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Introduction

Near Field Communication (NFC) technology has emerged as a powerful tool to complement and enhance the value and performance of consumer electronics (CE) devices – from game consoles to tablets to household appliances. NFC's read/write, peer-to-peer, and card emulation operating modes help simplify CE device operation, enabling disparate devices to connect and to work together.

NFC operates within a range of only a few centimeters. This is a distinctive and secure characteristic of NFC, as it requires the user to show intent of communicating over NFC by physically tapping a mobile device on (or approaching in very close proximity to) an NFC reader, NFC tag, or other NFC-enabled device.

One popular set of NFC use cases for CE is based on triggering the establishment of a connection to another network technology, such as Bluetooth or Wi-Fi. In addition to the connection establishment, the NFC touch can also trigger an action such as sending a file from one device to the other. To help enable such use cases, the NFC Forum has developed the Connection Handover Technical Specification.

This specification can be used to facilitate a wide set of different use cases, including audio or video streaming, remote control of a device, or file transfer using a non-NFC network technology. Even though the use cases are different, they share common user actions, most notably the NFC touch itself. Questions such as, what happens upon the first touch or the second touch when using two devices? are often answered differently by different implementations – even for the same use case. This leads to potential confusion for users, which endangers the user experience.

1 Objectives

NFC should be easy to use, simple, and intuitive for the user. Therefore, it is important to provide users with a consistent and pleasant user experience. A consistent user experience also reduces the failure rate for using NFC – which is a very important consideration, as the simplicity of the "touch paradigm" is one of the major advantages of NFC.

This document provides a set of recommendations to better align user experiences for Connection Handover use cases between different implementations.

2 Connection Handover Overview

The NFC Forum was formed to advance the use of Near Field Communication technology by developing specifications, ensuring interoperability among devices and services, and educating the market about NFC. Since then, the NFC Forum has created a set of specifications to cover various use cases – one of which is the Connection Handover specification.

Connection Handover (CH) is targeted for cases in which the amount of data to be transferred is too large to be transmitted over NFC during the time of a touch, or for situations in which data is to be streamed for a longer time.

Establishing a communication link between two devices with NFC is easy and fast, but the connection is then limited to a short communication distance and low data speed compared to other wireless carriers.
However, those other carriers often require a more complicated network configuration or connection setup.

Using the Connection Handover specification, it is possible to deploy applications that offer the best of both worlds by combining the simple, one-touch setup of NFC with the high-speed, longer distance communication of Bluetooth or Wi-Fi. The specification enables developers to choose the carrier for the information to be exchanged. If matching wireless capabilities are revealed during the negotiation process between two NFC-enabled devices, the connection can switch to the selected carrier.

The specification distinguishes between **static** and **negotiated** NFC connection handover.

- Using static connection handover, an NFC-enabled device in reader/writer mode detects an NDEF (NFC Data Exchange Format) tag that contains a static handover message. The NFC device analyzes the handover message, and if it contains valid data for a carrier the device supports, the device initiates a corresponding connection. Usually static handover is used to establish a connection between an NFC device and an **accessory** or **peripheral device**.
- Negotiated NFC handover is based on the peer-to-peer mode and it therefore occurs **between two NFC devices**. A touch initiates a negotiation between the two devices, in which one device proposes a set of carriers and the other may select one of those.

*Note: User experience recommendations for use cases that are based on touching two NFC devices are not within the scope of this document, so the material included here does not cover negotiated handover situations.*

Note that the Connection Handover specifies a framework only. The data definitions for specific carriers are outside the scope of the NFC Forum. Other communication standards bodies, such as the Bluetooth Special Interest Group and the Wi-Fi Alliance, have specified corresponding data structures.
3 Scope of This Document

This paper focuses on connection handover to the following carriers:

- NFC to Bluetooth
- NFC to Wi-Fi

For those carriers, this document targets the following use cases:

- Audio or video streaming (including services such as Miracast)
- Image or file transfer

This document assumes that the type of the device that is touched determines the action the user wants to perform. This is usually the case when:

- One of the devices is a (potentially mobile) multi-purpose NFC-enabled device (e.g., a smartphone). Such a device is referred to as an NFC Device in this document. An NFC device supports Reader/Writer mode and Peer-to-Peer mode. An NFC device may also support Card Emulation mode.

- The other device is an accessory or a single-purpose device such as a speaker or printer, referred to as an NFC Accessory Device in this document. NFC accessory devices usually offer either Bluetooth or Wi-Fi as carriers; both may be offered in rare cases.

