Near Field Communication (NFC) and Transit: Applications, Technology and Implementation Considerations

A Smart Card Alliance Transportation Council White Paper

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Smart Card Alliance
191 Clarksville Rd.
Princeton Junction, NJ 08550
www.smartcardalliance.org

About the Smart Card Alliance

The Smart Card Alliance is a not-for-profit, multi-industry association working to stimulate the understanding, adoption, use and widespread application of smart card technology. Through specific projects such as education programs, market research, advocacy, industry relations and open forums, the Alliance keeps its members connected to industry leaders and innovative thought. The Alliance is the single industry voice for smart cards, leading industry discussion on the impact and value of smart cards in the U.S. and Latin America. For more information please visit http://www.smartcardalliance.org.

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1 Introduction

Mobile devices and phones have been in use since the early 1990s, and their rapid acceptance may lead them to eclipse the use of personal computers everywhere. Powerful new handsets are attracting new customers, while mobile operators are upgrading networks to accommodate seemingly endless mobile applications; private companies and government agencies in turn are developing IT strategies to adapt and thrive in the mobile environment. Added to this is an innovation that will significantly influence the direction and growth of mobile commerce: Near Field Communication, or NFC, a radio frequency (RF) communication technology that allows data to be exchanged between electronic devices in close proximity. NFC is expected to be used for a wide variety of applications, including: payments, coupons and merchant promotions, and transit ticketing.

As a short range or proximity technology, NFC differs significantly from more common forms of mobile communication. Mobile payment implementations, in particular, typically require a back-end server and transmit data using mobile channels, such as short message service (SMS), mobile applications (apps), or a browser. Mobile payment alternatives currently include the use of contactless stickers, microSD cards, and 2-D bar codes.

In contrast, mobile payment with NFC technology relies on a handset provisioned with a payment application, which may be provided by one of the major card brands and personalized with a payment account from the consumer's financial institution. Mobile NFC payment and settlement processes are identical to the processes executed when a contactless or magnetic-stripe credit or debit card is used for payment. The difference is that NFC-enabled devices offer two-way functionality; that is, an NFC-enabled device may act as both a contactless card and a contactless reader. This supports interactive processes whereby the consumer may collect information on the NFC-enabled device in the form of coupons, directions, web site/app store links, or buyer incentives from electronic boards, posters, or maps. Based on this information, the consumer can then choose to make a purchase. The actual payment transaction may be the final step in a series of data exchanges between the NFC-enabled device and a contactless point-of-sale (POS) reader. In short, an NFC-enabled device offers additional options for obtaining information to make purchase decisions, as well as a convenient way to make contactless purchases.

This white paper presents a high level perspective on different NFC applications that can be used in the public transit industry. The Smart Card Alliance Transportation Council has prepared this white paper to foster greater understanding of NFC technology, explain its role in the transit industry, and shed light on key issues facing the transit industry in developing a mobile strategy. It builds on the knowledge base developed in earlier white papers, including those from the NFC Forum and Smart Card Alliance Payments Council. In particular, this white paper explores the use of NFC for payment, transit ticketing and transit information applications. The Transportation Council believes NFC can help transit agencies overcome challenges faced by all transit riders, including selecting the correct route, obtaining real-time schedule information, acquiring fare media, purchasing fare product, paying the best fare, and viewing the status of fare products, all by way of an NFC-enabled handset.

2 Overview of Transit Mobile Applications

The public transit mobile landscape includes passenger information needs, front-line employee communication, vehicle fleet monitoring, and facilities management. Each of these areas offers both challenges and opportunities for improving safety, customer satisfaction, and service reliability.

Most transit agencies have deployed wireless or mobile applications by supplementing conventional radio systems with a range of new applications, such as automated stop announcements, automatic vehicle location, and automated passenger counters. NFC technology builds upon these capabilities to provide personalized services for mobile computing, geospatial information, and even social media.

2.1 Provision of Real-Time Information

Transit users and motorists alike increasingly want real-time travel information. Mobile technology, and especially the mobile phone, is changing the way transit operators provide such information. Device functionality such as location services, Internet browsing, in-app messaging, and SMS provides an opportunity to disseminate information to riders. Underlying vehicle tracking and arrival forecasting technologies, combined with trip planning software, create a seamless system for planning transit trips. Until recently, for example, the common complaint about transit use was that the passenger was unable to determine vehicle arrival time, due to the absence of real-time information about the location of the next vehicle or its arrival (or last departure) time. In the past, riders waiting for a bus or train had to rely on published timetables and hope the service was running on time.

Today, many operators are developing the means to provide real-time vehicle location information and even allow vehicle tracking through innovative design solutions on Web systems, mobile applications, and urban information displays. Transit operators are also realizing the benefits of "open data," which provides free access to schedule and real-time information that was previously restricted or unavailable to the public. Recently, Transport for London (TfL) began providing free access to internal data, New York City Transit now permits access to schedule data, and the Washington Metropolitan Area Transit Authority (WMATA) has made its real-time data available to the public.

Mobile Internet access and smart phone applications commonly supplement traditional media to convey real-time information (e.g., dynamic message signs and interactive voice response). Trimet, the transit operator in Portland, Oregon, ranks among the industry leaders in developing applications to improve the passenger experience. Using open-source information technology, the agency shares schedule and route data with third-party developers, who create interactive travel planning and mapping capabilities. The increasing use of mobile devices by riders encouraged Trimet to create an online "app center" with links to more than two dozen transit applications. Some of the more popular applications include:

- **Vehicle Arrival Time**. Using the GPS and schedule data, this app provides vehicle arrival times to iPhones and allows passengers to bookmark frequently used stops.
- **Nearest Bus Stop**. Passengers can use this app to search for the nearest transit stops and obtain arrival information and a map.
- **Directions and Trip Planning**. This app uses text messages to provide public transit directions and trip planning information.
- **Points of Interest**. This app uses the GPS to provide points of interest around bus stops.

Currently, mobile phones equipped with NFC technology are not being widely used to access real-time transit information, although the potential for such use remains high. An NFC-enabled phone provides passengers with access to the current array of information and services now accessible using broadband cellular and Wi-Fi. In addition, using NFC, passengers can instantly

download a bus timetable, check fares, or determine a vehicle location by touching a phone to a kiosk or "smart" poster (i.e., a poster provisioned with an NFC tag).

Public transport occupies a unique place in the world of mobile technology. Passengers riding in a vehicle can access entertainment, information, and social networks. The availability of real-time information and related transit applications provide the foundation required for NFC to take hold, expand, and create further value. Buses and rail vehicles, for example, typically display posters and advertising to riders. If vehicle advertising or posters are smart, riders can learn about products and obtain coupons or directions. When a passenger taps a poster, the handset connects to the mobile network and to a back-end system that links the passenger to the poster. The server sends information back to the passenger that can even be tailored to a specific location.

The 2007 Transport for London pilot, for example, tested NFC-enabled phones and "smart" posters. Passengers in the trial entered a destination into their phone and, upon transferring to another line, touched the phone to a poster. The phone's handset screen instantly provided detailed travel information, including a map of the station and surrounding area and real-time travel information.

2.2 Additional Opportunities

Several successful trials have revealed that passengers also want to be able to pay transit fares with a mobile device. Ticketing and payment are applications that are well suited to NFC technology. By touching a phone on a bus fare box or NFC turnstile, the passenger could either process a virtual card resident in their phone or initiate an authentication process with a back-office server that can be configured to charge a flat fare or a distance-based (i.e., tag in-tag out) fare.

As an early adopter of contactless technology for fare payment, the transit industry is well positioned to take advantage of NFC technology for both payment and non-payment applications. Riders in several major cities are already accustomed to waving or tapping contactless cards against fare boxes and turnstile readers. Enabling mobile phones with NFC lets riders pay fares directly at the point of entry to the transit system. In a typical sequence, a transit rider could plan a trip and prepay the fare by connecting to a transit agency's Web site; the electronic ticket or fare can be downloaded to the mobile phone and presented to a reader at a transit station or bus fare box. Payment for parking is another option if the parking lot entry point is equipped with an NFC reader. Transit customers can then touch an NFC-enabled phone to the reader to complete the payment transaction.

2.3 Pilot Projects

In 2010, Juniper Research published a study on the growth of mobile ticketing and estimated that some 15 billion mobile tickets will be purchased by 2014.[1] The forecast volume strongly suggests that, over time, mobile ticketing could transition to many other industries outside of transportation.

Several pilot projects have successfully demonstrated the potential benefits of using NFC for mobile ticketing and transit payment and for transit information access. A more detailed list of NFC pilots in transit is included in Appendix A.

2.3.1 NJ TRANSIT, 2011

NJ TRANSIT is New Jersey's statewide public transportation corporation. An ongoing pilot features the acceptance of Google Wallet, which stores a virtual version of a credit, debit, or prepaid card on a mobile phone. The application is currently compatible with Sprint Nexus S NFC mobile phones, Citi MasterCard, and Google's prepaid card. Google is also working with

[1] *Mobile Payment Markets: Contactless NFC 2008-2013*, prepared by Howard Wilcox of Juniper Research, February, 2010.

POS system companies and top retail brands to allow consumers to be able to pay for an item using a credit card or gift card, redeem promotions and earn loyalty points.

