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Near-Field Communication Technology and Its Impact in Smart University and Digital Library: Comprehensive Study

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Abstract

The purpose of this paper is to highlight on the Near Field Communication (NFC) technology trying to raise awareness and knowledge about NFC within information science society and to improve understanding of its functionality and development, as well as to place it into the broader context of existing technologies that we can incorporate it into our universities, libraries, and services. The study is carried out through literature review, data gathering and contacting some information tech companies. This note reflects the advantages of adaptation NFC in the university, campus and library. NFC tries to harmonize today's different activities and make people's lives easier and more convenient. So it is considered an ongoing leap toward ubiquitous computing. Since NFC is a recent technology and the mainstream adoption is not yet obtained with little reports focus on its potential impacts, our comprehensive study is considered a contribution to explore on the impact of NFC technology and applications on the communities of university and digital library.

Keywords: Near Field Communication, Smart Digital Library, RFID, NFC, Emerging Technology, and Smart University.

1. Introduction

Near-field (or nearfield) communication (NFC) is a form of short-range (radio-frequency), low-power wireless communication technology for electronic devices which allows them to communicate with others by simple touching or bringing them at very close distance. This act of communication is called 'tap-in' or 'to tap and go'. The NFC communication protocol is usually occurred between either two active devices such as smartphones and laptops or even between a NFC device and a passive (or unpowered) 'tag'.

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The first device is usually called the initiator which uses magnetic induction to create a radio-wave field that the target (second device) can detect and access, permitting small amounts of data to be transferred wirelessly over a relatively short distance. In NFC's case, the distance in general must be less than 4 inches (NFC Forum, 2014; NFC World, 2014; Near Field Communication, 2014).

Currently, NFC has many applications mostly focus in the field of Identification and authentication, ticketing systems in public transport such as trains and buses as well as contactless electronic payment Electronic Point of Sales (EPOS) terminals at shopping centers. NFC has also shown promise in being used for data transfer or ‘data beaming’ in applications such as smart posters or simplifying the setup of more complex communication methods such as Wi-Fi (Vedat *et al.*, 2012; Vedat *et al.*, 2013; Fischer, 2009; Wei *et al.*, 2012, Halgaonkar *et al.*, 2013; and Kerem *et al.*, 2012).

2. Purpose and Objectives of the Study

NFC is still a nascent technology and the mainstream adoption is not yet assured. In this report, I try to raise awareness and knowledge about NFC technology within information science society and to improve understanding of its functionality and development, as well as to place it into the broader context of existing technologies that we can incorporate it into our universities, libraries, and services.

3. Methodology

The study is carried out through literature review, data gathering and contacting some information tech companies. This note reflects the advantages of adaptation NFC in the university, campus and library. NFC tries to harmonize today’s different activities and make people’s lives easier and more convenient. So it is considered an ongoing leap toward ubiquitous computing.

4. History and Background of NFC

NFC is a subset of Radio Frequency Identification (RFID) with a shorter communication range for security purposes. The first patent to be associated with the abbreviation RFID was granted to Charles Walton in 1983. In 1991, computer scientist Mark Weiser brought to light the concept of “ubiquitous computing” a futuristic vision of technology as “an invisible, integral part of the way which people live their lives”. He criticized the personal computer and predicted that digital information would be “embodied,” or brought into physical space, by hundreds of small, networked computers that would blend naturally into their environment. Finally, he suggested that “The most profound technologies are those that disappear (Fig. 1) (Kevin *et al.*, 2012; McHugh and Yarmey 2014; Bueno-Delgado *et al.*, 2012; Friedewald and Raabe, 2011; Rogers, 2006; Genevieve and Paul, 2007).

A B

Figure 1: A) Mark Weiser, the founder of ubiquitous computing.
B) Ubiquitous computing everywhere (http://pixgood.com).

In 2002, Philips and Sony electronics announced a cooperative plan to work together on a new wireless technology which will allow consumer devices to "talk" to each other (McHugh and Yarmey 2014; Richard, 2002). In 2003, Sony and Philips created near field communication (NFC), and later that year the International Organization for Standardization adopted ISO/IEC 18092, an interface and protocol specification that serves as the foundation for NFC's functionality.

In 2004, Nokia, Philips and Sony established the Near Field Communication (NFC) Forum to promote and develop the new technology. Though the NFC Forum formed in 2004, it wasn't until 2006 the first set of specifications for NFC tags were produced by the group (Near Field Communication, 2014). Tags of NFC technology are small objects, like a sticker, containing information that can be read and intercepted with NFC compatible devices, such as a smartphones, when passed over the NFC tag. The information on the tag is usually read-only in case of read-only tags, but certain tags allow the device reading it to write new information to it or alter old information on the tag as well (rewritable tags) (http://www.nfc.cc/; Violino, 2014) . In 2006, the specifications for "smart" posters were also created. Smart posters hold information that an NFC compatible device can read when passed over it. It can provide all types of information, such as information about a famous archaeological piece of artwork shown in a museum or a short biography of a famous person's life on a poster with their image on it (Fig. 2).

Figure 2: NFC tagged smart poster (http://www.revistaeventos.cl/).

In the same year, the first NFC-compatible cell phone, Nokia 6131 was also manufactured and a year after more specifications were emerged and the technology started to grew from payment methods to sharing links, games and videos invites between smartphones and other NFC devices. In 2010, Android produced its first NFC phone, the Samsung Nexus S. Nowadays; the NFC markets are most dominant in Japan, Europe and Asia, though the United States is also seeing rapid growth in this field. It is expected that NFC will be subjected to public use as an easy way for payment and data exchange in the United States in the near future (NFC Forum, 2014; Near Field Communication, 2014).

In the two decades since 1991, a huge development has been observed in the technology of communication and information transfer sectors with a rapid proliferation of mobile devices which made information access ubiquitous. Also development of quick response (QR) codes in 1990s improves the capacities of information storage and made the access to the data and information is quickly compared than before and act as a basic link between digital information and our physical world (Michelle, 2013a; Denso, 2010; Vazquez-Briseno *et al.*, 2012). Near field communication (NFC) is an evolution and extension of radio frequency identification (RFID) technology that is developed in 2000s and has been implemented in many museum and libraries (Hsi, 2008; Gibb *et al.*, 2011; Coyle, 2005; Walsh, 2011; and Ayre, 2005).

NFC is a big flip technological step allowing fast data exchanges, with little setup and cheap low required power. NFC succeeds to achieve many crucial anticipated points which Weiser was thinking of such as location (near data exchange), small-scale computing system (tabs, smartphones and smart computers), as well as capacity and rate of wireless data transfer with simplicity. Actually all of the above crucial points are addressed by NFC especially if it is married with other wireless techniques as Bluetooth and Wi-Fi. So it is considered an ongoing leap toward ubiquitous computing (Weiser, 1991; Mattern, 2001; Rogers, 2006). NFC technology has been increasingly adopted in Asia (South Korea, Japan, Singapore and China) and Western Europe (Germany, Spain, Finland, and UK), but in the United States, instances of market implementation remained scant. In Asia and Europe, the public sector and government provided subsidies or other incentives to enhance the development and mainstream adoption of NFC services (Tuikka and Isomursu, 2009; GSMA, 2012; Interaction, 2014).

In 2011 and 2012, however, a number of pilot projects from high-profile stakeholders attracted broader attention to the technology. Interest in NFC and its capabilities is steadily growing among merchants, telecommunications providers, and other businesses, while mainstream adoption will not be immediate. In 2014, Asia NFC Alliance is established four major telecommunications operators (HKT of Hong Kong, Chunghwa Telecom of Taiwan, SK Planet of South Korea and KDDI of Japan) to provide easy and quick NFC-enabled services to customers traveling between these countries. Also in China, there are big steps from government and private sector to promote NFC adaptation (McHugh and Yarmey, 2014). Despite all efforts carried by Asian and European organization for mainstream adoption, the public spread of this technology still need more time for complete implementation.

In USA, the situation is quite different and the implementation of NFC technology is still unconvinced to many stockholders. There are many factors inhibit the NFC public distribution in USA and summarized in the following:

1. Extensive agreement and collaboration among stakeholders as mobile operators, device manufacturers, retailers, and others is required.
2. General lack of consumer awareness and/ or enthusiasm.
3. Infrastructure. Manufacturers and retailers may need to update system components (such as point-of-sale terminals) in order to make them NFC-compatible.

