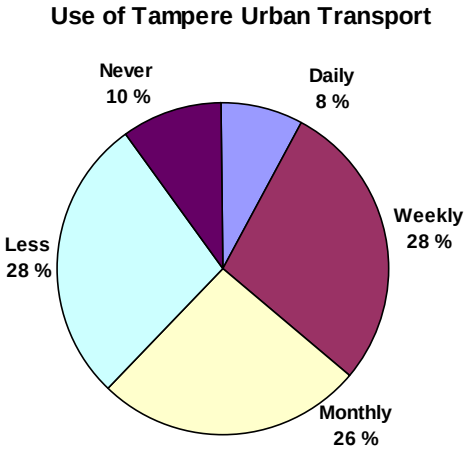

Figure 2. Frequency of Tampere Urban Transport Use

28% daily regional transport users use Tampere urban transport services weekly and 68% less. Only 4% of daily regional transport users use also urban transport daily.

Those who use regional transport slightly less, i.e. weekly, travel slightly more often on the urban transport, 16% daily and 29% weekly.

When asked how ones use of public transport services has changed due to the new combi card, over half answered that there was no change. 39% estimated that their own regional transport use had increased. Similarly also 32% had increased their use of urban transport. Only 4% answered that their use of regional transport had decreased. Changes in regional and urban transport are explained in figures 3 and 4. Especially those under 15 years had increased their use of regional transport. (n = 40). 68% of them said that their regional transport use had increased while of those under 15 (n = 45) only 12% estimated that their own regional transport use had increased.

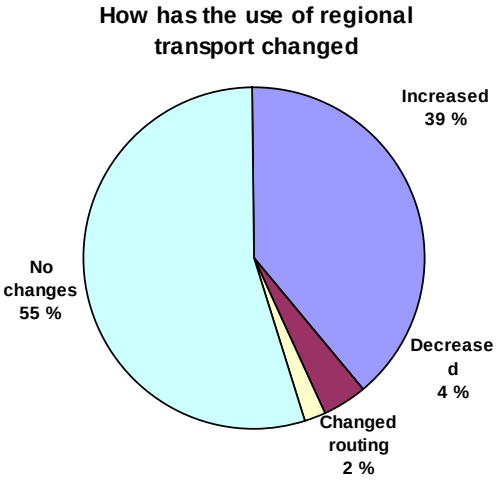

Figure 3. Changes in regional transport use

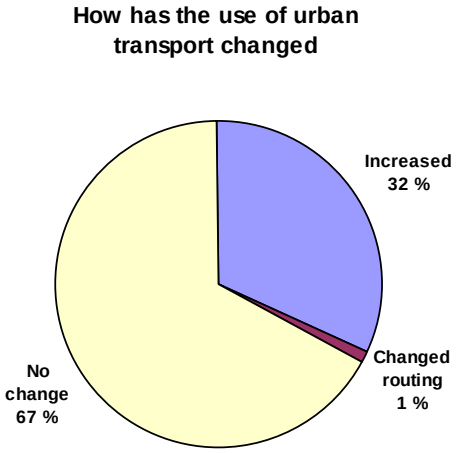

Figure 4 .Changes in urban transport use

4.4 Opinions about the New Combi Card

When asked about opinions on the new combi card compared to the earlier contact card, 71% answered that the new card is better than the old one. In addition 13% thought that the new card is as good as the old one. Only 2% thought that the new card was worse. The negative opinions may arise out of trying to use the combi-card on board such buses where it during the pilot phase did not work. Distribution of opinions among the whole sample is given in figure 5. Especially regular regional transport users thought that the new card was better then the old one. Distribution of opinions among regular regional commuters is

given in figure 6. Those under 15 (n = 40) were still slightly uncertain in their opinions (20%).

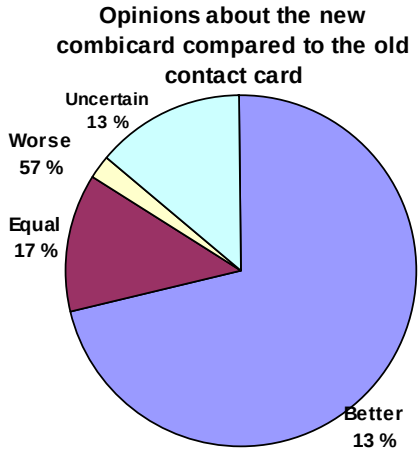

Figure 5. Opinions about the new combi card

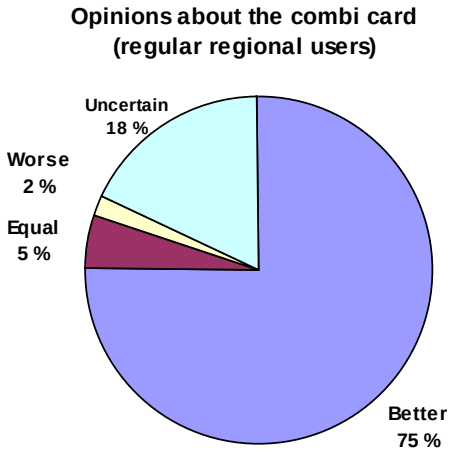

Figure 6. Opinions about the new combi card (regular regional commuters)

The next question was about what advantages/disadvantages one sees the new combi card to have compared to the old one. One was to answer either yes or no to the questions. Results are given in figure 7. A clear majority thought that payment was easier (88%) and faster (89%). There was more uncertainty about the safety and reliability of the transaction. Over half were uncertain about the safety and reliability.

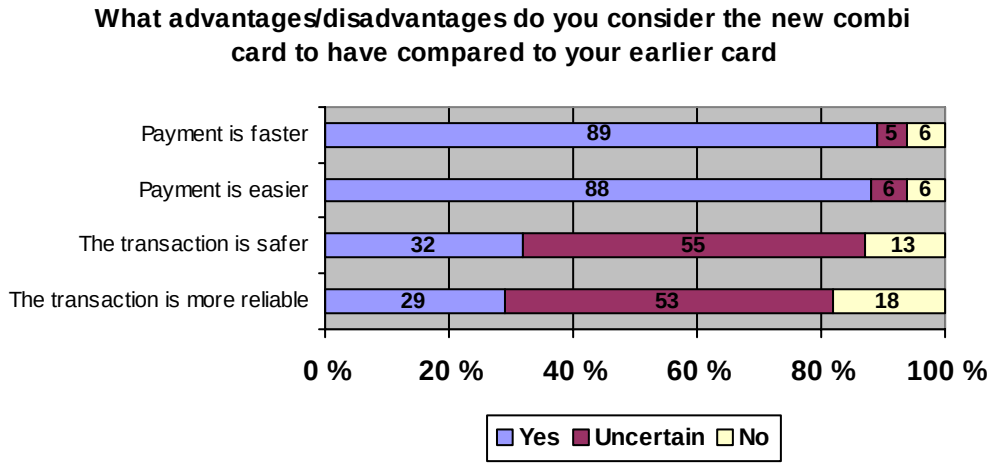

Figure 7. Your opinion about the ease and speed of payment and the safety and reliability of the transaction

Daily commuters (n = 56) were especially positive about the ease and speed. 93% of the daily commuter thought that payment is faster and 90% that it is also easier.

When asked what could be the reasons for which you could recommend your friends to change their earlier card to the new combi card did the alternative "payment with the combi card is faster" get the most positive answers. Also the other alternatives "it suites better regional transport", "I have good experiences myself" and "the combi card is anew technology" were considered as good reasons for a recommendation. The results are given in figure 8.

