Near Field Communication (NFC) in public transport

EMTA
European Metropolitan Transport Authorities

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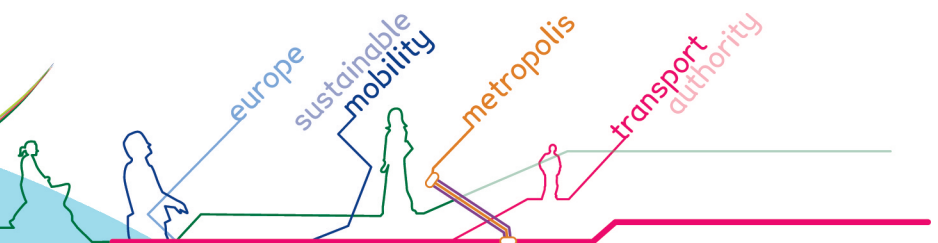
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We are proud to present the EMTA-White Paper on Near Field Communication.
Electronic payment services have become a cornerstone of the digital economy.

Buying goods and services online has been made quick and convenient by the electronic payment systems such as PayPal, Google Wallet and will be taken further by Apple Pay.

Near Field Communication technology now means that payment is made from passing cards over a card-reader. The crucial elements for successful payments schemes are security, ease of use and availability. Consumers need to know that their accounts are protected from attempts to defraud. They need to be able to make payments in what they consider a reasonable period of time and to use the payment method wherever they are.

Modern electronic payment systems go a long way to meet these criteria. The launch of Apple Pay in the US and its probable launch in Europe next year will probably lead to further improvements in user experience.
It cannot be ignored that NFC is developing into mass adopted tool which will positively affects our daily lives in making some or our basic activities easier and faster. Many of you may already use personalized devices or an NFC enabled bankcard to pay for small errands or for parking. The NFC app on a smartphone to collect direct information on actual services, in shops, in museums or even from an NFC-tag on a bus stop is becoming 'mainstream'.

The transfer of information and the payment in public transport in some cities and countries in Europe benefit already from contactless pay-as-you-go devices by card-emulation in a smartphone based on NFC-technology. In the EMTA community London with the new PAYG bankcard is well on its way. Other cities (Warsaw, Valencia) use NFC as a standard for contactless payment.

Developments in the technical domain accelerate and bring new types of solutions, instigated by key players in the ecosystem like mobile network operators, the banking business or smartphone providers. Many parties try to have a piece of the cake and expanding the business to the transport sector is considered a break-through in terms of mass adoption of NFC.

Public transport authorities need to be aware of the potential and the risks of NFC applications, of the way the contactless payment market operates and how to deal with interested stakeholders.

This report explains essentials on how NFC could work and perform to help the customers. It aims to lift any existing mystification around NFC and explain in the simplest way what shape solutions could take. It helps to clarify what options the public transport community in general and transport authorities in particular have to ask themselves before they consider to engage in deploying NFC in their payment and information strategy.

The working group of EMTA enjoyed working on it and while doing so we discovered that NFC is a "living creature": it continuously reinvents itself as applications are developing fast. EMTA hopes this report gives you a clear insight and helps to keep score of developments soon coming to you from the world of NFC.

We trust you will have some good use from the practical experience brought together in the description of some pilots among some of EMTA members.
Your comments to this subject will be welcomed to enrich and update latest experiences within our membership.

Benoit Boute
Chairman of NFC working group

Ruud van der Ploeg
EMTA secretary

Executive summary

This report describes the outcome of the survey of the EMTA NFC Working Group, which was launched in November 2011. The Working group's original objectives were to set up the EMTA organization and their members as recognized partners providing business expertise to influence the NFC ecosystem for transport applications, to increase EMTA members' awareness and credibility when making the decision on the NFC model implementations and to propose EMTA "NFC Ticketing channel" architectures to make it as simple as possible for customers and cost-effective when comparing NFC to PTA's current transport IT processes.

To achieve these objectives the following tasks were defined for the working group:

> *Analyse NFC trends and identify the largest players strategy (handset manufacturers and service providers) ;*

> *Define a valuable functional architecture compliant with Transport Authorities requirements. This should be easy to adopt by customers, Mobile Operators, or any other service system providers ;*

> *Define services to be implemented with ecosystem players role ;*

> *Understand the minimum required performance of NFC mobile implementations: criteria, level and certification process ;*

> *Propose one or two potential business cases in accordance to services provided ;*

> *Disseminate the results to EMTA members ;*

> *Propose an EMTA position to influence the ecosystem.*

Due to the differences of each member's ticketing system implementation and their progress on deploying a contactless media in mass transit, the objectives slightly changed, moving to studying the emerging e-ticketing solutions and seeing to which extent the NFC could be an alternative to complement or replace such media.

In chapter 3 this report tries to provide an answer why NFC could be an option for ticketing in public transport and reflects the benefits such system could provide for passengers as well as public transport authorities.

Chapters 4 and 5 present some key information about NFC technology and its multiple ecosystem, as well as the development of HCE (Host Card Emulation) as a new technology, highlighting the most important players in these types of environments and their likely business motivations and interests.

Chapter 6 outlines some basic considerations for a new business model for public transport including NFC technology in service provision for passengers.
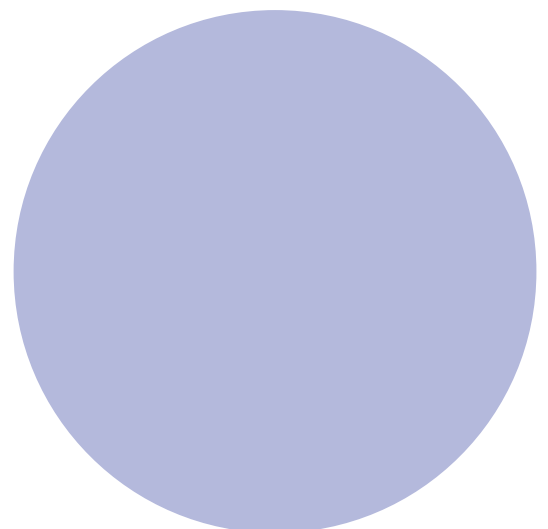
Chapter 7 describes the two main principles of NFC systems, the open and the close loops. Both solutions are described with theirs pros/cons based on the experience of the WG members. Chapter 8 summarises the current potential of NFC for the public transport sector along with key questions that still have to be clarified for a wider implementation of this technology.

Chapter 9 provides some important point to consider, which may serve as a decision tool allowing EMTA members to better understand the benefits, constraints and implications of NFC technology and its different implementations models.

To round up the report, chapter 10 presents some pilot projects, summarising the experience of the most advanced EMTA members from the NFC Working group in that context.

The contributing organisations include:

- > *STIF,   public transport authority Paris Ile-de-France, France*
- > *TfL,   public transport authority London, United Kingdom*
- > *ATM,   public transport authority Barcelona, Spain*
- > *Ruter, public transport authority Oslo, Norway*
- > *SL,   public transport authority Stockholm county, Sweden*
- > *ZTM,   public transport authority Warsaw, Poland*
- > *HSL,   public transport authority Helsinki, Finland.*

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1 List of abbreviations

CLF	Contactless front end
EMV	Europay International, Mastercard and VISA, a smartcard standard
ETSI	European Telecommunications Standards Institute
GSM	Global System for Mobile communication, standard for mobile phone networks
GSMA	GSM Association, industry association of GSM providers
HCE	Host Card Emulation
ISO/IEC	IT security standards
IT	Information technology
MNO	Mobile network operator
NDEF	NFC Data Exchange Format
NFC	Near-field communication
POS	Point of sale
PT	Public transport
PTA	Public transport authority
PTO	Public transport operator
RFID	Radio-frequency identification
SE	Secure element
SIM	Subscriber identity module,
TSM	Trusted service manager
UICC	Universal Integrated Circuit Card
WG	Working group
WiFi	Local area wireless technology

2 Introduction

NFC (Near Field Communication) is a set of standards for smartphones and similar devices that facilitate the radio frequency communication between electronic devices in close proximity, touching each other or getting close at a distance of about 4cm.

NFC allows the exchange of information between two active (powered) devices, such as smart phones and a reader installed in a payment terminal or an access gate. NFC also facilitates the transfer of information with a smart phone from a passive device, which could be chip cards or stickers and posters with an NFC tag.

In the context of public transport NFC offers the potential for a range of applications that may help to enhance the travel experience for passengers:

- **Information and travel planning** NFC tags placed within the PT system could be an easy way to provide general information about a station and its surrounding, the time table of a specific line or temporary changes due to construction works or events. NFC tags can provide direct access to mobile web pages and thus provide real-time service information at any stop ;

- **Access control** NFC readers can facilitate the restricted access to special facilities such as business waiting lounges, family areas, service centres for regular travellers, etc ;

- **Payment** with NFC passengers could use their smart phones to pay smaller expenses during their journey, such as a parking ticket, the newspaper or a snack ;

- **Couponing** NFC tags could also give public transport passengers access to discount codes and special offers of the PT agency itself or commercial partners. Developed in a systematic way, NFC could be the basis of customer loyalty programmes ;

- **Ticketing** NFC could allow using a smart phone directly as public transport ticket.

No doubt, the use of NFC for ticketing has the biggest potential impact on passengers as well as public transport organisations. Also, the NFC industry sees it as the most interesting option and often considers PT ticketing as the "killer application" that will help NFC to break through as generally used technology.