NJ TRANSIT is the first transit agency in the country to partner with Google Wallet to test NFC mobile payments, allowing customers to pay with a simple tap of a mobile phone. NJ TRANSIT is testing this technology at ticket vending machines and ticket windows in New York Penn Station and the Port Authority Bus Terminal, on seven bus routes from the Greenville Garage, and at Newark AirTrain Station. This technology offers NJ TRANSIT customers the following benefits:

- Improves the customer payment and ticketing experience
- Decreases transaction times
- Decreases bus boarding/dwell times
- Broadens the customer base for contactless payments

2.3.2 London, 2007

An NFC pilot project in London involved the collaboration of several participants, including TfL, Transys/Cubic, a mobile network operator (O2), Nokia, Barclaycard, and Visa. Approximately 500 O2 customers received a Nokia 6131 NFC-enabled mobile phone on which the Oyster card and credit cards were available. The phone allowed riders to load "pay as you go" value and calendar period passes to an Oyster card instance provisioned to the phone. Participants were able to tap and go on all Oyster-equipped Underground, bus, and tram fare terminals.

Given the lack of contactless payment awareness at the time, it is not surprising that the Oyster functionality created the highest customer satisfaction and interest. Contactless usage and terminal deployment were far more prevalent in transit than retail during this period, and twice as many users expressed strong interest in the transit features as compared to retail payment features. Overall, more than 90% of participants reported their expectations had been exceeded, with more than 50% stating that the presence of transit payment on the phone would influence their choice of handset. The firm compiling this data described these results as an incredibly high satisfaction rate for a new technology product.[2]

Patrons repeatedly cited the benefit of "not getting caught out forgetting your Oyster Card at home" as a key benefit. Being able to see the Oyster balance was also highly ranked as a feature consumers would like to see.

Going forward, TfL is pursuing an open payments strategy where contactless bank cards will be accepted at transit fare terminals. As such, it is anticipated that NFC implementation at TfL will see patrons using open payment cards held in the mobile wallet as the credential for mobile fare payment. From a user perspective, however, the key value propositions remain unchanged:

- A convenient, always-with-you form of fare media
- Convenient account management and top-up tools
- Access to real-time passenger information
- Opportunities for cross promotion between transport and retail merchant categories

2.3.3 San Francisco, January-May 2008

A Bay Area Rapid Transit (BART) NFC trial combined transport ticketing with mobile payment. BART riders used Samsung NFC-enabled handsets at all BART fare gates to access stations (and to pay for meals at Jack in the Box restaurants) in the San Francisco Bay Area. Project partners included ViVOtech, Cubic, Sprint, and First Data; the pilot also featured smart posters at BART stations that directed customers to retailers where they could redeem NFC-enabled contactless gift card credits. For transit, a BART EasyRider™ fare product was provisioned to the

[2] Source: Cubic

handset and processed without the need for software modifications to the gating system. Over the course of the pilot, 230 participants took over 9000 trips and performed 800 mobile top-ups. More than 80% of users found the application easy to use. Recent focus group research conducted by Cubic found increasing levels of mobile engagement and awareness across the overall transit population.[3]

2.3.4 Germany, 2008

The German rail authority, Deutsche Bahn, and its partners, Vodafone, Deutsche Telekom, and O2 Germany, conducted an NFC pilot on intercity trains connecting Berlin, Cologne, Dusseldorf, and Frankfurt; local rail services in Berlin; and transit services in Potsdam. The project's 3,000 participants used phones running a ticketing application called Touch&Travel. At the departing station, the rider placed a phone near a reader that contained an NFC tag with station location information. The departure location was sent to a back-end system over the mobile network, recording passenger check-in on the phone. Upon arrival, the passenger tagged the phone out, completing the journey and fare calculation.

2.3.5 Summary

Through the various field trials, full system implementations in Asia, and a variety of market and focus group studies, it has been continually demonstrated that transit patrons warmly embrace mobile fare payment and associated real-time information services. User acceptance rates are very high with the participants citing convenience, access to information (e.g., account balance and status), and transit service data all offering substantial value. These user benefits can be offered to consumers in both closed loop transit card systems (such as BART and Oyster) or in open loop environments, such as those now being introduced to markets such as London, Chicago, Philadelphia and New Jersey.

[3] Source: Cubic

3 NFC Applications that Benefit Transit

NFC technology is a standards-based wireless communication technology that allows data to be exchanged between devices located a few centimeters apart. The NFC based "touch paradigm" supports a range of new applications for mobile phones, including:

- Making payments with a touch of a device anywhere contactless POS readers have been deployed
- Reading information and picking up special offers, coupons, and discounts from posters or billboards on which an NFC tag has been embedded (for example, in smart posters and billboards)
- Storing travel data, fare product, or tickets for transportation, parking access, or events securely, and enabling fast transactions at the point of entry or exit
- Storing information that protects secure building access
- Sharing content between two NFC phones

This section provides an overview of the standards and specifications supporting NFC and describes three different NFC applications that can benefit transit:

- NFC-enabled bank card payment for transit fares
- NFC-enabled closed system transit ticketing and payment
- NFC-enabled transit information applications

3.1 Standards and Specifications

NFC-enabled devices are governed by multiple standards (ISO/IEC standard 18092, ETSI standard TS 102 10 V1.1.1 [2003-03], and ECMA standard 340) and by specifications published by the industry association, the NFC Forum. ISO/IEC 18092 allows for backward compatibility with current contactless devices by supporting ISO/IEC 14443 (the standard used by payment-network-branded contactless payment cards and devices) and the Japanese Industrial Standard (JIS) X 6319-4 (also known as FeliCa) contactless interface protocols.

An NFC-enabled device can operate in reader/writer, peer-to-peer, and card emulation mode. For mobile contactless payments and mobile ticketing, the NFC-enabled mobile device operates in card emulation mode; an external reader sees it as a traditional contactless smart card. Payment information is stored in the mobile phone in a secure element (SE), which is a smart card chip that protects stored data and enables secure transactions. For transit, card emulation mode can facilitate either a conventional read/write transit transaction or an account-based open payments transaction.

NFC-enabled mobile phones are compatible with the contactless smart card acceptance infrastructure (based on ISO/IEC 14443). NFC phones can therefore be used with current contactless payment and ticketing services without requiring additional investment in an already contactless-enabled terminal infrastructure. Current contactless applications such as MasterCard PayPass®, Visa payWave, or a transit fare payment card can be supported on a mobile phone—a new form factor. Use of a mobile phone for contactless applications replaces the "passive" plastic card with something much more powerful—a mobile device on which applications can be managed online and through which the consumer experience can be greatly enhanced, thanks to the mobile device's rich user interface.

The NFC Forum[4] has developed and released implementation specifications and has also launched a certification program that checks devices for compliance with NFC Forum specifications. Compliant devices behave consistently, facilitating an interoperable infrastructure.

[4] http://www.nfc-forum.org.

3.2 NFC-Enabled Open Bank Card Payment

One of the significant benefits to transit operators of supporting a fare collection system that accepts contactless bank cards is that other payment technologies compatible with ISO/IEC 14443 can easily be integrated into the system. A transaction processing model that supports contactless bank cards will support those same applications to the same extent, using NFC-based card emulation.

While basic integration for a payment transaction is relatively simple, NFC-enabled devices can support richer interactive user experiences than can a card, providing the consumer with both greater control and greater flexibility. NFC-enabled applications can deliver more robust capabilities in the three primary stages of the consumer fare payment life cycle:

1. Fare product acquisition
2. System entry and exit, and transaction processing
3. Post-purchase inspection and processing (consumer and operator)

For a more complete description of how contactless open bank cards are used for fare payment, see the Transportation Council white paper, "Transit and Contactless Open Payments: An Emerging Approach for Fare Collection,"[5] which describes the implementation model in more detail.

3.2.1 Fare Product Acquisition

An NFC-enabled mobile device equipped with an open payment application can make fare product acquisition more convenient for consumers. Consumers can purchase products using mobile applications and mobile Web sites or tap on NFC tags available throughout the transit system, making fare product purchases possible literally anywhere.

NFC capability allows agencies to explore new fare purchase use cases. For example, an operator can deploy a map with tags representing locations; passengers can touch their devices to the points on the map that represent their daily journey. The mobile app can then recommend the most efficient product based on the identified destination locations. The passenger can confirm the product selection and select a payment account using either a mobile wallet or a pre-registered funding account. In open payment environments, the payment product residing in the wallet can be used to pay for the fare product.

Some passengers have standing orders to repurchase a product when the current product runs out. In the mobile environment, the passenger has more control and can complete the purchase in real-time or permit the repurchase to occur as usual, at which time the passenger can be prompted to confirm that the product should be purchased. The passenger can be given the opportunity to alter the product to be purchased, the date of the purchase, or the source of funds used to pay for the purchase.

A mobile device can also make it easier for passengers to confirm the purchase of a transit product.

3.2.2 System Entry and Exit, and Transaction Processing

NFC-enabled devices function in a manner very similar to contactless cards at points of entry (and exit) when a transaction is processed. However, passengers have more control over how the information is presented.

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[5] *Transit and Contactless Open Payments: An Emerging Approach for Fare Collection*, Smart Card Alliance Transportation Council white paper, November 2011, http://www.smartcardalliance.org/pages/publications-transit-financial-2011

A key benefit is the passenger's ability to access available balances or the status of the payment account or of pre-purchased products, such as transit stored-value or multi-ride products, before reaching the boarding point. Additionally, different accounts can be selected for different journeys, avoiding possible conflicts when a passenger has multiple contactless accounts.

Another key benefit of the NFC-enabled mobile wallet is that passengers can turn the device's payment capability on or off as they choose. For example, a passcode may be required and an account selected before the device is presented to the gate, enhancing security and mitigating potential fraud. Alternatively, passengers can use the wallet to set up an easy-to-use "card" mode, in which a default application is selected, the NFC antenna operates in passive mode, and no direct passenger interaction is required to complete a payment.

If the transit operator can support offline authorization, counters in NFC-enabled mobile devices can be updated over-the-air, without requiring an online transaction, resulting in more frequent counter refresh and a lower likelihood of passengers running out of funds for offline transactions.

