Project Report of RFID Technology Incorporating NFC and other Wireless Connections in Cell Phones

UCLA MAE 295C Fall 2007

Alec Quan

http://analyticalst.com/analyticalst/img/mobile_suica.jpg


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RFID Technology Incorporating NFC and Bluetooth Connections in Cell Phones

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Abstract

The "Mobile Suica" is a technology that merges smart cards and cell phones introduced in the JR-East Railway in October, 2006. To investigate the further applications and features of merging RFID technology and cell phones, a future scenario of watching a movie in the theatre is considered. Since the “Mobile Suica” is limited by the nature of its technology, a solution of NFC and Bluetooth incorporation is suggested to solve the problem. NFC’s and Bluetooth’s different operating frequencies and complimentary features and applications make it easy and advantageous for them to co-exist within the same product. This leads to the further discussion of the simplified Bluetooth connection process by NFC, which will improve many of the current Bluetooth applications and develop many new classes of products, such as smart posters and smart labels.
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1. Introduction

1.1. Motivation

Cell phones are incorporating more functions day-by-day. In the 21st century, cell phones are not limited for communication, but it is also a portable electronic device which could work as an mp3 player, PDA, camera or even TV. These functions make our lives better by bringing more convenience, entertainment and information to us.

![Figure 1: Different functions of nowadays’ cell phones](http://analyticalst.com/analyticalst/img/mobile_suica.jpg)

1.1.1. Mobile Suica

In the recent years, smart cards for fast, contactless payments become very popular, especially in many Asian countries. The idea of merging smart cards and cell phones was first successfully implemented and widely used at the JR East railway in Japan. The Mobile Suica is a service for cell phones provided by “Osafu-Keitai”, first launched on 28th January, 2006 by NTT DoCoMo and au in Japan [1].

![Figure 2: Mobile Suica (left) & Sony’s FeliCa Card (right)](http://analyticalst.com/analyticalst/img/mobile_suica.jpg) ![http://analyticalst.com/analyticalst/img/mobile_suica.jpg](http://www.sony.net/Products/felica/abt/dvs.html)

Mobile Suica’s near field communication (NFC) technology is based on using the FeliCa chip from Sony [2], like many smart cards systems, such as the Singapore’s EZ-link card and the Hong Kong’s Octopus card. These smart cards have value in it,
which can be used as a public transport ticket and for payments in many retail stores. *Mobile Suica* is similar to other smart cards, but in addition, it includes the ability to review the remaining balance and transaction history with the cell phone’s display. This solves the problem of unclear or unsecured feeling that some current smart cards’ users may have. The following is the basic specification of the *Mobile Suica*:

<table>
<thead>
<tr>
<th>IC chip</th>
<th>Sony FeliCa IC chip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tag type</td>
<td>Passive</td>
</tr>
<tr>
<td>Frequency</td>
<td>13.56 MHz</td>
</tr>
<tr>
<td>Speed</td>
<td>212 kbps</td>
</tr>
<tr>
<td>Range</td>
<td>2-10 cm</td>
</tr>
</tbody>
</table>

Table 1: Basic specifications of *Mobile Suica*

Figure 3: “*Mobile Suica*” in use (Left two); Balance can be displayed on the cell phone screen (Right)

1.1.2. The Future Scenario

The future cell phones should provide even more functions. By merging cell phones with smart cards, it has already brought in a lot of different features as the cell phone has a display, like the on-screen usage log, promotions, coupons and loyalty programs. However, to really revolutionize our daily lives with merging RFID technology and cell phones, a streamlined scenario of watching a movie at the cinema could be used to illustrate the idea.

When a customer sees a future smart advertisement about a movie on the street, in the subway or at the cinema, by tapping his/her cell phone to the RFID tag on the ad, the customer could obtain the description and details of the movie. After the customer feel like the movie is kind of interesting, he/she can download the movie trailer by tapping the cell phone on the R/W of the ad again. And, once he/she decided to watch the movie, tickets can be purchased directly by tapping the cell phone on the schedule on the ad.
Now, the movie ticket is automatically stored in the cell phone, so the customer just need to walk up to the entrance and tap the cell phone to the R/W and enter the theatre.