In spite of all these challenges, NFC technology is poised to take off in the United States within the next few years (Vedat *et al.*, 2012; Vedat *et al.*, 2013).

5. NFC vs Other Wireless Information Transfer Technologies

Wireless technologies for communications and information transfer were groups of greatest discoveries in the 20th century. Wireless data communications technologies as Infrared (IR), Bluetooth, RFID, Wi-Fi and ZigBee become an essential component of modern computing devices.

Also, NFC is a recent wireless information transfer technology of a short-range radio frequency communication protocol operating on the 13.56 MHz frequency, with data transfers of up to 424 kilobits/sec. NFC communication is triggered when two NFC-compatible devices are brought within close proximity, around 4 centimeters. Because the transmission range is very short, NFC-based transaction is naturally secure (Xu and Liang, 2012; Schnell, 2013). Comparison of NFC to other short-range communication technologies is provided in the following Figure (3) and Table (1):

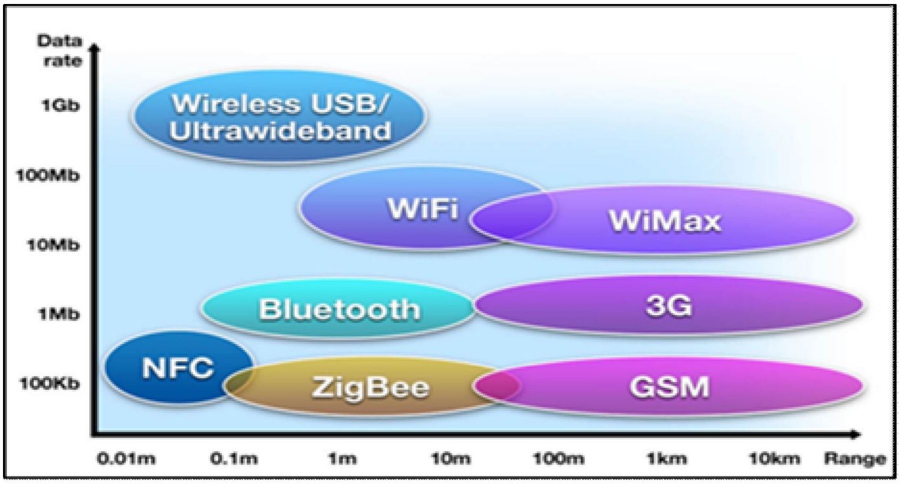

Figure 3: Comparing NFC with short range communication technologies (Xu and Liang, 2012).

Table 1: Comparing NFC with short range communication technologies (Xu and Liang, 2012; Schnell, 2013).

	NFC	RFID	IrDa	Bluetooth	Wi-Fi	ZigBee
International Standard	ISO 14443	-	-	IEEE 802.15.1	IEEE 802.11	IEEE 802.15.4
Set-up time	<0.1ms	<0.1ms	~ 0.5sec	~ 6sec	3-5 sec	30ms
Range	Up to 10 cm	Up to 3m	Up to 5m	Up to 30m	50-100m	10-100m
Operating Frequency	13.56 MHz	125KHz-2.5 GHz	800-900 nm	2.4 GHz	2.4 and 5 GHz	868 MHz (Europe)
Maximum Data Rate	0.42 Mb/s		20-40 and 115 kbits/s	3 and 22 Mb/s	11, 54 and 144 Mb/s	20, 40 and 250 kbits/s
Complexity	Low	Low	Low	Hi	Hi	Low
Usability	Human centric Easy, intuitive, fast	Item centric easy	Data centric easy	Data centric medium	More complex (Point to hub)	wireless mesh network
Selectivity	High, given, security	Partly given	Line of sight	Who are you?	Selective and secure	secure communications
Use cases	Pay, get access, share, initiate service, easy set up	Item tracking	Control & exchange data	Network for data exchange, headset	Wireless LAN connectivity, broad band access	Industrial control Home Control Building automation Smoke and intruder warning.
Consumer experience	Touch, wave, simply connect	Get informati on	Easy	Configuration needed	Configuration needed	Devices can join an existing network
Cost	Low	Low-High	Low	Low	Hi	Low
Power Consumption	∞	Hours/da ys	days	Hours/day	Hours	Very low months/years
Directional Communication	Two way	One way	One way	Two way	Two way	Two way

Compared to Bluetooth and Wi-Fi, NFC operates at drastically reduced transfer rates, with a maximum data transfer speed of 0.424 Mbps, which is less than a quarter of Bluetooth and only within a very small proximity. But why we use NFC technology? If that's the case, here are four reasons:

i. **NFC is extremely short ranged** and it is called *people-centric*.
ii. **Setup time**. NFC devices communicate instantly in less than 100 milliseconds when placed within range. NFC is requiring nothing more than a tap so it is completely effort-free.
iii. **Power consumption**. NFC tags and cards do not consume power, It consumes a mere 15 mA of power (practically nothing for today's jumbo smartphone batteries) so their lifespan can be unlimited.
iv. **Cost**. NFC tags and cards are inexpensive to manufacture compared to other wireless technologies.

From above table, NFC technology is definitely not suited to transferring large amounts of data over long distance which is definitely the job of other wireless communication protocols such as Wi-Fi. A good scenario of such compliment is the combination of NFC and Bluetooth, where NFC is used for pairing (authenticating) and Bluetooth session used for the transfer of data. Some articles confirmed that combination of NFC and Bluetooth not only increase the amount of data transfer but also reduce the total time of transfer up to 75-90% (NFC forum, 2014; Jorge *et al.*, 2014; Ortiz, 2008; Hopkins, 2009).

6. NFC Theory of Operation

The main working principal of Near Field Communication is based on RFID. The RFID system contains 3 essential parts which are the reader, tag, and middleware. The RFID reader is a device that continuously propagates Radio Frequency (RF) signals and waits for a tag to response and also called an initiator or an interrogator. Readers can be stationary (fixed RFID) or moving (mobile RFID). Tags, also known as transponders, and basically consists of a microchip with an antenna. They come in three varieties: Passive tags that do not contain a battery, Active tags that have a battery and are constantly broadcasting a signal (just like the reader), and Battery Assisted Passive (BAP) tags where the battery is activated only in presence of an RF field.

The tags have small size and can be stored easily in any small device or object according to their applications. A good example is tags stores on rental cars or criminals for tracking purposes. Also, they can be placed in animal collars or in garments in a clothes shop for inventory purposes. A reader can be programmed to accept information only from particular tags. For example, in faculty parking spaces on a university campus, only the faculty staff members are allowed to pass through whereas student cards are rejected. This depends on the encryption, modulation, frequency, *etc*. and this decision is made by a form of middle ware installed on the reader.

NFC tags are designed similarly to an RFID tag to be used at 13.56 MHz. At these frequency ranges, RFID tags mostly use the theory of Strongly Coupled Magnetic Resonance which basically depends on that two nearby loop antennae provide strong electromagnetic mutual induction resonance. This effect is also known as inductive coupling. During operation, other communication frequencies are disabled which allows very fast communication between coupled resonances. This phenomenon is valid only for loop antennae that are placed very near to each other (i.e. communication can only happen within this read range (or operating volume) (Fig. 4). The exact extent of this range varies with the strength of the initiator (among other factors), but it is typically only a few centimeters. It can, however, extend as far as 20 centimeters under certain conditions.

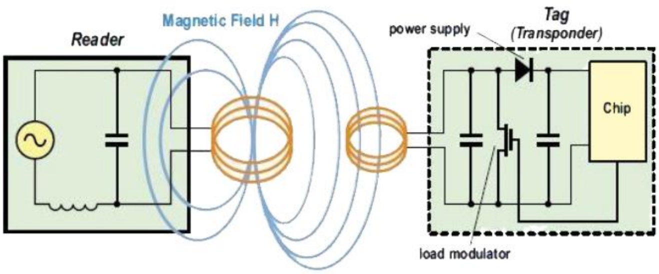

Figure 4: A full NFC/RFID system at 13.56 MHZ (http://eu.mouser.com/).

For an NFC exchange, the initiator uses an antenna to emit a radio wave at 13.56 MHz and if there is an NFC target within this range, the field will activate the target, establishing a communications link. If an initiator receives a response from more than one target, the initiator must then select the intended target before sending the content of the message. This selection and connection process happens quickly, within less than a tenth of a second and the initiator and target can then begin to communicate (Smith, 2012; Yaqub and Shaikh, 2012; Kerem *et al.*, 2012)..