3.2.3 Post-Purchase Inspection and Processing

After a transaction has occurred, a mobile device or application can present the passenger with a current balance or recent ride history. A transit app stored on the mobile device can retain a record of recent transactions that can be used for revenue inspection.

3.3 NFC-Enabled Closed System Transit Ticketing and Payment

NFC systems make it possible to buy new tickets, top up tickets, check maps, and check timetables using a passenger's NFC-enabled mobile phone. An NFC-enabled phone provides passengers with alternative means of acquiring a traditional closed system transit ticket conveniently over-the-air.

3.3.1 Fare Media Acquisition and Top Up

Passengers can use NFC-enabled phones to connect to an NFC-enabled kiosk and download a fare product, or a fare product can be sent directly to their NFC-enabled phone over-the-air (OTA).

Using the phone as an interactive device, a passenger selects a mobile transit application which will start the provisioning of the transit ticket to the NFC-enabled phone. The mobile phone transit application interacts with the trusted service manager (TSM) to load and install the ticket to the secure element (SE) on the phone.

Once installed, the ticket application and information on the SE emulates the traditional ticket and can be used as a normal closed-looped transit contactless fare card. OTA provisioning enables transit issuers to download and personalize credentials for public transportation securely. Different transit operators and issuing authorities have different requirements and processes, so that OTA services will need to be configured individually. As is explained in Section 4, OTA issuance and life-cycle management processes should be carried out by a trusted service manager (TSM).

Once the credential is provisioned to the phone, OTA top-up services offer significant benefits for both transit application issuers and passengers. One of the biggest benefits is a universal framework for purchasing unique products from any local transit system, enabling seamless travel. In addition, queuing at a ticket counter is no longer necessary, and real-time travel information can be delivered along with the ticket.

OTA services also support passenger requirements to reload value onto a ticket application. This service can be performed independent of time and place. This top-up functionality offers benefit to passengers and a powerful new service to issuers.

Passengers are likely to have multiple NFC applications on their mobile devices, including multiple transit applications. One such specification to manage multiple MIFARE applications is MIFARE4Mobile™. This specification extends the use of MIFARE implementations to a variety of secure element form factors, while still leveraging the full capabilities of the mobile device. The MIFARE4Mobile specifications are managed by an inter-industry group founded in June 2010. (Section 10 contains additional information on MIFARE4Mobile.)

In addition, NFC-enabled mobile phones can be used as a ticket vending machine to top-up an existing contactless transit fare payment card.

3.3.2 System Entry/Exit

After the fare product is successfully downloaded to the NFC phone, tapping the phone to a reader validates the ticket and permits access to the transportation system. Alternatively, in ungated systems, the ticket is stored on the handset for inspection and/or electronic validation.

3.3.3 Payment Validation

Putting payment and ticketing applications on NFC handsets facilitates payment and payment validation for merchants, banks, and mobile network operators (MNOs), as well as passengers. For merchants, NFC payments offer a fast payment experience using existing contactless payment readers. In addition, passengers have a record of even the smallest payments, which is more difficult when payments are made in cash.

Revenue enforcement officers can also use NFC-enabled mobile devices to validate proper fare payment.

3.4 NFC-Enabled Transit Information Applications

Contactless payment and transit ticketing are not the only applications supported by NFC technology. Other applications, such as service discovery, loyalty and frequent-user cards, coupons, event tickets, and logical and physical access control, can be stored on NFC-enabled mobile phones. These applications can then be used to collect points, enjoy rebates and events, or access information services and office facilities.

Since consumers apply for NFC services after they acquire enabled devices, applications need to be deliverable anytime, anywhere. OTA provisioning enables issuers to download and, if necessary, personalize applications on the consumer's NFC handset securely.

Service initiation can also occur when an NFC device is touched to an NFC tag, which then transfers a small amount of information to the device. The information can be several lines of text, a Web address, a phone number, or other simple data. For example, by touching an NFC handset to an NFC tag embedded in a smart poster at a transit station, a passenger can be directed to a convenient vendor for goods and services. Smart posters can be used to promote products, services, or events.

For example, Singapore's public transport provider, SMRT, has placed smart posters in stations to deliver news, entertainment, music, sports, services, and merchandise offers. The bus, train, and taxi operator launched its iMobSMRT spaces at six high traffic stations, allowing commuters to perform transactions, exchange digital content, and even book a taxi by tapping NFC-enabled smart phones on NFC tags. SMRT will now roll the smart posters out across the rest of its network.[6]

[6] Source: http://www.nfcworld.com/2011/10/18/310763/smrt-launches-nfc-posters-in-singapore/

4 The NFC Ecosystem and Implementation of NFC-Enabled Transit Applications

Deploying a secure NFC mobile application requires an ecosystem in which multiple stakeholders must cooperate.[7] Stakeholders may be involved in provisioning the NFC application to the mobile phone, delivering the NFC application service to the consumer, and managing the life cycle of the NFC application. Section 4.1 describes the roles of each of the ecosystem participants, with a description of how the ecosystem stakeholders work together to deliver one specific NFC application in Section 4.2.

4.1 Ecosystem Participants

The NFC ecosystem includes the following key stakeholders:

- Secure element (SE) providers and issuers
- Mobile network operators
- Handset manufacturers
- Operating system providers
- Mobile wallet developers
- Trusted service managers (TSM): secure element issuer (SEI) TSMs and service provider (SP) TSMs
- Application service providers: bank card issuers, transit agencies, merchants, other NFC application providers (e.g., coupons)
- Passengers/consumers
- NFC application acceptors: merchants, transit agencies
- Transaction processors: bank card acquirers, payment brands, closed payments system processors

4.1.1 Secure Element Providers and Issuers

The heart of a secure NFC application is the SE. The SE is a secure microprocessor (smart card chip) that includes a cryptographic processor to facilitate transaction authentication and security and provide secure memory for storing payment applications (e.g., American Express ExpressPay, Discover Zip, MasterCard PayPass, Visa payWave). SEs also support other types of secure transactions, such as transit payment and ticketing, building access, and secure identification. The Java Card operating system with GlobalPlatform support is the de facto industry standard for SE implementations.

The SE provider provides an SE in the form factor required by the SE issuer. The SE issuer is then responsible for issuing and maintaining the secure element. Depending on how the SE is incorporated in the mobile phone, the issuer could be the MNO, a bank card issuer, or another stakeholder; numerous stakeholder relationships are possible, depending on the SE form factor.

A mobile handset can incorporate an SE in one or more of the following ways:

- Embedded SE
- Universal integrated circuit card (UICC) removable SE
- MicroSD removable SE

[7] A detailed description of the NFC ecosystem can be found in the Mobey Forum white paper, *Business Models for NFC Payments*, October 2011, http://www.mobeyforum.org/content/download/17797/187847/file/Mobey%20Forum%20White%20Paper_Business%20models%20for%20NFC%20payments.pdf.

4.1.1.1 Embedded SE

One option for implementing an SE is to embed it in the phone when the phone is manufactured. This implementation does not provide the consumer with the option of moving the SE from one phone to a replacement phone. However, it allows phone manufacturers and mobile operating system providers to design, certify, and implement basic NFC SE transaction applications for a particular phone.

4.1.1.2 UICC Removable SE

A second option is to include an SE in a removable UICC or SIM card that supports the Single Wire Protocol (SWP). SIM cards have been used for years to provision GSM mobile devices. Consumers who buy a new phone for use with the same MNO can insert the SIM card from their old phone into their new phone, use the phone on the MNO's network, and port their contact information and phone number to the new handset.

4.1.1.3 MicroSD Removable SE

The microSD card is an SE form factor that can enable secure NFC applications phones that do not have built-in NFC capabilities. Many phones on the market already support microSD cards. The microSD card can contain a secure NFC application, a cryptographic coprocessor, the NFC controller and antenna, and even the user interface to a wallet. Mobile phones lacking embedded NFC capability can therefore be enabled for secure NFC applications by inserting a microSD card. It is important to note that microSD cards come with different configurations and interfaces that affect performance and often require hardware and software support from the handset.

Industry expectation is that future handsets will include an embedded SE or support a UICC removable SE. One reason that more NFC-enabled phones are not currently available is that handset manufacturers have been slow to adopt SWP, which is required for a UICC to communicate with the phone antenna and NFC modem. Several solutions are available that can bridge the gap and equip selected phones with SEs. Smart contactless stickers can be attached to mobile phones; such stickers act only as contactless payment cards, with no added value provided by the phone. As discussed in Section 4.1.1.3, microSD cards with smart card components can also be added to mobile phones, enabling phones with a suitable card slot to support NFC. Other accessories (such as iCarte™) are available that can provide iPhones™ with NFC capability.

4.1.2 Mobile Network Operator

The MNO maintains the mobile communication infrastructure and provisions wireless settings to the phones provided to consumers. The MNO also determines both the required handset features and functions and the service options to be provided with mobile phones sold by the operator. The MNO ensures OTA connectivity between the consumer and the NFC application SP.

4.1.3 Handset Manufacturer

The handset manufacturer defines which mobile phone models will be NFC-enabled, based on the MNO's requirements and the demand projected in the market. Handset manufacturers may also have a stake in the embedded SE model (as opposed to other SE approaches), potentially introducing additional business models.