The players pushing for NFC are different in different markets and may include mobile network operators (MNO), handset manufacturers, the banking sector, etc. Different technical setups have been developed and are promoted, which may not all be equally suitable within the context of public transport. It is crucial for PT actors to understand the potential benefits and challenges of NFC, as well as its general impact on the public transport business:

- With NFC new players are entering the ecosystem, which may have a direct impact on the cost structure of public transport. Some costs may be saved (e.g. the provision of physical tickets), but some new costs may occur (e.g. payment infrastructure or fees for additional service providers) ;

- NFC requires rethinking the commercial business model of public transport. In addition to the common up-front payment for a ticket, the technology allows post-trip transactions and best fare calculations, etc. It certainly facilitates the development of innovative and customer

friendly products, but such fare systems require a fresh risk assessment and allocation between partners ;

- Different technical set-ups and standards have been developed and are competing for the dominance in the NFC market, but as of now, no champion is evident. It has to be clear that the choice of technology and system set-up has a direct impact on some key business aspects of PT, such as gate throughput (depending on transaction time), existing infrastructure (e.g. ticket validators) and targeted customers (e.g. requirement to be a known traveller) ;

- Security plays a key role, while some NFC based transactions can be protected by additional means, such as PINs, passwords or the active confirmation of a transaction, this may not always be possible in public transport and could therefore require other mechanisms ;

- As for any innovative technology, the success of NFC will ultimately depend on user acceptance. NFC offers the possibility to design new fare structures and service packages, but a clear implementation and communication strategy will be required to convince users of the attractiveness and reliability of the new system.

3 Why NFC?

3.1 Relation to other modes

NFC has the potential to considerably enhance the user-friendliness of PT ticketing systems

- provide a fast, modern and reliable ticket system ;
- To provide more easy access for passengers unfamiliar with the PT network and tariff system ;
- To use a payment mean and/or ticket medium that the customer already has in his possession and is familiar to use (telephone/bankcard) ;
- To provide additional value and enable multi-purpose use ; ticketing, information, infotainment, entertainment, bundling with other products etc.

3.2 Motivation for PT authorities

There could be a variety of reasons for PT authorities to consider the implementation of NFC aiming to realise benefits in the financial, operational or image domain. Key motivations of PT authorities that are already planning or running NFC pilot projects include:

Costs

- Card issue and distribution are associated with substantial costs. Transferring the responsibility for the ticket medium to another party along with less commission of external sales points and less staff needed helps to reduce these costs for the PT authorities ;
- Ticketing systems often have changed during the recent years. Old types of tickets are often gradually replaced and validators accepting different types of tickets are expensive. If the variety of ticket media can be reduced, the ticketing infrastructure can be lighter and easier to be maintained ;
- NFC offers a wider range of self service ticketing, which means less ticketing on board of vehicles, therefore allowing staff to concentrate on driving and possibly less delays.

Income

- Offering an easier access can increase the passenger potential for any PT system, offering a ticketing system without hassle to register, sign up or study complicated tariffs can help to attract passengers, who are not familiar with the system and therefore hesitate to use public transport today ;
- Smart ticketing and NFC could be the basis for loyalty programmes for passengers offering incentives to use public transport more often.

Image and user experience

- NFC ticketing can help to make a public transport system more easily accessible to non-resident travellers. Without the need to change money into a "local travel

currency" there is no worry about what happens with tickets or credits not finished before departure. Using a normal bankcard or the wallet in a data network makes it easy to buy tickets as you go or allows buying tickets from abroad ;

- The online topping up of travel cards or accounts is possible with immediate effect, eliminating the waiting for a system update ;

- NFC facilitates the interoperability of services, enabling passengers to use all included PT services with one ticket medium ;

- NFC makes it easier to offer additional services and makes it more convenient to access such services ; everything the customers need is in one app ;

- NFC triggers other developments, such as full data network coverage or the availability of Wi-Fi in the PT system. Having access to such services is convenient for passengers and helps to increase the attractiveness of public transport ;

- Smart back office solutions allow fair and best fare calculation and can contribute to building confidence and trust among passengers ;

- NFC technology can be gradually implemented, thus contribute to an enhanced user experience without changing the complete ticketing system.

Security

- Smart ticketing and payment systems reduce the need to handle cash during the daily operation and hence the amount of cash that needs to be available in stations and vehicles. This reduction improves the security of staff and reduces the risk of vandalism at vending machines ;

- The introduction of NFC increases the importance of IT security (mainly concerning the handset part and depending on the IT-solution), thus it will have to be taken into account ;

- As a possibility accepting bankcard payment places IT security into the hands of a knowledgeable party and may thus relieve the PTA from a crucial responsibility. For other PT interested or with the need to control their own security, there is no difference in security management at validators (be the media used by the passengers a card or NFC-mobile).

Operations

- The introduction NFC and mobile payment can enable passengers to buy fare products "and special tickets more independently even when they are not familiar with the system. This development can help to shift the focus of staff from selling tickets to assisting customers ;

- Modernised back office structures and data management allows for better distribution of income and sharing of costs between all stakeholders in a PT system.

4 NFC technology

There are several kinds of solution found in the market adopting the NFC technology. The most common are found below. While they may seem incompatibles they can, however, coexist in the same device.

Nevertheless, the user experience may be different depending on the techonlogy being used. For example, in order to tap and go with the HCE based solutions, the mobile phone screen must be previously unlocked. This may affect other operations related with the PT, such as ticket inspection, etc.

4.1 Secure Element based solutions

These solutions are based on storing the card application (the cardlet) in the SE, regardless of the type of the secure element.

SE may be open or closed to accept 3rd party cardlets. In the former, the PT may install their own cardlet in the SE, whereas in the latter PT should adopt the currently implemented, and probably proprietary, solution in order to use those handsets as payment device. For example, Apple has packaged NFC in their last iPhone model (iPhone 6) use an embedded SE to store their proprietary payment solution. If the PT wants to use these handsets, the only solution is to adopt this proprietary payment solution as a payment mode in the PT.

4.1.1 Main elements

The main components of the NFC architecture within a mobile phone using a secure element based solution include:

- A secure element (SE), which is most of the time a microprocessor that allows to securely store keys and applications ;
- An antenna;
- A contactless frontend (CLF, the NFC modem), which manages all NFC communication between the secured elements and the other NFC objects, such as readers, tags, cards or another NFC handset ;
- A contactless application, which is composed of:
  - The cardlet, a secured application stored in the secured element that contains all relevant information for authentication and perhaps fare products or the validation/purchase history ;
  - The MIDlet, an interface application installed on the handset, which allows thee display of information from the cardlet.
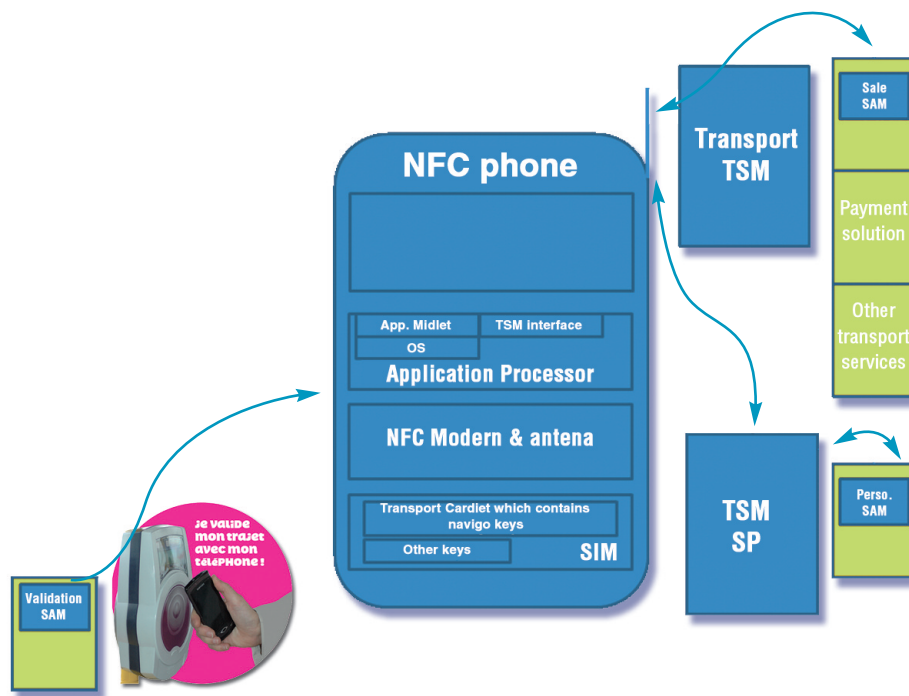
DIAGRAM1 : Universal solution for secure element stored in the SIM

4.1.2   Secure element variants

There are several ways to integrate a secure element into a mobile phone:

Universal Integrated Circuit Card (UICC)

> In this case the SE is in the SIM card of the mobile phone. It is removable, so any application stored on the SE could be transferred to another handset, provided that contains a CLF. As the mobile network operator owns the SIM card, he is a key interface for any application development.

Embedded secure element

> In this configuration the handset has a CLF and the SE directly embedded in the hard ware. The SE is not removable and applications would need to be re-installed on another mobile phone. With the SE bound to the handset, the handset manufacturers would play a key role in application management.In this configuration the handset has a CLF and the SE directly embedded in the hardware. The SE is not removable and applications would need to be re-installed on another mobile phone. With the SE bound to the handset, the handset manufacturers would play a key role in application management.

µSD Card

> With all necessary elements (SE, CLF and antenna) embedded into a µSD Card, this solution may enable non-NFC phones to permit NFC communication between a secure element and a contactless reader.

4.2 HCE based solutions

HCE (Host Card Emulation) basically consists of storing a virtualisation of the card in the device Operating System (software only-solution) and having the credentials for the transactions in the cloud.

HCE so far is enabled in only some mobile operating systems, but not in all of them. Currently, the HCE reference OS is the Google Android 4.4 (KitKat) although it is true that at the time it holds greater than 80 per cent market share.
To be noted, not all android NFC handsets on KitKat OS provide the HCE feature, mainly due to the limitation of the CLF component.