These use cases can often be enabled using static handover. In this situation an NFC accessory device is the Handover Selector and an NFC device is the Handover Requestor (see the Connection Handover specification for details). If static handover is used, NFC does not work when two NFC accessory devices are touched to each other, as both incorporate only an NFC tag, and two tags cannot communicate.

Concrete examples of targeted use cases are:

- Bluetooth audio streaming between a smartphone and a speaker or headset
- A Miracast session between a smartphone and a TV
- Transfer of an image between a digital camera and a smartphone over Wi-Fi

Note: User experience recommendations for use cases that are based on touching two NFC devices are not within the scope of this document.

Note: Some of the recommendations in this document may also be applicable to a wider range of Connection Handover use cases.
4 Recommendations

Three types of recommendations are supplied: general recommendations that apply regardless of the application, recommendations that are specific to audio and video streaming use cases, and recommendations specific to Bluetooth use cases.

4.1 General recommendations

GEN-01: NFC Touchpoint Indication

Recommendation

Position the touchpoint on a device where the NFC antenna is located so that it is clearly seen by the user.

Rationale

For NFC to work, the user must touch the devices together at the point where the antennas are located, in order to establish a connection. This is very difficult if the spot is not marked. Furthermore, NFC-enabled consumer electronics devices have a variety of designs, and the NFC antenna could be placed in various locations. Without an indicator, users do not know where the touchpoint is.

Being able to locate the touch point accurately significantly increases the success rate of using NFC connection handover.

GEN-01-A: Use of N-Mark

Recommendation

Use the NFC Forum N-Mark to clearly indicate the touchpoint.

Rationale

Different marks are confusing for the user. For more information about the N-Mark, please refer to the Appendix of this document or to http://nfc-forum.org/our-work/nfc-branding/n-mark/.

Figure 1: NFC Forum N-Mark
**GEN-02: No Network Enabling**

Recommendation

The devices should not require enabling the network carrier manually before or after touching.

Rationale

The intention of using connection handover is to reduce the number of user interactions to establish a connection. Requiring the user to enable or disable a carrier would endanger this targeted user experience.

**GEN-03: Automatic Pairing**

Recommendation

Automatically pair or authenticate devices without additional user actions after touching.

Rationale

NFC already provides by its nature a suitable level of device identification for the given use cases. The user should not be annoyed with additional confirmation messages such as “Do you want to pair ●●●?” and authentication mechanisms such as entering a PIN or passcode. Such actions harm the targeted simple user experience.

**GEN-04: Feedback upon Completion**

Recommendation

Give feedback to the user indicating when the user can detach the two devices.

Rationale

To make a connection, users need to touch one device to another device, targeting the touchpoint. However, a user cannot know how long to touch the two devices together. Therefore, when the devices have completed their operation over NFC, the user should be notified that the devices can be detached.

Providing such feedback significantly increases the success rate of connections using NFC handover, as the users can wait for feedback from the device; they do not need to make a decision to detach the devices.

Usually the NFC device is equipped with a richer user interface (UI) than the accessory device; therefore, the user feedback should be provided on this device and only optionally in addition on the accessory device.
Flow example

1. The user touches an NFC device to an NFC accessory device.
2. The NFC device discovers the NFC tag of the NFC accessory device and reads the stored NDEF message.
3. The NFC device provides feedback to the user, such as a visual indication or by vibrating.
4. The user detaches the NFC device from the NFC accessory device.

**GEN-05: Short Touch Duration**

Recommendation

The duration required for the NFC touch should be as short as possible, to optimize the user experience. For the majority of use cases and device configurations, a touch should not need to last longer than two seconds. If possible, a duration below one second is desirable (measured from the time the devices are brought close enough together to enable RF communication until the time the NFC transaction has finished).

Rationale

Even though some use cases or specific implementations may require touching the devices for a longer time period, the targeted user experience with NFC is a short touch of the two devices. A time of two seconds is long enough for exchanging the amount of data via NFC that is necessary for the targeted use cases, even if the device discovery is configured for a less frequent polling for other devices.

### 4.2 Specific recommendations for audio or video streaming use cases

**STR-01: Touching to Disconnect**

Recommendation

Touching two devices that are currently connected should disconnect the devices.

Rationale

There are many cases where repeating the same operation results in canceling the previous operation (e.g., the switch or on/off button on CE devices). This paradigm is therefore well understood by most users. To make connection and disconnection operations consistent, this rule should be applied to NFC handover use cases.

Disconnecting in this case is also the most natural behavior, as the other possible options — either to do nothing or to try to connect again — do not bring any benefit to the user.

