NFC-enabled e-Ticketing in Public Transport: Clearing the Route to Interoperability

White Paper
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Prepared by the Transport SIG
 Henk Danneberg, NXP Semiconductors
 Mike Eastham, ITSO
 Jean-Luc Guisset, Sony, Transport SIG Secretary
 Joerg Schmidt, Infineon, Transport SIG Chair
 John Verity, ITSO/Smart Ticketing Alliance

LEARN MORE. GET INVOLVED!
Help chart the course for NFC and the Transport Industry. Email our Transport SIG chairs at sctwg-chair@nfc-forum.org to learn how to get involved.
Executive Summary

The growing global use of smartphones and other mobile devices offers an opportunity for the Public Transport (PT) industry to better serve its customers and manage increasing demand. The best way to take advantage of this opportunity is to ensure that the millions of contactless readers and billions of smartcards already deployed by Public Transport Operators (PTOs) work seamlessly with the millions of NFC-enabled devices in the marketplace.

NFC makes the Public Transport experience more convenient and enjoyable for passengers by simplifying and accelerating fare purchases, providing one-touch entry to ticket gates, supporting ancillary applications (such as real-time travel updates and loyalty programs), and enabling use of the same means of payment and access across multiple modes of Public Transport (rail, bus, subway, etc).

The Public Transport industry requires smooth, reliable, and efficient functioning to ensure a positive experience for millions of daily users—under all circumstances. Until recently, however, that was a challenge, because the public transport and mobile device industries used standards from different bodies in their Radio Frequency (RF) interfaces. The result was that PTOs, Mobile Network Operators (MNOs), and handset makers who wanted to introduce NFC-enabled services had to make a concerted effort to ensure that particular NFC devices could exchange data reliably with the readers and cards of specific PT systems.

That situation is now changing as the result of an initiative led by the NFC Forum and GSMA. In 2015, the two organizations joined together with global PT representatives, Smart Ticketing Alliance and JR East, and standards bodies, including CEN and ISO. This initiative was successful in harmonizing the specifications of mobile device NFC interfaces and PT readers and cards and establishing standards for testing mobile devices and PT equipment.

With the pieces now in place to enable RF interoperability for PT systems without changing PT infrastructures, the time to move on NFC implementation is now. By adhering to NFC Forum specifications and certifying mobile devices against these specifications, PTOs, MNOs, and handset manufacturers can quickly ensure consistent, reliable, efficient performance of NFC-enabled devices across all PT mobile business use cases.

Over time, public transport users have readily adopted new ticketing solutions that have provided ever-increasing levels of convenience and ease of use. The availability of “PT Ready” NFC-enabled mobile devices makes it easier for PTOs to bring these benefits to their riders.
Evolution of Public Transport Systems

Growing Demand Fuels New Solutions

According to the World Health Organization, the percentage of the world’s population residing in cities grew from 34% in 1960 to 54% in 2014. As that trend continues, it is putting increased demand on public transport resources. In the United States, for example, public transport ridership hit a 58-year high in 2014, with an estimated 10.8 billion rides, according to APTA.

Cross-city, cross-border and intermodal travel for business and leisure are also on the rise, spanning everything from trains, subways, and buses to trams, taxis, river boats, and ferries. All of these trends are leading governments, municipalities, and transport authorities to seek ways to deliver a smarter, more passenger-centric travel experience – one that encompasses all aspects of travel, including journey planning, payment, ticketing, and real-time in-journey updates.

Automatic fare collection (AFC) systems or electronic ticketing and innovative transport ticketing solutions were created as a way of meeting growing demand and creating a better travel experience.

Electronic Ticketing Brings Convenience and Efficiency to Public Transport

Development of contactless infrastructures

Beginning in the 1990s, Hong Kong, Seoul, Paris, Chicago, and London became the first cities to implement passive contactless smart card ICs for automated fare collection. Compared to previous fare collection methods – cash and paper and magnetic-stripe tickets – contactless tickets provided clear advantages for customers and transport operators. As a result, the user experience improved, enabling customers to enjoy faster access.