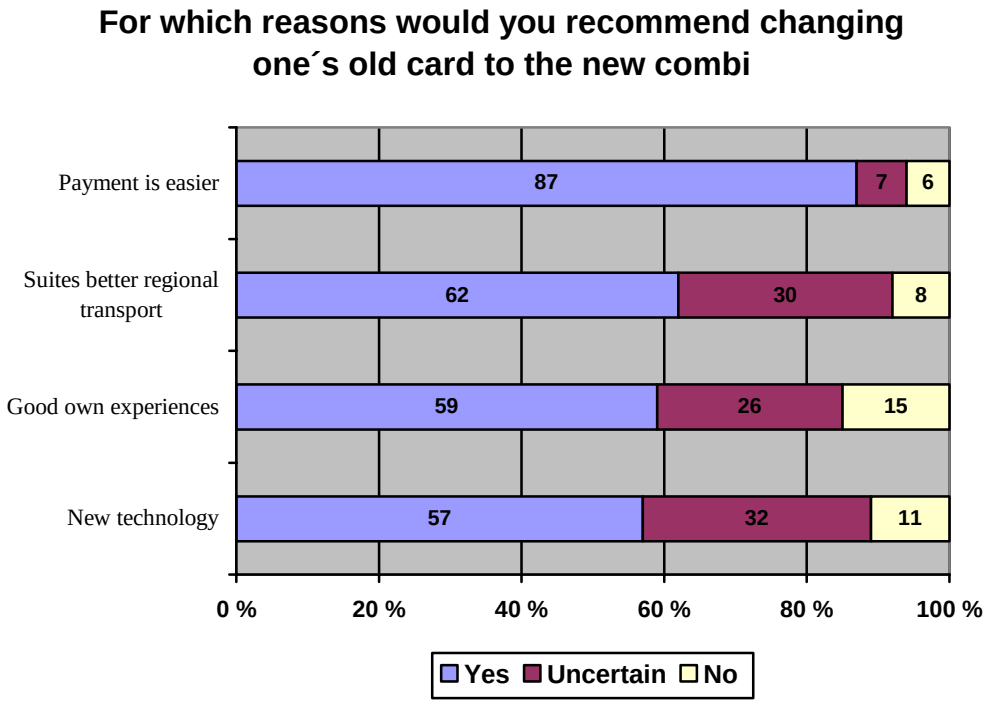

Figure 8. Reasons for recommending the new combi card to you friends

4.5 Sources of information

Figure 9 shows from which source and how well information about the new combi card had been received. The alternatives and scale were given. Information had in general been received poorly. Best sources had been acquaintances, and information leaflets distributed to homes. In addition to the given alternatives ha4 12% received information from school and 1% from the Internet. Taking into consideration that the group is a test group; they had received information very poorly. There had, on the other hand, been no general and widespread information about the new card yet, as the population anyway was a limited test group. The combi-card launch involved the local press, local radio and television. An information leaflet, but no actual training, was given to the pilot group together with the card.

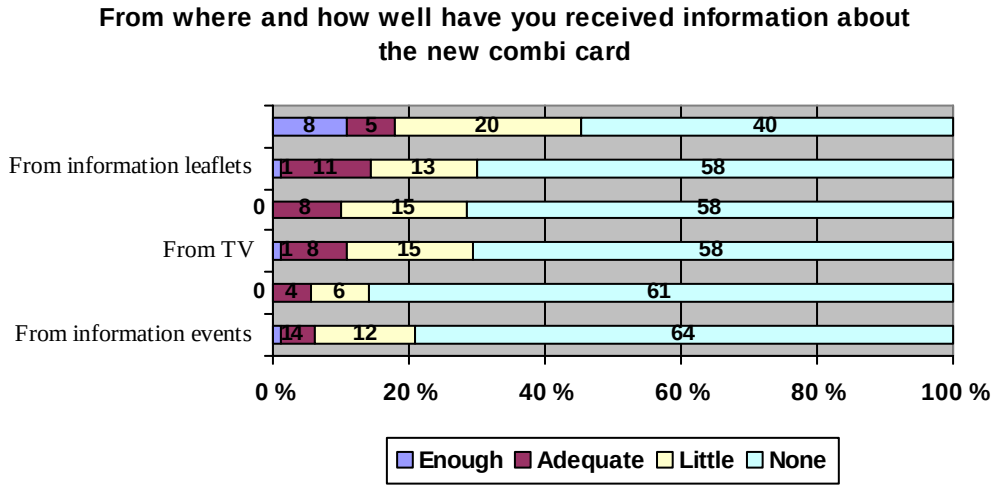

Figure 9. From which sources have the participants received information about the new combi card.

4.6 Impacts of the Combi Card

Figure 10 explains the distribution of answers, when the users were asked what the combi cards impacts were on public transport level of service and public image of Matkahuolto, image of public transport and the service provider's public image. The combi card was mostly believed to improve the level of public transport service and Matkahuolto's public image. Daily commuter had more positive opinions that the average population in all cases. 59% of them thought that the combi card improved the level of service and only 4% that it made it worse. The new card improves more Matkahuolto's than the service provider's public image according to the answers. The questions seemed to have been slightly difficult for this group and the share of "uncertain" answers was quite high (24-42%).

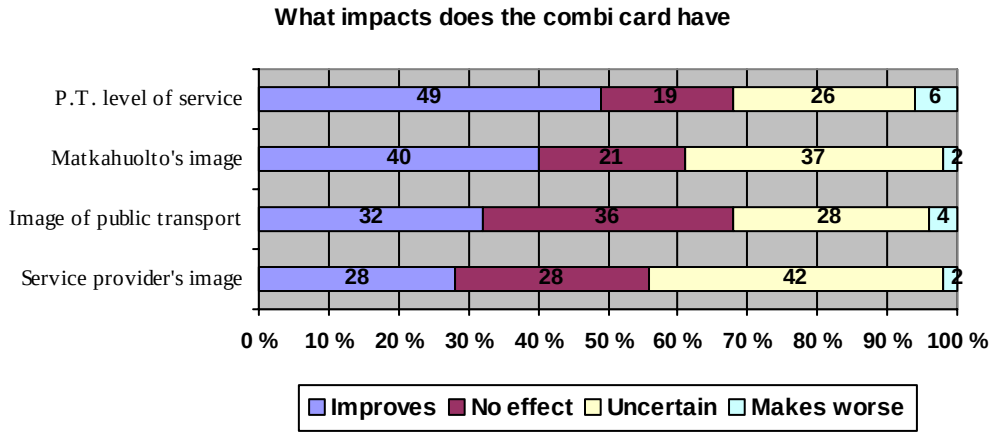

Figure 10. What impact does the combi card have on public transport level of service, public image of Matkahuolto, your imager about public transport and the public image of the service provider?

4.7 Most Popular Places for Charging Additional Value

The last question was where the participants would rather charge additional value on their cards. More than one alternative was possible. The most popular charging place would be on board the bus, 54%. The Internet was given as the alternative own choice. Four persons recommended this. The answers are given in figure 11.

Especially those under 15 would like to continue as now and charge their card on board the buses. Over 58% of them were in favour of the bus while only 26% of those between 15 – 25. The latter group seems more eager to try alternative charging methods, such as ATMs (30%) and Matkahuolto's charging machines (32%).