7. NFC Data Exchange Categories and Specification

NFC standards define two categories of operation for data exchange: **Active and Passive**.

In **active communication**, both the initiator and target communicate by generating their own electric fields. The two devices can then interact in a two-way, peer-to-peer data exchange (half duplex) The active or initiator device sends a message to the passive, or target device and then target can respond, but this only happen once it has received the message from the initiator. The transmitted code that is used between the two devices is Manchester coding.

The device that begins the communication is still considered the initiator, both devices must be able to serve as either initiator or target. In this mode both devices will typically have power supplies (Kevin *et al.*, 2012).

Table 2: Supported Data Rate (http://www.radio-electronics.com/).

Amplitude-shift keying (ASK) is a form of amplitude modulation that represents digital data as variations in the amplitude of a carrier wave.

Speed	Active device	Passive device
424 kbit/s	Man, 10% ASK	Man, 10% ASK
212 kbit/s	Man, 10% ASK	Man, 10% ASK
106 kbit/s	Modified Miller, 100% ASK	Man, 10% ASK

NFC employs two different codings to transfer data. A modified Miller coding with 100% modulation is used if an active device transfers data at 106 kbit/s, but in other cases Manchester coding is used with a modulation ratio of 10%.

In **passive communication**, the initiator actively generates a RF signals and the target responds by modulating the initiator's field. The Passive mode is the more common application and it is very similar to previous RFID standards in which a reader initiates communication with a passive RFID tag. The initiator usually sends a message to the target and then waits for its response. A passive target does not require a power source in order to transfer data to the initiator; it is essentially "field energized," powered by energy from the magnetic field generated by the initiator. It is possible for the active device to take on both active and passive roles, but the passive device is always the target (Kevin *et al.*, 2012).

7.1. NFC Standards

NFC standards are based on existing RFID standards including ISO/IEC 14443 Type A and Type B standards and FeliCa. The first standard is ISO/IEC 18092 (NFCIP-1) "Near Field Communication-Interface and Protocol", which approved by Ecma International as ECMA-340 in 2003 and recently revised in 2013. SO/IEC18092 (IOS 2013) "specifies the protocol and interface for simple wireless communication between close coupled devices;" its intent is to ensure interoperability between NFC initiators, targets, and applications developed by different manufacturers and service providers. A second NFC standard, ISO/IEC 21481 (IOS 2012), "Near Field Communication Interface and Protocol–2" (NFCIP-2) was first approved by Ecma International as ECMA-352 in 2005 and was revised in 2012.

More NFC-related standards and specifications are developed and maintained by the nonprofit NFC Forum (NFC Forum, 2014), which was founded by Sony, Philips, and Nokia in 2004. The Forum has released 18 specifications to date which enhance and ensure interoperability in the growing ecosystem of NFC devices and applications. Among them are the NFC Data Exchange Format (NDEF), NFC Record Type Definition (RTD), the NFC Controller Interface (NCI), NFC Forum Tag Type Technical Specifications, and the Personal Health Device Communication Technical Specification (Ben and Monica, 2012).

7.2. NFC Communication Modes

The NFC forum established three communication modes, as illustrated in figure 5. 1) **Peer-to-Peer mode**, which defined for device to device link-level communication. 2) **Read/Write mode**, allows applications for the transmission of NFC Forum-defined messages. 3) **NFC Card Emulation mode**, allows the NFC-handset behave as a standard Smartcard (Vazquez-Briseno *et al.*, 2012; Xu and Liang, 2012).

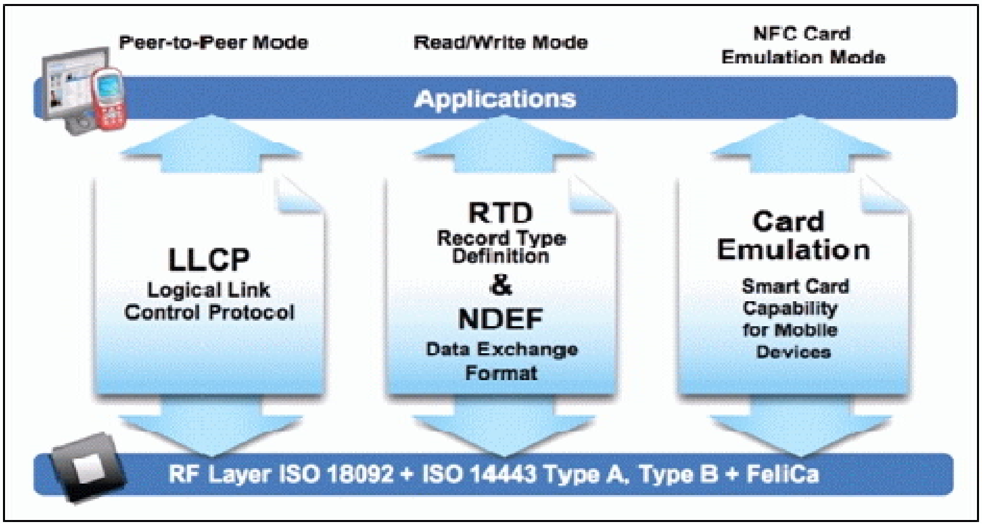

Figure 5. NFC Communication Modes (http://www.oracle.com/).

7.3. NFC Functionality Requirements

I. NFC Devices

Any enabled NFC device must operate in peer to peer mode as well as reader/writer mode. Also, NFC devices can operate in card emulation mode, which means that an NFC device can act as a simple target to be read by another device. NFC functionality requires two important physical components: an NFC controller chip and an antenna. Early these components were added onto device hardware but now they are integrated directly into mobile device hardware (Ortiz, 2008; kerem *et al.*, 2012).

II. NFC tags

NFC tags are classified into 4 types according to signaling, data transfer rates and memory capacity. Types **1** and **2** work at 106 kbps, store up to 96 bytes and 48 bytes, respectively, and can be expanded to store up to 2 kb of data. Type **3** (FeliCa) works at 212 kbps and can store up to 1 Mb. Type **4** operates at 424 kbps and can store 32 kb. Tag Types 1 and 2 are manufactured as rewriteable but can be locked by the user to become read-only whilst Types 3 and 4 are set as either rewriteable or read-only.

All are small, lightweight, and relatively inexpensive and all are passive and do not require a dedicated power source, so they can easily be embedded into small objects such as stickers, posters, and key fobs (NFC forum, 2014; Sonntag, 2011; http://www.radio-electronics.com).

NFC tags are usually showing some differences from the QR (Quick Response Code) as shown in Table 3.

Table 3. NFC tags vs QR Code

functionality	NFC tags	QR Code
Appearance	 Integrated into objects and posters without distracting from visual design	A harsh appearance, but are eye catching and self-evident from a user perspective.
Environmental requirements	can be used in dark, dirty, and busy environments in which QR codes could be difficult to read	require a direct line of sight for scanning, but can be read from a distance.
Hardware requirements	users must have an NFC-enabled device in order to read an NFC tag	QR codes require cameras
Software requirements	The software ecosystem for NFC is still evolving.	a barcode scanner application
Data storage	Store up to 1Mb.	Store up to 100 bytes
Data exchange	two-way interactivity	only provide a one-way, one-time data dump
Accessibility	a smoother user interaction, in that a user simply taps their device to a tagged object. So, it is ideal for access of visually impaired as well as users with limited use of fine motor skills	visual cues and require the user to first see the code and then photograph it

7.4. Uses and applications

Four main applications are reported for NFC technology, including: "sharing, pairing, transaction in addition to wireless charging and powering.

Firstly, sharing includes file web pages, videos and documents sharing. NFC's active communication mode permits data exchange via peer-to-peer mode communication.

For example, Google's Android operating system offers API application for peer-to-peer file sharing via NFC (2011). API allows NFC-enabled Android phone to share documents, videos, map directions, contacts with other NFC-enabled android phone by tapping the two phones together. Similar integrated applications are "Tap and Do" system in Microsoft's Windows 8 (2012) and Blackberry Tag in BlackBerry OS 7.1 (2011) (Nosowitz, 2011; McHugh and Yarmey, 2014).

In general, NFC can easily transfer small data files quickly with little or no setup but large data transfer required combination of NFC with other wireless communication technologies like Bluetooth and Wi-Fi (pairing). Taping phone to another phone can instantly configure a Bluetooth or Wi-Fi connection, without the need for passwords. The rate of NFC data exchange can be 106, 212, or 424 kbps; 848 kbps is available in some NFC-enabled devices.