Operators also gained enhanced revenue protection against fraud, lower maintenance costs (compared to mechanically moving parts in magnetic stripe reader equipment), and more efficient operations through faster boarding times.

By 2016, more than 1,000 cities had embarked on contactless technology for payment and access to transportation. Early implementations were not standardized, however, and it quickly became clear that the industry would benefit from standardizing the contactless air interface. That led to the development of ISO/IEC 14443 and ISO/IEC 18092, today’s international standards for contactless communication for many applications.


BENEFITS OF CONTACTLESS TECHNOLOGY TO CUSTOMERS AND OPERATORS

Contactless technology has provided an array of benefits to public transport customers and operators alike:

CUSTOMERS BENEFITS
- Offers greater convenience and ease of access
- Delivers improved cost-efficiency (operators can offer best value fare pricing)
- Protects passenger’s fare token
- Works better in harsh conditions (high humidity, electromagnetic fields, dust)
- Supports secure data updating for more accurate fares
- Enables multi-application cards (one card, one token – allowing other usages like access control for parking or paying for parking, newspaper, coffee, flowers, etc.)
- Fare tokens can be reported and blacklisted if misplaced or stolen, and new fare tokens can be issued in the amount remaining on the misplaced fare token
- Option of individualized/personalized cards with automatic money top-up feature

OPERATOR BENEFITS
- Offers better revenue protection from fraud
- Lowers cost of maintenance
- Facilitates faster boarding
- Enables new business models for fares
- Allows remote maintenance including software upgrade, defect correction, and evolution of ticket acceptance business rules
- Enables cross-border fares, interoperable travel
- Supports convergence with complementary applications and technologies, including open-loop credit/debit payment cards, account based ticketing, micropayment schemes, multi-application cards, NFC mobile devices

3 A list of card projects is available at https://en.wikipedia.org/wiki/List_of_smart_cards.
4 A ‘fare token’ refers to the embodiment of the passenger’s fare stored in a ticket or in a contactless card.
The expanded benefits of additional applications

The advent of smartcards opened new doors of opportunity. Originally fare media were mainly used for one mode of transport (e.g., the metro) and one transport operator. But after the introduction of contactless cards, tokens began to be used for more applications – first, by different transport operators offering the same mode of transport, and later for different modes of transportation, such as train, bus, and taxi. Today, many commuters also use their Public Transport contactless cards for payment applications (coffee, newspaper, parking), loyalty programs (discount programs, recording of “travel” miles) and even access control (access to rental bikes or parking garages).

All these benefits can be further leveraged and expanded through the use of mobile services and NFC.

Mobile Services in Transport Applications

Mobile devices, such as smartphones and tablets, are playing an increasing role in people’s daily lives, providing anywhere/anytime access to communication, information, entertainment, navigation, mobile payment, location-based services, and more.

The relevance of mobile services for public transport applications

For example, a mobile phone can facilitate a traveler's journey by:

- Providing information about
  - the transport network
  - lines
  - stops
  - stations
  - delays
  - departure times
  - walking maps
  - bike hiring
  - carpooling

- Offering journey plan support, going from one point to another using any mode of transport
- Delivering live traffic information, next available vehicle, disruptions, and waiting time at a bus or tram stop
- Rescheduling of journey options when there is disruption
- Providing ticket download options (as QR code or NFC ticket)
- Providing ticket information service (e.g. expiration date, validation, value information)
- Providing payment options

For all of these reasons, it is likely that travelers and commuters alike will welcome the opportunity to use mobile services to improve their journey experience and reduce travel times.
Near Field Communication (NFC)

The invention of NFC technology in 2002 was a milestone in the development of contactless technology. NFC brought contactless communication to mobile phones and offered, in combination with the online and sensor capabilities of smartphones, a new user experience.

NFC technology enables simple and safe two-way interactions between electronic devices, allowing consumers to perform contactless transactions, access digital content, and connect electronic devices with a single touch. The short operating range and one-tap user interface of NFC ensure that only intended transactions take place. NFC complements many popular consumer wireless technologies by utilizing the key elements in existing standards for contactless card technology (ISO/IEC 14443 A&B and ISO/IEC 18092). NFC can be compatible with existing contactless card infrastructure and it enables a consumer to utilize one device across different systems.