Flow example:

1. The user touches an NFC device to an NFC accessory device.
2. The NFC device discovers the NFC tag of the NFC accessory device, reads the stored NDEF message, and establishes a connection, such as for audio streaming.
3. The user detaches the NFC device from the NFC accessory device.
4. The user touches the NFC device to the NFC accessory device a second time.
5. The devices disconnect (and may turn off Bluetooth immediately or after some idle time).

**STR-02: Connection by a New Device**

**Recommendation**

When an NFC accessory device that currently has an active connection with an NFC device is touched by another NFC device, it should disconnect from the currently connected NFC device and establish a new connection with the more recently touched NFC device.

**Rationale**

By touching the devices, the user has expressed the intention to connect the devices. The last touch should always have a higher priority than previous touches, as it represents the latest intention from the user.

A consequence of this rule is that an NFC accessory device can only be actively connected with a single NFC device at a time.

*Note: This recommendation applies only if the connection is established via NFC. Parallel connections to multiple devices should still be possible using other means of establishing connection.*

**Flow example:**

1. The user touches NFC device A to an NFC accessory device.
2. NFC device A discovers the NFC tag of the NFC accessory device and reads the stored NDEF message.
3. NFC device A is connected to the NFC accessory device, such as for audio streaming.
4. The user detaches NFC device A from the NFC accessory device.
5. The user touches NFC device B to the NFC accessory device.
6. NFC device B discovers the NFC tag of the NFC accessory device and reads the stored NDEF message.
7. The user detaches NFC device B from the NFC accessory device.
8. NFC device A is disconnected from the NFC accessory device.
9. NFC device B is connected to the NFC accessory device, such as for audio streaming.
STR-03: Connecting to a New Accessory Device

Recommendation

When an NFC device that currently has an active connection with an NFC accessory device is touched to another NFC accessory device of the same type, it should disconnect from the currently connected NFC accessory device and establish a new connection with the more recently touched NFC accessory device.

The type of an NFC accessory device refers to the combination of the function offered by the device and the carrier used; for example, a Bluetooth speaker and a Bluetooth headset are of the same type.

Rationale

By touching the devices, the user has expressed the intention to connect the devices. The last touch should always have a higher priority than previous touches, as it represents the latest intention from the user.

A consequence of this rule is that an NFC device can only have an active connection with a single NFC accessory device of a given type at a time.

Flow example:

1. The user touches an NFC device to NFC accessory device A.
2. The NFC device discovers the NFC tag of NFC accessory device A and reads the stored NDEF message.
3. The NFC device is connected to NFC accessory device A, such as for audio streaming.
4. The user detaches the NFC device from NFC accessory device A.
5. The user touches the NFC device to NFC accessory device B.
6. The NFC device discovers the NFC tag of NFC accessory device B and reads the stored NDEF message.
7. The user detaches the NFC device from NFC accessory device B.
8. The NFC device is disconnected from NFC accessory device A.
9. The NFC device is connected to NFC accessory device B, such as for audio streaming.
4.3 Bluetooth-specific recommendations

BT-01: Use of All Supported Profiles

Recommendation

When an NFC device is touched to an NFC accessory device to establish a Bluetooth audio connection, all audio-related BT profiles supported by both devices should be used for the connection.

Rationale

If only a subset of the possible functionality is used, the user would be confused about which features are available over the connection.

Example

For example, if a mobile phone is touched to a Bluetooth headset, A2DP, AVRCP, HFP, and HSP profiles should all be connected.
Appendix

More about the NFC Forum

The NFC Forum was formed to advance the use of Near Field Communication technology by developing specifications, ensuring interoperability among devices and services, and educating the market about NFC. This mission drives efforts to provide programs that create a highly stable framework for extensive application development, seamless interoperable solutions, and security for NFC-enabled transactions. This foundation offers an ideal environment for experts in the Near Field Communication ecosystem to collaborate on solutions across the business and technical needs of their industries and to develop NFC programs to support them.

NFC opens up possibilities that are limited only by the imagination in payment and non-payment applications across every business sector. Non-payment NFC applications have the potential to revolutionize daily lives by creating new ways of carrying out tasks, accessing information, and interacting with people and organizations.

The NFC Forum’s Sponsor members, which hold seats on the Board of Directors, include leading players in key industries around the world. Interested companies are invited to become NFC Forum members and to help accelerate the delivery of exciting new NFC solutions to consumers and businesses. Membership levels accommodate companies across a wide range of industries at different phases in NFC solution development. More information on becoming an NFC Forum Member appears on our website.