Pairing is the second significant application for NFC technology. As mentioned before Bluetooth and Wi-Fi are ways of transferring information wirelessly between devices over greater distances than NFC. Bluetooth and Wi-Fi are capable of much faster data transfer speeds (3 Mbps and 600 Mbps, respectively) than NFC, which currently maxes out at 424 kbps. However, Bluetooth and Wi-Fi connections require manual configuration before data transfer begins, whereas NFC can establish a communications link very quickly, within a tenth of a second, and the subsequent data transfer then occurs over Bluetooth or Wi-Fi. Combination of NFC technology with wireless standards such as Bluetooth and Wi-Fi not only help in large data transfer but also save the time of transfer up to 35% as reported (Nosowitz, 2011; McHugh and Yarmey, 2014).

Pairing is coming to reality in 2011 after the agreement of the NFC Forum and the Bluetooth Special Interest Group and two years later, the two organizations announced a formal partnership to enhance interoperability between the two technologies. This agreement has been activated in the market particularly with the appearance of some products use this technology. For instance, NFC-enabled phone can stream the music by taping phone to Nokia's Play 360° wireless speakers via Bluetooth. Another example, many technological companies as Sony, Samsung, and Panasonic released professional NFC supported cameras, printers, watches and camcorders which can tap to share or sync their photos, documents, video with other devices (McHugh and Yarmey, 2014).

Transaction is the most obvious application of the four, and a smartphone with an NFC chip could very easily be configured to work as a credit or debit card. NFC could work well for public transit passes, hotel room keycards, office building passcards and library cards. Also, the government-issued IDs like passports and driver's licenses can be replaced or augmented with NFC to push the security concerns to high levels.

Wireless charging and powering is the fourth application of NFC technology. As mentioned NFC transmissions require very little power. In passive communication, the magnetic field generated by the initiator device powers the target. This feature of the NFC may have big implications for application. For example, new research suggests that NFC-enabled devices will be able to provide and receive wireless charging from other small NFC-enabled devices (Strömmer *et al.*, 2012).

For example, users could charge their NFC-enabled phones by placing them on an NFC-enabled laptop. The laptop would serve as a charging plate, with no cords, plugs, or other accessories required. Currently, the power that an NFC transfer can generate is limited which prevent its public use and already a few cases have emerged for powering or charging small devices. Full commercial implementation of this kind of use case would require amendments to the existing NFC specifications, but the NFC Forum has demonstrated its interest, establishing a Wireless Charging Task Force in 2012 to work through engineering issues (McHugh and Yarmey, 2014).

From above, we can summarize the main NFC applications in commerce, social networking, identity, gaming into (Wayan, 2012; David *et al.*, 2012, Antti *et al.*, 2014):

- **Wireless payments**. The NFC devices can replace the traditional smart cards that have been used for many years in cashless payments. The short setup time for NFC devices allows mobile payments to be even easier.
- **Smart magazines and posters**. NFC devices can be used easily now to get more information about something in a magazine or on a poster on the street by tapping the page to get more information, or the URL to store the bookmark for later use.
- **Transit tickets**. NFC-enabled phones are simple and convenient when used in scenarios for mass transit.
- **Business-card exchange**. NFC devices are ideal for business-card exchanges because setup times for communication between NFC devices are very short.

7.5. NFC Programming

7.5.1. Contactless Communication API

Two APIs, namely JSR 177 and JSR 257, are required to developed NFC applications. JSR 257 provides reader/writer mode application programming resources, whereas JSR 177 and some classes in JSR 257 provide access to Secure Elements (SEs). For peer-to-peer mode programming, propriety APIs are required, since this mode is not supported by the standard Java APIs (Kerem *et al.*, 2012).

I. JSR 177 (Security and Trust Services API, SATSA): This type provides access to smart cards and provides security operations targeting SEs using APDU (Application Protocol Data Unit) and JavaCard RMI (Remote Method Invocation) protocols. JSR177 allows access to a smart card using an APDU Connection or Javacard RMI Connection (http://www.jcp.org).

II. JSR 257 (Contactless Communication API): This API describes contactless communication and the push registry in NFC. It provides an application programming interface that allows applications to access RFID tags, smart cards, and visual tags (barcodes). Different packages are defined for each target type and an application using this API can discover contactless targets and then can connect to the target by using the related package based on the target type. JSR257 allows access to a smart card with ISO14443Connection (http://www.jcp.org).

JSR 257 is the Java ME API that allows mobile phones to communicate with a variety of devices within short distances. The Contactless Communication API allows your Java ME MIDlets to read and write data to the following entities: External contactless smart cards, NFC tags, Generic RFIDs, 2D barcodes, Other NFC-capable phones, and Internal secure element.

The Contactless Communication API Java specification is led by Nokia and defined under the Java Community Process as JSR-257 as a set of APIs for proximity contactless-based communication. The Contactless Communication API consists of five Java packages, as described in the following table:

Table 4: JSR 257 Java Packages

Java Package	Interfaces	Classes	Exceptions
javax.microedition.contactless A mandatory package that contains all the target discovery and classes common to all targets	Tag Connection Target Listener Target Properties Transaction Listener	Discovery Manager Target Type	Contactless Exception
javax.microedition.contactless.ndef An optional package for communicating with NDEF formatted data tags	NDEF Record Listener NDEF Tag Connection	NDEF Message NDEF Record NDEF Record Type	
javax.microedition.contactless.rf An optional package for communicating with RFID (no NDEF formatted data) tags	Plain Tag Connection		
javax.microedition.contactless.sc An optional package for communicating with external smartcards	ISO14443Connection		
javax.microedition.contactless.visual An optional package for reading and generating visual tags	Image Properties Visual Tag Connection	Symbology Manager	Visual Tag Coding Exception

* Note that the only mandatory package is javax.microedition.contactless

The Contactless Communication API allows you to discover and exchange data with contactless targets such as RFID tags, NDEF tags and external smartcards as well as providing support for visual tags (Ortiz, 2008).

7.5.2. Anatomy of a Contactless Communication API MIDlet.

The next figure covers the elements of a typical mobile Java application (MIDlet) that uses the Contactless Communication API looks (Ortiz, 2008).

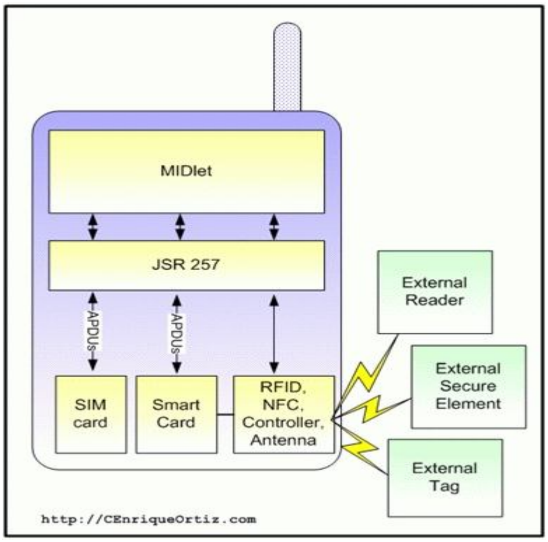

Figure 6: Anatomy of a Contactless Communication API-based Java MIDlet (Ortiz, 2008).

The system consists of the following typical elements:

- MIDlet application running on a handset
- The Java Runtime with JSR-257 implementation
- A SIM card, as well as secure and external elements
- RFID/NFC transponder, controllers, and baseband.

From Above figure we can identify the following:

I. External Readers. External readers include contactless payment readers in Point of Sale stations, ticketing systems on transportation systems, external radio, visual tags such as NFC, RFID and barcodes, or Smartcards.

II. Secure Elements. Secure elements (SE) can be internal or external elements; example of a secure element is a Java Card-based smartcard. MIDlets can access secure elements by using the Security and Trust Services API (SATSA), and/or the Contactless Communication API (JSR 257). External readers access internal secure elements directly via the RFID circuitry (using the Card Emulation mode) (Ortiz, 2008).

7.6. NFC Disadvantages and How to Overcome Them

Although the NFC has inherent security, attacks and threats are still possible. We can classify the threats to the following points:

I. Eavesdropping

Eavesdropping is occurred when two devices, using RF waves, communicate actively to each other via NFC. An attacker can use an antenna to receive the transmitted signals. Either by experimenting or by literature research, the attacker can have the required knowledge on how to extract the transmitted data out of the received RF signal. The research reported that the eavesdropping can be occurred at up to 40 cm without any suspicion. In general, passive communication is more resistant to eavesdropping than active peer-to-peer communication (Haselsteiner and Breitfuß, 2006; Brown *et al.*, 2013; Hancke, 2011; Diakos *et al.*, 2013; Nelson *et al.*, 2013).