Extending the capability of contactless card technology, NFC also enables devices to share information at a distance that is less than 4 centimeters with a maximum communication speed of 424 kbps. Users can make transactions, access information from a smart poster or provide credentials for access control systems with a simple touch.

For the end user, NFC enables easy connections, quick transactions, and simple data sharing.

Following the lessons learned regarding the need for interoperability, the NFC Forum was founded in 2004 in order to serve as a platform for harmonization and standardization. The organization has developed a growing set of specifications that provide a basis for a wide range of use cases.

NFC-enabled devices are becoming increasingly ubiquitous. The installed base of NFC-enabled mobile devices is expected to exceed one billion devices in 2016, growing to 1.9 billion devices in 2018. Industry analyst IHS Technology forecasts that shipments of NFC-enabled handsets will grow to 2.2 billion worldwide by 2020.

Removing the Obstacles to NFC in Public Transport

The growing global availability of NFC-enabled mobile phones has increased interest in the use of NFC in Public Transport. Proponents of NFC cite the many benefits the technology would bring to Public Transport schemes, including:

- Support for multiple applications
- Convergence with payment schemes
- Reduction of card issuing costs
- Use of just one fare medium across several transport schemes (intermodal, cross-city and cross-border)
- Easy over-the-air download, activation, and top-up of transport tickets
- Utilization of the NFC mobile device as a terminal for contactless chip cards

Furthermore, the NFC interface integrates all applications and services that need to be covered during the lifecycle of a mobile Public Transport service.

However, there is an issue that has, until recently, prevented the widespread adoption of NFC in Public Transport: the fragmentation of contactless specifications. Although the relevant standards and specifications – ISO/IEC 14443, ISO/IEC 18092, EMVCo L1, and NFC Forum Analog – are built on the same technical foundations, they have developed differences over time that can lead to interoperability issues. PTOs and their partners have had to investigate case by case whether a certain NFC-enabled service will be supported by a particular NFC mobile device.

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Impact of Specification Fragmentation

As of today, there is no way to determine if a particular NFC mobile device will operate properly as a fare medium or as a PT terminal in a specific PT fare management system. This has created several obstacles to the introduction of NFC-enabled mobile services in Public Transport:

1. PTOs have to test NFC mobile devices for feasibility before they can be approved for use in their particular PT systems. Testing requires significant time and effort. With many models of smartphones on the market and shorter product cycles, testing of all devices is impractical.

2. Without guaranteed interoperability, PTOs must have a backup plan (e.g., barcode) for customers who do not have feasible mobile devices.

3. PT customers with NFC mobile devices may be confused or frustrated to discover that their PT system does not support NFC-enabled mobile services on their particular device.

4. PT customers can’t be sure if their NFC mobile device will support PT services when travelling.

5. Handset makers have had to face a fragmented PT fare management market. No clear information was available to guide them in determining which features and standards had to be supported by a NFC mobile device in order to be interoperable with all globally relevant PT infrastructures.

6. Handset makers offering NFC mobile devices as fare media could not always rely on the standard conformance of existing PT infrastructures. Many system implementations that claimed to be, for example, ISO/IEC 14443-conformant never passed certification.

QUALIFYING NFC DEVICES IN A FRAGMENTED WORLD

LOCAL NETWORK – For qualifying the NFC handsets on transport readers

INFRASCTURE PROVIDER
(for the contactless readers)

HANDSET MANUFACTURERS
(for NFC handsets available in the country or region)

TESTING LAB
To confirm that handsets equipped with the transport app are properly working with contactless readers

PTO

Communication to travelers about:
- Compatible NFC phones
- Alternative solutions

MNOs
(if involved with the transport application)

Until recently the process of qualifying NFC handsets for PTOs has been complex and time-consuming.
The fragmentation of PT specifications has led national PT authorities or operators seeking to enable mobile phones for mobile ticketing to build their own certification schemes to test mobile phones with their transport infrastructure readers.