The availability of NFC-enabled handsets continues to grow. According to Juniper Research, at least one in five smartphones will include NFC technology by 2014. More than 20 mobile phone manufacturers are currently producing or rumored to be in preproduction of NFC-enabled

handsets.[8] Since there are frequent announcements of new handset availability being made, this section provides only a snapshot of handset availability.[9]

Currently more than 10 NFC-enabled handsets are available for purchase worldwide. Samsung leads the way with multiple handsets: the Galaxy S II and S5230 (marketed under various names depending on the country); the Nexus S and Nexus S 4G (available on T-Mobile and Sprint). Nokia has released both the C7 (Europe) and Astound (U.S.);[10] Motorola and Casio have released their respective industrial personal data assistants, the MC75A[11] and IT-800RGC-35.[12] Research in Motion now offers multiple Blackberry models with NFC. Other manufacturers, such as LG, Toshiba, and Fonelabs, have issued limited release/proof-of-concept NFC-enabled handsets and are expected to produce something similar to Blackberry and Samsung smart phones.[13] Internationally, Sagem Wireless[14], Hedy[15], Shanghai Simcom, Fifth Media[16] and Pantech[17] are offering NFC-enabled phones.

4.1.4 Operating System Provider

An operating system (OS) provider maintains the core OS used by various handsets, including version upgrades, and provides application programming interfaces so that application developers can provide compatible applications. The OS provider may also provide a wallet application and other value-added applications.

4.1.5 Mobile Wallet Developer

A mobile wallet developer provides the consumer with an interface on the mobile phone to manage multiple NFC applications and credentials, including, if applicable, transit credentials and applications. A wallet developer can provide the wallet directly, as part of an application provider's NFC solution, as an application provided by the MNO, or through another vendor or SP.

The mobile wallet is a software application that manages payment and other credentials and transactions made from the mobile phone. A mobile wallet application can also be used to hold and control a number of applications (for example, payment, coupons, tickets), in much the same way as a physical wallet holds a collection of physical cards. The wallet enables the consumer to select the NFC application to be used for a transaction, analogous to a consumer opening a wallet or purse and selecting the card to use for a transaction. Mobile wallets can manage applications, payment accounts and/or other credentials that are either stored in the SE on the mobile phone or that are held in an issuer's back office.

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[8] Clark, Sarah, *List of NFC Phones*, NFC World, SJB Research, 13 June 2011, http://www.nearfieldcommunicationsworld.com/nfc-phones-list/

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The mobile wallet can also have the ability to interface with other applications and systems to support value-added services. For example, for transit payment, the wallet may interact with the transit back-end system, interface to a mobile fare services application that provides passengers with tools to support their account and credential, interact with the ticket application and credentials stored in the SE, and/or provide the user interface for the passenger to view the products in the wallet.

4.1.6 Trusted Service Manager

The TSM is a trusted third party who provides OTA services to the NFC application service provider and the owner of the SE (e.g., the MNO or retailer). The TSM handles provisioning and management processes so that application service providers do not need to deal with multiple MNOs, phone models, and operating systems, and MNOs do not need to deal with multiple providers. The TSM role can be played by many different entities, including the MNO, an application service provider, a personalization bureau, a payments processor, or some other third-party SP. Multiple TSMs may be involved in provisioning an NFC SE application.

The primary role of the TSM in the NFC ecosystem is to facilitate management of the NFC application on the secure element on the consumer's phone. Functions provided by the TSM can include OTA activation or provisioning of the NFC SE application, life-cycle management of the SE application, and bridging services for transferring SE applications from one SE to another. A core piece of the OTA provisioning process includes preparing the data and accessing the appropriate security keys required to provision the NFC SE application initially and then to update it once it is provisioned. The TSM's role is central to provisioning NFC services. The TSM acts as the secure connection point between SPs, such as banks, transit agencies, and merchants, and the SE owners, such as MNOs. (The role of the TSM in the NFC ecosystem is discussed in more detail in Section 4.3.)

4.1.7 Application Service Providers

Application SPs provide the applications and services required to deliver applications to NFC-enabled mobile phones. The NFC ecosystem can include numerous application SPs: bank card issuers, transit agencies, and merchants, among others.

Application SPs work through TSMs to deliver NFC functionality to consumers. They may also work with existing SPs for service delivery. (For example, bank card issuers may work with their personalization bureaus to create personalization data, set application security keys, and pass data to a TSM who then provisions the data into a consumer's NFC-capable phone.)

In the context of this white paper, application service providers may be any of the following entities:

- Bank card issuers, who provide payment applications and payment accounts to consumers and accept transactions from the bank payments infrastructure. In the standard card payment system model, the bank (issuer) holds the funding account for a consumer's payment card and is responsible for provisioning credit and debit cards to the bank's customers. In the emerging NFC payment system model, the bank continues to hold the funding account but works with other parties to provision the payment application to NFC-enabled mobile phones. In most cases, issuers will deploy physical "companion cards" for use at locations where NFC mobile payment is not accepted. The bank card issuers' host systems will need to support mobile contactless transactions.
- Transit agencies, who offer mobile transit applications and issue closed transit fare payment credentials to consumers and accept transactions within the transit environment.
- Merchants, who issue merchant-specific payment or other applications and accept transactions within the retail environment. Merchants can accept NFC payment

transactions and also issue NFC payment applications. To accept NFC payment transactions, merchants need NFC-enabled contactless POS terminals that are certified to work with each payment brand's application. Merchants can also choose to implement closed-loop NFC payment applications (such as gift cards or a merchant-specific payment card) or other value-added applications (such as coupons or loyalty cards). A transit agency that accepts open bank card payments is acting as a merchant, accepting contactless credit, debit, and prepaid transactions from NFC-enabled phones and processing them through the financial networks.

- Other SPs, who offer value-added applications such as coupons, loyalty programs, merchant promotions and offers, and location-based services.

4.1.8 Passengers/Consumers

The passenger/consumer is a customer of the NFC application provider. How the consumer becomes aware of NFC application options can determine how the NFC applications and credentials are loaded to the consumer's handset.

4.1.9 NFC Application Acceptors

Both merchants and transit agencies can be viewed as NFC application "acceptors" — participants in the ecosystem who have enabled their acceptance infrastructure to interact with a consumer's NFC-enabled mobile phone to complete a transaction. In the case of NFC-enabled mobile contactless payment, the transit agency acts as a merchant to accept mobile contactless credit, debit, and prepaid transactions and process them through the bank card payment infrastructure.

4.1.10 Transaction Processors

Transaction processing stakeholders are determined by the type of NFC application.

For open bank card payments, the merchant or transit agency routes the transaction to the merchant acquirer for authorization, clearing, and settlement through the payment networks to the issuers. To support NFC payment transactions, acquirer terminals at merchant customer locations must support NFC/contactless transactions. To support NFC payment transactions, payment networks must support contactless messaging and authentication functions.

For closed payment systems, the merchant or transit agency routes the transaction to the appropriate back-end system for processing and settlement.

4.2 NFC Ecosystem Relationship Examples

As described in Section 4.1, NFC ecosystem stakeholder roles and relationships can vary depending on the NFC application being implemented and the SE form factor.

Figure 1 illustrates one simplified example of stakeholder relationships for implementing NFC-enabled open bank card payments with a bank issuer/application SP when the SE is embedded in the phone and provided to the consumer by the MNO.

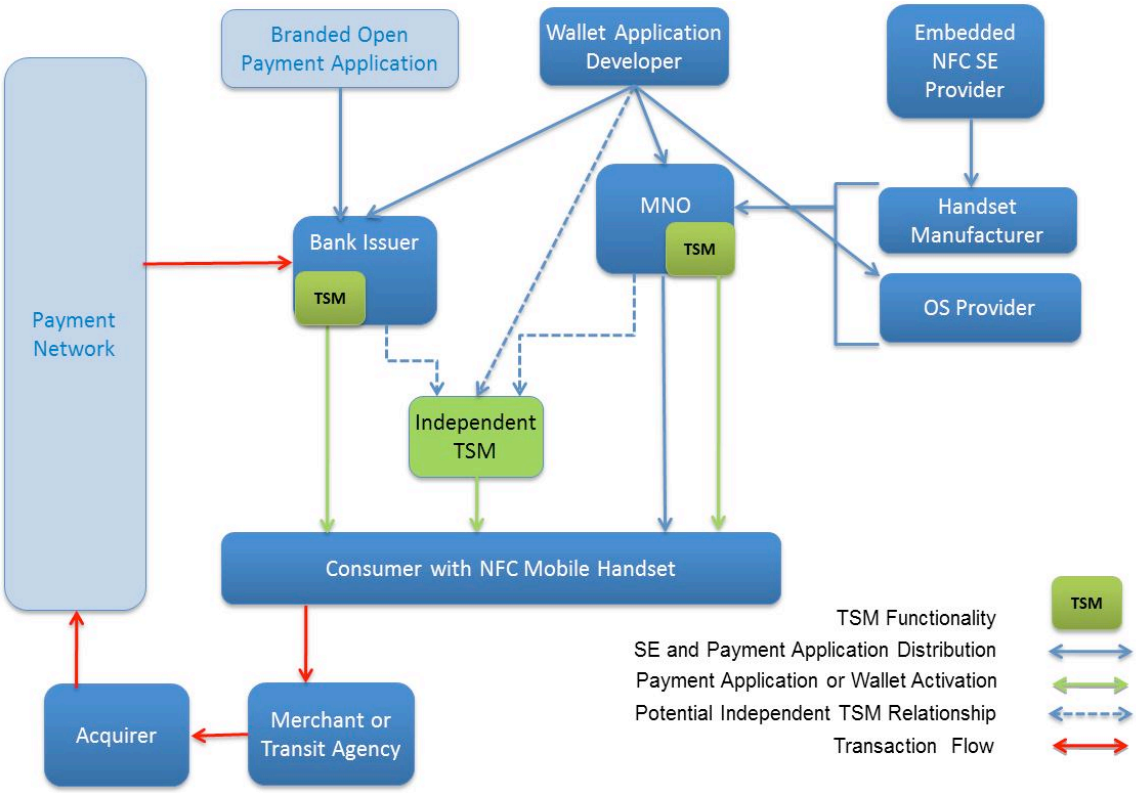

Figure 1. NFC Ecosystem Relationships: Bank Card Issuer and Embedded SE

In this example:

- The MNO typically owns the SE and controls distribution to consumers.
- Embedding an SE as a standard hardware feature within certain phones enables payment application service providers to align with mobile OS providers to bring new applications to market (for example, Google Wallet).
- Multiple entities can provide the payment and wallet application activation, personalization, and life-cycle management functions that are typically associated with a TSM. The MNO, a bank, a private label card merchant issuer, or a third-party payment application service provider or wallet provider can provide TSM functionality or outsource this functionality to a third party TSM (as illustrated by the box labeled "Independent TSM"). Any payment application SP or wallet provider can use the services of the independent TSM.