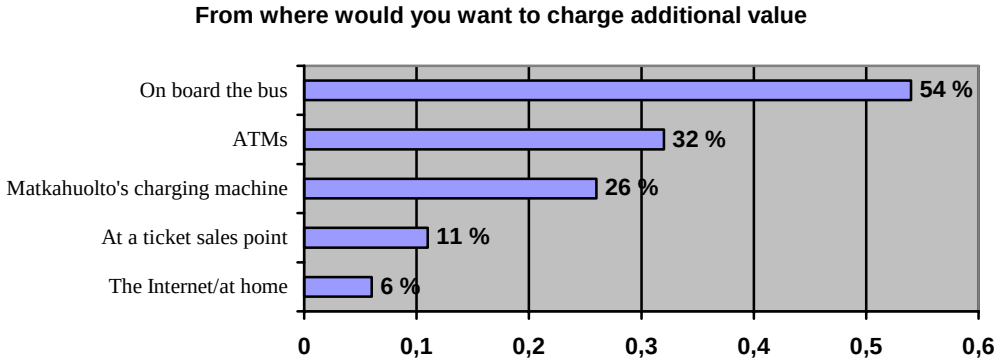

Figure 11. . Preferred places of charging additional value on the cards

4.8 Proposed Improvements to the later Survey

Below are comments and recommendations for additional questions for the coming real combi card user survey:

- Do you have a Matkahuolto combi card (unless the population consists only of Matkahuolto combi cardholders)?
- What other means of PT fare payment do you have besides the Matkahuolto combi card?
- How often do you use the combi card for fare payment (regional transport, urban transport, elsewhere)?
- What means of payment did you use before the Matkahuolto combi card (alternatives) and for how long have you used it/them?
- For how long have you had the Matkahuolto combi card?
- The Internet should be added as one alternative source for information and also as an alternative charging method.
- What are the reasons for changes in PT use (alternatives)?

- The level of PT service should be split into factors in which the transaction has effect (transaction speed, waiting time, reliability of time tables, driver behaviou

5 TECHNICAL REPORT

5.1 City of Turku

5.1.1 Background

Since the early 90's contactless memory cards have been used widely in public transport in Finland. During recent years demand to combine also other applications like general electronic purse, city card, etc. on the same card platform has arisen. Different cards and technologies like hybrid-, combi-, and dual interface cards have been developed, but not really implemented to fulfil the requirements of multi-application capability and compatibility with existing platforms. At the same time ISO 14443-standard has been under development.

The local "Turku Test Site-project" has been initiated under ADEPT III-project to test the latest technology available, to select the technology that provides a stable platform for coming years and to create a real multi-application platform.

One of the biggest challenges in the project was to implement the low frequency memory card technology used in Turku since the mid 90' and the ISO 14443 technology in the same platform without interfering with the existing system, and to get the usability and functionality of the new technology on the same level.

5.1.2 Pre-selection

Based on the Combi Card Study funded by the Ministry of Transport and Communications Finland, the Turku-project made the pre-selection of suppliers of Dual Interface technology and cards. After the pre-selection a request for proposal was sent to different suppliers with basic requirements.

Basic requirements for the card were:

- It should be fully ISO 14443-4 A/B standard compatible
- It should support standard security algorithms like DES
- It should have multi-application capability
- It should be a Dual Interface card (contact/contactless)
- It should support Finnish electronic purse (AVANT)

Offers were received from three companies. After an analysis the project recommended the Board of Public Transport of Turku that pilot test cards should be ordered from Setec Oy. The contract with Setec Oy was signed at the end of 1999.

The project also decided to test memory cards and Dual Interface cards from different sources at the same time to get references, and to test the functionality and

compatibility of validator hardware with different suppliers' technologies and cards.

5.1.3 ISO 14443-4 standard

During the project evaluation phase in 1999, the ISO 14443-standard was in "Final committee Draft" phase and it was assumed to be finalised quite soon. Due to different reasons the last part of the standard was published as late as in July 2001.

Due to the stage of ISO 14443-4 in the beginning of the project, there were no components based on this standard (cards, RF-card interface modules) available on the market. Several Dual Interface cards and RF-modules were tested in the development project. The tests are taking a much longer time than expected due to the unavailability of fully ISO 14443-4 compatible components and the incompatibility of cards and RF-modules from different suppliers.

There are still only few component suppliers, especially for RF-modules, but the situation is changing quite fast. Anyhow, there is still a lack of compatibility between components of different suppliers. The testing standard (ISO 10373-6), test environments and testing processes are also brand new. Therefore the usability and functionality of components from different sources must be tested carefully in connection with each implementation.

5.1.4 Hardware device

The objective of the project was to create a fare collection system where all smart cards following the ISO14443 standard are permitted as means of payment regardless of card platform and operating system. Requirement for the reader device was that the reader must read the card from the distance of 10 cm as described in the standard. The project was intended as a so-called pilot project, i.e. to gather information and experiences of the use of ISO14443 cards.

A decision was made to use the existing devices of Buscom in the project, and to update them in such a way that standard cards could be processed with them. In practise this would imply that ISO14443 card reading electronics would be added to the customer operated reader, PR200, of Buscom. Buscom decided no to manufacture the reading electronics, but to use reader modules already available on the market. The following selecting criteria was used:

- reads both ISO14443 type A and type B
- Mifare memory card processing not considered as mandatory, but regarded as an asset
- promised reading distance the standard 10cm
- reader module can be connected to the PR200 reader of Buscom.

5.1.5 Testing the reader modules

Investigations on the reader modules on the market started as the first test cards were received from Setec. At first only reader IC-circuits and table-model readers were available. Mifare memory card readers were available and they could be used for processing the type A card, but not the type B card. Additionally, the size of the memory block processed at a time in the Mifare system is 16 bytes and in the card selected in the project 127 bytes. The application on the card was designed in such a way that longer data (64 bytes) would be read from it and written on it. Processing the data in sections of 16 bytes would decelerate the card processing considerably.

Several reader modules manufactured by European and Asian manufacturers were evaluated during the project. All readers with serial connections functioned, but the connection to the parallel bus was often problematic. Following differences were observed in the reader module testing:

- length of the sent data block varied from 16 bytes into 128 bytes
- the power of the transmitter varied and therefore affected the reading distance
- serial- and parallel connected modules

Connection method of the separate antenna varied; adapted 50 Ω or unadapted cable or ”direct connection of the antenna” to the reader

After several tests the reader module of Omnikey, an Austrian company, was selected. According to the data sheet, the characteristics of the reader module were:

- reads ISO14443 of types A and B as well as the Mifare memory card
- reading distance 9 cm depending on the antenna and the card
- TTL-level asynchronous serial connection, speed 9600 bps … 57600 bps
- operating voltage 5 Volts.
- temperature area –20°C … +80°C

Additionally, the module offered by Omnikey could also be used in the fare collection device of Buscom.

Some things that were not mentioned in the data sheet appeared in the testing of the Omnikey-module:

- The reader waits the response from the card for approximately 10 ms. The card can process commands for up to 80 ms.
- The reader reads the Setec-card poorly.

- The reader adds delay in the system approximately 4 ms / message.
- Length of the transmission- and receiving register is 32 bytes (with the Setec card 127).
- Operating distance with ISO14443 cards is max. 7cm, 5cm in practical applications.
- Some of the problems were solved in co-operation with the manufacturer of the reader module and card.

5.1.6 Updating the current hardware

The next phase was to connect the reader module to the PR200 reader. Since the operating distance of the reader was weak and the knowledge of the fact that the metal sheets behind the antenna weaken the operating distance due to eddy currents, the antenna had to be brought as far outside the reader as possible. Therefore it was located in the keyboard element. The distance between the reader and the antenna should be as short as possible, which was the reason for locating the reader module physically close to the antenna, in the antenna card of the previous card reading electronicsA serial data communication card had to be added in the exixting electronics because of the selected reader module only included serial connection possibility. The card was attached to the CPU-card.