While this model has been successful in some cases, a greater opportunity exists to achieve RF interoperability on a global scale. In order for NFC to succeed in the marketplace, NFC mobile devices have to support guaranteed technical interoperability within the globally relevant contactless infrastructures and applications.

**PROOF OF CONCEPT: MOBILE SUICA**

In 2006, the East Japan Railway Company (JR East) expanded its Suica contactless card solution to mobile wallet-enabled phones with Mobile Suica. Within two years, JR East reported that there were one million Mobile Suica users. JR East has since worked to make Mobile Suica interoperable with other IC card ticket schemes throughout Japan, and expanded the availability of Mobile Suica to NFC-enabled Android devices in 2011. In 2016, support for Suica was further expanded when Apple announced that it was launching Apple Pay in Japan, specifically to work with Suica and JR East. Learn more about Mobile Suica and NFC here.

**QUALIFYING NFC DEVICES IN AN INTEROPERABLE WORLD**

Harmonization of standards and specifications greatly simplifies the process of qualifying NFC devices for PT systems.

A Better Approach to Achieving Interoperability

Any approach to ensuring the interoperability of NFC mobile devices and PT infrastructures has to respect and appreciate the relevance and the roles of all stakeholders: PTOs, MNOs, industry associations, standards bodies, handset manufacturers, infrastructure providers, and consumers.

This means that the NFC mobile device has to be interoperable with all of the four standards and specifications: ISO/IEC 14443, ISO/IEC 18092, EMVCo L1, and NFC Forum Analog. With the exception of EMVCo L1, the standards also have to support the "reader mode."
As an industry consortium with a commitment to global interoperability, the NFC Forum has opted to pursue a global network model that enables any certified NFC Forum phone to communicate with any transport infrastructure (with the proper operator application loaded on the phone). In this fashion, NFC technology can drive RF interoperability – and become a game changer for transport ticketing applications.

### NFC Is a Game Changer for Transport Ticketing Applications

#### NFC Phones and Transportation

As the number of NFC-enabled devices on the market continues to grow beyond 1 billion units, the potential for NFC as a driver of global PT interoperability becomes more real. The NFC-enabled phone becomes a game changer in transport ticketing in several ways:

<table>
<thead>
<tr>
<th>WHAT NFC OFFERS</th>
<th>WHAT NFC MEANS TO PTOs</th>
<th>WHAT NFC MEANS TO CUSTOMERS</th>
</tr>
</thead>
</table>
| **Contactless card emulation** | • Protection of investment in fare management infrastructure  
• Greater deployment flexibility  
• The opportunity to integrate with other vendors  
• The opportunity to add value by layering on new applications  
• The opportunity to build regional PT networks  
• The opportunity to strengthen customer loyalty  
• Increased customer engagement | • Faster, more convenient PT access  
• Easier ticket reloading  
• More seamless and information-rich travel experiences  
• More enjoyable journeys |
| **Value top-up** | Tickets can be reloaded via the phone connection |  |
| **Reader mode operation** | PTOs can use NFC devices in reader mode. This creates the opportunity to use readily-available devices (instead of a custom reader) as a validator or reader of the customer's contactless tickets, concessions, and reservations. Customers can use their phones to read their card balances, travel history, and top up their cards. |  |
| **On-phone data storage** | Tickets can be stored on the phone in a secure manner. |  |
Making an Impact: An Ecosystem-wide Effort

Achieving RF interoperability has been a concerted effort spanning the global PT ecosystem. The NFC Forum and EMVCo were the first to agree upon cooperation that targeted the harmonization of analog/RF and digital layer specifications for NFC mobile devices. The NFC Forum has since extended the scope of the effort by establishing similar relationships with transport organizations and other standardization organizations. In 2015, the NFC Forum and GSMA launched an initiative in concert with global PT representatives, Smart Ticketing Alliance and JRE, and standards bodies, including CEN and ISO.