4.3 NFC and the Trusted Service Manager

Trust is essential to mobile NFC services. Applications such as credit cards and transit credentials must be issued and used in such a way that security is not compromised and that both business stakeholders and consumers maintain trust and confidence. For this reason, an SE is required to store and process the NFC applications on a NFC phone. The SE is currently (and for the foreseeable future will continue to be) a multi-application smart card chip. The different SE form factors all deploy smart card technology for security and for multiple application support.

Trust is critical during application issuance and life-cycle management processes. Traditional plastic chip cards are personalized with applications and data before they are issued to consumers. However, NFC applications are primarily issued after consumers purchase their

phones. Because an NFC phone is connected to the mobile network, applications can be issued and their life cycles managed OTA, directly with the consumer's phone. OTA issuance and life-cycle management processes must be secure, robust, and capable of supporting all appropriate technologies.

4.3.1 Role of the TSM

Different TSMs can offer different services; at one end of the spectrum are TSMs who offer a broad range of managed services, both to SE issuers and to a particular category of SPs (banks, retailers, or transit agencies, for example), while at the other end of the spectrum are TSMs who focus only on one particular SP segment. Common to all TSMs, however, is the ability to provide very secure aggregating services.

In typical deployments, TSM roles include two types: the SP TSM (SP-TSM) role and the secure element issuer TSM (SEI-TSM) role.

4.3.1.1 Service Provider TSM Requirements

The role of the SP-TSM can be performed by an SP or offered as a shared service for many SPs. The SP-TSM deals with service life-cycle operations from the SP's perspective: deploying a service, personalizing the application, locking/unlocking the applications, and performing similar operations. Integration with the SP's IT systems is necessary to facilitate extension of current provisioning processes to include NFC support.

The SP-TSM can implement its own OTA process for communication with the mobile device and SE; however, an SP-TSM is more likely to communicate with an SEI-TSM to perform this function. A standard GlobalPlatform messaging interface allows an SP-TSM to communicate with many different SEI-TSMs, thus accessing a number of SEs (for example, to support a payment service being offered to subscribers of four different MNOs).

4.3.1.2 Secure Element Issuer TSM Requirements

The SEI-TSM manages the secure element on behalf of the SE issuer allocating space, deploying applications, or enforcing aspects of the service life cycle. The SEI-TSM typically implements the OTA infrastructure or mechanism for communicating with the SE. As with the SP-TSM, the SEI-TSM can communicate with many different SP-TSMs, and offer services to numerous SPs without regard to the specifics of the services or integration with them.

Each MNO or other SE issuer must make an SE issuer service available, and this service must be able to interact with all TSMs serving the different SPs in the market in which the particular SE issuer is operating. Similarly, a TSM serving a particular SP must be able to interact with every SE issuer in that market. The TSM outsources these services, both to SPs and MNOs.

4.3.1.3 Additional TSM Requirements

While TSMs play an essential role in the management of SE applications on consumers' NFC phones, the actual consumer-facing entities are the parties who issue the SEs and the SPs (banks, retailers, transit operators) who wish to have their applications enabled on the NFC phones.

As an SE issuer, an MNO (or other issuer, depending on the SE form factor) needs the following capabilities to support NFC services:

- The capability to create security domains in the SE for the SPs; each SP has a dedicated security domain where its applications are stored.
- The capability to manage SE memory allocation for security domains.

Depending on the privileges given to the security domain, the MNO may also support loading and removing SP applets (loading does not include applet personalization).

The SP must be able to control its own applications and therefore requires TSM services that support the following:

- Key management for the SP's security domain, including (for example) rotation of initial security domain keys, if necessary
- Loading of applets into the SP's security domain
- Personalization of the SP's applets, potentially including data preparation services
- Life-cycle management of the SP's applets, including locking, unlocking, post-issuance scripting (for example, to reset PIN counters by bank issuers or to load product or top-up stored value for transit), and data updates
- Services related to the management of mobile applications, such as a mobile wallet, providing a user interface for the SP's applications
- Removal of the SP's applets

Figure 2 illustrates the TSM-related infrastructure and stakeholders in the mobile NFC ecosystem.

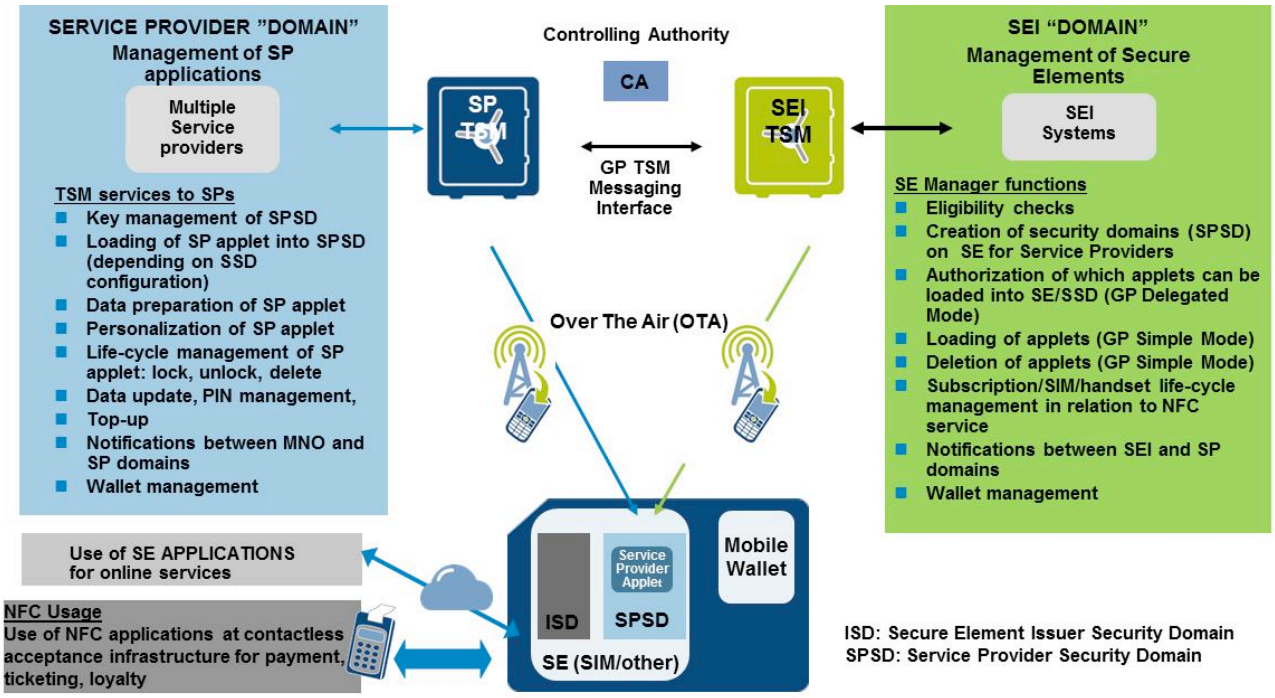

Figure 2. TSM Infrastructure and Stakeholders

In Figure 2, the SEI-TSM provides SE management services, and the SP-TSM provides the services required by SPs. Both implement OTA communication to the NFC phone and SIM (or other SE form factor); the services are provided directly to the consumer's NFC phone over the mobile network. These two entities interact through the OTA services framework to issue and manage the life cycle of SP applications on an SE issued by an MNO (or other issuer). For example, when the SP-TSM receives a provisioning request from the SP, that TSM sends a request to the SE issuer to create a security domain. After the security domain is created and the initial security domain keys are received from the SE issuer, the SEI-TSM takes over and completes the OTA provisioning service.

4.3.2 Requirements for Filling the TSM Role

The mobile NFC ecosystem is extremely complex, involving multiple vertical industry segments that all work in the same ecosystem but have their own specific mobile technologies and requirements for interoperability and degree of backward compatibility. For this reason, the role of the TSM is demanding. Some of the key requirements are summarized below:

- A flexible and modular service concept and platform, since the NFC mobile ecosystem is at an early stage of development and can evolve in many directions
- Efficient and fast business process modeling to facilitate the introduction of new services for a new SP segment
- The technical ability to support any SE form factor, any SE vendor, any NFC device, and any mobile network
- Support for a multitude of online interfaces to other systems
- Scalability and high performance
- High security in compliance with essential market requirements, such as the payment brands' security requirements
- 24/7 service availability

In theory, SE issuers, such as MNOs and SPs, can implement the capabilities provided by TSMs in-house. However, there is clearly a need for specialized aggregating SPs as well. Each SE issuer and SP will have to decide what services to provide in-house and what services to outsource to a TSM.

Regardless of what choice is made, SE issuers and SPs remain the consumer-facing entities in the NFC ecosystem, while TSMs provide services as a service offering in a business-to-business environment. Considering the investment in technology, a data center, service integration, service operation, and vertical industry expertise required for a successful TSM operation, TSMs provide significant value to all stakeholders in the mobile NFC ecosystem. And while in the NFC ecosystem the value added by a TSM currently focuses on the SE applications that rely on NFC, TSM services can also be used to manage other types of security-sensitive SE applications.