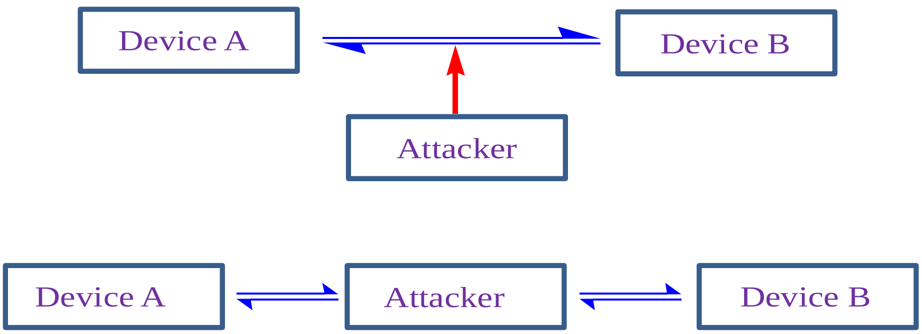

Figure 7: NFC man in the middle Attack

II. Data Corruption/ Modification

Instead of just listening, an attacker can try to block or modify the data which is transmitted via the NFC interface. In a simple way the attacker can disturb the communication leading to that the receiver is not being able to understand the data sent by the other device. Also, data corruption can be achieved by transmitting valid frequencies of the data spectrum at a correct time. The correct time can be measured and calculated if the attacker has a good understanding of the used modulation scheme and coding (Nelson et al., 2013; Haselsteiner and Breitfuß, 2006).

III. Data Insertion

This means that the attacker inserts messages into the data exchange between two devices. Possibly this can be happened if the answering device needs a very long time to answer. In this case, the attacker could then insert his data earlier than the valid receiver. This insertion will be successful, only, if the inserted data can be transmitted, before the original device starts with the answer. If both data streams overlap, the data will be corrupted (Nelson *et al.*, 2013; Haselsteiner and Breitfuß, 2006; Chattha, 2014; Alzahrani *et al.*, 2013).

IV. Relay Attack

In this case, the attacker intercepts a message sent to the victim and responds to the sender, pretending to be the intended receiver (Haselsteiner and Breitfuß, 2006; Roland, 2013; Sportiello, 2013; Francis et al., 2011).

V. Spoofing

Hackers can “spoof” an NFC tag either by reprogramming the tag (if it is read/write), or by simply sticking a new tag over the real tag (Mulliner, 2009). When a user reads the tag with an NFC-enabled phone, the phone is tricked into performing a harmful operation, such as “improper redirection to an unknown Web site; initiation of an unknown service; [or] receipt of unwanted content” (Cavoukian, 2012).

To overcome all these types of attack, many ways should be implemented at the application level, such as:

1) Continued standardization of NFC data management and transmission practices,
2) Use the NFC Forum’s Signature Record Type Definition (RTD) to add a digital signature to NDEF messages or to enable authentication,
3) Data encryption,
4) With public use of NFC, the security for public NFC tags should be enhanced by designing tags which can’t be removed from advertising posters and locked to be as read-only,
5) Programming of NFC devices to prompt the user for confirmation prior to executing some or all commands received via NFC,
6) Programming of NFC devices to monitor the radio frequency field during transmission; data corruption requires additional power and should therefore be detectable and could help against data corruption.
7) Monitoring the radio frequency field and time of reply can detect any data modification and/or insertion,
8) NFC devices could also be configured to compare all incoming radio frequency signals and to select the strongest, which is likely the closest and thus the intended, valid transmission,
9) Programming NFC-enabled devices to automatically disable NFC functionality when the device’s screen or keyboard has been locked, and resume working when the user has turned on his screen and unlocked his device,
10) A user’s mobile device must be secured in case of theft. Users can take steps to protect their devices—for example, setting a lock code for their device and knowing how to remotely wipe a stolen phone,
11) commercial NFC tags should be designed and placed such that the tag could not be easily removed and replaced by a malicious tag,
12) Use electromagnetic (EM) for security,
13) Use passworded EAS (electronic article surveillance) and AFI (Application Family Indicator) which can be only done on SLIX and SLIX-S chips only (Jalkanen, 2006; Roland and Langer, 2010; Michelle, 2013b). Many precautions can be taken to improve the security of data transform and exchange via the NFC technology. But without doubt more effort is required to secure the NFC use in particular with the future broad public use.

8. The NFC-Enabled University

The university environment consists of a set of different groups of people with a high variability of processes, customs and use of new technologies among and within them. Therefore, one of the main challenges and difficulties to introduce NFC technology in the university environment is the choice, design and development of appropriate application scenarios (Ruiz *et al.*, 2009). NFC technology has many applications in the university field, and can be summarized as following:

I. Identification Purposes

Using European Unique Identification (EUI) by students or teachers via NFC enabled phone is an easier, more secure and cheaper way for identification than using the current student's cards. This way has a clear benefit which allows persons to authenticate at any university, anywhere, and can access all kinds of services as payment, access and identification services in an easy way (Miraz *et al.*, 2009; Bueno-Delgado *et al.*, 2013).

II. Payment services

The NFC-based applications could be used as a payment method in the university environment as in cafes and restaurants, photocopy services and vending machines, stores, university transportation (bus, train, and bicycle) as well as sports facilities (Miraz *et al.*, 2009; Bueno-Delgado *et al.*, 2013).

III. General Control and Management

NFC systems can be used in the management and control of the available resources at universities, e.g. libraries, spaces dedicated to teaching, laboratories, computer rooms, *etc*. Also, it can control the assistance of the students to class and teachers compliance of the course schedule and responsibilities (Benyo *et al.*, 2012; Miraz *et al.*, 2009; Subpratatsavee *et al.*, 2014).

IV. Dissemination of information and accessing to services

- **Teaching Services**

NFC technology can help in providing information about many aspects as: a) information on class schedules, locations and subjects to students and teachers; b) information on teaching incidences, schedule changes, locations, cancellations, delays etc.; c) information about teachers: location, public data, tutoring; d) information about exams, marks; e) access and turn for faculty secretary, department, tutoring…*etc*; f) tracking student attendance as in Universidad Pontifica de Salamanca (Fernandez *et al.*, 2013). NFC readers were built into student desks, such that students could tap the desk with NFC-enabled smartphones or ID cards to log their attendance. Student names were then displayed on the instructor's station, mapped to the students' seats.

The classroom response feature allowed students to tap their desks throughout the class to indicate whether or not they had understood a concept, sending real-time feedback to the instructor. g) NFC encourages and participates in interactive, participatory social learning via NFC's peer-to-peer information sharing capability (Miraz *et al.*, 2009; Lee, 2014; Bucicoiu and Tapus, 2013; Borrego-Jaraba *et al.*, 2013).

- **Administrative Services**

Many Administrative aspects and services are continuously needed for students including (regular registration, extensions of registration, enrolment courses extension, validations, fellowships, studies abroad, application for certifications, delivery of documentation etc.). NFC technology can be used in information posters and services located in different locations as Faculty secretary and any location in the campus. Moreover, payment services would be incorporated avoiding the inconveniences and queue times that many of these services have associated. The NFC applications include a) request for certification and payment, b) registration, enrolment and payment, c) information on locations, people and timetables, d) information on marks, e) reports on grants and scholarships, f) request for access to administrative services through ticketing systems, g) access and use of facilities (libraries, computer rooms, *etc.*) and monitoring presence, and others (Ghiron *et al.*, 2009; Bueno-Delgado *et al.*, 2013).

In general NFC technology can help in building smart environments by using Smart Posters. Smart posters can provide a) academic information (organizational structure, university courses, departments, maps, locations…*etc*) to students on their mobile devices easily, quickly and effectively, b) provide a ticketing service allowing students to get turn attention for administrative services, c) software development for the mobile phones as well as the server service devoted to the request and dispatch the attention turn for the administration service of the Faculty and d) software development of an application that allows the construction of the tags inserted later in the smart poster. Besides the information, a user can requests a turn ticket for an appointment at the faculty secretary through the poster and store it on his mobile phone (Ruiz and Gomez-Nieto, 2009; Miraz *et al.*, 2009).