1. The RFID tag embedded in the ad contains the descriptions and details of the movies

2. The movie trailer can be downloaded by some kind of wireless connection

3. Today’s tickets can be purchased by tapping on the schedule

4. Entering the theatre by using the same cell phone

Original poster obtained from:

http://www.sony.net/Products/felica/index.html

Figure 4: Illustration of the future streamlined scenario of watching a movie
1.1.3. Limitations of Mobile Suica

To make the scenario proposed in the previous section to become reality, the near field communication technology used in the FeliCa IC chip in Mobile Suica is not sufficient. The followings are the three main fundamental reasons, which limit the applications and features of Mobile Suica:

1) **Limited Power** – Since the FeliCa IC chip is a passive tag, minimal power can only be transferred through RF to the card. Thus, reduces both the communication speed and distance.

2) **Limited Communication Speed** – This leads to limited information and data can be transferred, since the usual read/write processing time for the current use is within a sec.

3) **Limited Communication Distance** – This makes the use for downloading larger amount of data to be inconvenient, as the user is required to place the cell phone on the R/W within a couple of centimeters.
1.2. Solution

Since the nature of near field communication is meant for minimal-data and short-range, the applications mentioned in “The Future Scenario” section for high-speed and mid-range communication would not be able to achieve with NFC solely. Some other forms of wireless communication technology have to be used to overcome the limitations of the Mobile Suica.

Bluetooth is a very common wireless communication technology. It has become a standard feature for cell phones nowadays. Therefore, if NFC and Bluetooth can be incorporated, this is the solution to fulfill the mentioned scenario. NFC can be used to read the RFID tag of the smart ad and it could also be used to initial the communication of Bluetooth and enable the download of a movie trailer. This process simplifies the normal process of searching and authorizing in a Bluetooth connection.

NFC’s and Bluetooth’s different operating frequencies and complimentary features and applications (Table 1) make it easy and advantageous for them to co-exist within the same product. A quick comparison of these two wireless communication technologies is shown below.

<table>
<thead>
<tr>
<th></th>
<th>NFC</th>
<th>Bluetooth (Version 1.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Type</td>
<td>Point-to-point</td>
<td>Point-to-multipoint</td>
</tr>
<tr>
<td>Frequency</td>
<td>13.56 MHz</td>
<td>2.4 GHz</td>
</tr>
<tr>
<td>Range</td>
<td>&lt; 0.1 m</td>
<td>~ 10 m</td>
</tr>
<tr>
<td>Max Speed</td>
<td>424 kbps</td>
<td>721 kbps</td>
</tr>
<tr>
<td>Set-up time</td>
<td>&lt; 0.1 sec</td>
<td>~ 6 sec</td>
</tr>
<tr>
<td>Communication modes</td>
<td>Active/Passive</td>
<td>Active</td>
</tr>
<tr>
<td>Features</td>
<td>Low cost, Reliable, Global compatibility</td>
<td>Multiple applications, Globally accepted</td>
</tr>
<tr>
<td>Applications</td>
<td>Contactless Payments, Access authorization</td>
<td>Cell phones, PDAs, Headsets</td>
</tr>
</tbody>
</table>

Table 2: A quick comparison of NFC and Bluetooth
2. Technology

2.1. Near Field Communication (NFC)

Near field communications is a short-range wireless communication technology that enables information sharing, service initiation, and payment and ticketing capability through short distance. NFC is similar to other contactless systems, which are based on RFID. One of its main applications is for contactless payments for public transportation and retail, as NFC is compatible with the existing contactless infrastructure. After all, NFC technology is mainly aimed at being used with cell phones in the coming future.

The NFC Forum is a non-profit industry association founded on 18th March, 2004 by NXP Semiconductors, Sony and Nokia to advance the use of NFC short-range wireless interaction in consumer electronics, mobile devices and PCs. The NFC Forum promotes implementation and standardization of NFC technology to ensure interoperability between devices and services. In September 2007, the NFC Forum has over 130 members [3].