5 Key Considerations for Developing a Mobile Strategy

As transit agencies explore the use of new fare payment and collection systems based on open standards, it is becoming increasingly clear that developing a mobile strategy is critical to those efforts and may carry benefits that extend beyond those directly related to fare collection.

Mobile devices can provide additional functionality that strengthens a transit agency's ability to derive value from both current and new customers while providing convenience and value-added services that enhance the customer experience. For example, integrated mobile applications that combine fare payment with trip planning and service status information allow for a more personal interaction with the transit agency. Similarly, NFC technology not only provides an attractive mechanism for contactless transit fare payments at the point of entry, it can also provide for an interactive consumer experience with retailers that allows for customized loyalty programs, facilitating a transit agency's opportunity to offer customers new marketing and incentive programs.

5.1 Business Considerations

Transit agencies need to assess how a mobile strategy fits within and changes its business model and vendor relationships for fare payment.

5.1.1 Vendor and Partner Relationships

The mobile NFC ecosystem represents a radical change from traditional transit fare payment and customer service models. Historically, agencies have maintained a high degree of control over such systems, with relatively minimal involvement by other parties. For example, an agency procuring a new fare payment system may contract with one or several vendors to build self-contained systems to collect fares. The evolution to “open payment” systems potentially expands the vendor pool; mobile NFC further introduces a host of new entrants to the marketplace, such as leading handset manufacturers (e.g., Samsung, RIM, HTC) and other industry players (e.g., Google, Isis, Apple, Amazon). Transit agencies need to understand the new, unfamiliar corporate entities, technologies, business models, and value propositions better—and quickly.

Transit agencies will also need to understand the role of the various stakeholders and providers in the NFC ecosystem (Section 4.1) and consider partnerships with a variety of business entities, from handset manufacturers to industry leaders such as Google, Apple, and Amazon. The NFC ecosystem is new, and transit agencies seeking to leverage NFC are unlikely as yet to have internal subject matter experts. Agencies will need to invest time and resources in becoming familiar with key firms in the industry, NFC technology, and various business models to realize maximum benefits from the NFC value proposition. Being more informed will help transit providers develop more effective and efficient tools for their organizations and customers. Furthermore, agencies should understand that shifting into mainstream payment solutions (as opposed to traditional approaches) may also introduce intellectual property concerns.

5.1.2 Merchant Acceptance

Contactless payments have not been implemented in the majority of retail outlets, and where they have been implemented, their use is still well below that of magnetic stripe cards. Contactless POS infrastructure changes are essential, both to drive awareness and benefits to transit, and to be able to accept NFC mobile contactless payment transactions. Merchant adoption has not occurred due primarily to the cost of changing the infrastructure.

Merchant adoption of contactless payment is vital to helping to lower the cost of the actual contactless card. The rate at which adoption occurs is directly linked to the rate at which issuers deploy cards. Although there seems to be general agreement that contactless cards will be widely deployed by the later part of the decade, there is every likelihood that conventional magnetic stripe cards will continue to be in wide circulation in the interim, thus complicating

merchant decisions about reader technology and merchant planning for NFC deployment and acceptance.

5.1.3 New Revenue Streams

The mobile NFC ecosystem creates an opportunity for new revenue streams. Revenue opportunities similar to those associated with contactless open bank card-based implementations can be realized with mobile NFC. A mobile NFC device facilitates the inclusion of various payment products (credit, debit, prepaid or white label card) in an electronic wallet, and the manner in which the payment product is issued determines the revenue potential. For example, a white label product issued by a transit agency can provide new revenue opportunities by creating cross-marketing and co-branded arrangements with other city services, major city events and attractions, and local retailers. A transit agency could offer bundled pricing for sporting events that would encourage customers to take public transit to a public event. Partnerships with local retailers could enable loyalty benefits (such as a free cup of coffee at a local coffee shop) to be offered to transit agency customers, thereby encouraging increased ridership. Overall, transit agencies can benefit from increased ridership revenue and direct or indirect revenues from cross-marketing or co-branded partnerships.

5.2 Technology Considerations

Before investing in and deploying any new technology, it is necessary to understand the nature and requirements of the technology. It is too easy for businesses to be carried away by the newest technological fad and adopt a technology without first considering their business objectives and whether the technology will help realize those objectives. One major consideration for businesses evaluating NFC is whether mobile devices are to be an extension of a current contactless-enabled system or the system itself.

Transit agencies in particular need to understand how NFC technology fits into the fare payment acceptance technical infrastructure. Several key points require consideration:

- The performance of the mobile device communicating wirelessly with nearby passive and low-power devices.
- Support for read-only functionality as opposed to full NFC functionality. The acceptance infrastructure may need two-way communications to fully benefit from NFC (such as for ticket redemption, receipts, coupons).
- The form factors (embedded chip, UICC, microSD card) and handset type that are available to support NFC applications.
- The application-level standards that need to be supported by the NFC applications.
- The security standards (e.g., AES, 3DES) that need to be supported by the NFC applications.
- The transit payment system specifications (e.g., MIFARE, CIPURSE[18]) that need to be supported by the NFC applications.

5.3 Application Considerations

NFC applications are still in the early stages of roll-out. Transit agencies need to consider when to introduce NFC into their local markets and integrate this introduction with transit planning. They should also evaluate partners and application availability carefully. NFC-based application availability depends on handset availability and on partnerships that can deliver applications.

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[18] Additional information on CIPURSE can be found in Appendix C and at http://www.osptalliance.org.

In the United States, Isis and Google are the primary NFC-based mobile contactless payment services that have been announced. Isis, the mobile carrier joint venture that includes AT&T, Verizon, and T-Mobile, will be piloting its service in Salt Lake City, UT, and Austin, TX. Users will be able to tap their phones to pay for fares on Utah Transit Authority buses and trams and make purchases at merchant outlets that accept contactless payment in both Salt Lake City and Austin. The pilot projects will begin in the first half of 2012. Isis will work with American Express, Discover, MasterCard, and Visa for its NFC rollouts.[19]

Google announced Google Wallet in May 2011, with general availability during October 2011 in New York and San Francisco. Using Google Wallet, consumers can use a Sprint NFC-enabled phone and a MasterCard PayPass or Google prepaid card to pay for purchases at merchants who accept MasterCard PayPass. NJ TRANSIT became the first transit agency to partner with Google Wallet to test NFC mobile payments, allowing customers to pay with a tap of their mobile phone.

5.4 Summary

Considering the complex and varied operational needs of a transit agency, it is likely that a comprehensive system will be required that integrates a variety of solutions based on open standards that include NFC mobile technology. The acceptance of NFC-enabled mobile devices for fare payment can be part of a strategic approach that addresses differences between services (for example, ungated rail and gated rail; fare boxes in buses; visual inspections or tap in-tap out), while providing non-fare-payment related benefits to a transit agency. While there is not yet any full-scale implementation of NFC mobile technology in a transit environment in the U.S., the pilot projects being conducted in Utah (Isis) and New Jersey (Google Wallet) indicate that commercial opportunities are close at hand.

[19] *Isis Challenges Google Wallet with Visa, MasterCard, Amex*, eWeek, July 24, 2011, http://www.eweek.com/c/a/Mobile-and-Wireless/Isis-Challenges-Google-Wallet-with-Visa-MasterCard-Amex-857133/

6 Conclusions

NFC technology has the potential to redefine the mobile arena by offering new opportunities for people to communicate, make purchases, and access information. However, the complexity of the NFC ecosystem and the challenges of widespread deployment have so far limited NFC deployment primarily to pilot testing.

A combination of changing demographics and new technologies challenges the transit industry to look beyond traditional means of providing information to riders; dynamic message signs and personal-computer-based Internet services must be supplemented. Riders want to access more information than just schedules and routes, and they require real-time transit information, including next vehicle arrival time. The majority of riders use mobile phones and smart phones, which provide Internet access and mobile e-mail service. NFC offers an additional opportunity to access information: touching a handset to the tag on a smart poster can reveal several lines of text, a Web address, or phone number. In addition to reading posters with NFC tags, other uses include building access, personal identification, ticketing, and purchases.

Riders in large U.S. cities are also accustomed to fare payment using contactless cards, which can transition to fare payment using a mobile device. NFC supports a variety of mobile phone applications and extends the benefits of smart cards by combining a computer chip and an active reader in one package. An NFC-enabled device can operate in several modes, including peer-to-peer, reader-writer, and card emulation. To an external reader, the mobile device operates in card emulation mode and appears to be a traditional contactless smart card. A smart card chip serves as the SE that protects stored data and enables secure transactions.

For payments, NFC supports a richer user experience than contactless cards. Transit applications can deliver new capabilities, including payment acquisition, system entry/exit, payment processing, 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.

Understanding the NFC ecosystem is central to understanding the dynamics and potential deployment of NFC-enabled transit applications. The complex landscape includes many new stakeholders. First and foremost, mobile NFC services rely on trust: applications such as bank cards and transit tickets must be issued and used with NFC phones without compromising security. A TSM can provide outsourced management services to several service providers. Ultimately, NFC ecosystem stakeholders must decide what services should operate in-house as opposed to being outsourced to a TSM.

Numerous NFC trials have been executed worldwide over the last three years, and many of these trials have included the use of TSMs. The trials play an important role in developing commercial readiness by providing an environment in which to test and verify technologies, processes, end-user experience, and assumptions in general. With the anticipated launch of new NFC phones in 2012, the mobile NFC ecosystem is ready to move from trials to commercial deployments, and TSMs are available to support these initial implementations. While additional work is required in certain areas of the TSM ecosystem, the standards and technologies in place are sufficient for TSM services to support commercial launches. Properly designed TSM services and the underlying TSM platform can (and will) evolve to meet future market requirements.