V. Create a social network environment at university or campus

NFC technology can help in creating a social network environment at the university or campus, and boost student retention through:

- Help connection between staff, classmates and senior students as well as facilitating introductions and interaction between old and new students.
- Engage students distributing rich media and distribute multimedia files offline, and create a customized online interface where students can view and share the information they collected.
- Implement the recent social media technology and surprise tech savvy students introducing a cutting-edge social media platform, and engage them online and offline.

- Gain insight into students' interest and build a rich database about it, and track them across enrollment and orientation process (http://www.poken.com; Laura, 2011; Chih-Hao *et al.*, 2014).

VI. Examples of the NFC-Enabled Universities (Smart Universities)

Many universities worldwide are looking at it seriously to enhance the experience of the student on campus, and a growing number of early adopters are emerging internationally (Schnell, 2013; Hugh, 2013a/b; McHugh and Yarmey, 2014).

1. Newham College of Further Education in London is using NFC for attendance monitoring, saving time that can be rechanneled into teaching and learning. When linked up to back-office systems, the data that NFC generates can trigger early warning signals about students in trouble, helping the college to take action and retain as many students as possible. Teachers at Newham College of further education have used NFC enabled phones to record attendance and punctuality and to save time and paperwork costs (Hugh, 2013a).
2. Spain’s Universidad Católica UCAM aimed to be the first university to implement NFC technology across its entire campus. It is implementing NFC for a range of functions, including physical access, payments, and attendance across all staff and its 20,000 students. Users will be able to use their mobile handsets to access university buildings (such as the gym and the library), check bus times, hire bicycles, access campus parking lots, and make payments using a stored-credit system, with users loading funds onto their phones via a network of payment points (Hugh, 2013b).
3. In the United States, those students at Villanova University who have an NFC-enabled mobile phone can enter dormitories and academic buildings securely. This development at Villanova is driven by an understanding that students want to use their phones, which they have in their possession at all times, for as many campus activities as possible (McHugh and Yarmey, 2014).
4. Central College Nottingham is helping language students by developing out-of-classroom collaborative activities using NFC tags embedded into posters. The posters are linked to an online location-based dictionary called Toponimo developed by the University of Nottingham’s Learning Sciences Research Institute to help foster language acquisition. The college plans to develop an analytic system to measure the impact and popularity of these NFC smart posters (Simon, 2013).
5. Students attending the University of London can access information about the activities taking place in buildings at the Mile End campus through NFC posters (https://www.jisc.ac.uk).
6. The University of Cordoba in Spain developed applications using NFC to supply information to students about the university and allow them to make appointments with administrative staff (Hugh, 2013a).
7. Apart from the higher and further education sectors in addition to a growing number of public institutions such as museums and galleries have started to introduce NFC technology to enhance the learning experience. Visitors are able to access audio guides and texts related to exhibits via NFC.

For instance, the Museum of London has used the technology to provide visitors with additional information on their exhibits and to enable them to ‘like’ and ‘check-in’ on, and Foursquare. Visitors can also access vouchers for the museum's shop and cafés (Museum of London, 2011).

Improvements in network infrastructure are playing their part in breaking down the barriers to more widespread use of smartphones on campuses. In the final semester of 2011, for example, almost 25,000 students at the University of Iowa used the campus wireless service from a tablet or smartphone, an increase of almost 10,000 compared with three years earlier. With the use of GPS now mainstream in this heavily penetrated market, mobile innovators are introducing technologies that complement GPS to create a new generation of location based services for mobile devices that will improve both accuracy and usability. As smartphones and tablets come onto the market with in-built near field communication (NFC) readers, it is time to start developing services that work with the impressive capabilities of this emerging technology (Hugh, 2013a).

VII. Implementation and Economical values of NFC Services in University

Introducing NFC technology in the university community has many benefits. In the economic aspects, NFC chips are inexpensive and durable. Actual NFC tags cost less than one dollar each. The core platform, of which the NFC component is a standard part, is under $40,000, which includes all implementation costs and covers use by all students. There is also an ongoing annual subscription based on the size of the institution. The tags come in different shapes and sizes and are adhesive on one surface, so they can be easily fixed in locations across campus (Hugh, 2013a). Universities can add a design overlay and cover them with plastic to prompt users to interact with them in a certain way. Also, universities can write data to the chips very easily; they are easy to set up and customize, and they require no power to run or effort to maintain (Miraz *et al.*, 2009).

In the first instance, universities can set up NFC touchpoints next to foyers and rooms and write location-specific data to these NFC tags. Access management, attendance reporting, and contactless payments are great examples of NFC making life easier on today’s campuses, but they are only the beginning. With NFC, universities can offer menus of information and service options that are contextual to the geolocation of the touchpoint. As a user enters a room on campus, for example, a menu might pop up on the device with location-sensitive options such as “check availability” or “book the room.” It might also offer relevant information such as a floor plan, a room inventory, or even operating instructions for the equipment in the room. The mobile device would pick up a unique identifier for that location, such as a room number, and then backend systems would provide the services and information needed (David *et al.*, 2014). In teaching and learning, educators in many subjects are now experimenting with this technology and can conveniently collect learning resources from tags or other devices with a single tap, thereby reducing the divide between digital and real world activities (Hugh, 2013a).

9. NFC Implications in Libraries

NFC has been implemented in various ways across multiple platforms since it emerged as on sales and marketing, there are also interesting applications emerging in education and health care. Also, NFC is now introduced in libraries for a whole range of activities from selfissue and return, security, stock management, sortation and more. NFC technology applications in Library can be explained in the following points:

I. Mobile Payment

Mobile payment is one of important applications of NFC technology. Users of NFC-enabled mobile can use it to act as a credit or debit card. The users simply tap their device at an NFC-enabled point of sale terminal to make a payment, without the need of using a physical credit card, the customer's signature and PIN. This type of easy payment, NFC's two-way, peer-to-peer data exchange capability, enables additional benefits to the retailer and potentially to the customer. As a point-of-sale terminal reads a phone's NFC chip to collect credit card data, it can also interact with other data stored in the customer's digital wallet. Upto now, several of the major NFC payment systems that are launched around the globe are floundered, despite enormous attention and efforts from many world's largest companies (McHugh and Yarmey, 2014; McHugh and Yarmey, 2012).

Among the major struggled NFC mobile payment systems are Google Wallet and ISIS those initiatives in the U.S. Google's mobile payment system Google Wallet (http://www. google.com/wallet) Launched in September 2011 allows users to pay for purchases at NFC-enabled points of sale. Users install the Google Wallet app on their mobile devices, and then associate the app with either a Citi MasterCard or a Google prepaid credit card. ISIS is a joint AT&T, T-Mobile, and Verizon Wireless venture that have established partnerships with major credit card companies (including American Express, Chase, Discover, and Wells Fargo, among others). ISIS conducted major trials in summer 2012 in Salt Lake City, Utah, and Austin, Texas, partnering with national merchants like Coca-Cola and Macy's as well as local businesses in both cities (Broadway world, 2013; Louis, 2013; McHugh and Yarmey, 2014).

Notably, Apple launched iBeacon in 2013 release of iOS 7. iBeacon conducts these wireless data exchanges using not NFC but Bluetooth Low Energy (BLE, also known as Bluetooth Smart). BLE is similar to Bluetooth Classic, but it uses less power and transmits data more slowly. Compared to NFC, it has a greater range (up to 50 m) and the ability to maintain multiple simultaneous connections, rather than NFC's one-to-one data transfer. As a result, BLE and NFC are not directly comparable technologies, and each brings advantages and disadvantages for mobile payment systems. BLE's greater range frees retailers and consumers from the restriction of a fixed point of sale, likely reducing waiting lines and saving time. On the other hand, this freedom may introduce security vulnerabilities. A comparison report by UL Transaction Security concluded that while BLE "has the potential to improve the overall shopping experience," NFC remained "the preferred technology for the in-store mobile payment transaction itself" (Louis, 2013; Van Klaarbergen, 2013).

Despite the challenges faces the mobile payment adoption, its application will be improved by the time. In library, library patrons will most likely want to use the technology in all venues where payments are necessary, such as paying library fines, purchasing tickets to library events, or donating to library fundraisers. Patrons may also want to use their digital wallet rather than spare change or copy cards to pay for printing, scanning, and photocopying. Libraries purchasing new machines should inquire about the possibility of adding NFC payment capabilities onto existing hardware in the future. Already, Bibliotheca's smartserv 1000 self-serve kiosk, introduced in September 2013, includes NFC as a payment option.