Figure 5: The NFC Forum

- NFC works by magnetic field induction and it operates at the globally available and unlicensed RF band of 13.56 MHz.
- The communication distance is usually less than 10 centimeters
- There are three communication speeds: 106 kbps, 212 kbps & 424 kbps.
- NFC is standardized in:
- NFC also incorporates a variety of pre-existing standards including the global standard for RFID: ISO 14443, Philips MIFARE technology, ISO 15693 and Sony’s FeliCa card. [5]
- There are two communication modes that make it different from regular passive tags and RFID readers:
  1. Passive Mode: This mode is when the NFC-enabled devices are one is passive and the other one is active. The NFC target device behaves like a regular passive tag, like a contactless card, while the initiator is an active card reader/writer. The NFC initiator device produces the RF signal and the target device may draw the operating power from the electromagnetic field and communicate back with the initiator. Therefore, the target device is a transponder in this mode.

![Figure 6: NFC Passive Mode Operation](http://i.cmpnet.com/wirelessnetdesignline/2006/02/philips-fg1b.gif)
(2) Active Mode: This mode is when both the NFC-enabled devices are active, so they both need a power supply in this mode. The initiator still behaves like a card reader/writer, while the target behaves like an active RFID tag. Both the initiator and target device send out RF signal in the idle condition and they will deactivate its RF field while it is waiting for data.

![Figure 7: NFC Active Mode Operation](http://i.cmpnet.com/wirelessnetdesignline/2006/02/philips-fig1a.gif)

- NFC has two different types of codings for transferring data. In the active mode at 106 kbps, a modified Miller coding with 100% modulation is used. In all other cases, Manchester coding with a modulation ratio of 10% is used.

<table>
<thead>
<tr>
<th>Speed</th>
<th>Active Device</th>
<th>Passive Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>424 kbps</td>
<td>Manchester, 10% modulation</td>
<td>Manchester, 10% modulation</td>
</tr>
<tr>
<td>212 kbps</td>
<td>Manchester, 10% modulation</td>
<td>Manchester, 10% modulation</td>
</tr>
<tr>
<td>106 kbps</td>
<td>Modified Miller, 100% modulation</td>
<td>Manchester, 10% modulation</td>
</tr>
</tbody>
</table>

**Table 3: Different codings and modulation ratios at different speeds**

- NFC devices are able to check the RF field and detect a collision if the received signal does not match with the transmitted signal since receiving and transmitting data can occur simultaneously.

- NFC can be used to initiate and perform the pairing between many electronic products with other wireless connections such as Bluetooth, Wi-Fi or Ultra-wideband.
2.1.2. Advantages of NFC

These are the main features that make NFC different and complementary to any other wireless network technology:

(1) **Shorter distance / More secure:** NFC has been intentionally designed with a comparatively short operating range (< 10 cm) to prevent accidental or unauthorized connection.

(2) **Simply linking procedure:** NFC linking procedure was developed to work the way ordinary consumers do, very similar to today’s very successful smart cards. For example, a transaction with an NFC-enabled PDA or cell phone is accomplished by simply holding it close to the reader/writer.

(3) **Two communication modes:** NFC enabled devices have the abilities to behave like a passive tag and an active reader/writer. Therefore, applications such as contactless payment or access control by acting as a passive tag and the applications of being a RFID reader/writer can be achieved with the same device. Moreover, with these two ways of communication, an NFC-enabled cell phone could demand a password or a personal identification number be entered to complete a high-value transaction, so it is much secure than regular RFID-based smart cards.

(4) **Low power consumption:** During the passive mode of communication, power is drawn from the electromagnetic waves from the source, so no internal power is required. During the active mode, power required to operate is still low comparing with other wireless connection technologies.
2.1.3. Applications of NFC

NFC is not as widely adopted as Bluetooth in consumer electronics products nowadays. However, its popularity is increasing because of its fast and simple ‘proximity’ linking process. Besides the many very successful smart cards systems, its usage is expected to be emerged into cell phones in the near future. The following is a list of applications of NFC:

- Electronic tickets in public transport
- Electronic payments in retails

![Figure 8: Current Smart Cards for electronic tickets and payments: EZ-link & Octopus](http://en.wikipedia.org/wiki/Near_Field_Communication)

- Credit / Debit cards
- Identification documents
  - Driver licenses, student ID, library card, etc
- Loyalty programs / Membership cards
- Access control / Electronic keys
  - Car keys, house/office keys, hotel room keys, etc
- Smart posters / labels / books

![Figure 9: NFC-enabled device interacting with a smart poster](http://en.wikipedia.org/wiki/Near_Field_Communication)

- Bluetooth pairing
2.2. Bluetooth

Bluetooth is a mid-range wireless communication technology by using RF. However, its main difference with NFC is that its technology is intended to be a cable replacement for a variety of applications. It is an industrial specification for wireless personal area networks (PANs), which is designed for exchanging information between devices such as cell phones, computers, printers, digital cameras and video game consoles over a PAN.

![Bluetooth logo](image)

Figure 10: The Bluetooth logo

The Bluetooth specifications are developed and licensed by the Bluetooth Special Interest Group (SIG). In 1998, Ericsson, IBM, Intel, Toshiba, and Nokia, formed a consortium and adopted the code name Bluetooth for their proposed open specification. As of September 2007 the SIG is composed of over 9,000 member companies that are leaders in the telecommunications, computing, automotive, music, industrial automation, and network industries. SIG members drive the development of Bluetooth wireless technology, and implement and market the technology in their products varying from cell phones to printers. [6]
2.2.1. Specifications of Bluetooth [7]

- Bluetooth is a radio communication system that allows two devices to exchange data even if the devices are not in line of sight of each other.

- The protocol operates in the license-free ISM band at 2.4-2.4835 GHz. To avoid interfering with other protocols that use the 2.45 GHz band, the Bluetooth protocol divides the band into 79 channels (each 1 MHz wide) and changes channels up to 1600 times per second.

- As long as the received transmission is powerful enough, the range of communication goes up, so the communication ranges are different in the three power classes:

<table>
<thead>
<tr>
<th>Class</th>
<th>Maximum Permitted Power</th>
<th>Range (Approximate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>100 mW</td>
<td>~100 meters</td>
</tr>
<tr>
<td>Class 2</td>
<td>2.5 mW</td>
<td>~10 meters</td>
</tr>
<tr>
<td>Class 3</td>
<td>1 mW</td>
<td>~1 meter</td>
</tr>
</tbody>
</table>

Table 4: Different power classes for Bluetooth

- Bluetooth 1.1 and 1.2 reach speeds of 721 kbps. Bluetooth 2.0 implementations feature Bluetooth Enhanced Data Rate (EDR) and reach 3.0 Mbps. The proposed Bluetooth 3.0, adopt ultra-wideband (UWB) RF technology will even enable data transfer go as high as 480 Mbps. The following shows the data rates of different Bluetooth versions:

<table>
<thead>
<tr>
<th>Version</th>
<th>Data rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version 1.1/1.2</td>
<td>721 kbps</td>
</tr>
<tr>
<td>Version 2.0 / +EDR</td>
<td>2.1 / 3.0 Mbps</td>
</tr>
<tr>
<td>Version 3.0 (proposed)</td>
<td>53-480 Mbps</td>
</tr>
</tbody>
</table>

Table 5: Data rates of different Bluetooth versions

- A master Bluetooth device can communicate with up to seven devices at a time.

- During setting up connections, any Bluetooth device will transmit the following sets of information on demand: Device name, device class, list of services, technical information, for example, device features, manufacturer, Bluetooth specification, clock offset and etc.
The specifications of Bluetooth were formalized by the Bluetooth Special Interest Group (SIG), which is established by: Ericsson, Sony, IBM, Intel, Toshiba, Nokia, Philips and many later joined companies.

2.2.2. Advantages of Bluetooth

There are also a few main features that make Bluetooth complementary to any other wireless network technology:

(1) **Longer distance**: Bluetooth takes power from its devices to establish the radio communication system, so its range can go as high as 100 meters for the Class 1 Bluetooth devices. Therefore, the devices need not to be in line of sight of each other, and the communication can even be done in different rooms.

