NFC Test Challenges for Mobile Device Developers

Presented by:
Miguel Angel Guijarro
miguel-angel_guijarro@agilent.com
Outlook

About NFC
Developing a NFC Device
Test Challenges
Test Solutions
Q&A
What is ‘NFC’ (Near Field Communication)?

“A fusion technology that provides new valuable service to the users by integrating RFID Technology with Mobile Communication devices & Wireless Internet infrastructure”.

Goals:

- Create new value for Mobile Phone Users.
- Build new markets for Mobile Technologies.
- Apply RFID Technology to Various Application Domain.
- Extend the applications for the RFID technology to the B2C area.

Enable contactless Communication with a simple touch
A driver for new market of mobile applications
NFC Technology main features

The concept is to make two devices communicate, bring them together or make them touch.

✓ Based on RFID technology at 13.56 MHz.
✓ Operating distance typically up to 10 cm.
✓ Compatible with today’s contactless RFID technologies.
✓ Data exchange rate today up to 848 kbit/s.
✓ Three modes of operation: P2P, Card Emulation and Reader/Writer
✓ NFC is complementary to Bluetooth® and Wi-Fi technologies.

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Application scenarios

Library book-tracking

Access Control in buildings

Apparel Item tracking

Baggage tracking

Supply Chain applications

Payment

Item Level Management

Mobile RFID

Personal Identification
NFC available from

- Smartphones
- Tablets
- Laptop
- TVs
- POS
- Payment Cards
- Passive Stickers
NFC ecosystem and related consortia
Industry promoters

- The **NFC Forum** is a non-profit industry association formed to advance the use of NFC short-range wireless interaction in consumer electronics, mobile devices and PCs.

- The NFC Forum will promote implementation and standardization of NFC technology to ensure interoperability between devices and services.

- **EMVCo** (Europay, MasterCard and VISA) founded in the mid-1990s in order to develop specifications to facilitate interoperability between chip cards and terminals (PoS).

- Payment Systems such as VISA and MasterCard define the business rules for issuing and acceptance of EMV products.

- EMVCo is collaborating with other industry groups to define standards for contactless mobile payment, such as NFC Forum.

*Source NFC Forum, EMVCo*
Adoption trend (*)

**Berg Insight**

- *100 million* cell phones using NFC technology predicted to be sold this year alone

**ABI Research**

- 102 million NFC handsets to ship in 2012; 285 million will ship in 2013
- NFC-enabled smartphone shipments are anticipated to increase by 481% from 2012 to 2015

**Deloitte**

- In 2013 there may be as many as *300 million* NFC smartphones, tablets and eReaders sold

**Frost & Sullivan**

- By 2015, NFC will be the most-used solution for mobile payment, enabling worldwide transactions totaling about $151.7 billion

**Gartner Research**

- *50% of smartphones* will have NFC capability by 2015

**Juniper Research**

- By 2017, 1 in 4 US consumers will use NFC-enabled devices to pay for goods in-store

(*) Source NFC Forum
Developing a NFC Device
Contactless legacy standards

- ISO/IEC 10536 close coupling cards
- ISO/IEC 14443 Proximity Standards for cards and readers and ISO/IEC 10373-6 test methods. Two different technologies Type A and B
- ISO/IEC 15693 Vicinity Standards for cards and readers and ISO10373-7 test methods

- Some implementation examples
  
  - Mifare is compatible with ISO14443A
  - Calypso is compatible with ISO14443B
  - Sony Felica is compatible with ISO18092

- Key differentiators between products based on the different standards are operational range and data transfer rate.