NFC Forum Specifications

An important part of the work of the NFC Forum is developing and distributing specifications, so as to enable development of NFC products and services and facilitate interoperability. At the time of this document's publication, 23 NFC Forum specifications have been approved, spanning these core functions:

- Data exchange formats
- Tag types
- Record type definition
- Device interface controller
- Protocols
- Reference applications
- Personal Health Device Communication

A list of all published specifications – with links to download them -- is available on the NFC Forum website.

NFC Marks

NFC makes life easier and more convenient for consumers around the world by making it simpler to perform transactions, exchange digital content, and connect electronic devices with a touch. The NFC Forum has established two brand marks that support the NFC ecosystem: the N-Mark and the NFC Forum Certification Mark.
The N-Mark

The NFC Forum N-Mark, a stylized letter “N,” is a universal symbol for NFC, helping consumers to easily identify NFC-enabled products, devices, and touchpoints, providing simple and nearly effortless access to the full power, ease, and convenience of NFC solutions.

Consistent use of the N-Mark where NFC touchpoints and services are available on mobile devices and other consumer electronics, as well as smart posters, signs, badges, labels, etc., indicates where to touch to enable NFC services. The N-Mark on a display screen, digital media, product packaging, or product or service promotional material indicates that the particular software, product, or service has NFC capabilities.

The N-Mark can be used by anyone at no cost after completing the N-Mark Trademark License Agreement and as long as asserting that the tag or device meets the applicable NFC Forum technical specifications. A device using the N-Mark is not required to be certified under the NFC Forum Certification program. Complete guidelines on how to use the N-Mark correctly are available on the NFC Forum website in the NFC Forum N-Mark Brand Guide.

NFC Forum Certification Mark

The NFC Forum Certification Mark is the industry-facing mark used to indicate that an NFC-enabled device implementation has met the standards of the NFC Forum Compliance Program (see more about this program in the NFC Compliance and Interoperability section of this document, below). It signifies global credibility and serves as an indicator across the NFC eco-system that NFC Forum Member products meet global interoperability standards and will perform consistently.

Use of the NFC Forum Certification Mark on collateral, supporting materials, packaging, and documentation is granted only to NFC Forum member companies that have successfully completed certification.

NFC Compliance and Interoperability

The NFC Compliance program was established because of the importance of certification and interoperability for the infrastructure and devices. The NFC Forum Compliance Program was established to encourage and facilitate development and increase market availability of products that exemplify high-level compliance with NFC Forum specifications, thereby assuring interoperability between manufacturers. Together, the components of the Compliance Program form the foundation for a gold standard in NFC implementations and support the goals of achieving interoperability.

The NFC Forum operates two programs to meet compliance and interoperability: the NFC Forum Certification program and Plugfest events. By fully embracing the NFC Forum Compliance Program, participants establish confidence and credibility in the technology for everyone in the value chain, to ensure a flourishing NFC ecosystem.

NFC Forum Certification Program

The NFC Forum Certification program confirms an implementation's compliance to NFC Forum specifications. Conformance to the specifications delivers consistency of behavior across NFC-enabled devices and sets the foundation for interoperability. NFC Forum members facilitate the development and
market availability of products that comply with the NFC Forum specification(s) through participation in the NFC Forum Certification Program.

Only available to NFC Forum members, NFC Forum Certification affords differentiation by shortening the adoption process, lowering adoption costs, and making it easier for partners to work together. Certification is granted through a top-notch testing process for implementations that meet NFC Forum Device Requirements. An NFC device is a device capable of operating in NFC Forum Peer-to-Peer Mode and/or NFC Forum Reader-Writer Mode that may also support NFC Forum Card Emulation Mode. Because NFC Forum certified implementations are easier to integrate, they are always recommended. Companies cannot claim NFC Forum compliance without successfully completing the certification process.

The NFC Forum ensures the highest level of quality, reliability, and integrity at each step of the certification process. NFC Forum Approved Test Tools go through a formal validation process before approval for use in certification testing. Only an NFC Forum Accredited Test Laboratory (a laboratory that has satisfied and continues to satisfy all requirements defined by the NFC Forum) is authorized to provide certification-testing services to product manufacturers. Each application is carefully reviewed to ensure that the implementation meets all policy and technical requirements. Finally, an issue resolution panel is in place ensuring effective management of certification, technical, and procedural issues. By ensuring conformance, the Certification Program provides for consistency in the behavior of compliant devices, thereby setting the foundation for interoperability.