4.2.1   Main elements

The main components of the NFC architecture within a mobile phone using an HCE based solution include:

- An antenna ;
- A contactless frontend (CLF, the NFC modem), which manages all NFC communication between the HCE application and the other NFC objects, such as readers, tags, cards or another NFC handset ;
- A contactless application, which is composed of:
    - The card emulation, a software based card emulation that answers the PCD card commands as if it was the actual card ;
    - The cardlet, a tokenised application that contains all relevant information for authentication and perhaps fare products or the validation/purchase history ;
    - The MIDlet, an interface application installed on the handset, which allows the dis-play of information from the cardlet. It also manages the token exchange with the cloud SE.
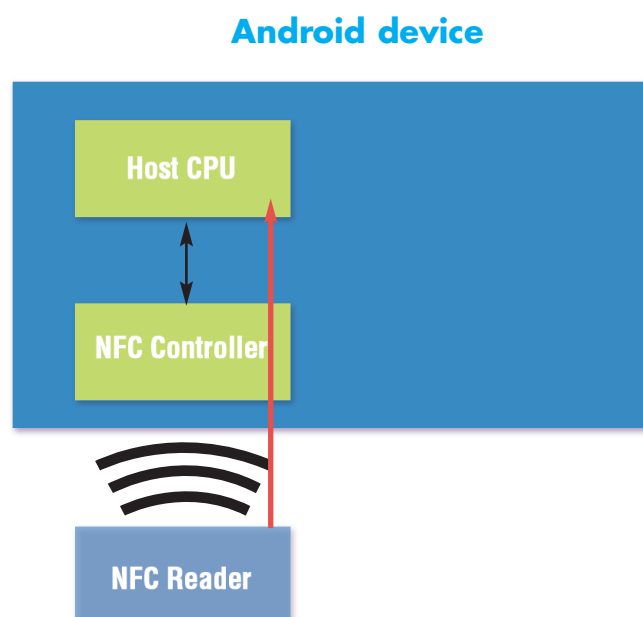
Android device

DIAGRAM II : HCE standard architecture

4.2.2   Security

In the SIM based model, there is no gap of security but the operations model is complex and not always proven to be suitable for the transport environment (along with that the business model is not already fixed in a comprehensive nor global basis).

In the HCE case the SE is commonly located in the local memory of the handset –software based solution– along with a remote secure server, which is accessible by the internet. Hence, the mobile phone requires internet connectivity each time the SE has to be accessed. Since the connection with the SE may be slow or inexistent at the PT gates, HCE doesn't make use of the SE as in the SE solution and the connections between the mobile phone and the SE are reduced compared with the other models, and the connection is not necessary in the validations to enter the PT gates. This is achieved using the concept of tokenisation.

Cloud SE are not as secure as the other SE, but eliminate the dependence on the MNO or mobile phone manufacturers.
While HCE is clearly a simplified model that can help boosting the mobile phone in the transport environment, for mass adoption there is still the need to have a strong, reliable solution to prevent theft of user's identification and also in order to prevent from hackers, for whom finding software based solutions covers their particular field of operation.
All in all, and although the maturity of HCE has not yet reached its full capacity, some efforts towards achieving more security in accountability of data storage and exchange are still being examined (with the yet known TEE Trusted Execution Environment as an adequate example).

4.3 Hybrid solutions

A third possibility is a hybrid solution between the two worlds, taking the best of both. The physical secure element would be used to perform the mutual authentication between handset and PCD but the HCE would be used to provide flexibility and independence.
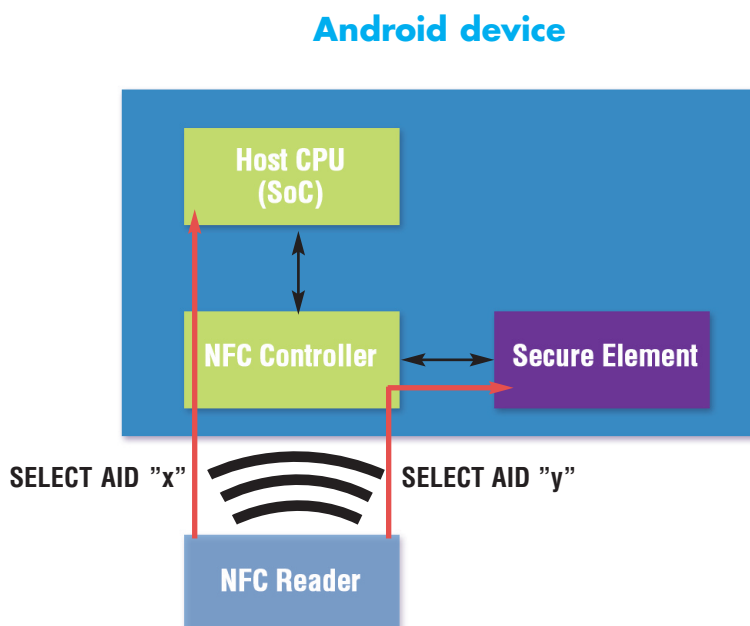

DIAGRAM III: Example of an hybrid solution implementation

Furthermore, NFC stickers could be fixed to a mobile phone to enable some NFC functionality. Passive stickers are recognised as a contactless card, but the missing link with the handset does not allow any application management via the mobile phone. Active stickers contain a thin battery and can communicate with the handset via a Bluetooth connection. This connection allows the installation of a MIDlet and thus the display of sticker information on the screen.

The last options should, however, be seen as temporary solutions and workaround while mobile phones are not generally NFC enabled.

4.4 Standards

Standardization is a key factor in making the NFC an available technology in mass produced media as mobile phones. The aim is to provide specifications to ensure interoperability between cards, devices ans system part on the NFC ecosystem.

4.4.1   Existing bodies
Since this "new" technology is expected to have a large range of applications and a great potential, many standardization bodies have agreed on defining specifications to insure compatibility between the different parties involved in the set up of a NFC service. The main different bodies taking part in the definition of the NFC standards are:

- ISO/IEC ;
- Global platform ;
- ETSI ;
- NFC Forum ;
- GSMA ;
- EMVCo ;
- MasterCard ;
- VISA ;
- American Express ;
- SIM alliance.

There are also national specifications issued by some industrials and service entities (MNO/service providers/banks).

4.4.2   Existing standards
The NFC standard is partly defined in ISO/IEC 18092. This technology is based on the RFID technology. NFC supports the existing ISO/IEC standards 14 443 and 15 693 that specify the radio protocol.

Global Platform defined the means to securely install personalize and manage contactless cardlets in secure elements (SIM cards).

ETSI defined a toolkit for contactless applications development and associated tests specifications. ETSI also specified the communication protocols between secured elements and CLF (Single wire protocol and Host Controller Interface).

NFC Forum defined the different types and encoding of NFC Tag and NDEF Tag.

The bank schemes (VISA, MASTERCARD, AMERICAN EXPRESS) have defined their own contactless bank application and certification.

In France AFSCM (Association Française du Sans Contact Mobile) and AEPM (Association Européenne Payer Mobile), association mainly managed by MNO, have taken the lead to produce national specifications on the overall process of provisioning, installing personalizing and managing NFC application in a SIM card to limit the developments they have to make to connect their infrastructure to a new service provider. They also deal with the main after sale process and business cases. Since they are French associations, other countries do not necessarily follow the specifications.

4.4.3   Gaps

As NFC technology is defined in several specifications by many bodies, it is difficult to have a clear view of which features to implement to insure the development of a functional NFC service. Since there isn't a unique way to provide or manage NFC applications, the services providers use distinct means to deploy their services. These choices make it even more complex to factorize and simplify the developments.

Furthermore, no end to end tests specifications exists to fully insure the proper functioning of the whole chain of elements intervening in the deployment of a service. Each interconnection/element has to be tested independently and no "on the shelf solution" exist nowadays.

The application roaming is not yet defined, so it makes it impossible to install a NFC service on a SIM of a foreign MNO (The bank applications are an exception).

VISA and MasterCard have decided to put in place a certification process that they control.

Eventually and in general terms, a path must be yet paved regarding standardisation and certification in order for NFC to be mass spread.
The appendix 1 gives an overview of the main caractristics of the NFC implementation solution.

5 The ecosystem

In the traditional payment ecosystem a passenger uses a card to pay for a fare product at the Point of sale (POS) of the merchant. The acquirer of the merchant for authorisation and confirmation processes the payment and a clearing process takes place between the acquirer and the payment service provider. In that case the eco-system incudes:

- The passenger with his card ;
- The merchant, who accepts the payment and issues the ticket ;
- The acquirer, who processes the paymen ;
- The payment service provider.

In order to facilitate contactless payment, it is necessary that the sales and validation infrastructure are fit to accept NFC, POS and transaction processing need to be contactless. The passenger will still pay with his card, but rather than a physical card it is now stored in the SE of a mobile phone.

NFC ticketing will involve new players into the eco-system:

- GSM Manufacturer in their traditional role as providers of NFC enabled mobile phones ; they can act as SE issuer in case embedded SE solutions ;
- Mobile Network Operator (MNO) as provider of the communication network for OTA provisioning and life cycle management. Besides their traditional role, MNOs might act as SE issuer (for SIM card based systems) ;
- Secure element provider (SE provider), who provides an SE as required by the Secure element issuer ;
- Application Provider, who provides applications and related services for NFC enabled phones. Depending on the ticketing system, this could be bankcard issuers facilitating open payment ticketing systems or the PT authority itself for travel card emulations ;
- The Secure element issuer (SE issuer) is responsible for issuing and maintaining the SE. Depending on the type of SE, different stakeholders can act a SE issuers –the MNO in case inte-gration of SE in the SIM card or the GSM manufacturer– in case that the SE is integrated into the GSM during production ;
- The Trusted Service Manager (TSM) is a key player of the system, the secure connection point between application providers and SE issuers. The TSM facilitates the management of NFC applications, ensures that applications providers do not need to worry about different MNOs, phone models or operating systems and MNOs do not need to deal with different application providers. A TSM is necessary as traditional chip cards are personalised with applications and data before being handed out to the customer, in case of NFC applications the installation happens after the phone was already purchased ;

- Mobile wallet provider, who provides the interface on the mobile phone to manage multiple NFC applications. The mobile wallet is an application to manage payments and other transactions. It can be used to control and handle different applications (like different cards in a physical wallet ;

- The Cloud SE Provider is responsible for issuing and maintaining the Cloud SE used in the HCE based solution ;