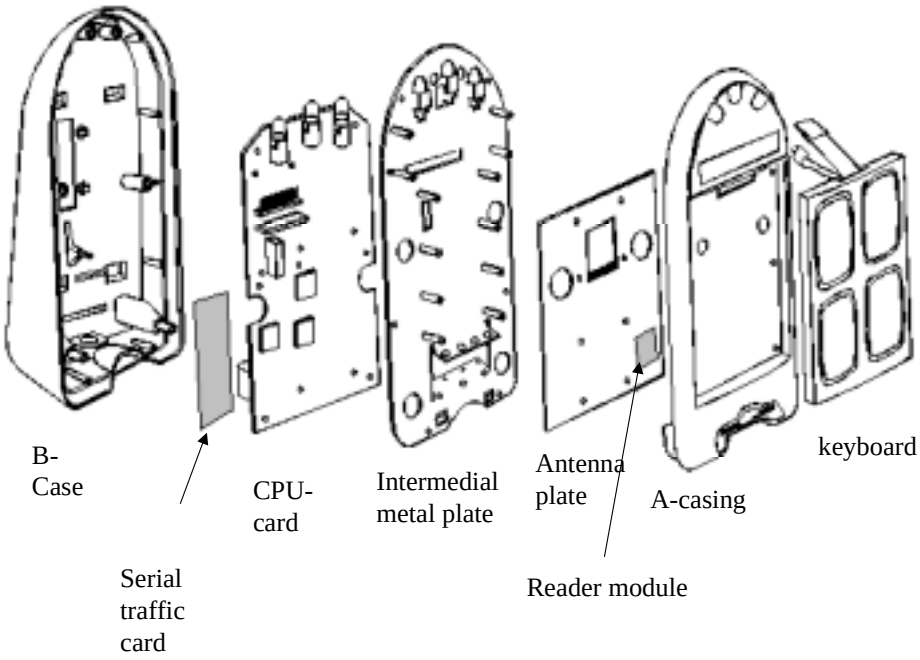

Figure 12. The parts of reader device

The operating distance achieved with this structure was however not sufficient, so measures were taken to investigate means for increasing the reading distance. In practise there were three alternatives for increasing the operating distance:

- increasing the transmitter power
- isolating other electronics from the antenna
- moving the antenna further away from other electronics.

Increasing the transmitter power implied building a RF-amplifier. The Buscom product development did not have enough know-how to build the amplifier, and additionally it was suspected to add eddy currents in the parts located behind the antenna, which again would weaken the operating distance. Because no ready-made amplifiers were available even for experimentation, this option was discarded.

Isolating other electronics from the antenna meant adding a ferrite plate behind the antenna. Ferrite plate is relatively expensive material and difficult to handle. Additionally the frequency used by the card and the reader, 13,56MHz, is problematically low for ferrite which caused problems in finding the right material. The operating distance was improved in the tests with the ferrite plate, but further research would have been required. The use of ferrite was abandoned mainly because of expenses.

The last option was to move the antenna further away from other electronics. This meant changing the appearance of the reader. At the same time the reader was changed into one-key model because there is no need for four keys in Turku and other projects in the near future. The keyboard of the PR200 reader device was lifted upwards in order to get the antenna farther. As a result of this change sufficient reading distance was achieved.

The result of the HW development is a customer operated reader with one key and ISO14443 card reader. Since the operation and appearance of the reader differ from the old reader, the trade name of the product is changed to PR220.

Figure 13. Reader device

5.1.7 Security solutions:

Security solutions of the Buscom card application are based on the 7816 - standard

More detailed security definitions are dependent on the operating system of the card

The Buscom application uses a security module, i.e. the security solution is based on a public calculation algorithm, but on a secret key.

Each card has an individual key.

Safety module (BPSAM) has been developed specifically for the Buscom public transportation application. The safety module enables fast calculation of authentication responses.

The BPSAM-solution was selected since no suitable security module application was available. The BPSAM-solution enables fast calculation of authentication responses because the card platform of SAM is equipped with a DES co-processor.

5.1.8 Structure of the multi-application card:

The following diagram describes the structure of the multi-application card. The card owner can define permitted applications. Another restricting factor is the amount of card memory (eeprom). SetCOS 4.5.0 –cards have 16kB of eeprom memory. Approximately 3kB of the card is reserved for the Buscom application. The shared files of the following diagram are intended to card owner use.

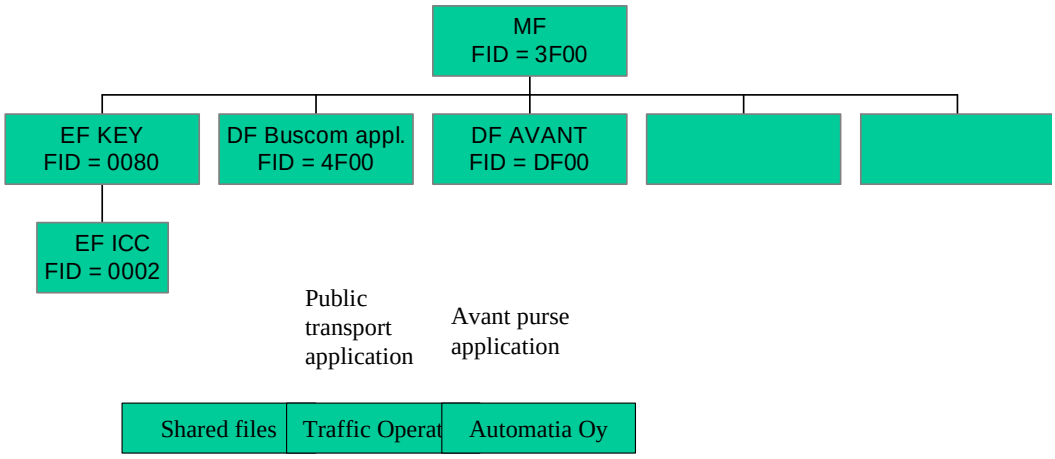

Figure 14. Structure of the multi-application card

Products of the Buscom application are usually used through a contactless interface of a dual interface card. Loading and reloading of the Buscom application is always done through a contact interface.

The Avant-purse is used in the reloading of the Buscom application season product. The purse is always used through a contact interface.

5.1.9 Execution time distribution:

The execution time distribution can be divided into five different part components. The figure illustrates the execution times of the components of the total time that the card processing sequence uses.