It will be worth monitoring other library automation companies for NFC integration as well (McHugh and Yarmey, 2014; McHugh and Yarmey, 2012).

II. Access and authentication

In library, smart enabled NFC mobile phones are useful in library checkout replacing student library cards. NFC authentication may provide the opportunity for libraries to streamline access to other services and resources. For example, users could tap their NFC-enabled phone or contactless library card to log in to library computers, printers, and other hardware. NFC-enabled mobile devices or cards could be used to unlock reservable spaces in libraries, such as digital media labs, classrooms, or community meeting rooms. Like NFC-enabled TV Everywhere, library patrons might even be able to use NFC authentication to access digital library resources, such as databases, e-journal subscriptions, ebook collections, and nonpublic digital collections, from anywhere using any device (Randy *et al.*, 2012).

NFC-enabled mobile devices could replace student identification cards for after-hours library building entry, Wi-Fi access, and printing, copying, and scanning services, protecting student information and library resources with added security while eliminating the inconveniences of multiple logins. NFC might allow libraries of all kinds to provide more convenient access and authentication options to patrons (Shankland, 2013; McHugh and Yarmey, 2014; McHugh and Yarmey, 2012).

III. Marketing

In the librarianship field, libraries could easily implement NFC tags in their new book displays with tags that link to bestseller lists or related content in the library catalog or digital collections. Similarly, NFC tags placed throughout the reference collection could link to relevant databases, digital collections, or ebooks. NFC tags placed on library doors or promotional flyers could share library hours, a schedule of events, or floor plans for the building. For example, at the Renison University College Library, visitors can tap an NFC-enabled library smartcard to retrieve a digital brochure of library services in a variety of formats, including PDF, EPUB, and MP3. Beyond merely sharing links, however, libraries could also take advantage of NFC's interactive capabilities for their outreach and event promotion. For example, libraries could use NFC tags on their event posters for patrons to scan and register for an event, add the event to their personal calendar, join the friends of the library, or download a library app.

Users could tap a smart poster promoting a virtual reference service in order to send a text message to a librarian. NFC-enabled promotional materials can even invite viewers to engage with library content outside of the library building itself. The Field Museum in Chicago promote an exhibit about the 1893 World's Fair, the Museum placed NFC-enabled outdoor smart posters throughout the city. The posters depicted a personage from 1893 from behind and invited the viewer to "See What They Saw." Users could tap their NFC-enabled mobile device to the smart poster (or read a QR code) to download an app from the field museum that included 360° images of the fair as well as videos highlighting items in the exhibit.

Libraries could also use NFC to support fundraising efforts. At the museum of London, visitors can tap their NFC-enabled phones to tags posted throughout the building in order to buy prints of items on display, join the Museum's Friends organization, follow or "like" the museum on Twitter and Facebook, and, for a £5000 donation, "buy a year of London's history". Public libraries could also consider using tags as a means of community engagement and outreach. For example, the Rock the Vote "We Will" campaign used NFC-enabled smart posters at bus stops to assist in voter registration (Museum of London, 2011; McHugh and Yarmey, 2014; McHugh and Yarmey, 2012; Randy *et al.*, 2012).

IV. Ticketing and Transportation

While NFC-enabled transportation may not directly related to libraries, but since 2013 in USA, public transit systems may offer an ideal platform for NFC-enabled library outreach and promotion for passenger use during their commute. Students from New York's Miami Ad School in 2013 developed a fictional promotion for the New York Public Library that would leverage public transportation.

In their vision of an "Underground Library" (Vimeo, 2013), subway riders would tap NFC-enabled smart posters to download excerpts from best-selling books from New York Public Library (NYPL) to read during their commute. The data transfer would occur via NFC, an important feature in underground tunnels without access to Wi-Fi. The data is stored in a poster in a tag containing RFID and subway passengers just have to hold their phones close enough to the tag for the data to transfer. After which the first 10 pages will be automatically downloaded to their mobile device in an easy-to-read ePub or PDF format. When they reach their stop and release aboveground, a map will pop up and direct them to the nearest available NYPL branches to nab the physical copy (Jordan, 2013).

Another example to public library served by the Metropolitan Transit Authority (MTA) is the Queens Library, New York. The following April, the Free Library of Philadelphia launched a "virtual library" in Philadelphia's train stations as a National Library Month promotion. Users could download books, music, or podcasts from the advertisements. However, the advertisements used QR codes as opposed to NFC tags, and the promotion was thus limited to platforms where Wi-Fi was available.

NFC-enabled ticketing has also been deployed in other commercial sectors, outside of transportation. Libraries may be able to take advantage of NFC-enabled ticketing for large library events.

For example, users with library card credentials on their NFC-enabled mobile device could tap to pick up a free ticket to a library event, or possibly even receive a discount on a paid ticket for an event held by a community partner (Michaelson, 2013; Randy *et al.*, 2012).

V. Social Media

Several applications of NFC technology involve social media and networking. Libraries would also be able to benefit from using NFC to engage and interact with patrons via social media. The visitors of the Museum of London could tap a smart poster to instantly link to library Facebook page. Also, libraries can also incorporate library-relevant social media.

For example, a library patron could to tap an NFC-enabled book to their Good Reads (http://goodreads.com) or LibraryThing (http://librarything.com) account. Libraries can also use NFC to encourage patrons to share library resources with their social networks. For example, at the 2011 STRP art and technology festival in Eindhoven, the Netherlands, visitors tapped their phones to NFC-tagged works of art to “heart the art” and share information about the work with their social media networks.

NFC could make a library visit a more social experience. At the Centre Pompidou modern art museum in Paris, an initiative targeted at teens “allows visitors to synchronize their location with friends who are also visiting the gallery” by tapping NFC tags placed throughout the building (Clark, 2010). The Wolfsoniana in Genoa developed a Smart Museum mobile app that visitors could use to add comments or responses to works of art as well as see a map visualization of the works they had viewed so far (Ceipidor *et al.*, 2013).

VI. Inventory Tracking, Smart Packaging, and Shelf Labels

An exciting and immediate use case for NFC in libraries is for self-checkout: a patron browsing the stacks could tap an NFC-tagged book with their phone to check it out without visiting the circulation desk or waiting in line. In summer 2011, library system vendor Bibliotheca (http://www.bibliotheca.com) premiered a prototype of their NFC-based SelfCheck system for mobile borrowing “straight from the shelves” (Mobile Borrowing, 2011). TechLogic Innovation (http://techlogic.in/) reportedly has an NFC-based circulation tool in development as well.

Smart packaging is important NFC application in library. The concept of smart packaging has significant implications for libraries as a new opportunity to connect physical collections (from books to media) with digital extras. In NFC enabled books, It is easy for anyone to access the relevant digital information: bibliographic information in a variety of citation formats, editorial reviews, the author’s biography, a projected rating for the book based on the user’s LibraryThing or GoodReads preferences, or links to similar resources. In the fall of 2013, the Renison University College Library began pilot testing this concept, converting a printed book into an NFC-enabled “smartbook.” The book selected for the pilot (DANCE: Five Steps to Living Your Best Life) was donated to the project by the author, an alumna. The library created a bookplate for the text which features both a QR code and an embedded NFC tag.

Users can tap the bookplate with an NFC-enabled device (or scan the QR code) to access the text of the book in one of several formats, including PDF, MP3, and EPUB. Library director Tony Tin described the project as a “great success,” noting that it was “inexpensive to produce (less than 50 cents per NFC card)” and “easy for users” (McHugh and Yarmey, 2014). The Hanno library in Japan is considered one of the experimental trials for NFC tag shelves where collaborative partner Fujitsu placed 100 NFC tags on library bookshelves called "Tatchitagu". Visitors of the library can tap their phones on the tags to get all kinds of information, Wikipedia links to authors, pictures, reviews, as well as access to services.

If you want to review books, or recommend them to other readers, just tap and type. Even better, the system lets you check out books or add them to a sort of wish list so you can remember to check them out later. No need to jot it down in a notebook, just tap. This pilot implementation has been successful, and both the library and Fujitsu plan to expand the system (Ceipidor *et al.*, 2013; Clark, 2013; Hall, 2013; Price, 2013; Fujitsu, 2013).

Smart Packaging also includes electronic shelf labeling that customers may tap for additional information, such as up-to-date pricing. In a prototype called Project Y-Mart, such labels could interact with consumers’ NFC-enabled mobile devices to provide personalized information, such as purchasing history, targeted promotions, and loyalty rewards (Teng *et al.*, 2013). Store Electronic Systems, a major vendor in the retail industry, recently signed on with Identive Group to implement NFC shelf labels and has already purchased three million tags.