- Application Acceptors, who need to have enabled their infrastructure to accept payment and interact with NFC enabled phones. In the context of ticketing, PT operators act as acceptors for emulated travel cards or bankcard systems and process them through the bankcard payment infrastructure.
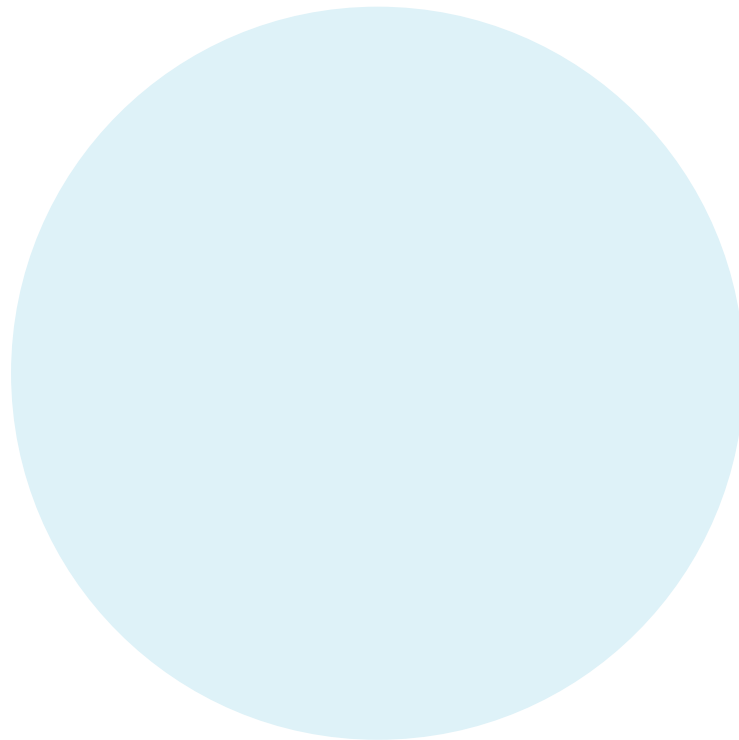
6 Business models

Implementing NFC technology will have a substantial impact on the public transport business. It will require creating a new business model, which has to be balanced. NFC may give new business opportunities, but you have to give up a monopoly, the PT authorities and operators will not exclusively own the customer relationship anymore.

NFC technology has the potential to create new benefits and thus make public transport more attractive. NFC can help to improve the satisfaction of existing customers:

- Tailormade travel information could help to make better use of existing capacities, during peak hours passengers checking in could be invited for a coffee to wait for a later train ;

- NFC could be used as a new sales channel making passengers aware of new products, services or special offers ;

- push notifications could ensure that passengers are aware of problems in their journey and alternative connections ;

- loyalty programs could help to increase the use of public transport.

In partnership, NFC can also help to acquire new customers. Integrated ticket offers with events, museums or other businesses may bring a people to public transport, who have not been regular travellers so far.

In general, the easy access to information could help to increase the income from advertisement in public transport.

Besides those new opportunities, you need to be aware that NFC brings new players to the public transport market, so you have to share your business and customers. In that context, it is important to monitor the ecosystem and understand the role of all parties, Is really everybody needed for a well-functioning NFC system?

Involving partners has advantages ; you can give the responsibility for processes or services to somebody else, what is this worth for you? For example, if you save costs for card issuing, you can give a percentage of the revenue to the party that issues the card in your place.

There could be several drivers for the implementation of NFC technology in public transport ticketing, each of them with very individual business interests. It is crucial to be aware of these interests and keep them in mind when looking for partners in order to make in NFC ticketing scheme successful.

The main challenge in developing a successful business model is the lack of practical experience in PT sector. Traditionally, ticketing has been an exclusive responsibility but involving external partners could help to benefit from innovation and experience in other business sectors. It is mainly a matter of defining the margins, and agreeing on what is a fair way of sharing.

7 NFC implementation in public transport

7.1 NFC functionality

In the ticketing context, NFC is a step further from traditional contactless smart cards. These smart cards are known from travel passes, such as the Navigo pass in Paris or the Oyster card in London. In many European countries also smart bankcards in form of contactless credit cards are introduced to the market.

There are several ways to use NFC technology in public transport ticketing:

The NFC phone as a smartcard
An NFC phone can work in card emulation mode. At ticket validation points, an application stored on the phone emulates a contactless smartcard and the external reader sees the mobile phone as a card, hence NFC can be compatible with contactless smartcard infrastructure already installed.

NFC phone as travel card reader
As an initial added value for passengers NFC phones could allow direct reading of information stored on a card, such as remaining balance or trips. The card simply needs to be held close to the handset in order to read. Information directly stored on the card could be red over the air; in order to access account data stored in the back office Internet access would be required.

NFC phone as payment terminal
The mobile phone could be used to buy a fare product or top up a balance via Internet and then transferred to a travel card that is held close to the handset. Internet access is required for the acquisition, but the transfer if data to the card could be done over the air.

7.2 NFC functionality

Basically, there are two ways to manage the information linked to contactless smartcards or NFC phones, back-office based or front-office based. The choice is essential, because it has consequences on functionalities and infrastructure. While a back-office architecture is more flexible and can be updated, enlarged and changed quickly, a front-office architecture is more rigid and allows to have more control.

- A back-office architecture implies account management, all information concerning the passenger, purchased fare products, accepted payment channels or discounts is stored in the account, the smart card or app only contains the information necessary to identify the passenger account. Using the card only for authentication has the advantage that the information stored on the card is simpler and requires less space ;

- The front-office architecture stands for a card-centred solution. Having all relevant information concerning the passenger, purchased fare products, discounts, etc. stored on the card, does correspond with the traditional model of upfront payment, buying a ticket before starting a journey. Translated into contactless card of NFC environment this model has however several disadvantages.

A comparison of several operational aspects of both architectures can be found here after.

Back-office solution

Ticket platforms

- Different card platforms can be managed, the system could accept travel smart cards, bank cards, NFC phone SIM cards. New platforms to be added later only need an app with card emulation. The effort for integration is at the newcomer's side, the PTA only has to accept a new player.

System extension

- Non-travel applications, such as payment in shops, can easily be integrated. As for ticketing all that is necessary is an app with card emulation.

Card management

- Passengers can top up cards or add new fare products with immediate effect ; as soon as the transfer to the account is executed the credit is available on the card or device ;

- The account can be centrally updated if the traveller is entitled to/or losing discounts ;

- The account management allows best-fare calculations based journeys done in a specified period. Account-based fare collection allows to register all journeys a passenger does a "zero taps", registered entries into the PT system without any money transfer. At the end of the day, week or month the fare aggregation system calculates the correct fare in a post-billing model.
  Such approach would allow tariff capping, the passenger does not have to decide anymore what fare product is the most advantageous for his travel, but based on the real journeys the system can charge the optimal product ;

- The card can be centrally blocked if lost, stolen or used for unauthorised travel, the blocking would be with immediate effect ;

- Any credit or fare product could be transferred to a new card or device as these token only serve to identify the relevant account.

Ticket validation

- Back-office architectures allow post payment schemes. Entering the PT system the validator only focuses on identifying the ticket, the balance or credit of the account is only checked when the passenger is already in the system ;

- The transaction time at the validation point is very low as only a validity check needs to be done.

Ticket inspection

- Ticket inspection requires connecting the inspecting device with the back office in to verify whether a passenger has actually checked in.

Battery down

- It does not matter whether the battery of a passenger's GSM is down, the validator only needs to identify the phone, all fare calculations and transactions are done in the back office ;

- However, it is a fact that the HCE based solution requires the device to be fully powered.

Complaint management

- In case of complaints or faulty transactions, the issue can be investigated in the back office and settled without the need for further active customer intervention.

Unsolved issues

- Fare collection over several cards or devices linked to the same account may present a problem. If passengers use different tokens for the same account, although they would all be valid, such approach is problematic for a best price calculation; the back office has no indication to decide whether one or more passengers have been using the account ;

- Bankcard providers may charge transaction commissions for foreign cards, which might make the use of a bankcard as a PT ticket very expensive for foreign travellers.

Front-office solution

Ticket platforms

- Different ticket platforms can be managed, but the decision which card or devices to accept needs to be taken in the design phase. It is not easy to include additional ticket platforms later, the effort for integration would be on the PT authorities side as all necessary information needs to be prepared in the format needed for the new device.

System extension

- The integration of additional services is rather complex. While PT authorities here hold the master key for the card and thus have full control, any additional services need to be integrated into this system and the effort to do so entirely lies with the PTA.

Card management

- The topping up of smart cards via Internet has a delay because validators need to be updated with the new credit information for each card. The immediate top-up of smart cards still requires a ticketing machine. Phone-based ticket apps solve that problem, as GSM and ticket app are both in the Internet a top-up is possible immediately ;

- Fare products including discounts and concessions need to be defined in advance, if a passenger is entitled to such discount as a newcomer, he has to present the card physically once for an update.

Card administration

- A card cannot be blocked immediately. All validators in the system will need to be updated to ensure that card is not accepted any more ;
- Once stolen or lost, any credit still available on the card is lost for the passenger ;
- The possibility to transfer credits and fare products to another card or device is depending on the compatibility of the travel card app with the new device ;
- Front-office architectures rely on pre-payment schemes. Entering the PT system, the validator seeks to identify the ticket and to confirm the payment; a passenger is only admitted into the PT system if the payment can immediately be verified ;
- The transaction time at the validation point is longer as the information on the card is directly updated.

Ticket inspection

- Ticket inspection is easy as the ticket inspecting device only needs to read the smart card/NFC phone; all relevant information is stored here.

Battery down

- If the battery of the GSM holding the ticket app is down, the handset can still be used if a valid ticket or credit is stored on it as the validators see a phone as a smart card ;
- The handset cannot be used to top up or buy a new ticket wireless. Fare products could be bought by presenting the GSM to a reader at the ticketing machine.

Complaint management

- In case of faulty transactions or complaints the initiative is with the customer. The card/phone needs to be physically presented at a service point.

7.3 Ticketing models

The ticket platform

As already described, NFC ticketing basically could be developed using smart cards or SIM cards as ticketing tokens.

For a ticket validator there is no difference between the two, it recognises both tokens as a smart card. With the currently available technology, however, the reading speed is faster for smart cards than for SIM cards.

As for contactless smart cards, NFC ticketing can basically follow two models the phone can emulate a travel card or the PT validators are enabled to accept bankcard payment.

Developing an own ticket app, the PT authority is fully in control in the app. Lacking the backbone of a globally established standard, however, an own application may be slower, more fragile and requires more effort to ensure compatibility with new phone types coming on the market.