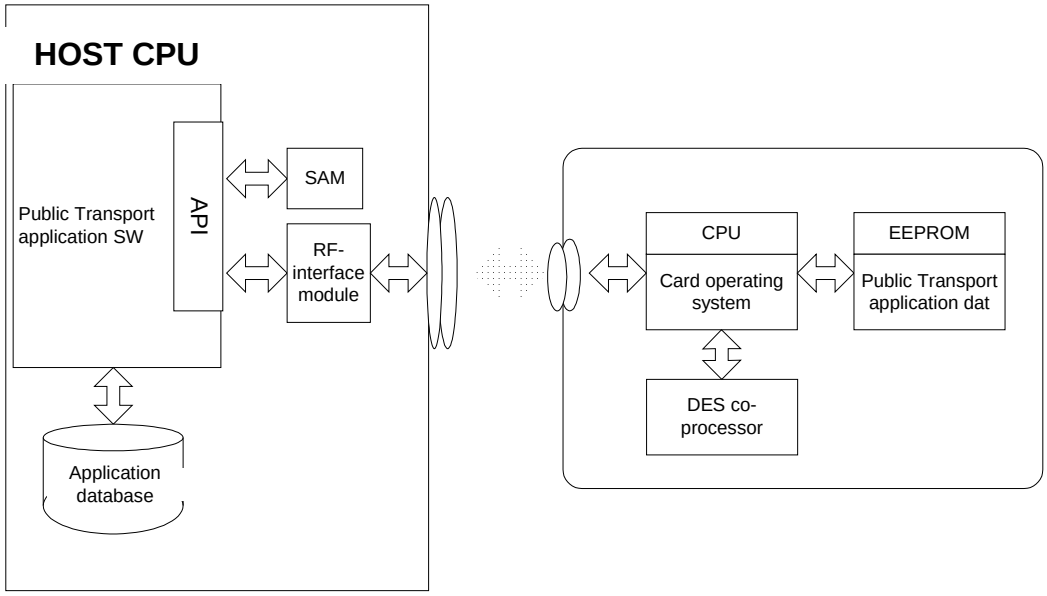

Figure 15. Components the card processing sequence uses

1. Data communication
2. Host
3. RF-interface module
4. Card Processing Time
5. BPSAM

Figure 16. Distribution of execution time

The card is processed with a reader module that is connected to a host device with a serial connection. The SW-interface of the reader module offers a transparent card processing interface that sends data to the card according to the T=CL protocol.

As the card platform changes from a processor card to a memory card and the amount of processed data remains the same, the execution time of the card decreases with approximately 40 percent. Then correspondingly the reader module share of the total execution time increases percentually. The data transfer capacity of the card is proportional to the execution time that the reader module takes of the total processing time.

5.1.10 Piloting

Pilot testing has been started with JLT's own personnel and 50 pcs. of Easyflex City cards from Schlumberger in the beginning of December 2002. Dual Interface card technology and ”Combi Fare” will be tested in this phase. Main goal of this test phase is to ensure that the technology platform, ISO 14443-readers and cards function in the bus environment without any effect on the existing card system and to test the implemented ”Combi Fare” -fare structure.

First results show that Dual Interface cards in accordance with the ISO-standard can be used also in public transport as a part of the platform. Implementing of different technologies in same platform causes some delay on card handling and has some effect on reading/writing distance of 13.56 MHz technology. Card transaction handling speed with today's ISO-standard compatible components and cards is much slower than with memory cards or manufacturer proprietary technologies. However, components in accordance with the ISO-standard are developing quite fast. Therefore new implementations should be based on the fully ISO compatible scheme. It is also possible to build a platform where different technologies can be used simultaneously. This way the transition from existing technologies to ISO-standard cards can be done smoothly and without a ”one night” update process.

The pilot will continue later with multi-application Dual Interface cards. In this phase electronic purse is also located on the card. The electronic purse can be used for paying a single ticket or for paying a new season ticket.

5.2 Matkahuolto

5.2.1 Summary

Project was implemented as planned during 1998. Matkahuolto Tampere Combi pilot was developed, tested and implemented with very good results. All the target goals where reached.

A 4000 Easyflex combi cards enabling both proximity and contact handling was selected and tested for travelling in a production environment in Tampere starting the end of year 1998. The test purpose was to verify the technical and func-

tional applicability of the combi card and its maturity before implementing it in full-scale production use

The major challenge was to implement existing Matkahuolto contact card ticketing system into the selected Easyflex Combi card by maintaining the security and speed needed for a contactless ticketing. These goals where reached due to the Multitasking capability of the MTS system and due the well proven contactless ISO14443A - Mifare technology.

All goals where reached without compromising security. Transaction speed and performance was enabling faster transactions. Comparing 2 – 3 second contact ticketing transactions, contactless ticket transactions are 0,5 – 1.0 second including card-presenting time.

Reliability and security was maintained at the present system level due to fast and secure Mifare contactless card system.

The pilot as such did not provide any new ticket products. The target goal was to enable the use of all the Matkahuolto ticket products that are accepted as means for payment on the buses of the transport operators

Matkahuolto Tampere pilot was successful due to the experience of Mifare technology and as a result of good security planning. Pilot results have proven that with goal setting of the existing contact card ticketing compatibility, it was possible to reach a reasonable performance.

5.2.2 Technology Description

The main objectives of the ADEPT III Matkahuolto site was:

- to implement Combicard for regional contract transport use;
- to reach faster and ergonomic contactless transactions in urban transport;
- enable the use of all the Matkahuolto ticket products that are accepted as means for payment on the buses by making use of the contact interface;
- maintaining high security

Fare Collection System:

- 400 vehicles
- 50 sales points
- over 100.000 transactions / day
- 170.000 Contactless cards
- 4.000 Combicards

5.2.3 *Basic Fare Collection System Description*

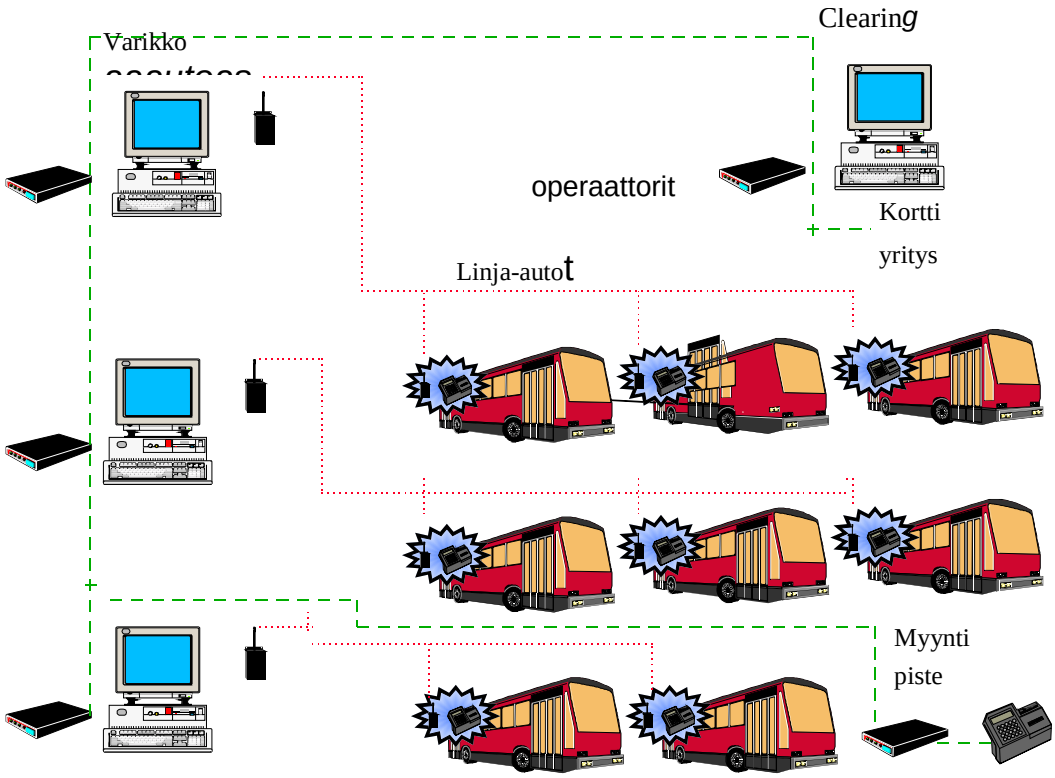

Figure 17. Basic fare collection system

Fare Collection System is based on Intermarketing Oy's MTS-Multi Ticketing System. Intermarketing also supplies the in-vehicle equipment and their software.