A major challenge facing the transit industry is the creation of a mobile strategy. The industry must immerse itself in the operational details of the NFC ecosystem and thoroughly understand the technology and business models to realize the benefits of the NFC value proposition. Forming partnerships with a variety of entities, from handset manufacturers to industry leaders are critical to the industry's future success.

7 Publication Acknowledgements

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Publication of this document by the Smart Card Alliance does not imply the endorsement of any of the member organizations of the Alliance.

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About the Smart Card Alliance Transportation Council

The Transportation Council is one of several Smart Card Alliance Technology and Industry Councils, focused groups within the overall structure of the Alliance. These councils have been created to foster increased industry collaboration within a specified industry or market segment and produce tangible results, speeding smart card adoption and industry growth.

The Transportation Council is focused on promoting the adoption of interoperable contactless smart card payment systems for transit and other transportation services. Formed in association with the American Public Transportation Association (APTA), the Council is engaged in projects that support applications of smart card use. The overall goal of the Transportation Council is to

help accelerate the deployment of standards-based smart card payment programs within the transportation industry.

The Transportation Council includes participants from across the smart card and transportation industry and is managed by a steering committee that includes a broad spectrum of industry leaders.

Transportation Council participation is open to any Smart Card Alliance member who wishes to contribute to the Council projects. Additional information about the Transportation Council can be found at http://www.smartcardalliance.org/about_alliance/councils_tc.cfm.

Trademark Notice

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9 Appendix A: Transit NFC Activities

NFC technology has been deployed in pilots and commercial services worldwide, supporting transit applications such as payment, ticketing and information access. Table 1 lists examples of NFC mobile payments projects and announcements, illustrating the breadth of interest.

Table 1. Examples of NFC Projects and Announcements Supporting Transit Applications

Location	Participants	Status	NFC Applications Deployed
Austria[20]	Mobilkom Austria, Innovision Research & Technology, Nokia, ÖBB	Pilot launched Mar. 2009	WAP page access; transit tickets.
China[21]	China Unicom, Beijing Municipal Adminstration and Communications Card Co (BMAC), Watchdata	Commercial service launched Jan. 2011	Payment for retail and transit purchases.
Czech Republic[22]	Telefonica O2, Nokia, PMDP	Commercial service launched May 2010	Payment for retail and transit purchases.
France, Nice[23]	Orange-France, SFR, Bouyges Telecom, NRJ Mobile, BNP Paribas, Credit Mutuel, Veolia, Samsung, Gemalto, Oberthur	Commercial service announced May 2010	Payments for retail and transit purchases.
France, Paris[24]	STIF, Neowave	Pilot launched Feb. 2010	Ticketing.
Germany[25]	Deutsche Bahn	Commercial service launched Aug. 2011	Touch & Travel NFC mobile ticketing. Deutsche Bahn and RMV are now cooperating to combine the two applications.
Germany[26]	RMV	Commercial service	HandyTicket NFC ticketing and smart posters. Deutsche Bahn and RMV are now cooperating to combine the two applications.

[20] http://www.nearfieldcommunicationsworld.com/2009/03/19/3878/mobilkom-austria-customers-to-use-nfc-tags-to-access-wap-pages/
[21] http://www.nearfieldcommunicationsworld.com/2010/06/09/33896/china-unicom-launches-nfc-payments-service-in-beijing/
[22] http://www.nearfieldcommunicationsworld.com/2010/05/27/33754/telefonica-o2-launches-first-commercial-nfc-service-and-sets-out-strategy-for-future-deployments/
[23] http://www.nfctimes.com/news/french-make-it-official-nice-nfc-launch
[24] http://www.nearfieldcommunicationsworld.com/2010/02/11/32680/paris-transport-operators-begin-nfc-ticketing-trial/
[25] http://www.nfcworld.com/2011/08/25/39363/deutsche-bahn-to-roll-out-touchtravel-across-germany/
[26] http://www.nfcworld.com/2011/03/03/36340/transport-operators-deutsche-bahn-and-rmv-to-co-operate-on-national-nfc-ticketing-system-for-germany/

Location	Participants	Status	NFC Applications Deployed
Germany[27]	Vodafone, T-Mobile, Telefonica O2 Germany, Deutsche Bahn, Atron, Giesecke & Devrient, NXP	Pilot launched , Oct. 2009	Ticketing.
Italy, Milan	Telecom Italia, ATM, Samsung	Pilot announced Mar. 2011	Transit ticketing.
Japan[28]	KDDI, Toyota, MasterCard, Orient Corp., Credit Saison, ANA, JAL, Toho Cinemas, IBM, NTT Data, Hitachi, Gemalto, Nomura Research Institute, Dai Nippon Printing, T-Engine, Japan Remote Control Co.	Pilot launched Apr. 2010	Payment, travel services, ticketing, smart posters, plus other services. Compliant with GSMA PayBuyMobile specifications.
Korea[29]	KT	Service announced Oct. 2011	Smart posters for real-time bus service information.
Malaysia[30]	Maxis, Nokia, Maybank, Touch 'n Go, Visa	Commercial service launched Apr. 2009	Payment for retail, toll, transit, parking and theme park purchases.
Poland[31]	PTC, Inteligo, MasterCard, Samsung, Giesecke & Devrient, Venyon	Pilot launched June 2010	Payment.
Russia[32]	Moscow Metro, MTS	Commercial service planned 4Q10	Transit ticketing.
Singapore[33]	SMRT, Nokia	Service announced, Oct. 2011	Smart posters to deliver news, entertainment, music, sports, services, and merchant offers to commuters.
Spain[34]	Renfe, Vodafone	Pilot announced Oct. 2011	NFC ticketing.

[27] http://www.nearfieldcommunicationsworld.com/2010/04/27/33523/frankfurt-transport-network-gets-nfc-and-qr-code-smart-posters/
[28] http://www.nearfieldcommunicationsworld.com/2010/04/22/33481/kddi-to-run-multiple-nfc-tests-in-japan/
[29] http://www.nfcworld.com/2011/10/04/310451/korean-bus-stops-get-nfc/
[30] http://www.nearfieldcommunicationsworld.com/2009/04/27/3993/first-commercial-nfc-service-launched-in-malaysia/
[31] http://www.nearfieldcommunicationsworld.com/list-of-nfc-trials-pilots-tests-and-commercial-services-around-the-world/
[32] http://www.nearfieldcommunicationsworld.com/2010/06/23/34014/moscow-metro-and-mts-to-launch-nfc-ticketing-service-in-q4-2010/
[33] http://www.nfcworld.com/2011/10/18/310763/smrt-launches-nfc-posters-in-singapore/
[34] http://www.nfcworld.com/2011/10/11/310592/renfe-tests-nfc-train-tickets/

Location	Participants	Status	NFC Applications Deployed
UK	Transport for London	Commercial acceptance planned 2012	Payment.
UK[35]	O2, Transport for London, Barclaycard, Visa Europe, TranSys, Nokia, AEG	Pilot completed May 2008	Payment for retail and transport purchases.
U.S.A., New Jersey	NJ TRANSIT, Google	Pilot launched Oct. 2011	Fare payment using NFC mobile phone with Google Wallet.
U.S.A., San Francisco[36]	SFMTA, PayByPhone	Service announced Dec. 2011	Parking payment with NFC stickers
U.S.A., San Francisco[37]	Sprint, BART, Jack in the Box, ViVOtech, Samsung, Cubic, Western Union, NXP, Acumen Transit, BAH, First Data	Pilot launched Jan. 2008	Stored value payment; smart posters with coupons and information.
U.S.A., Utah	ISIS: Verizon, AT&T, T-Mobile, Discover Financial Services, Barclaycard, Utah Transit Authority	Service announced, with launch expected in 2012	Joint venture for ISIS, a national mobile commerce network that will provide a mobile wallet that enables payment and commerce services using NFC devices.

[35] http://www.mobilemarketingmagazine.co.uk/content/o2-launches-major-london-nfc-trial

[36] http://www.nfcworld.com/2011/12/18/311965/san-francisco-gets-nfc-parking-meters/

[37] http://www.nfctimes.com/project/us-multiapp-trial-involves-transit-agency-fast-food-restaurant

10 Appendix B: MIFARE4Mobile

MIFARE4Mobile[38] is a specification that extends the use of MIFARE implementations to a variety of form factors, including embedded SEs, UICC SIMs, and microSD cards, while leveraging the full capabilities of the mobile device.

The MIFARE4Mobile specification defines two primary interfaces:

- The TSM interface for provisioning and managing MIFARE cards
- The wallet interface for interaction with a mobile wallet

MIFARE4Mobile, initially created by NXP Semiconductors, is currently built upon the MIFARE™ Classic standard. MIFARE4Mobile has been widely accepted and downloaded for evaluation over 460 times worldwide.

The MIFARE4Mobile inter-industry group was founded in June 2010. This group consists of seven major companies working on a standardization of version 2.0 of the specification, which will enable the management of multiple applications based on MIFARE technology.

Enhancements under MIFARE4Mobile v2.0 include:

- Fully supporting MIFARE Classic, MIFARE DESFire™, and MIFARE DESFire™ EV1 applications
- Supporting multiple TSMs
- Supporting multiple MIFARE applications on the same SE
- Leveraging the GlobalPlatform 2.2 specification
- Allowing end-to-end security between a service provider and the MIFARE application

MIFARE4Mobile v2.0 will enable multiple applications to be accessed through the contactless interface simultaneously. This functionality supports the legacy infrastructure while combining MIFARE applications with other payment-enabled applications.[39]

Members of the MIFARE4Mobile group are implementing the solution across their particular platforms, resulting in a portfolio of different form factors, including embedded SEs, UICC SIMs, and microSDs. The MIFARE4Mobile specification ensures interoperability at the mobile device level regardless of form factor or platform.