THE PUBLIC TRANSPORT RF INTEROPERABILITY INITIATIVE

<table>
<thead>
<tr>
<th>AREA OF FOCUS</th>
<th>NFC FORUM GROUP DRIVING THE COLLABORATION</th>
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<tr>
<td>Market feedback</td>
<td>NFC TRANSPORT</td>
<td>SMART TICKETING ALLIANCE, JR, APTA</td>
</tr>
<tr>
<td>Technical specification alignment</td>
<td>NFC TECHNICAL COMMITTEE, NFC COMPLIANCE COMMITTEE</td>
<td>GSMA, ISO, CEN</td>
</tr>
</tbody>
</table>

Working together, the organizations embarked on two work packages to achieve RF interoperability:

1. An analysis of user requirements and the identification of gaps among the standards; and the determination of radio parameter adjustments necessary to close those gaps and enable mobile/transport reader interoperability

2. The definition of testing and certification plans for NFC mobile devices and PT infrastructures

PTOs’ Role in Interoperability

While the harmonization of the RF interface of NFC devices is an important pre-condition for a broader adoption of the NFC technology, it does not deliver global NFC interoperability of one unique application in all transport schemes. Due to the global diversity of technology platforms and fare collection systems, PTOs cannot expect a one-stop NFC solution. In addition, each PTO is responsible for any ancillary activities, such as making NFC apps available to customers and making any necessary adjustments to transport scheme backend systems. So, while the NFC Forum has created the basic prerequisites for the adoption of NFC technology in transport ticketing systems, the execution, adoption and adjustment of an NFC-capable AFC system remains the responsibility of the PTO or system integrator.

ACCOMPLISHMENTS TO DATE

- All relevant technical standard analog parameters are harmonized. Interoperability is now assured independent of antenna size, and for a minimum defined operating distance.\(^7\)
- NFC Forum specifications are “Public Transport Ready.” NFC Forum Analog Specification 2.0 fully supports RF interoperability. Organizations that test and certify products to NFC Forum specifications will be assured of interoperability according to the requirements summarized in the NFC Forum’s “Public Transport Ready” document.
- The introduction of NFC Forum related test cases and certification is planned for the end of 2016.

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\(^7\) NFC performs communication and/or power transfer using magnetic coupling. Generally, the ratio of the reader to card antenna size, as well as their relative distance, determines the coupling which has a significant impact on communication stability and/or power transfer.
The time to begin your NFC Implementation is NOW

The advent of global interoperability between NFC-enabled smartphones and existing contactless readers can be a game changer for public transit operators. Interoperability removes important technical roadblocks to relatively fast deployment of mobile ticketing. With a contactless infrastructure in place, public transit operators already have the equipment they need for mobile ticketing. Their main task for deploying mobile ticketing will be to write the app for the mobile transport service and decide on the mobile ticket security scheme (see sidebar).

The NFC Forum Transport Working Group recommends that PTOs seize the opportunity and leverage their existing infrastructure to modernize the mobile ticketing and travel experience by following these guidelines:

- Stay current with the latest global NFC standards and developments in the transportation industry. Click here for more information.
- Ticketing managers, purchasers should refer the latest standards:
  NFC Forum specifications for mobile phones, latest CEN TS 16794 especially for infrastructures in Europe, latest ISO/IEC 14443 series and ISO/IEC 18092 for contactless readers and cards. Click here to access.

GET STARTED

- Start planning your NFC public transport implementation for the next upgrade of your infrastructure.
- Get involved with the NFC Transport Working Group. This is where your organization can make a contribution to the global transportation industry. Email the Working Group’s chairpersons at sctwg-chair@nfc-forum.org.
Appendix