* Source Smartcard alliance

<table>
<thead>
<tr>
<th>Features</th>
<th>14443</th>
<th>15693</th>
<th>125 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standards</td>
<td>ISO/IEC 14443</td>
<td>ISO/IEC 15693</td>
<td>None³ (de facto)</td>
</tr>
<tr>
<td>Frequency</td>
<td>13.56 MHz</td>
<td>13.56 MHz</td>
<td>125 kHz</td>
</tr>
<tr>
<td>Operational range</td>
<td>Up to 10 centimeters (~3.4 inches)</td>
<td>Up to 1 meter (~3.3 feet)</td>
<td>Up to 1 meter (~3.3 feet)</td>
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<tr>
<td>Chip types supported</td>
<td>Memory Wired logic, Microcontroller⁴</td>
<td>Memory Wired</td>
<td>Memory Wired logic</td>
</tr>
<tr>
<td>Encryption and authentication</td>
<td>MIFARE, DES/3DES, AES, RSA⁵, ECC</td>
<td>Supplier specific, DES/3DES</td>
<td>Supplier specific</td>
</tr>
<tr>
<td>functions</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Memory capacity range</td>
<td>64 to 64K bytes</td>
<td>256 and 2K bytes</td>
<td>8 to 256 bytes</td>
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<tr>
<td>Read/write ability</td>
<td>Read/write</td>
<td>Read/write</td>
<td>Read only²</td>
</tr>
<tr>
<td>Data transfer rate (Kb/sec)</td>
<td>Up to 106 (ISO)</td>
<td>Up to 26.6</td>
<td>Up to 4</td>
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<tr>
<td>Anti-collision</td>
<td>Yes</td>
<td>Yes</td>
<td>Optional</td>
</tr>
<tr>
<td>Card-to-reader authentication</td>
<td>Challenge/Response</td>
<td>Challenge/Response</td>
<td>Password</td>
</tr>
<tr>
<td>Hybrid card capability</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Contact interface support</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Different RF and protocol communication between different technologies

* Source Smartcard alliance
NFC Forum specifications

* Source NFC Forum
The NFC phone interacts with another NFC enabled device such as an NFC phone, TV, camera, printer, etc., to transmit relatively small amount of data and mainly to enable the use of other technologies, e.g. Bluetooth, Wi-Fi.

Application scenarios could be:

- To transmit pictures from a mobile phone to a printer using NFC to enable a Bluetooth connection.
- To obtain the security settings of a Wi-Fi network and configure the access automatically.
Application scenarios. Reader/Writer Mode

✓ The Mobile phone is equipped with an NFC reader and when it detects the RFID tag sends and receives information through the Mobile Network.

✓ Application scenarios could be:

  • In supermarkets to obtain additional information from tagged goods.
  • Multimedia contents or event information from advertisements or posters carrying RFID tags.
  • Automated messages and automated voice services.
The Mobile phone behaves as an RFID tag and when it gets into the interrogation field of an RFID reader, it uniquely identifies the mobile phone user.

Application scenarios could be:

- Mobile phone payment operations.
- Unlock doors or authentication for granting access to restricted areas.
- Presence indication
NFC Forum – Technologies

- A NFC Technology can be defined as “A group of transmission parameters defined by the NFC standard that make a complete communication protocol.” Some of this parameters would be: RF carrier, communication mode, bit rate, modulation scheme, bit level coding, frame format, protocol, and Command set.
- A NFC device may support one or more communication technologies: Type A, B and F, in each case it may act as Poller and/or Listener.
- NFC device in active mode (initiator) – generates field, starts communication
- NFC device in passive mode (target) – scans for detecting initiators

### NFC Technical Standards Specifications of the Air Interface

<table>
<thead>
<tr>
<th>NFC-Forum Standard</th>
<th>Polling / Listening</th>
<th>Coding</th>
<th>Modulation</th>
<th>Data Rate</th>
<th>Carrier frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFC-A</td>
<td>Polling</td>
<td>Modified Miller</td>
<td>ASK 100%</td>
<td>106 kb/s</td>
<td>13.56 MHz</td>
</tr>
<tr>
<td></td>
<td>Listening</td>
<td>Manchester</td>
<td>Load modulation (ASK)</td>
<td>106 kb/s</td>
<td>13.56 MHz +/- 848 kHz subcarrier</td>
</tr>
<tr>
<td>NFC-B</td>
<td>Polling</td>
<td>NRZ-L</td>
<td>ASK 10%</td>
<td>106 kb/s</td>
<td>13.56 MHz</td>
</tr>
<tr>
<td></td>
<td>Listening</td>
<td>NRZ-L</td>
<td>Load modulation (BPSK)</td>
<td>106 kb/s</td>
<td>13.56 MHz +/- 848 kHz subcarrier</td>
</tr>
<tr>
<td>NFC-F</td>
<td>Polling</td>
<td>Manchester</td>
<td>ASK 10%</td>
<td>212 / 424 kb/s</td>
<td>13.56 MHz (without subcarrier)</td>
</tr>
<tr>
<td></td>
<td>Listening</td>
<td>Manchester</td>
<td>Load modulation (ASK)</td>
<td>212 / 424 kb/s</td>
<td>13.56 MHz (without subcarrier)</td>
</tr>
</tbody>
</table>
Operation volume

- Devices shall meet required performance in operation volume
- Conformance test specs define reference antennas to test response in operation volume