For SIM card apps, the EMV platform is the fastest and the current main platform for NFC payment. Having been initiated by the large credit card schemes EMV is a wide spread platform, it is robust and children diseases are overcome. Using this standard for a ticketing model allows an easy integration of non-travel applications as EMV already is globally implemented and accepted.

Model 1 - Own application

Smart travel cards are already widely available in the public transport sector. Going a step further, the NFC phone would hold a virtual travel card. The application and information installed on the NFC device emulates the traditional ticket and can be used as the normal contactless smartcard, the validator would see a PT ticket when tapped. Model 1 is characterised by:

- **Payment and validation are separate processes**
  In order to use such system, the passenger needs to install a specific travel card application on his NFC phone and make sure there is a valid fare product or enough credit on it before starting the journey. If that is not the case, the mobile phone could be used to buy a new ticket or top up the credit via Internet ;

- **Target group are registered travellers**
  In general, passengers need to be registered or buy a pre-paid product; no spontaneous travelling for non-resident passengers is possible. Such inclusion of non-resident travellers would require too many bilateral agreements with MNOs ;

- **High degree of control**
  The PT authority is in charge of all development and maintenance aspects of the ticketing system. The system design phase is rather complex and comprises the need to define:
  - Security scheme and risk management ;
  - Application structure ;
  - Certification processes for infrastructure (validators, cards, media) ;
  - Partners and services that are integrated into the system ;
  - Responsibility to issue and maintain the token, which could be an application, a card, any medium ;
  - Procedures to ensure compliance of own app with existing and new GSM models and SIM cards ;

- **System architecture**
  Basically any fare product could be programmed into the application.
  Information about the traveller, valid fare products or any discounts could be stored directly on the virtual card or in the back office system ;

- **Incentive and loyalty schemes**
  Travel card apps could give access to travel-related incentives. The system structure requires a service that is also under control of the PT authority, e.g. parking discount at station or free travel on birthday.

Model 2 - Bankcard payment

An alternative setup is not to rely on a specific ticketing application, but to enable the PT system to accept bankcard payment. In this case the NFC phone emulates a normal bankcard that could be used for payment anywhere, the passenger only needs to have a general payment application installed.

A ticket validator would only check for a valid bankcard and accept the passenger into the system. The fare calculation is done after the end of the journey or the journey period. It is not necessary to have a pre-paid ticket installed, or to be a registered traveller; hence a bankcard-based system could be very useful to offer an attractive solution for non-resident or non-frequent travellers.

Model 2 characteristics include:

- **Payment and validation is one process**
  The PT authority focuses on the validity of the bankcard, but assumes no responsibility for the actual transaction. The PTA only needs to provide the customer account with the correct travel history, the transfer security is ensured by a third party (bank or card issuer, or MNO) ;

- **Target group includes occasional travellers**
  Bankcard payment facilitates easy access for occasional and non-resident travellers, as the EMV standard is mainstream and widely accepted ;

- **Partnership and negotiation**
  In contrast to model 1, the PT authority accepts external standards and makes the ticket system compatible to another system. This requires agreements with external partners, banks or card issuers. A risk management scheme has to be designed in the development phase, but all other items from the list above (transaction security, compliance, etc.) are in hands of third parties. This approach requires trust and more effort in negotiation, but relieves the PT author-ity from the responsibility for the entire ticketing system ;

- **System architecture**
  Integrating the ticketing system into an external system implies the development of a back-office system. Passenger and fare information need to be account-based, the ticket token can only be used for identification ;

- **Incentive and loyalty schemes**
  Bankcard payment schemes give access to any business that accepts the same payment and allow to develop incentive and loyalty schemes that go beyond transport, e.g. a free coffee or free newspaper if you travel past peak hour.

7.4 Risk management

NFC ticketing brings new players and new processes into PT ticketing eco system. NFC brings new opportunities, but also brings some risks that need to be addressed.

New phenomena include:

Post payment

If a card or NFC app is only used for authentication of a passenger, there is a risk that a journey is started without sufficient credit or a valid fare product. If passengers have to check in and check out, the payment could be settled at the exit, for a check-in only system, a different approach will have to be developed.

As a solution entry criteria could be defined such as a minimum balance on the card or a clearing from the bank. As post payment would only be possible for bankcard payment system, the entry criteria need to be settled during the negotiation process with external partners.

A key aspect in this context is the maximum damage that could be caused by non-authorised payment and would correspond to the maximum travel distance and maximum ticket price.

App security

The NFC transport ticket application may have different levels of security depending on the NFC solution being adopted. While in a SIM based solution there is no gap regarding the security of transactions, in an HCE based solution it should be taken into account that the identification of the device is a key factor, especially in the case where the passenger has special conditions for the use of a specific ticket (subsidized or social tickets).

Mobile payment security is different to website security because it includes the actual transfer of money. The potential damage created is higher than in purely maintaining a user account. If account data gets stolen, not only a travel card number is compromised, but a bankcard, which could be used for transaction. Extra encryption will be required to meet payment security standards.

Revenue inspection

Using the SIM card of a mobile phone as a ticket token, presents a challenge in bankcard payment systems if the battery of the GSM is down. In such case the ticket inspector could verify only the existence of a user account, but not if the passenger has actually validated a ticket.

To tackle this challenge, the PT authority should aim to build up a risk customer profile for each user in order to determine when to deny entry. For example if someone always pays a regular amount over a long period, he may be allowed to travel without inspection verification as he is considered a trusted passenger.

Using the HCE solution, it has to be taken into account that the mobile phone must be powered on and the screen unlocked in order to have the transport NFC application enabled.

Pre-paid cards

Ticket validators in bankcard payment system cannot tell a bank card linked to an account from a pre-paid card, so people could enter the system with insufficient balance. No technical solution has been found yet, the issue remains to be addressed with the banking sector. However, a PTA may decide to accept this risk in order keep the entry threshold into the system low and NFC and public transport therefore attractive.

Involvement of external parties

In NFC ticketing systems, the responsibility for key processes is with external parties, hence system security is only as good as with the weakest partner. Clear agreements and standards are required as well as a trustful business relation.

Counterfeit apps

The sales channel for mobile payment in public transport is not very mature yet, so people might fall for look-alike apps, a problem known from online banking. PT authorities should establish a certification process of external apps and monitor the app market.

Vendor lock-in

NFC stakeholders often refer to public transport related applications as "killer-apps" that could be the breakthrough for NFC at a larger scale. Whilst being a courted partner in early stages, a PT authority that decides for a unique partnership might become dependent on one party and may end up in a price/commission pressure. In order to avoid this, it is important to leave alternative solutions open, to be able to work with smart cards and NFC phones, to use the EMV platform but not to discard own travel card applications.

8 Conclusions

Due to the important differences between countries specific environment and fare system, the NFC architecture choice will depend on the country specific context. The telecom operators' maturity and the existing NFC services already available to the transit customers will have to be taken into account. The NFC solution seems very lean and provides a solution to deploy quickly new fares or ticketing products. This technology usually needs a few upgrades of the pre-existent validation equipment in small scale experiments, and has also a path ahead to reach a standardized and certificated status, in technical terms. Stability and the business model are not yet ready for a large scale deployment.

Is NFC more than only a practical piece of technology for transport ticketing?

It became clear that NFC could become a persuasive driver for having a consistent pay-as-you-go tool. NFC has the potential to make our everyday life as traveller much easier, by delivering transport tickets options more tailored to users' needs (bike rental, discount for outside peak travel…), by avoiding physical purchase of tickets.

For the coming years NFC holds the promise to support a unique customized tool to communicate, make transactions and deal with travel information (i.e. real-time information, travel planner) for more than just the regular transport user, considering also their different origins. NFC has the potential to redefine the division of roles in the mobile arena by offering new opportunities for industries and PTA's to communicate, make purchases, and make information accessible, up to giving an impetus to a change in travel patterns.

However, the WG discovered that the NFC ecosystem is becoming more complicated and complex. The growing number of partners and the dependence to a media owned by another party are some of them. The challenges are widespread and are both of technical and strategic nature; it delivers impediments for NFC embedded application mass adoption: many pilots have stumbled over flaws in the testing phase.

For PTAs NFC offers a reliable and faster transaction time in mass transit witch is the promise from NFC based devices. Efficiency and cost reduction is a main driver for PTAs from that. However, the step towards such a transition is surrounded by many concerns and insecurities. How will Smartphone distribution or contactless ticketing be valued by users and adequately supported by the Smartphone companies? What will be the price of this migration process, in terms of investments in new infrastructure, in software upgrade of equipment and of redistribution of the revenues? Will this new distribution be sufficient to replace the old system or will the PTA have to maintain both? And how will investments pay itself back over a reasonable period of time? What is there to say about giving away your own influence on these processes when new stakeholders enter the podium?

In general the Working Group tried to assess in which terms NFC could be beneficial to suit the needs of transport authorities, and how new players in the NFC eco-systems are triggered to deploy their applications.

For governments and industry NFC offers a whole new potential: apart from a potentially safe, speedy and reliable device for payment, control and inspection of transport fares or payment in mass transit, it embodies a chance to deliver updated travel information pre-trip and on trip via apps and support the seamlessness and interoperability of services by communicating with the customers. Through their connectivity, mobile phones offering the NFC feature can provide a richer user experience on transit than contactless cards. Transit applications can deliver new capabilities, including payment acquisition, system entry/exit, clearance and post-purchase inspection processing.

In effect, transit ticketing is poised to become one step in a seamless process of purchasing, topping-up accounts, planning trips, and viewing next vehicle arrival information.

NFC equipped contactless cards or Smart phones represent a commercially wide stretching catchment area. NFC in transport has to offer an immense cost-cutting opportunity as it does for retailers, banks, museums, concerts, sports events and other applications. However, how do we demonstrate this when so far a lasting working solution is lacking? In this sense, and related to the business and operation model, the NFC technology based in the HCE solution simplifies it and hence it can help boosting the mass adoption of all NFC technologies.