(2) **Higher data rate**: In Bluetooth 2.0 +EDR, its data rate is as high as 3.0 Mbps. The proposed next version, Bluetooth 3.0, adopt ultra-wideband (UWB) RF technology will even enable data transfer go as high as 480 Mbps.

(3) **Secure connection**: Starting in Bluetooth 1.2, a technology called Adaptive frequency-hopping spread spectrum (AFH), has improved the resistance to RF interference by avoiding the use of crowded frequencies in the hopping sequence. With AFH, the signal “hops” and thus limits interference from other signals. Furthermore, Bluetooth technology has built-in security such as 128-bit encryption and PIN code authentication. When Bluetooth products identify themselves, they use the PIN code the first time they connect. And, once connected, they are always securely connected.

(4) **Globally Accepted Specification**: Since the first release of the Bluetooth specification in 1999, more than 8,000 companies have become members in the Bluetooth Special Interest Group. Meanwhile, the number of Bluetooth enabled products is multiplying rapidly in the market.

(5) **Low Cost**: The cost of a Bluetooth chip is under US$3. [8]
2.2.3. Applications of Bluetooth

Because of Bluetooth longer, faster and securer connection, Bluetooth’s applications are mainly focused on the replacement of a cable. The following experience icons from the Bluetooth SIG website will demonstrate how Bluetooth can enhanced our lives as a mid-range radio communication system.

The following is a list of common applications of Bluetooth:

- Connecting hands-free headset with a cell phone
- Information transfer between cell phones / PDAs
  - Pictures, movies clips, mp3s, etc
- Wireless networking between PCs
- Wireless connections with PC input/output devices
  - Mouse, keyboard and printer
- Controllers of game consoles
  - Nintendo Wii, Sony PlayStation 3
2.3. Incorporating NFC and Bluetooth

The following sections show the result of merging the technology and characteristics of NFC and Bluetooth. Bluetooth 2.1 is the new version of Bluetooth that has NFC cooperation. A simplified Bluetooth connection process by using NFC to perform the paring will be compared with the regular process to show the result.

2.3.1. Bluetooth 2.1 [9]

Bluetooth 2.1 is fully backward compatible with the previous versions of Bluetooth. With its new feature of NFC cooperation, automatic creation of Bluetooth connections can be established by using the NFC interface of the devices. An improved pairing process makes initial device pairing easier by reducing the number of steps required for pairing. No complicated procedures or verification PIN is needed. And, the standard Bluetooth connection process of searching, waiting, pairing and authorization will be replaced by a simple "touch" of the two devices that enables Bluetooth 2.1 and NFC. For example, the process of connecting a hands free headset to a cell phone that supports Bluetooth 2.1 and NFC will be as easy as the following three steps:

1. Turn on the hands free headset
2. Select the "Add Bluetooth device" option on the phone
3. Bring them close together and accepting the pairing

http://www.bluetooth.com/Bluetooth/Learn/Technology/Core_Specification_v21_EDR.htm

Figure 13: Process of connecting a hands free headset to a cell phone with Bluetooth 2.1
2.3.2. Nokia 6131 NFC [10]

The Nokia 6131 NFC is a cell phone incorporating the near field communication (NFC) technology and Bluetooth 2.1. It allows the user to merge their credit cards, loyalty cards and travel cards all in one place and use it as a multi-purpose smart card. The NFC interface can be used to make fast and secure purchases at the NFC credit card readers. And, the Bluetooth interface is used for transferring larger amount of data when needed. It supports Java specification requirement 257 (JSR 257); therefore, 3rd party NFC applications can be developed easily.

![The Nokia 6131 NFC](http://europe.nokia.com/A4307094+Icons/)

**Figure 14: The Nokia 6135 NFC**

The following are the important highlights of the Nokia 6131 NFC. A complete specification can be found in the appendix.