[38] Additional information can be found at http://mifare.net/index.php/products/mifare4mobile1/

[39] Some MIFARE-based (closed) transit applications require an SE that has the capability to emulate the MIFARE protocol for 'near field communication.

11 Appendix C: CIPURSE

The CIPURSE open specification[40] provides an advanced technical foundation for developing highly secure, interoperable, and flexible transit fare collection solutions. It is built on proven standards, including ISO/IEC 7816, AES-128, and ISO/IEC 14443-4 for securing multiple payment types. CIPURSE is designed to:

- Stimulate innovation and market opportunity for fare collection solution and system developers
- Support more secure, flexible design and deployment alternatives for transit system integrators and consultants
- Foster a broad range of cost-effective, interoperable transit fare collection solutions

CIPURSE was created by The Open Standard for Public Transit (OSPT™) Alliance, an international association chartered to define a new open technology standard for secure public transit fare collection solutions. As of December 2011, the organization included its four founding technology company members—INSIDE Secure, Giesecke & Devrient, Oberthur Technologies and Infineon—as well as Samsung Semiconductors, Watchdata, Ecebs, and SmartTrac. Transit operators are represented by the Open Ticketing Institute (Netherlands), UTI (India) and NSB (Norway).

CIPURSE is form-factor independent and designed to be adopted in smart cards, NFC mobile phones and other devices. Implementations ranging from low-end memory chip/card, to low-end microcontroller, to high-end microcontroller, to NFC solutions are possible. Because CIPURSE defines only a minimum feature set, implementers are free to add their own functionality to their products so long as they do not affect interoperability. Adoption of CIPURSE within NFC-enabled devices such as microSD cards, mobile phones and other consumer electronics devices is expected to be a major driver for CIPURSE.

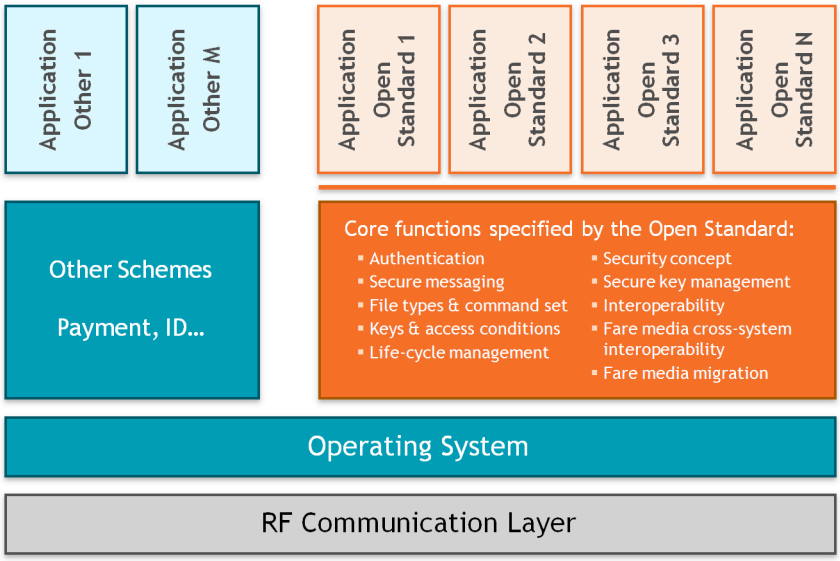
Features of CIPURSE include:

- **Advanced security:** CIPURSE's advanced security mechanisms include a unique cryptographic protocol that encourages fast and efficient implementations. Its protocol provides robust, inherent protection against differential power analysis (DPA) and differential fault analysis (DFA) attacks.
- **Consistent command set**: A consistent command set and architecture supports multiple applications and payment schemes with easy interoperability.
- **Independent testing:** Independent testing helps ensure interoperability between solutions and with legacy systems, as well as consistent application of the standard.
- **Convenient and cost effective:** CIPURSE-based applications will enable users to use a single device for transit across systems and locations.
- **Preparation for NFC mobility**: Handset and mobile device manufacturers require an open security standard as the global basis for supporting NFC transit applications. CIPURSE is the way to achieve cross-device, cross-transit-system commonality; true scalability; non-proprietary implementations; and faster transition of transit systems to the use of NFC devices.

Figure 3 illustrates the CIPURSE architecture.

[40] Additional information can be found at http://www.osptalliance.org/.

Figure 3. CIPURSE – Defining the Open Standard for Modern Fare Collection



12 Appendix D: Glossary

Contactless payment
Payment transaction that requires no physical contact between the payment device and the physical POS terminal. The consumer holds the device (a contactless card or other device) less than 2–4 inches from a merchant POS terminal, and payment account information is sent wirelessly over a radio frequency.

ECMA standard 340
ECMA-340: NFCIP-1 Interface and Protocol. ECMA International is an industry association founded in 1961 and dedicated to the standardization of Information and Communication Technology (ICT) and Consumer Electronics (CE). ECMA is active in defining standards for NFC.

ETSI standard TS 102 10 V1.1.1 [2003-03]
ETSI TS 102 10 V1.1.1 (2003-03)) "Near Field Communication (NFC) IP-1; Interface and Protocol (NFCIP-1)"

Global System for Mobile Communications (GSM)
The predominant standard for mobile telecommunications globally. The GSM standard is managed by the European Telecommunications Standards Institute (ETSI).

GlobalPlatform
An international, non-profit association that establishes, maintains and drives adoption of standards to enable an open and interoperable infrastructure for smart cards, devices and systems that simplifies and accelerates development, deployment and management of applications across industries.

ISO/IEC 14443
ISO/IEC standard 14443, “Identification Cards—Contactless Integrated Circuit(s) Cards—Proximity Cards,” the international standard for contactless smart chips and cards that can be read from or written to at a distance of less than 10 cm (4 in.). This standard operates at 13.56 MHz.

ISO/IEC 18092
ISO/IEC 18092 – “Information technology – Telecommunications and Information Exchange between Systems – Near Field Communication – Interface and Protocol.” ISO/IEC 18092:2004 defines communication modes for NFC interface and protocol (NFCIP-1) using inductive coupled devices operating at the center frequency of 13.56 MHz for interconnection of computer peripherals.

Java Card
A smart card operating system that runs multiple applications.

Mobile contactless payment
Payment to a physical merchant that is initiated from an NFC-enabled mobile phone held in close proximity (within a few centimeters) to the merchant's POS equipment.

Mobile network operator (MNO)
Mobile telecommunications company that has the relationship and mobile phone account with the end user.

Mobile wallet
Software application that is loaded onto a mobile phone to manage transactions made from the mobile phone. A mobile wallet application can also hold and control a number of other applications (for example, loyalty or additional payment cards), much as a physical wallet holds a collection of physical cards.

Near Field Communication (NFC)
Standards-based wireless communication technology that allows data to be exchanged between devices that are located a few centimeters apart. NFC-enabled mobile phones incorporate a smart chip (called a *secure element*) that allows the phone to store the payment application and consumer account information securely and use the information as a virtual payment card. NFC payment transactions between a mobile phone and a POS terminal use the standard ISO/IEC 14443 communication protocol currently used by EMV and U.S. contactless credit and debit cards.

Open payment system
Payment system that enables any bank, anywhere in the world, to link its customers (cardholders or merchants) with those of any other bank to transact business almost instantaneously using payment cards. This is also called a four-party system, in which the parties are the bank issuing the cards, the merchant's bank that acquires the transaction, the merchant, and the cardholder who conducts the transaction and now must make payment in the case of a credit card or who made payment in the case of a debit card. This type of payment system requires no contractual relationship between the merchants accepting the card for payment and the card issuer. Instead, all card issuers and all merchant acquirers agree to abide by the rules and policies established and adopted by neutral third-party organizations.

OTA (Over-the-air)
Ability to download and install content over a wireless network, typically on demand. OTA makes it possible to send data to and receive data from a mobile device in a distributed environment. In mobile networks, OTA can be accomplished using a data connection or short message service.

Personalization
Process of incorporating the unique personal data for a user into a generic device or card.

Reader
Device that transmits data or assists in data transmission between a card, token, or other device and a host computer or database.

SD (secure digital memory) card
Flash memory card that provides storage for digital cameras, mobile phones, and personal data assistants. Although SD cards support encryption and content protection, they are mostly used for storage due to their small size and fast transfer rate. [41]

Secure element (SE)
Component of a mobile device that stores and executes sensitive applications. The secure element is a smart card chip that contains a dedicated microprocessor with an operating system, memory, an application environment, and security protocols. The secure element can reside on the SIM or in a dedicated chip on a phone's motherboard (embedded secure element), or be an external accessory.

SIM (Subscriber Identity Module)
Smart card included in GSM mobile phones that is configured with information essential to authenticating the phone, thus allowing the phone to receive service whenever the phone is within coverage of a suitable network.

Sticker
Form factor for deploying a contactless chip that can be attached to the external case of a mobile phone or other device without requiring physical integration with the device.

Trusted service manager (TSM)
Neutral third party who provides a single point at which mobile operators can integrate with financial institutions, transit authorities, and retailers who want to provide payment, ticketing, or loyalty applications to their customers with NFC-enabled phones.

[41] Source: http://www.pcmag.com/encyclopedia_term/

UICC (Universal Integrated Circuit Card)
The equivalent of a SIM card in WCDMA/UMTS (3G) phones.

White label card
A payment card produced by one company that is available for other companies to brand to appear as if they are the payment card issuer.