9 Points to consider

By now it should be clear that there is more than one way to implement NFC technology and more than one model to build up a system. As often, there is no right and wrong, the best implementation strategy and moment depend on many factors and not all of them are under control of the PTA. The following points have been complied to help reflecting about individual situations and facilitating the decision taking:

Are you ready to accept external players?

The implementation of NFC will bring new players into the PT market. While the traditional ticket sales channels mainly involved a sales agent of the PT operator or authority and the customer on the other side, NFC will give a role to more parties, who will want to have "a piece of the cake", but who may also bring an added value. Some questions to be considered in that context may include:

- Our primary business goal is to move people, is ticketing really part of it? Do you have to control the payment process yourselves or could you leave it to an experienced party?

- Public transport has to be a service for all citizens ; the availability of a bankcard or a mobile cannot be a condition for access. How to ensure not to exclude anyone?

- The involvement of new players means to share the revenue of the PT market among more parties. On the other hand, what benefits could be realised by sharing costs (eg. for development, maintenance and management of the ticketing system) with other partners? Could new business relations open new revenue possibilities?

- In a shared business model tasks and responsibilities need to be allocated between partners and the PTA needs to decide what to outsource. Would that only concern "invisible" background activities, such as managing financial transfers and risk or are you ready to outsource the fare product distribution and customer relationship as well? What impact does that have on your image and brand?

- Are you ready to share "your" data?

It is important to make sure there is competition in the NFC market, it should be avoided that a PTA becomes dependent on one party. You should try to understand the stakeholders interest/cost/revenue when collaborating in to develop and run NFC-based services. There is a need to define a method of governance including all the stakeholders.

Is your society ready for the implementation of NFC?

Still, the percentage of population equipped with smartphones varies from country to country and so does the appetite of people for apps and contactless services, especially those that involve financial transactions. What is a realistic time horizon in your region to launch an NFC application and achieve a critical mass for economic success?

While public transport is often referred to as the potential killer application that could finally bring the breakthrough for NFC technology, it may not be enough. What other NFC services on smartphones exist or are being tested in your country?

The situation of the mobile communication market in your country could be an important criterion for success or failure of NFC services. Are services stable, robust and provide a sufficient network strength and density? How fierce is the competition between MNOs? Would a transport purse stored on a mobile phone be a barrier to change the network provider?

NFC can only be successful if it is also attractive and competitive in comparison with other sales channels. What alternatives do exist and what costs do you save when changing the distribution system?

It is crucial for success to make sure the passengers are following and embrace the NFC offer. You should not overestimate the adoption of the service by your customers, people are not all likely to rush on an NFC service only because it is new or innovative, it takes some patience and continuous promotion and improvement to get there.

Do you really need to be different?

Recent years have seen a major shift from cash to cashless payment. You can buy a news-paper, lunch or entrance tickets with the same bankcard using mostly the same procedure. Should public transport not be as easy? Passengers do not want to buy a ticket ; they want to buy a ride.

Smart ticketing could allow moving many processes into the background and improving the accessibility of PT systems for passengers. Direct acceptance of common payment methods such as bankcards or the integration of travel application into mobile purses could remove a lot of worry about having the right ticket.

There are solid and secure cashless payments on the market, passengers are familiar with them and use for other transactions. Why not offering the same for public transport and use existing solutions for encryption, card reading, account management etc.?

Of course, technology is developing fast, solutions that currently state of the art may be outdated in a while and standards existing today may change in the future. But then again, isn't it better to face such a challenge as part of a larger business community than alone?

Rather than making huge efforts to find a proprietary solution that "for sure" will survive for the next 30 years a more agile approach might be smarter, let's explore and test interesting developments such as NFC to find what could really bring a benefit to both PT providers and customers.

As long as the NFC is a non-standardized functionality do not underestimate the run cost of the service even if the built cost seems attractive. Try to contractualize a fee capping system in order to keep control of your income.

Is your system open or gated? Physical validation?

When implementing NFC ticketing technology, several points need to be considered concerning physical validation. In a card-centric system, where all information is stored on the card or chip itself, any information update needs to be communicated to and from all validators. A back-office system makes the communication procedure between ticket medium and validator much easier, but requires the connection to the back-office.

With high passenger numbers the validation and transaction speed becomes increasingly important. New ticketing solutions need to be thoroughly tested to ensure that passengers are not slowed down at check in or check out.

Security is an important factor to develop a reliable ticketing system. With NFC security can be built up in layers, where controls can be done in several levels, at the card end or at the back office/account end. Protocols must be tested and managed carefully, it is important to ensure protocols work for ticket selling, validation and inspection.

NFC ticketing makes an end to anonymous travelling ; you need rules to respect privacy and data protection.

Who would be your target group for NFC?

It is important to have a clear idea who is the (initial) target group for your NFC project. The technology may provide interesting benefits for many groups, but the needs and constraints of these groups may have a key impact on the set-up and business model of the mobile ticketing system.

- Regular Traveller – commuter, season ticket holder – a trusted customer can form a different risk model to a new user. A PTA may be willing to grant greater flexibility or higher limits as it is known that a regular traveller always pays his/her fare ;

- Occasional Traveller – Pay As You Go user or occasional low value season ticket user (daily / weekly). This can include customers who infrequently travel but are frequent travellers and require consistency each time they travel. Fare products for those travellers could be smart card based or gsm based as they most likely have a subscription with a local MNO ;

- Domestic Visitors – customers can plan and pay for travel before arriving in their desired location for travel. Being able to provide a card-less ticketing solution for theses customers may help to substantially reduce costs for ticket issuing ;

- International Visitors – by using mobile payment, you reduce the reliance on foreign cur-rency exchange. An app in the user's native language could also be easier than using card centric ticketing. As it will be difficult for a PTA to negotiate agreements with foreign MNOs, the consideration of bank card payment might be more straightforward ;

- Concessions & Discounts (e.g. Elderly / Disabled / Children / War Veterans / Police / PTA Staff)- These customers may require free travel or reduced rate travel ; this can change the customer proposition if these customers use a token to open the gates instead of a monetary transaction needing to occur.

NFC can also allow extra functionalities and can be used outside of travel ticketing with added services such as advertising, parcel collection, tourist attraction ticketing and loyalty programs.

In general, some points need special attention when designing NFC ticket solutions:

- Not everyone has a mobile phone or a contactless bankcard, so all NFC can ever be is a supplementary form or payment ;

- Not everyone with a phone is prone to use it for travel – even those with the money and technology may not trust the system or the phone (eg. Battery capacity) ;
- Will NFC be used to replicate all current tickets, or just those tickets used by particular demographics?
- Can NFC payments be tied to third party payments, for example, allowing customers to use governmental benefits money on transport ;
- Still, the use of mobile phones abroad implies charges for international travellers, there is a general need to find a solution if NFC services should be widely adopted.

Does NFC fit in with your general strategy?
Do not think NFC ticketing service independently of your whole service policy.

NFC is a fascinating technology that certainly allows and requires a new approach towards customer service, also in public transport. The market potential seems interesting for various business segments and often public transport is referred to as the "killer application" that may bring the final breakthrough for NFC technology.

PT authorities may find themselves pushed into a business environment that is very different from the traditional PT market, and with a lot of parties trying to get a piece of that new market cake, one thing is important - that a PT authority knows what it wants.

Implementing NFC comes along with investment, whether made by the PTA itself or realised through partnership agreements you will have to think long-term and probably big. It is therefore important to carefully plan steps and be consistent.

- Identify for which parts of your development strategy NFC could be beneficial- could NFC solve more than one problem/help reaching more than one goal?
- Define what added value NFC could offer for your customers which "combined products" do you want to offer – is using NFC the key to any of these?
- Analyse the market penetration of NFC based cards and phones in your context how wide would an NFC-based solution reach, does the audience you could reach correspond with a target group you have in mind?

If you decide to launch a really innovative NFC service, deploy first a pilot to acquire experience and make not launch an NFC service alone without the perspective of having other services coming soon.

Even if you do not consider yet that NFC implementation should be on the top of your business agenda, it could be an idea to choose a step-by-step approach. If your market is not ready yet, don't close doors for future possibilities by investing in non-NFC compliant technology.

Can NFC improve customer support/services/communication?
Of course NFC is a ticketing service tool, but it should also be seen as an information and service tool. For a real breakthrough it seems important to ensure the "universality" of the service, island solutions may not promote trust and loyalty.

In order to implement an NFC solution successfully, PT authorities need to move from seeing passengers as user towards regarding them as customers. In that context, NFC is a convenient tool to:

- Allow customers to have a means in their pocket to consult their travel data on a smart card ;
- Ensure customers can consult their travel account and balance ;
- Provide personalised information to customers concerning their journey, incl. changes, incidents, delays, new services, etc... ;
- Enable customers to schedule their journey time more flexibly ;
- Facilitate information or entertainment services as well as the bundling of such services.

Individual needs can be difficult to address, when all communication channels are general. The key advantage of NFC is its potential for customisation, passengers can receive the information they need for their own journey, be it related to fare products, connections, problems or simply access routes for passengers with reduced mobility.

A key question that needs to be answered in order to provide a reliable and attractive NFC service is: Who is the point of contact for customer service, technical problems, lost or stolen phone?

10 Pilot projects

STIF – NFC ticketing in the Paris Ile-de-France region

STIF Navigo e-ticketing system exists since 2001. The whole system was based on a proprietary communication protocol (type Innovatron) since the ISO 14 443 standards were not well established at that moment. All the season fares have migrated from the magnetic stripe tickets to the Navigo contactless card (from the annual pass to the week pass) since then.

Nowadays two types of media coexist in the ticketing system: contactless cards (for long season fares) and magnetic stripe tickets (for single trip to 5 days fares).

STIF is currently working in the modernisation of its whole ticketing system. One of the stakes is to find an alternative to the magnetic stripe tickets that are said to be outdated and easy to make copy of. The NFC transport application on a mobile seems to be one of the emergent technologies that can partially contribute to the replacement of the magnetic stripe tickets used by occasional commuters.