* Source NFC Forum
NFC devices – Poll activities and Listen SM

✓ Poll Device Activities

✓ Technology detection: scan for devices of certain technologies in the range (NFC A, B and F)
✓ Collision resolution
✓ Device activation
✓ Data Exchange
✓ Device Deactivation

✓ Listen Device State Machine

* Source NFC Forum
Testing of NFC Components
Testing NFC devices - Overview

- Two main groups of tests: Digital (Protocol) and Analogue (RF).
- Digital test cases check low layer protocol exchanges, link timings, framing, etc.
- Analogue test cases measure power levels, waveform quality, frequency accuracy, modulation, etc.
- Different testing strategies for each stage of the NFC Mobile devices development

Key to Success: Ensure Interoperability in devices reaching the market
Testing strategy vs. development stages

- NFC Components Development
- System Integration
- Certification
- Operator Acceptance

R&D and Pre-Conformance
- Conformance
- Regulatory

Conformance & Interoperability
Performance & Usability
R&D Testing Challenges

Several protocols supported NFC Forum, ISO 14443 A/B, FeliCa, Mifare, etc.
Different operation modes P2P, R/W and Card Emulation.
Additional protocols may come in the future (e.g. NFC Forum 15693)
Different products requires different antenna factor
Challenging Magnetic coupling with HF technology
R&D Testing Approach

- Test signal modulation, bit level coding, bit rates, frame formats, protocol and command sets.
R&D Testing Approach

- Verify Protocol commands and sequences are correctly implemented.

Required cross domain for Digital and Analogue
Different modulation and codification schemes.

NFC devices are tested via magnetic field coupling

Products already have multiple RF interfaces

Different type of devices, form factors, antenna sizes, etc

RF and Protocol measurements are required

Big amplitude signals in the presence of low signals

Avoid Holes on operation volume.

Free guard area shall be observed
Pre- & Conformance Testing Approach

Time domain measurements capabilities.
Set of different reference test antennas.
Protocol analysis capabilities and NFC devices emulation.
Automatic Positioning Robot
Reporting tools
Conformance test cases customization

<table>
<thead>
<tr>
<th>Poll</th>
<th>NFC Forum</th>
<th>EMV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generate Field</td>
<td><img src="image1.png" alt="NFC Forum Poll" /></td>
<td></td>
</tr>
<tr>
<td>Sense Rx from DUT</td>
<td><img src="image2.png" alt="NFC Forum Poll" /></td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Listen</th>
<th>NFC Forum</th>
<th>EMV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sense Poll field strength</td>
<td><img src="image3.png" alt="NFC Forum Listen" /></td>
<td></td>
</tr>
<tr>
<td>Respond Listener commands</td>
<td><img src="image4.png" alt="NFC Forum Listen" /></td>
<td></td>
</tr>
<tr>
<td>Sense Rx from DUT</td>
<td><img src="image5.png" alt="NFC Forum Listen" /></td>
<td></td>
</tr>
</tbody>
</table>

* Additional coils admitted to amplify reception of very small signals

* Source NFC Forum, EMVCo
Pre- & Conformance Testing Approach

RF behaviour across operation volume

Fine analysis of complete protocol exchanges

Fine debug of samples to meet conformance milestone
Certification schemes

NFC Forum

- Require Device R/W, P2P and CE (optional)
- Require Device requirements and DTA
- Accredited certification labs performing
  - Wave 1 Certification including Digital Protocol
  - Wave 2 Certification * including RF Analog, P2P

EMV contactless (EMVCo)

- Contact testing (ISO/IEC 7816)
- Contactless testing (ISO/IEC 14443)
- L2 according to each payment scheme

*NFC Forum and EMVCo may mutually recognize L1 certification*

* Planned for 2013
Wave 1 Certification: DP and Tag Operation

<table>
<thead>
<tr>
<th>Poll Mode Test Cases (135)</th>
<th>Listen Mode Test Cases (110)</th>
<th>Tag Operation Test Cases (30)</th>
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</thead>
<tbody>
<tr>
<td>Installation Type A (18)</td>
<td>Installation Type A (49)</td>
<td>Type 1 Tag (11)</td>
</tr>
<tr>
<td>Installation Type B (14)</td>
<td>Installation Type B (13)</td>
<td>Type 2 Tag (6)</td>
</tr>
<tr>
<td>Installation Type F (2)</td>
<td>Installation Type F (3)</td>
<td>Type 3 Tag (8)</td>
</tr>
<tr>
<td>Type 1 Tag (1)</td>
<td>-</td>
<td>Type 4 Tag (5)</td>
</tr>
<tr>
<td>Type 2 Tag (3)</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Type 3 Tag (3)</td>
<td>Type 3 Tag (1)</td>
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<tr>
<td>Type 4a Tag (32)</td>
<td>Type 4a &amp; 4b Tag (8)</td>
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<tr>
<td>Type 4b Tag (35)</td>
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<tr>
<td>P2P with NFC-A (13)</td>
<td>P2P with NFC-A (20)</td>
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<tr>
<td>P2P with NFC-F (14)</td>
<td>P2P with NFC-F (16)</td>
<td>-</td>
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</tbody>
</table>