5.2.4 Easyflex Combi Card

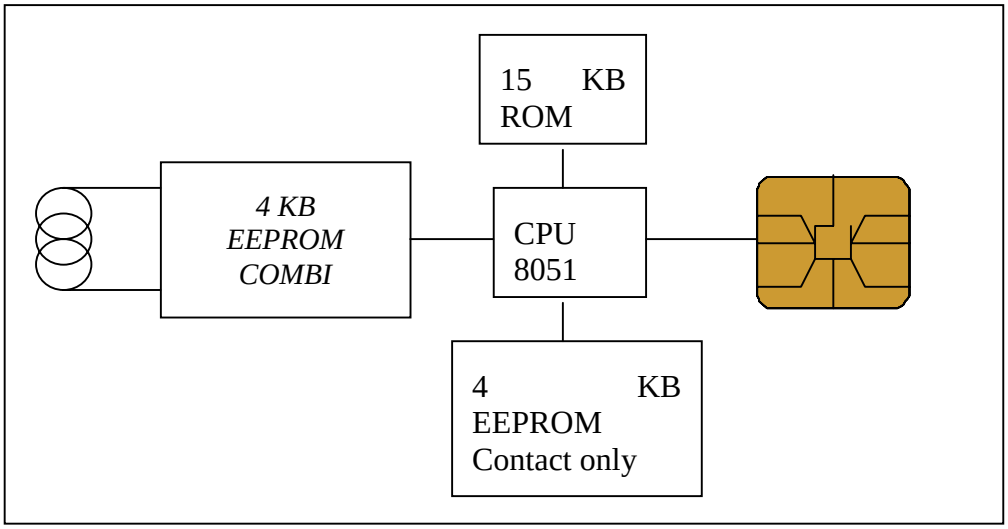

Figure 18. Easyflex combi card

Fast and High security:

- Card Operating system is restricting the access from remote contactless side to EEPROM which is protected only for contact side
- Mifare fast protected file structure is shared from both interfaces

5.2.4.1 Characteristics

- Complies 100% to the Mifare - System for contactless cards
- No battery
- ISO 7810 compliant
- ISO 14443 Type A compliant
- EEPROM. 4Kbyte divided into 32 sectors
- More than 100.000 write cycles
- Security: Each sector has two 48-bit diversified keys and its own access conditions
- Enciphered communication. Replay attack protection
- Three-way handshake with mutually generated of random numbers input

- Anti-collision logic allowing the presence of several cards operated in the reader's field simultaneously
- Communication speed: 106 Kbytes per second
- Configurable access to additional 4-Kbyte common EEPROM as data memory for controller and contactless interface

5.2.5 IN-Vehicle MTS Equipment

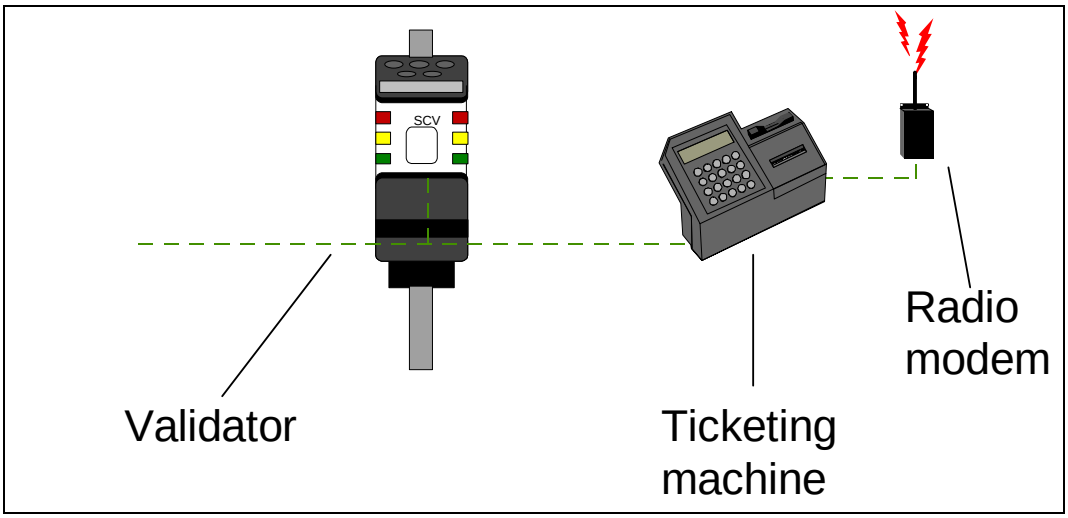

Figure 19. In vehicle device

ETM – Driver ticketing module is controlling the in-vehicle equipment and housing security modules.

TICKETING MACHINE DESCRIPTION

-Intel 87C196KC, 16MHz 16-bit microprocessor

-Protected program memory 16kB

-Flash EEPROM program memory 1MB

-Battery backed up SRAM

-Integrated contact and Mifare smart card reader

-Integrated magnetic stripe card reader

-Graphics thermal printer

-Keyboard for driver

-Display for driver

-Display for customer

-ISO standard contact smart card

SCV – Contactless Card Validator is processing contactless transactions and requesting security services from ETM.

SMART CARS VALIDATOR DESCRIPTION

-Intel 87C196KC, 16MHz 16-bit microprocessor

-Protected program memory 16kB

-Flash EEPROM program memory 1MB

-Battery backed up SRAM

- Mifare smart card reader and antenna

-Display for customer

5.2.6 MTS –Basic Software description

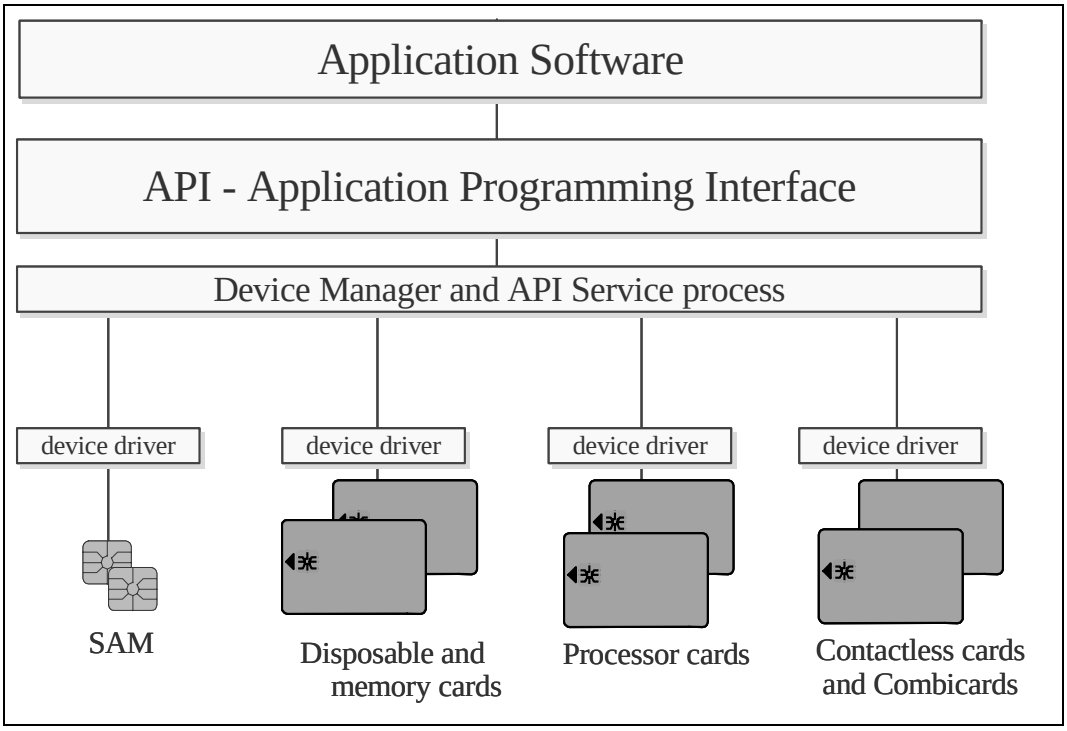

Figure 20. The modular structure of the MTS

The modular structure of the MTS - System allows simultaneous use of different type of cards, everything from memory cards to contact or contactless processor cards.