<table>
<thead>
<tr>
<th>Connectivity</th>
<th>Near field communication (NFC) with read, write, and peer-to-peer capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bluetooth 2.1 with Enhanced Data Rate specification (includes SIM access, and headset and hands-free profiles)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Near field communication (NFC) features</th>
<th>Contactless payment and ticketing capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Access to mobile services and information with a simple touch</td>
</tr>
<tr>
<td></td>
<td>Uses Java specification requirement 257 (JSR 257) for third-party NFC applications</td>
</tr>
</tbody>
</table>

**Table 6: Important highlights of the Nokia 6131 NFC**
2.3.3. Nokia 6131 NFC SDK 1.1 [11]

The Nokia 6131 NFC SDK is the software development kit (SDK) provided by Nokia to allow developers to create and emulate Java applications (MIDlets) for the Nokia 6131 NFC cell phone. The SDK includes the Contactless Communication API (JSR-257), which allows the use of the Near Field Communication (NFC) features of the cell phone, such as accessing information on contactless cards and NFC tags. In addition to the standard JSR-257 API, the SDK also includes extensions for sharing information over peer-to-peer (NFCIP-1) connections, and branding configuration can be used for setting up branding-elements, such as images, audios and videos. The following table summarized the key features of the Nokia 6131 NFC SDK.

![Figure 15: Nokia 6131 NFC SDK 1.1](http://sw.nokia.com/id/1f028915-a36d-4e21-8817-880be9c5e4a4/DS_N6131_NFC_SDK_1_1_v1_0_en.pdf)

The following table summarized the key features of the Nokia 6131 NFC SDK.

**Key features**

- The Contactless Communication API (JSR-257).
- JSR-257 extension implementations for:
  - Infra Ultra Light.
  - Infra Standard 1k.
  - Infra Standard 4k.
  - Infra DESFire.
  - Innovision Tagaz.
  - Innovision JavaL (read only).
  - Sony Felica (nonsecured elements).
  - Peer-to-peer communications using the Near Field Communication Interface and Protocol (NFCIP-1).
- Branding configuration.
- Java technology-based Nokia 6131 NFC MIDP Emulator, supporting:
  - Emulation for Infra Ultra Light, Infra Standard 1k, Infra Standard 4k, and Java Card technology-enabled smart cards.
  - External reader support for Omniky Cardman 5121, Omniky Cardman 5321, and NFD-C R0701.
- Support for MIDP 2.0/CDC 1.1 profile.
- Documentation.
- Example MIDlets.

![Figure 16: Key features of Nokia 6131 NFC SDK](http://sw.nokia.com/id/1f028915-a36d-4e21-8817-880be9c5e4a4/DS_N6131_NFC_SDK_1_1_v1_0_en.pdf)
2.3.4. Simplified Pairing Process by using NFC

As taking pictures with cell phones is becoming more popular, the convenience of transferring a picture from a cell phone to another electronic device is being more important. The following is a comparison of transferring a picture taken by a cell phone to an electronic picture frame with: 1) A standard Bluetooth connection process, 2) A simplified process by using NFC.

<table>
<thead>
<tr>
<th>Standard Bluetooth Connection Process</th>
<th>Simplified Process by using NFC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Choose a picture</td>
<td>1. Choose a picture</td>
</tr>
<tr>
<td>2. Select to send via Bluetooth</td>
<td>2. Touch Devices</td>
</tr>
<tr>
<td>3. Search for Bluetooth devices in range</td>
<td>3. Connection established</td>
</tr>
<tr>
<td>4. Select a device</td>
<td></td>
</tr>
<tr>
<td>5. Wait for send authorization</td>
<td></td>
</tr>
<tr>
<td>6. Connection established</td>
<td></td>
</tr>
</tbody>
</table>

Table 7: A comparison of the standard and simplified Bluetooth Connection Process

While a standard Bluetooth connection process takes 6 steps to establish the connection, the simplified process by using NFC streamlined the same task to a 3 steps process. Roughly speaking, the differences may be 30 seconds or over. This efficiency is in good part due to the fact that NFC is a relatively simple protocol comparing with Bluetooth. It helps to streamline a Bluetooth connection by reducing the connection procedures and time.
3. Applications

Since NFC compliments Bluetooth’s longer range and higher data rates, and Bluetooth complements NFC’s fast and simple linking procedures, devices equipped with both technologies will have greater flexibility and offer a much better user experience. One way to explore the applications of emerging NFC with Bluetooth is to imagine Bluetooth as a "cable" that can be used for exchange of data between any two electronic devices, while NFC serves as a “universal adapter” that makes the connection process quick and easy.