Prototype architecture.
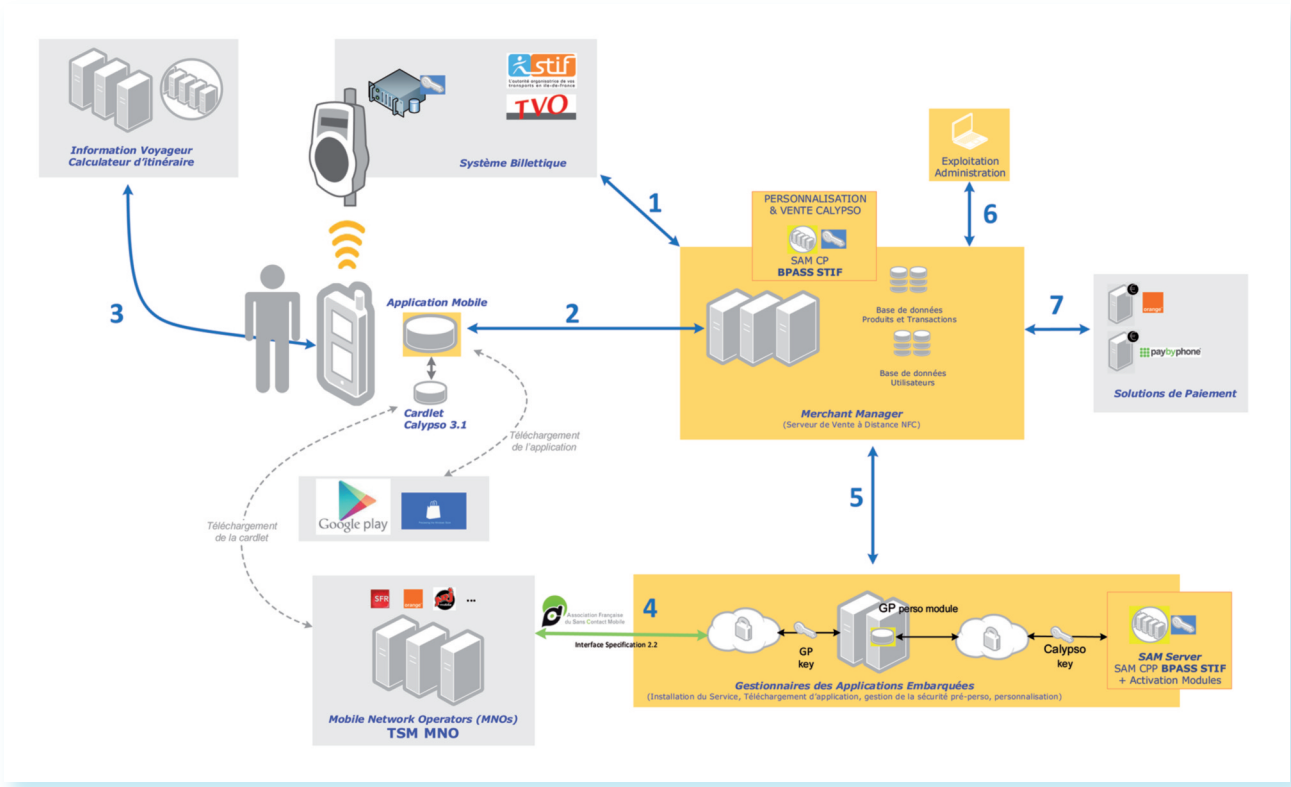
By Digimobee - Diagram IV Technical architecture of the STIF experiment

Stakeholders pushing the NFC

In France many actors are pushing the NFC:

- The French government through governmental initiatives and funding is encouraging the PTA and other administrations to adopt the NFC. It hopes, through this approach, to rekindle the French industry ;

- Some industrials (i.e. TSM solution providers) are eager to impose this channel to offer their services ;

- The MNO, since network operators are pushing the SIM centric architecture and have invested quite a lot in this technology over the last decades, NFC will position them as an inevitable partner. They would be able to generate new income (depending on the business model) ;

- PTO: Some PTO like SNCF, is promoting the Triangle 2 application, that would allow the media interoperability between several networks. NFC would be a way to rapidly deploy this "common" application.

Expectations and requirements

NFC could be a driver helping to reduce the cost of issuing cards and selling tickets, especially as it could help to reduce the use of magnetic stripe tickets. NFC could be very useful to address foreign travellers, helping them to prepare their travels in Paris on beforehand. NFC could allow to rapidly testing new fare products (t-purse, off-peak fare) as well as adding integrated services, such as travel planners or real time information.

In order to proceed with NFC technology it is important that interoperability can be achieved that all NFC phones behave the same way and are compatible with the equipment already installed. It could be achieved by:

- Defining NFC certification process to evaluated end to end NFC solution ;

- Defining a unique way to install a NFC application ;

- Having a unique interface between the service provider TSM and the MNO TSM.

STIF must be certain that:

- The total costs would not exceed existing the costs for other fare media ;

- The user experience is comparable, independently on the MNO or handset used ;

- Coherent procedures are defined to change from one MNO to another ;

- The governance and responsibilities within the NFC ecosystem are clearly defined and accepted by all parties ;

- The transaction time is similar to the one of a smart card ;

- The battery off mode is possible for validation ;

- The evolution of the elements is well planned, has no impact on the service and can insure backward compatibility ;

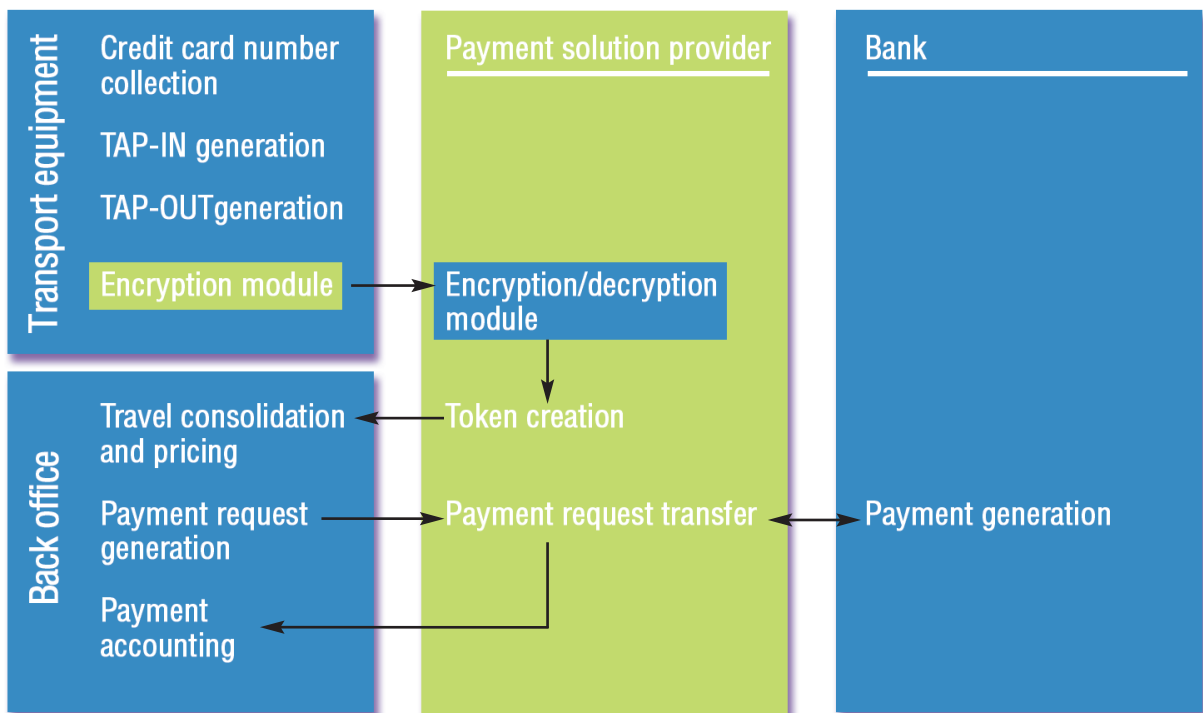- The sustainability of the NFC services is ensured.

Lesson learned

- In order to manage the risk associated with a new technology, a small-scale experimentation should be deployed first due to the possible under-estimation of the technical complexity of the NFC area, and the lack of many stakeholders preliminary knowledge of NFC at a large scale ;

- In order to evaluate the certification, you will have to do evaluate the level of current standardization on NFC functionality. Check that the certification process is defined and shared with all the technical actors. Do not overestimate the level of standardization of the NFC. As long as the NFC functionality is not defined by the GSMA or by another organization, do not underestimate the cost of running tests on new phone models to check their compatibility with the existing versions of the NFC application ;

- Do not overestimate the public appetite for a new NFC service and focus on the real added service provided to the customer via NFC. The evaluation through a public survey is necessary to quantify the public interest/eligibility for. Do not think the problem is to launch an NFC service. It is more to make it more attractive and guaranty its sustainability. The effort needed will have to be maintained after launch. In order to not overestimate the adoption of the service evaluate in your specific context the existing barriers for customers to use the serv-ice for the first time and for the following times ;

- Do not think of the NFC ticketing as a standalone service. The NFC service must be integrated in the big picture of the customer service strategy. It must not be a heterogeneous service but integrated in the whole customer communication project ;

- If you launch a transport NFC service before the other major players, such as big banks or a chain of shops, do not expect a mass adoption of the transport service. A « bunch of services » should exist prior to the transport NFC service. If you launch a NFC service with only selective phone operators, take into account that it will be more difficult to help customer adoption by doing mass communication campaigns ;

- Consider carefully your specific context and your motivations. In the French context, the motivation to develop a NFC service is mainly driven by the will to offer extra services to travellers. Since magnetic stripe tickets are nowadays very cheap to issue and distribute, no cost reduction is possible. Evaluate if your country is in the same position or if you can expect extra revenue, cost reduction ;

- In order to evaluate the stability of your NFC service, identify who is in charge to decide a change in one of the technical component required to use the NFC service ;

- In order to keep under control your costs, consider that once the NFC will be mass adopted, the service will be taken for granted for users and it will not be possible to suppress it. You have to estimate if the fee structure could evolve and be a future extra charge for the PTA or the transport company. NFC creates third party dependencies, which must be studied. In order to evaluate the debt creation on your ticketing system identify the new constraints that NFC impose on your equipment (validators, inspection devices…) and your back-office system.