5.2.7 MTS –Card Ticket description

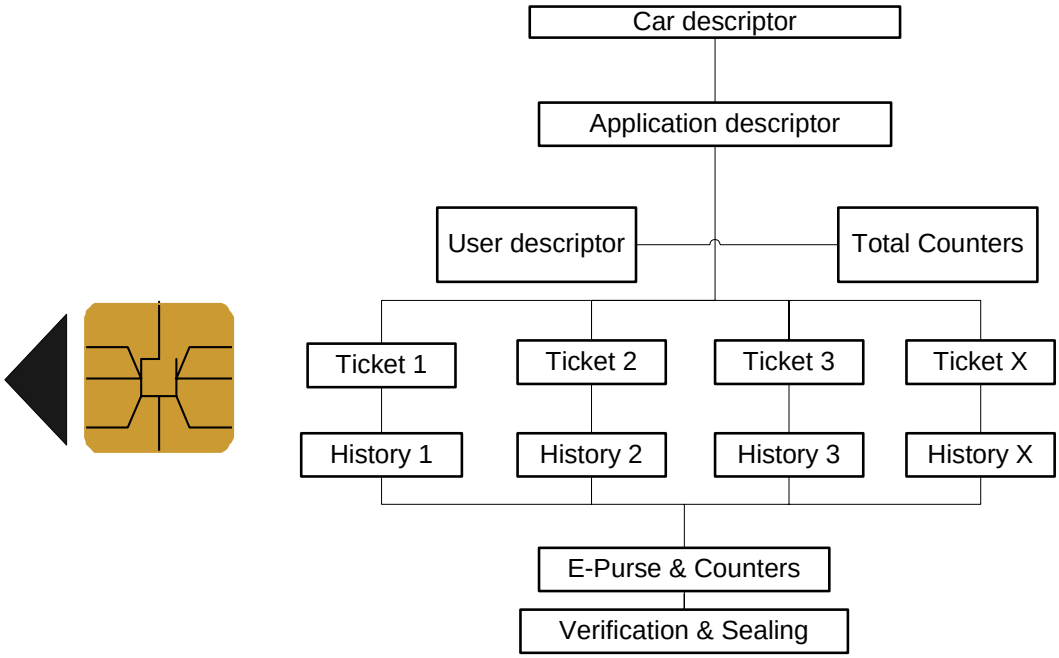

Figure 21. MTS-ticket description

The system software is written using the C-programming language. This makes further development and customising of the software flexible.

5.2.8 Basic Regional Ticket products:

- Season Ticket
- Serial Ticket
- Value Ticket

History and sealing was needed for transit control and for restricted tickets. Compatibility for contact side was critical element for speed goal.

5.2.9 Clearing of the sales and travelling transactions

Oy Matkahuolto Ab handled all clearing and card transactions. No development was needed for clearing due to the Combi cards

5.2.10 How the card is used

A client acquires the Combi card from a Matkahuolto sales point where all ticket products that the client requires are charged on the card. The sales points are the ones within the operational area of the transport operators.

A client can recharge the products already in use on a card both at Matkahuolto sales points and on board the buses of transport operators. On-board recharging makes use of the contact interface.

Figure 22. Drivers device

A client is validating using contactless tickets in Smart Card Validator. Same ticket can be validated also in driver ETM.

A client can use all the products already in use at Matkahuolto´s existing system on board the buses of transport operators. On-board recharging makes use of the contact interface.

Figure 23. In vehicle device

5.2.11 Performance evaluation and measurements

IN-Vehicle transactions where measured with application software and comparison was made between contact and contactless interface.

A passenger validating ergonomic transactions where measured with timers but due to ergonomic time to insert and remove final speed was measured via antenna coupler when card was introduced.

5.2.12 *Contact Card performance*

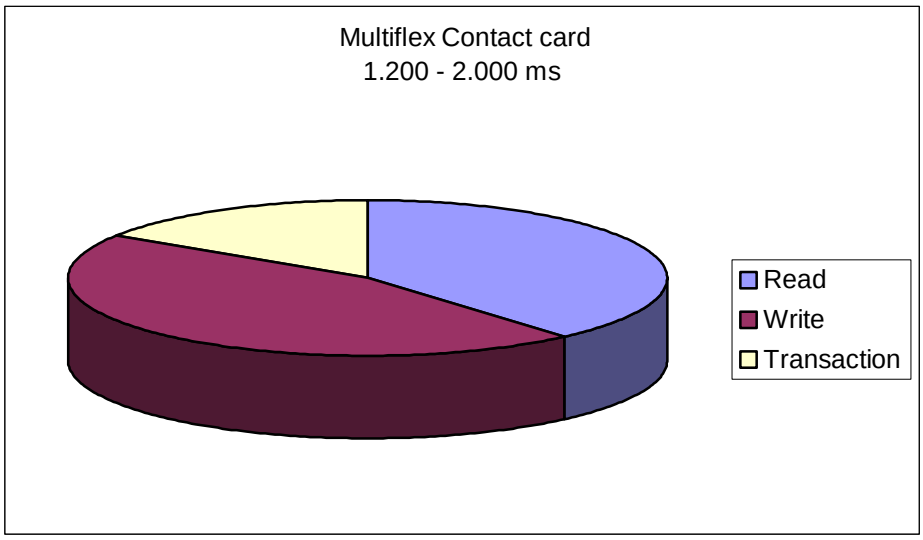

Figure 24. Contact card performance

The total performance is depending of size of the parameters and the card data as well as the slow speed of the contact interface. The transaction speed is depending of the Security module and the size of the transaction data.

5.2.13 *Contactless Combi Card Performance*

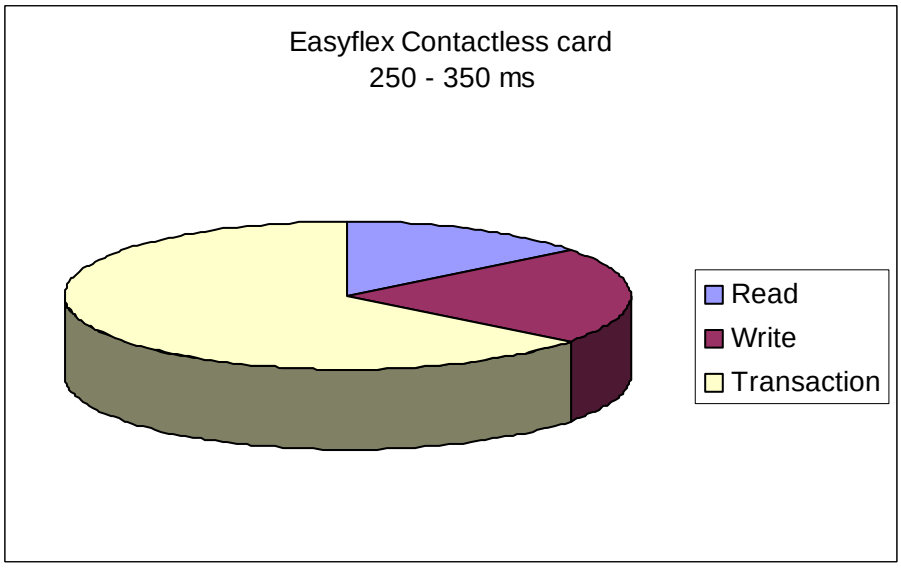

Figure 25. Contactless card performance

The total performance is better than contact side due to the faster contactless interface as well as the fast file structure format. Final speed of the transaction is depending of the Security module and the size of the transaction data.