To go further from the listed applications that NFC or Bluetooth are expected to find their own targeted market, this section will explore how the simplified Bluetooth’s linking process with NFC can help improve the current applications of Bluetooth and develop new classes of products in the telecommunication industry.

3.1. Enhancing Current Applications of Bluetooth

3.1.1. Headset/Hands-free Connections

As mentioned in an early section, NFC can be used to simplify the process of linking Bluetooth-enabled cell phones with headsets or hands-free systems. The NFC-enabled cell phone need to read the passive RFID tag that corresponds to the headset or hands-free unit to enable the pairing. When the two devices are held closely together, the cell phone reads the passive RFID tag to determine both the offered functionality of the headset and the Bluetooth set-up parameters.

![Figure 18: A hands-free device with Bluetooth 2.1](image-url)
3.1.2. Computers/Cell phones Synchronization

Cell phone users will also enjoy the benefits of NFC-enabled Bluetooth when they synchronize their contact lists, calendars, and other data with their desktop or laptop computers. The synchronization will be initiated by holding the cell phone close to the NFC R/W of the PC, and finished by Bluetooth. Moreover, this application could also be emerged with many other technologies, such as the GooSyn offered by Google. [12]

![GooSyn](http://www.goosync.com/)

Figure 19: GooSyn can synchronize your Google calendar with your cell phone

3.1.3. Gaming

NFC will also find many applications in the world of electronic gaming industry by enabling local networked game playing. When used in conjunction with Bluetooth, NFC overcomes many of the problems currently associated with establishing a connection that have slowed its acceptance. Unlike connecting Bluetooth headsets to cell phones where a link is usually configured only once, network gaming requires a gamer to establish a new link every time they hook up with a player. The standard connection procedure was acceptable for a one-time set-up of a phone and headset, but it becomes a time-consuming hassle if a user has to repeat it every time.

NFC provides the solution to this problem, allowing the network to be formed quickly and easily. No matter it is a popular gaming device, or a game embedded in the cell phone or PDA, NFC makes setting up a multiplayer connection a simple "touch-and-go" operation. The two gamers only need to touch their devices and allow the NFC software on the devices to handle the discovery, inquiry, authentication and encryption required to establish a Bluetooth gaming network.
3.1.4. Images or other Multimedia Transferring

Digital photography is one of the fastest growing industries in the world. After images were taken with our cell phones and digital cameras, we always want to transfer it to another digital device for storage, viewing or sharing. NFC-enabled Bluetooth links can provide a simpler alternative to the USB cables and memory cards readers that are currently used for the transfer. If the electronic devices are NFC and Bluetooth incorporated, one just needs to touch the cell phone/digital camera with another cell phone, printer, digital picture frame, or computer, then the picture(s) will automatically be transferred.


Figure 20: Images/Audios/Videos will be transferred easily with NFC and Bluetooth

3.1.5. Contact Sharing

One of Bluetooth’s applications is for sharing contacts with another cell phone. However, it is not commonly used because of Bluetooth’s lengthy connection process comparing with just asking the number of the other party. NFC becomes very useful in solving this problem as touching the cell phones will share the corresponding contacts of those two cell phones. This process of 'beaming' their contacts is definitely more intelligent than sharing their business cards or obtaining contacts from a friend.

http://www.nokia.com/A4305082

Figure 21: Touch to share contact
3.2. Developing New Classes of products

3.2.1. Smart Posters

Smart Poster is one of the key uses of NFC in the future. The idea of making a poster ‘smart’ is that it is capable of storing additional data in a passive NFC tag, other than those printed on the advertisement itself. A user can extract the data by touching it with their NFC-enabled device, such as a cell phone. The data could be a free ringtone, some text, a picture, or even the configuration for a Bluetooth or a local Wi-Fi connection. For the application mentioned in the future scenario, the information of the movie can be transferred with the NFC interfaces to the cell phone. However, for larger amount of data, such as a picture, an mp3, or even a movie clip, the poster may require a Bluetooth interface. Bluetooth connection will be initiated by touching the cell phone with the NFC interface of the smart poster.