The Future Ticketing Project (FTP) enables the acceptance of Contactless Payment Cards (CPCs) across London's transport system where Oyster cards are accepted today, as a means to access the transport system and pay for travel.

FTP will enhance the ticketing system, using new technologies to reduce operating costs and make business processes more efficient. It will also deliver customer benefits by providing a more convenient way for customers to pay for travel.

Transport for London - Future Ticketing Programme

Transport equipment
- Credit card number collection
- TAP-IN generation
- TAP-OUTgeneration
- Encryption module

Payment solution provider
- Encryption/decryption module
- Token creation
- Payment request transfer

Bank
- Payment generation

Back office
- Travel consolidation and pricing
- Payment request generation
- Payment accounting

Open loop card processing environement

One of the new technologies being explored are NFC ticketing on smartphones with the replication of both EMV standard CPCs as well as a TfL issued card. Having issued 60 million Oyster cards for travel, there is a clear business case to reduce card issuance and moving customers to self-servicing with their own mobile handset.

Using the TfL built Fares & Aggregation Engine (FAE) back office, TfL aim to allow entry to the system via NFC enabled handsets using a secure element. The expectation of where this secure element sits is up to the market to deliver. Ideally customers will be able to load funds, check journey history, apply for refunds and journey plan in one synchronised and efficient mobile application.

TfL have engaged with the major payment schemes, banks, MNOs, faster payments networks to understand what the market can deliver and if they meet TfL's requirements. Due to a combination of the London Underground estate being gated and the high volumes of customers, there are still issued with the transaction speed of NFC ticketing needing to be quicker.

One major benefit in the UK is the efforts of the market to launch mobile payments on a united front with many partnerships being formed to make negotiations and direction easier.

There have been lessons learned already through early market engagement. The market has not fully matured to a state where every party knows their role. It is important to keep a firm hold on your requirements and constraints. It is essential to have a good business case that is specific to your business and not be swayed by what the market thinks you may require.

TfL aims to launch pilots of NFC technology beyond ticketing, focussing firstly on pushing personalised information to customers who want it as well as exploring further opportunities to aid business as usual internally.

Ruter – NFC in the Oslo-region

MNO Telenor and bank DNB is currently running a pilot on contactless payment in retail (kiosks). This is done by using the app "Valyou" from the trusted service manager TSM Nordic. Ruter is not a part of this pilot.

Ruter has been looking into a comparable service for our customers. We would like to offer the customers the possibility to buy (at first stage) a single ticket for one zone. Before going into a pilot stage, we need to:

- Identify the added value to the customers offering this possibility ;
- Identify the extra cost and savings related to this service ;
- Develop the card readers to be able to read EMV based tickets ;
- Clarify the business rules related to this ticket, including the ticket inspection.

We do not have a clear timeline as to when we will start this fundamental, basic clarification work. For the time being, there are only a couple of small banks offering contactless bankcards, and NFC phones are not too widespread, as iOS is the dominant operating system among active smartphone users.

Ruter is offering ticket sales through a mobile application for iOS, Android and Windows Phone. If considered advantageous, it could be possible to replace QR codes with NFC based solution to read/start the ticket when market penetration of NFC-phones is sufficiently high.

Ruter has currently no plans to emulate travel cards on phones.

There has also been started a test project enabling NFC-phones to read the content of a mifare-card. This could also enable purchasing tickets via smartphone and then download the ticket on the customer's travel card – if the customer prefers to use the card as the ticket carrier and not the smartphone. This test project is run by the state railway (NSB).

ZTM – NFC ticketing in Poland

NFC technology today is very popular in Poland and payment solutions are being tested in retail, banks and public transport. A key concern is still the security of the technology for both, the customer and company offering the service. Therefore, NFC in Warsaw public transport is in a test phase.

In Warsaw there is a big interest in NFC among the mobile network operators. Each of these companies has another application developed, but every these solutions based are on NFC (tags, mobile phones etc.).

If we want to use NFC in public transport ticketing and collect fares from passengers we have to thoroughly assess the risks associated with this technology. In the interest of the passenger we have to address the risk of theft of funds from the NFC purse, in the interest of the PT providers we need to guarantee the reliable communication between NFC chip and validator to ensure correct payment.

A further challenge identified concerns the handling of financial transactions between all partners involved, the PT authority as well as the mobile network operators or banks. It has to be ensured that all fares from buses, trams etc. will be correctly monitored and transferred.

ATM Barcelona: T-Mobilitat project

The Barcelona metropolitan area is poised to make a quantum leap in urban mobility, which will subsequently be rolled-out to the rest of Catalonia.

Barcelona's new transport pass is the logical consequence of the development of the integrated public transport system that was launched in 2001, which allows users to make journeys with the same ticket involving all OT and transfers with no financial penalty. This system's maturity, together with techno-logical development and the spread of mobile importance among users, have almost naturally led to the concept of the T-Mobilitat.

The contactless technology used to develop the new system, designed and promoted by the MTA, have made possible to follow the model established in Directive 2010/40/EU on Intelligent Transport Systems (ITS), mainly focused on the concept of interoperability.

The transport ticket will be based on high performance chips –so far DESFire, CIPURSE- applicable to any medium: be it a card or NFC mobile phones and also the use of bank-cards will be permitted in the future.

Regarding NFC, the policy adopted is that provided the security is guaranteed –which will be the responsibility of the ATM–, all technologies will be put available (SIM based or Secured HCE) so that the Transport System can take advantage of the business model while fitting the passengers' preferences.

Thus, by the NFC-based technology, the new system adapts Catalan public transport to modern users, who are increasingly being hyper-connected and demand on-line information, and extends the scope of smart mobility as a whole.

The implementation of the T-Mobilitat involves the entry into force of a new fare system that basically is expected to adjust the prices for trips to each user's profile.

Innovation has also reached the marketing channels: new ways of charging the ticket via the internet and mobile phones will be possible, as well as a post-paid direct debit for the service.

The new mobility paradigms in Catalonia have recently started their works, after being engaged in a PPP tender process through 2014. A pilot phase is expected by end 2015. The public launch of the system is due in 2016, and for the Barcelona Area it will coexist with the current magnetic ticketing system until 2017.

Appendix :

synthetic comparison of the existing NFC solutions as described in the chapter 4 of this document.

Few definitions used in the following table

Secure Element: most of the experience gained on this topic is based on projects using UICC as se-cure element.

HCE: Host-Based Card Emulation – technology promoted by Google since Android 4.4.

Hybrid Solution: a solution that combines the use of HCE together with a way of improving its security, for example by the storage of keys in the TEE.

ApplePay is a recent example of another type of hybrid solution: it combines the use of an embedded secure element together with Limited validity payment tokens. It is so far only available on Iphone 6, but overall is a step forward and a step backward: totally proprietary system, only valid for bank trans-action payment.

TEE: Trusted Execution Environment.

ID: identifier of the device that can be used in combination with a mobile application

TSM: Trusted Service Manager – wording used for the management of application in a secure element.

TAM: Trusted Application Manager – wording used for the management of application in a TEE.

11.1 Comparison

	Secure Element (SE)	HCE based solution	Hybrid solutions (*)
Security			
Logica Security type	(OS of the chip) and physical thanks to the tamper-resistant hardware	Logical: software with lower protection Device identification not against clone.	Logical in combination with physical contribution (ID, TEE)
Security level risk mitigation	Proven and high Ex : EAL4+ security certification level of French UICC	Low, non proven. Covered – no protection against clone. To be used in combination with limited validity tokens to reduce the level of risk. Complexity in assessing and verifying level of risk	Medium – to be proved Device identification might be provided Ex : GP Protection Profile for TEE EAL2+

Technology			
Required components in the mobile	Cardlet (Applet in the secure element) together with physicaland physical Possibility to store keys and confidential data in the cardlet.	Mobile application Possibility to use tokens (see above)	Mobile application + keys or ID in a hard-ware or TEE
Sustainable technology (interoperabil-ity)	A reference for compliance (normalization) exists for the deployment of app	OS dependent (to date, only for Kitkat -Android 4.4- and Blackberry 10)	As HCE based solutions
RF protocol	ISO14443 Type A and B + possible implementation of Mifare	ISO14443 Type A and B only No implementation of Mifare	Same as HCE
Standardization	High	Low solution pushed for/by Google	As HCE based solutions
Maturity	High	Low	Low

Provisioning App			
Operational impact (trans-port)	Significant either regarding internal parties (customer office) and third parties (owner SE=MNO and TSM)	Easier provisioning, requires neither MNO nor TSM.	Requires the TAM

User experience			
Installation of the service	Service discovery for the existing stores. Initial app installation may be long and complex.	Good customer experience: simple application download from a store.	Service discovery for the existing stores. No experience on the impact of the TAM on installation process
Use of the service	As simple as using a card + additional functionalities	Active handset required (powered on and not idle) The need to unlock may be requested – option per service	As HCE based solutions
	Battery off possible		
Lost&stolen	Better than physical card	Idem	Idem
Involved parties			
Organization	Secure Element Issuer and its TSM Service Provider and its TSM	Service Provider	Service Provider + TAM (for TEE)

Complexity	Multi-party ecosystem (out of the transport operator control)	Complexity lies with the issuing solution (transport operator or authority in command)	Not experienced yet
Business Model			
Organization	Highly complex, many actors. Global business model doesn't exist yet.	Simpler. Likely to be deployed at mass scale	As HCE based solutions + price for the TAM service
Integration div. Services	SE management conditioned	No physical constriction. Easier	As HCE based solutions
Auditability	Robust, formal process	Not necessary	As HCE based solutions
Costs of investment	Significant (covered by SE issuer and Service Provider due to the need of TSM on both sides)	Unknown but expected to be much lower as there is no TSM in the loop	The need for the access to the TAM will probably probably increase the cost of investment compared to SE
Operational cost	Significant (mainly covered by user or service provider. Transaction level Regular upgrade of mobile application	Much lesser (Likelihood to be Fee for SW license) Regular upgrade of mobile application	As HCE based solutions + price for the TAM service Regular upgrade of mobile application

EMTA

European Metropolitan Transport Authorities

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