EXAMPLES OF CONTACTLESS PUBLIC TRANSPORT CARDS AROUND THE WORLD

• Argentina – SUBE
• Atlanta – Breeze
• Bangkok – Rabbit
• Beijing – Municipal Administration and Communications Card
• Belgium – MOBIB
• Boston – CharlieCard
• Chicago – Ventra
• Chile – FESUB
• Delhi – Metro
• Denmark – Rejsekort
• Dubai – NOL
• Dublin – Leap
• Finland – Waltti
• Germany – VDV KA
• Hong Kong – Octopus
• Istanbul – Istanbulkart
• Japan – Suica
• London – Oyster
• Luxembourg – mKaart
• Madrid – CRTM
• Malaysia – Touch ‘n Go
• Manila – Beep
• Melbourne – Myki
• Moscow – Troika
• Netherlands – OV-Chipkaart
• Paris – Navigo
• Rio de Janeiro – RioCard
• San Diego – Compass
• San Francisco – Clipper
• Sao Paulo – Bilhete Unico
• Seattle – Orca
• Shanghai – Public Transportation Card
• Shenzhen – Tong
• Singapore – EZ-Link
• South Korea – T-money
• Sydney – Opal
• Taiwan – Easycard
• Toronto – Presto
• Valparaiso – Metroval
• Vancouver – Translink
About the Organizations

The American Public Transportation Association (APTA) is a nonprofit organization, which serves as an advocate for the advancement of public transportation programs and initiatives in the United States. 
http://www.apta.com/Pages/default.aspx

The GSMA, Global System for Mobile Association, represents the interests of mobile operators worldwide, uniting nearly 800 operators with more than 250 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and Internet companies, as well as organizations in adjacent industry sectors.
http://www.gsma.com/

The ISO, International Organization for Standardization, is an independent, non-governmental international organization with a membership of 161 national standards bodies. Through its members, it brings together experts to share knowledge and develop voluntary, consensus-based, market relevant International Standards that support innovation and provide solutions to global challenges.
http://www.iso.org/iso/home/about.htm

ITSO Ltd is a [UK] Government-backed, non-profit distributing organization that aims to make travelling on public transport throughout the UK seamless and easier by using smart ticketing technology. The company is the guardian of the ITSO Specification – a Crown Copyright open national standard for smart ticketing.
https://www.itso.org.uk

East Japan Railway Company (JR East) is one of the largest passenger railway companies in the world. JR East provides transportation services via its Shinkansen network, which connects Tokyo with regional cities in five directions, as well as conventional lines in the Tokyo metropolitan area and other networks. JR East’s networks combine to cover 7,458 kilometers and serve 17 million people daily.

The NFC Forum’s mission is to advance the use of Near Field Communication technology by developing specifications, ensuring interoperability among devices and services, and educating the market about NFC technology. The Forum’s global member companies are currently developing specifications for a modular NFC device architecture, and protocols for interoperable data exchange and device-independent service delivery, device discovery, and device capability. The NFC Forum’s Sponsor members include Apple Inc., Broadcom Corporation, Dai Nippon Printing Co. Ltd., Google, Inc., Intel, MasterCard Worldwide, NXP Semiconductors, Qualcomm, Samsung, Sony Corporation, STMicroelectronics, and Visa Inc.
http://www.nfc-forum.org

The Smart Ticketing Alliance drives a coordinated effort towards global ticketing interoperability for the public transport sector. This includes the establishment of a trust scheme that mirrors the schemes used in the mobile phone industry, banking sector and with other stakeholders.
http://www.smart-ticketing.org
**Abbreviations**

IC – Integrated Circuit  
MNO – Mobile Network Operators  
NFC – Near Field Communication  
PTO – Public Transport Operators  
RF – Radio Frequency  
PT – Public Transportation  

**Definitions**

Near Field Communication (NFC) is a standards-based short-range wireless connectivity technology that makes life easier and more convenient for consumers around the world by making it simpler to make transactions, exchange digital content, and connect electronic devices with a touch. NFC is compatible with hundreds of millions of contactless cards and readers already deployed worldwide.

Fare token refers to the embodiment of the passenger’s fare stored in a ticket or in a contactless card.

Card emulation mode enables NFC devices to act like smart cards, allowing users to perform transactions such as retail purchases and transit access with just a touch. This mode is capable of functioning when the device is powered-off, although it is the service provider’s decision whether to allow this. An example is where an NFC device acts as an NFC tag.

Card reader mode enables the NFC device to read NFC Forum-mandated tag types. NFC-enabled devices can access information from embedded tags in smart posters, in displays.  
In the case of public transport, the NFC phone can read the card information, show to the user the card balance, travel history, and other data. PTO may allow to top-up the transportation card using this mode.