The NFC Forum has already defined the “NFC Smart Poster Record Type Definition (RTD) Technical Specification” in 2006. It defines an NFC Forum Well-Known Type on how to put URLs, SMSs or phone numbers on an NFC tag, or how to transport them between devices. Examples of NFC Data Exchange Format (NDEF) message, as if it was read from a tag or received from another NFC device, are listed in the document. [13]
3.2.2. Smart Labels

Smart labels are basically RFID tags on commercial products.

Smart labels are very similar to smart posters, except that it is smaller in size and embedded in commercial products, for example, medicines, food packaging, books, magazines and etc. A smart label is a RFID tag that stores either additional information, like the smart posters, or the electronic version of the printed material. With a NFC-enabled cell phone or other handheld device, it allows us to read the information in the RFID tag. Moreover, if the cell phone is connected to a computer with a wireless connection such as Bluetooth, the information can automatically transferred to the computer screen for better viewing.
4. Conclusion

NFC is gaining wider acceptances because of its fast, simple, and user-friendly “proximity” connection process. Like Bluetooth, which was started in, 1998 [6] and incorporated in every cell phones nowadays, NFC is likely to share the same path in the near future. NFC devices will become the functional cores of cell phones and many other handheld electronic devices, making it a mandatory design feature. When NFC and Bluetooth are incorporated, their different characteristics and features will compliment each other. By introducing the simplified Bluetooth connection process by NFC, many current Bluetooth applications are going to be even more popular. This widespread acceptance of NFC as an enabling technology for wireless protocols will help create new generation of wireless products that interoperate to exchange text, audio, video and electronic money seamlessly.

http://www.wilsontai.com/hongkongnights/vivid.jpg

Figure 25: The Hong Kong Victoria Harbor’s Skyscrapers
5. Appendix

- Technical Specification of Nokia 6131 NFC [10]

Key features
- With near field communication (NFC) technology, your credit cards, loyalty cards, and travel card are all in one place
- Make fast and secure purchases with your phone at NFC credit card readers
- Just touch and ride. Use your phone as your travel ticket
- Add value or time to your travel card over the air
- Explore mobile weather and news by touching your phone to radio frequency identification (RFID) tags
- Quad-band GSM/EDGE coverage capability on five continents (850/900/1800/1900)

Display and user interface
- Main display: 2.2" QVGA TFT display with up to 16.7 million true colors (240 x 320 pixels)
- External cover display: 1.36" TFT screen (128 x 160 pixels)
- Enhanced Series 40 user interface Clearly separated keys for easy dialing and messaging

Imaging
- 1.3-megapixel camera with 8x digital zoom
- Full-screen viewfinder for both main and outer display

Multimedia
- Music player supporting WMA, MP3, MP4, AAC, AAC+, and eAAC+ formats
- FM stereo radio
- Video streaming support for 3GPP format
- Video ringing tones
- MIDI ringing tones up to 64 polyphonic tones
- DRM (digital rights management) release 1.0

Memory functions
- 11 MB free user memory
- Expandable memory capacity with hot swappable 2GB microSD memory card

Applications
- Java MIDP 2.0 games and applications

Connectivity
- Near field communication (NFC) with read, write, and peer-to-peer capabilities
- Integrated secure chip (global platform 2.1.1) stores your personal information securely
- Nokia PC Suite with USB, Bluetooth, and IrDa connectivity
- Bluetooth version 2.0 with Enhanced Data Rate specification (includes SIM access, and Headset and Handsfree profiles)
- Local/remote SyncML data sync
- Hot swappable microSD memory card slot
- Pop-Port™ connector with USB connectivity

Near field communication (NFC) features
- Contactless payment and ticketing capabilities
- Access to mobile services and information with a simple touch
- Uses Java specification requirement 257 (JSR 257) for third-party NFC applications
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