5.2.14 Ticket Validating Performance Measurement

This measurement was applied because measured transaction speed was faster than passengers ergonomic card presenting and removal. Antenna RF-Communication and transaction was measured via inductive loop with oscilloscope when card was inserted and removed.

Heavy Ticket Transaction

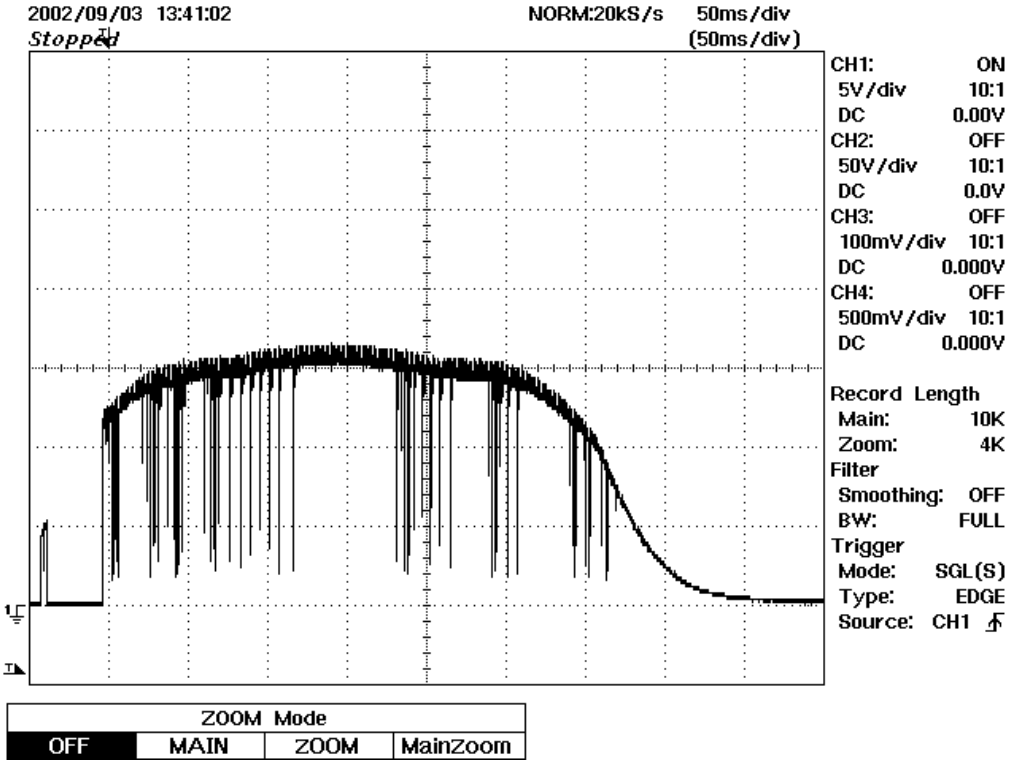

Figure 26. Heavy ticket transaction

Measured transaction shows how the card is detected when validator is polling the card and how fast the card is authenticated and responding.

Transaction is done before the card is removed from the antenna field. Transaction is done in 250 ms and card has been in the antenna field 350 ms.

Light Ticket Transaction

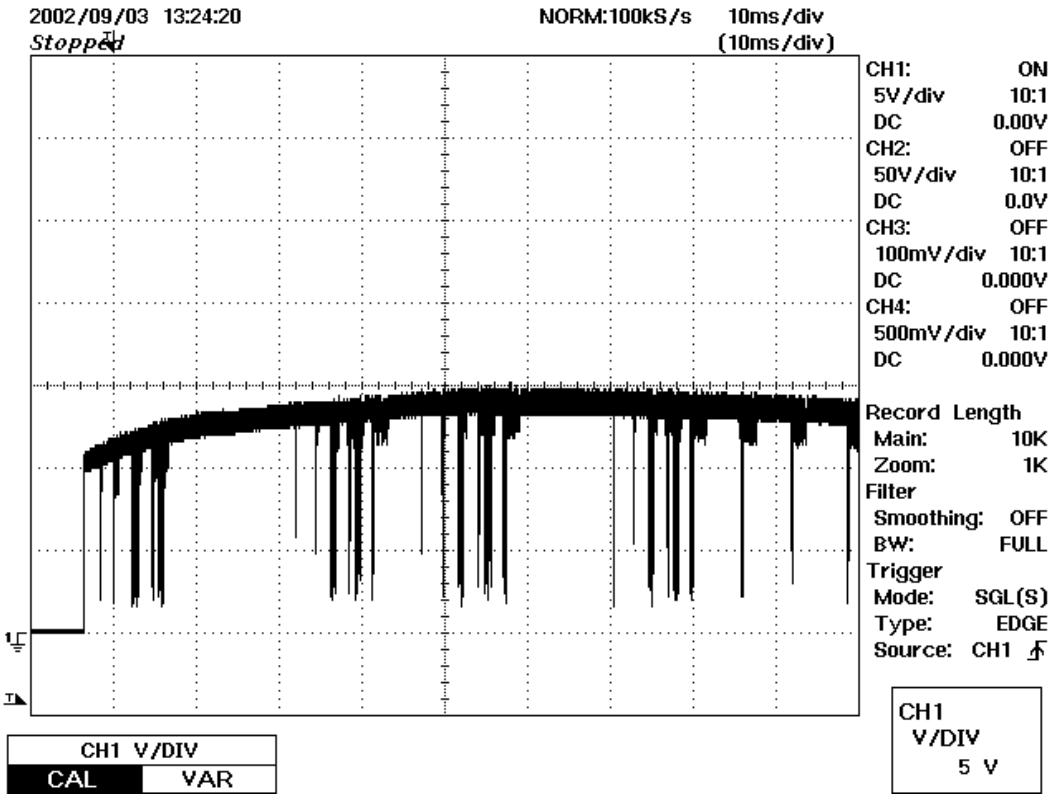

Figure 27. Light ticket transaction

Ticket transactions can be optimised for very fast transactions when no history or other data write to the card are not needed. With optimising fast, less than 100 ms transaction speed can be reached.

5.2.15 Conclusions and lessons learned

Pilot results has proven that with goal setting of the existing contact card ticketing compatibility and better contactless speed, it was possible to reach a reasonable performance. However this needs very careful planning and design.

The transaction times more than a 400 ms are critical and less ergonomic for the end users but can be implemented.

Without the need of compatibility with existing contact card system and with the best performance designed for contactless interface it is possible to reach better results.

It is possible to have less than 100 ms transactions with ISO 14443 A Mifare technology, which is designed for high secure and fast transactions.

Matkahuolto Tampere pilot was successful due to the experience of Mifare technology and as a result of good security planning.

Critical topics for Dual Interface Cards are:

- Security level
- Speed of the Security System
- Structure of data for fast and ergonomic transactions
- Access of the E-purse with shared applications

5.2.16 Task Force

System was designed and implemented based on MTS-Fare collection System.

Intermarketing Oy Raisio and Espoo Smart Card Programming team:

- Project co-ordinator Pauli Mäkelä
- Engineer Esko Hakala
- Engineer Risto Falck
- Software Engineer Joel Pusa
- Software Engineer Reijo Tammisto

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