(*) exact number of test cases subject to changes
Wave 2 (*) Certification Analog RF Test Cases

(*) expected in 2013, exact number of test cases subject to changes

<table>
<thead>
<tr>
<th>Poll Mode Test Cases (11)</th>
<th>Listen Mode Test Cases (22)</th>
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<tbody>
<tr>
<td>Minimum Power Emission Measurement (1)</td>
<td>Power Reception (9)</td>
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<tr>
<td>Maximum Power Emission Measurement (1)</td>
<td>Loading Effect (1)</td>
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<tr>
<td>Carrier Frequency Measurement (1)</td>
<td>Carrier Frequency Test (1)</td>
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<tr>
<td>Reset characteristics Measurement (1)</td>
<td>Power On and Off (3)</td>
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<tr>
<td>Threshold Level Test (1)</td>
<td>Subcarrier Modulation (2)</td>
</tr>
<tr>
<td>Modulation Polling Device to Listening Device (3)</td>
<td>Modulation Polling Device to Listening Device at limit conditions (3)</td>
</tr>
<tr>
<td>Load Modulation Sensitivity (3)</td>
<td>Load Modulation Amplitude (3)</td>
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<table>
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<td>0</td>
<td>-10</td>
<td>5</td>
</tr>
</tbody>
</table>
Wave 2 (*) Certification LLCP/SNEP Test Cases

- LLCP defines an OSI layer-2 protocol to support peer-to-peer communication between two NFC enabled devices.

- SNEP allows exchanging NFC Data Exchange Format (NDEF) messages between NFC Forum devices operating in NFC Forum peer-to-peer mode (makes use of the LLCP connection-oriented transport mode).

<table>
<thead>
<tr>
<th>LLCP Test Cases (69* TC)</th>
<th>SNEP Test Cases (25 TC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAC (17)</td>
<td>Basic Test for Client Mode (2)</td>
</tr>
<tr>
<td>LLC (17)</td>
<td>Basic Test for Server Mode (5)</td>
</tr>
<tr>
<td>Connectionless (CTL) (5)</td>
<td>PUT coding Test for Client Mode (3)</td>
</tr>
<tr>
<td>Connection-Oriented (CTO) (29)</td>
<td>GET coding Test for Client Mode (3)</td>
</tr>
<tr>
<td>Aggregation (1)</td>
<td>ACCEPT NDEF Message for Server Mode (7)</td>
</tr>
<tr>
<td>---</td>
<td>RETURN NDEF Message for Server Mode (5)</td>
</tr>
</tbody>
</table>

(*) expected in 2013 exact number of test cases subject to changes
Objective is to ensure

- Positive user experience (confidence!)
- Smooth roll out of NFC based applications and services

Testing Approach includes

- Demand of certified Mobile devices

Additionally, MNOs own their customized test plans

- Conformance testing (spot checking)
- Performance testing, mobile devices benchmarking
- Usability of NFC apps and also combined with other radio technologies
- Interoperability with legacy devices
- Radio coexistence tests
- Battery Drain test
- Manufacturing testing
What does our test set up require?
Testing NFC devices – Test Bench requirements

- NFC device (both Reader and tag role) emulator
- Signal Generation, Acquisition and Analysis
- Protocol Code and Decoding capabilities
- Conformance and Design verification features
- Automatic positioning tools
- Uncertainties
Agilent Example Solutions

**T3111S RFID HF Conformance Tester**

- RF and Protocol testing in one single instrument
- One-box test solution. No need for external instrumentation
- Robots Supported

**T3121S RFID HF R&D Tester**

- Users can build their own test cases
- Automated test cases execution
- NFC & RFID devices emulator
Conclusions

New NFC devices extend capabilities from legacy contactless readers and cards.

More power device, more complex protocols and applications including payment and others.

Different players in the chain have different NFC testing challenges, sometimes shared with upstream partners/customers.

Several testing approaches to solve these challenges.

Needs of qualified test tools that can offer accuracy, configurability and versatility.

Certification, a mechanism for NFC interoperability.
Thanks for your attention!

Q&A