NFC Forum Plugfest Events

The NFC Forum Plugfest events, open to both Forum members and non-members, are designed to support early adoption of the NFC Forum specifications by providing a real-world environment where device, tag, and test tool interoperability can be verified across manufacturers’ products. This program complements conformance testing under the Certification Program and fosters interoperability of NFC implementations.

These unique events offer a safe, real-world environment for vendors to verify the level of interaction of their product-specific implementations and to demonstrate how a device will work with other NFC implementations. NFC Forum Plugfest events are multi-day events that take place several times each year in different regions of the world. Although optional, Plugfest events are part of a comprehensive integrated effort that reduces risk and the investment required in adopting new technology.
NFC Modes

NFC devices are unique in that they can support three modes of operation: card emulation, peer-to-peer, and reader/writer. The NFC Forum technical specifications unlock the full capabilities of NFC for the different operating modes and are based on the ISO/IEC 18092 NFC IP-1, JIS X 6319-4 and ISO/IEC 14443 contactless smart card standards (referred to as NFC-A, NFC-B and NFC-F in NFC Forum specifications).

- **Card emulation mode** enables NFC devices to act like smart cards, allowing users to perform transactions such as purchases, ticketing, and transit access control with just a touch.

- **Peer-to-peer mode** enables two NFC devices to communicate with each other to exchange information and share files. Peer-to-peer mode is standardized on the ISO/IEC 18092 standard and based on NFC Forum's [Logical Link Control Protocol Specification](#).

- **Reader/writer mode** enables NFC devices to read information stored on inexpensive NFC tags.

Terminology, Abbreviations, and Acronyms

This section provides a glossary of terms and abbreviations, and a reference list of acronyms used in this document. It is not intended as a comprehensive dictionary.

**Glossary**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Bluetooth</td>
<td>Short-range (10-100m) wireless communication protocol</td>
</tr>
<tr>
<td>Card Emulation Mode</td>
<td>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.</td>
</tr>
<tr>
<td>NDEF Application</td>
<td>The logical, higher-layer application on an NFC device that uses NDEF as a means to exchange information with other NFC devices or NFC Tags.</td>
</tr>
<tr>
<td>Near Field Communication</td>
<td>Near Field Communication (NFC) complements many popular consumer level wireless technologies, by utilizing the key elements in existing standards for contactless card technology (ISO/IEC 14443 A&amp;B and JIS-X 6319-4). NFC can be compatible with existing contactless card infrastructure and enables a consumer to utilize one device across different systems.</td>
</tr>
<tr>
<td>NFC Accessory Device</td>
<td>An accessory or a single-purpose device such as a speaker or printer that has NFC capability implemented.</td>
</tr>
<tr>
<td>NFC Data Exchange Format (NDEF)</td>
<td>The NFC Data Exchange Format (NDEF) specification ensures a uniform format for data exchange in any NFC application. It defines the data structures for the exchange of information.</td>
</tr>
<tr>
<td>NFC-Enabled Device</td>
<td>An NFC-enabled device, also called an NFC device, is a device that is capable of performing near field communication.</td>
</tr>
</tbody>
</table>
NFC Tag
A contactless tag that can store NDEF information and can be accessed by an NFC device.

Peer-to-Peer mode
Peer-to-peer mode enables two NFC devices to communicate with each other to exchange information and share files. Users of NFC-enabled devices can quickly share contact information and other files with a touch. Two NFC-enabled devices create a connection to share information. Peer-to-Peer mode is based on ISONFC Forum Logical Link Control Protocol (LLCP).

Reader/Writer mode
Reader/writer mode enables NFC devices to read information stored on inexpensive NFC tags embedded in smart posters and displays. NFC-enabled devices can access information from embedded tags in smart posters. An example is when an NFC device reads an NFC tag or device acting in card emulation mode.

User Interface
A user interface (UI) is the system by which users interact with a machine. The user interface includes hardware and software components. On a mobile device the software component of a UI is realized though a mobile application (app).

Wi-Fi
Wireless Fidelity -- wireless networking technology based on IEEE 802.11 standards.

Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BT</td>
<td>Bluetooth</td>
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<tr>
<td>LLCP</td>
<td>Logical Link Control Protocol</td>
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<tr>
<td>NDEF</td>
<td>NFC Data Exchange Format</td>
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<td>NFC</td>
<td>Near Field Communication</td>
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<tr>
<td>RF</td>
<td>Radio Frequency</td>
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<tr>
<td>UI</td>
<td>User Interface</td>
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<tr>
<td>Wi-Fi</td>
<td>Wireless Fidelity</td>
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