In publishing, several companies have tested smart packaging for books, using embedded NFC tags to share additional content with readers. In 2011, Simon and Schuster imprint Atria Books published one thousand copies of Gary Schwarz’s Impulse Economy: Understanding Mobile Shoppers and What Makes Them Buy, each bearing an NFC tag on its cover which readers can tap to access interactive mobile content related to the book (“Atria Publishes,” 2011). In 2012, Elektor Publishing released Catch the Sun: Ballooning Across the Globe, a “fully integrated NFC book” that has tags throughout the text that users can tap to play video clips, download music, access information about NFC technology, or connect with other readers via social media. Catch the Sun prompted an executive at NFC chip manufacturer NXP to remark on the future of NFC-enabled books: “Embedding NFC into a physical volume suddenly creates a digitally-connected object that really enhances the reading experience.

Use of RFID in smart packaging and inventory control is not new and many libraries used this technology to provide additional services to users and to store book recommendations or other digital information. The main problem which could face users NFC-enabled smart phones that the interaction of RFID and devices are complicated. For more explanation many library systems use high frequency (HF) RFID tags which operate like NFC at 13.56 MHz, while some library RFID tags are based on the ISO/IEC 15693 standard.

Only some NFC-enabled devices (including many Android devices) are capable of reading ISO/IEC 15693 tags, the NFC Forum does not require this compatibility for NFC compliance. The clear example for this incompatibility is the inability of students in Bristol University to record bibliographic information from RFID-tagged library resources with NFC-enabled phones in the University's Chemistry Library because there is incompatibility with the researchers' NFC-enabled mobile devices (Jones, 2012).

VII. Gaming

Since 1990s, people have been using their mobiles to play games. Makers of mobile games try to enhance gaming experiences by different ways and one of them is exploring NFC as an interesting recent way. In several NFC pilots, players can tap each other's phones together and receive access to a new level, earn extra points, or get clues. Libraries might also explore designing their own NFC-based games. At the Luvia municipal library in Finland, librarians partnered with faculty and students from Satakunta University of Applied Sciences to develop an NFC-based game called "Literature Race" for introducing children to the library (Koivisto *et al.*, 2013).

Several European research groups have developed NFC-based, scavenger hunt-style games for museums (McHugh and Yarmey, 2014). The Musée du Quai Branly in Bordeaux, France, for example, developed an educational game for its Museum of Music in which visitors try to match NFC-tagged instruments in the exhibit to the correct instrument sound and instrument family. Libraries could leverage this type of NFC implementation to enhance preexisting outreach and programming centered on gaming in addition to creating game environments in real world physical settings. Should this style of NFC-enabled gaming expand in popularity, libraries could consider circulating NFC-tagged game accessories for use by library patrons (McHugh and Yarmey, 2014).

VIII. Disabled and Visually Impaired

NFC may also have significant implications for library services for the disabled. As Kyung-Jae *et al.* (2007) presciently recognized, NFC can simplify information access and retrieval for the visually disabled and print disabled. At the LG Sangnam Library in Seoul, Korea, a service model is created in which a print-disabled user could tap her NFC-enabled phone (widely available in Korea) to a dongle to download and listen to a Digital Talking Book. The library also used RFID-tagged posters to distribute learning materials to disabled patrons, recognizing NFC and RFID technology could make location-based information transfer more comfortable for disabled users (Kyung-Jae *et al.*, 2007; Bhattacharya, 2014).

IX. Interactive and Social Learning

NFC's peer-to-peer information sharing capability could serve as an entry point for libraries to encourage or participate in interactive, social learning. NFC technology can be used to facilitate sharing the bibliographic resources in easy way among students and educators.

Also, an embedded librarian could use NFC's peer-to-peer mode to easily exchange information, such as a link to an active database search, with students in the classroom. The privacy and security concerns accompanied with using NFC technology in social and interactive learning should be aware by librarians. A report by the information and privacy commissioner of Ontario, Canada, identified three major privacy concerns for NFC technology: "unwanted data leakage or collection; tracking of a user's location; [and] identifying users in situations where they wish to remain anonymous" (Cavoukian, 2012). If NFC becomes mainstream, the privacy implications of this data collection may be difficult for users to understand and anticipate, and appropriate legislation and regulation of consumer data will likely lag far behind available technology. Librarians, then, have an obligation to educate patrons about NFC, and what precautions they should take to protect their privacy.

X. Managing Library Books

The book managing services authorization request is book lending authorization request, returning book authorization request and library seat allocation authorization request. The system consists of: 1) A computer-readable recording medium for storing a set of instructions to perform a library book managing method, 2) A server for managing a library book by using a smart device. The method involves connecting a book managing server to a user terminal. Book managing service authorization request is received from the user terminal a book managing application. The book managing services authorization request is recognized through NFC technology. Judgment is made for confirming whether the book managing service authorization request is recognized. The user terminal is provided with a book managing certification tag. Validity of the book managing service authorization request is authenticated by the book managing certificate tag.

This method enables performing different book managing services e.g. loan of book, return and seat allocation, by utilizing a smart device of a user. The method enables effectively authenticating the book managing service authorization request by recognizing the book managing certificate tag. The method enables reducing processing time (Kyung, 2014; Yusof, *et al.*, 2014). Also, the prototype of the first ever mobile SelfCheck was premiered at the 100th German Librarian Day in Berlin: an NFC smart phone makes borrowing easily and possibly direct from the shelf. Users can check out, extend the lending period and manage their media with a mobile device. Bibliotheca RFID Library Systems has applied for patent protection for this system innovation (http://nxp-rfid.com). Library book losses from theft could also be also monitored.

XI. Making the physical library more digitally interactive

With the movement of libraries into the digital age and improvement of smart phone usability is by implementing mobile tagging technology as NFC to facilitate access to more of their collection and to simplify other processes. Mobile tagging technology as NFC allows adding embedding information for scanning to each book, containing bibliographic information, link to similar resources and even due dates on a checked-out book.

NFC technology can be utilized to give users access to information on library layouts, allowing them to locate the book or journal quickly and easily and know more before borrow it. Also, NFC can give users instant access to an ebook version of a publication. NFC offers a much faster connection than WiFi and Bluetooth, and store more data than QR code, so it may be a more effective way of accessing large files such as e-book. Also, using NFC give the users the ability to check out books themselves as well as paying library fines which cut down admin (Mary-Frances, 2012; Sheila, 2014).

10. Factors Affecting Distribution of NFC in Libraries

Despite the NFC is very beneficial technique to libraries, it hasn't been universally adopted in the libraries or in the consumer markets, and may be for some reasons:

1) Compatibility. Which users should have compatible mobile devices with a scanner application? Some users have old mobile phones or none at all.
2) Lack of Standards. At present, there are no standards or accepted methodologies for adopting NFC in libraries.
3) Potential threats as change the security status, look an item, overwrite library data, delete data and lock user memory.

In addition to some other factors as lack of awareness and infrastructure establishment which could be solved with time. The librarians should be aware of all positive and negative impacts, and what actions should be done to alleviate the potential threats (McHugh and Yarmey, 2014; McHugh and Yarmey, 2012).

11. Conclusion

NFC technology is a short-range wireless technology playing a significant role in the information environment. NFC tries to harmonize today's different contactless technologies, presenting current and future solutions as payment, ticketing, access control, information collection and exchange, transportation, health care, social networking as well as education. With the huge observed development in contacting technologies and all of these have been consolidated into one device, NFC tries to make people's lives easier and more convenient by enabling more intuitive access to new media and content services.

Library is one of important field of NFC applications. To date, little discussion of NFC roles in the library community, although there is a rich body of information addressing radio frequency identification (RFID), a closely related and compatible technology, and its application in libraries community. This encourages us to highlight on NFC potential significance for libraries.

In the library field, NFC exhibits many applications including the physical access authentication, secure payment, interactive and social learning, managing books, e-lending, and inventory tracking, smart packaging, shelf labels….*etc*. Despite all NFC benefits in library community, the librarians should be aware of both NFC's positive and negative implications of this technology.

As NFC is still a nascent technology and the mainstream adoption is not yet assured, we try in this report to raise awareness about NFC technology among information science professionals and facilitate understanding of its functionality and development, and place it into the broader context of existing technologies that we have already incorporated into our libraries, collections, and services.

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