Analysis of Near Field Communication (NFC) and other Short Range Mobile Communication Technologies

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<u>**Project Guide**</u>

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CERTIFICATE

This is to certify that Mr. Apuroop Kalapala, pursuing Electronics and Communication Engineering (E.C.E.) at IIT, Roorkee has undertaken a project as an intern at IDRBT, Hyderabad from May 14, 2013 to July 9, 2013.

He has done project work on "Analysis of near Field Communication (NFC) and Other Short Range Mobile Communication Technologies" under my guidance. During the course of the project he has undertaken the study of various short range mobile communication technologies and did an excellent work.

I wish him all the best for all his endeavours.

Dr. V.N. Sastry

(Project Guide)

Professor

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My report on the "Analysis of Near Field Communication (NFC) and other Short Range Mobile Communication Technologies" was possible because of the esteemed guidance and support of my mentor Dr. V.N. SASTRY who left no stone unturned to guide me through the completion of the project. I sincerely thank him, not only for providing me this great opportunity of developing my technical and intra-personal skills but also for the unmitigated support he extended throughout. His enthusiasm and expert help, kept me motivated to achieve my goal and continues to inspire me.

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Abstract

The evolution of mobile communications has increased the need for faster, quicker and efficient means of communication for sending data, mobile payments, product tracking, human identification, health etc. With increase of these demands, there is increase in complexity of technology in terms of hardware and software.

Near field communication (NFC) is a technology in which two devices exchange information or data over a wireless connection by being in close range of each other. In this project report, security aspects have been thoroughly discussed based on standards given by NFC- forum. Various aspects of NFC have been studied and a detailed comparative analysis has been done with other technologies like Bluetooth, 3G/Wi-Fi etc. Based on this comparison all the benefits, applications, cons have been mentioned. Besides this some upcoming technologies like Zig bee, Wi-Fi direct have also been discussed which have potential to become alternatives to NFC technology.

It concludes with future technologies as well as new payment methods like retina scan, finger printing, voice recognition to more advanced methods like snapping of fingers, reading thoughts etc.

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LIST OF ABBREVIATION

NFC   :Near Field Communication

RFID   :Radio Frequency Identification

QR Code   :Quick Response Code

3G   :3rd Generation

Kbps   :Kilo Bits per Second

Corp   :Corporation

P2P   Peer to Peer

IEEE   Institute of Electrical and Electronics Engineers

POS   Point of Sale

1. INTRODUCTION

1.1 NFC: A subset of RFID

Near field communication (NFC) and Radio-Frequency Identification (RFID) are wireless communication technologies that connect two wireless devices. They are very similar wireless technologies. NFC and RFID are two close cousins in a world filled with wireless wizardry.

NFC stands for near field communication, while RFID means radio frequency identification. Both employ radio signals for all sorts of tagging and tracking purposes. NFC is still an emerging technology; RFID, however, is currently in widespread use all over the world.

RFID tags contain an antenna and a memory chip that stores data. To see that data, you need an RFID reader. These tags and readers are used in a mind-blowing array of applications.

The tags are embedded into retail products to help stores keep tabs on inventory. Indeed, inventory and package tracking are two of the most common uses of RFID. But these tags can do much more. They're stuck under your dog's skin so that the dog catcher can identify if he gets lost. The RFID highway toll tag in your car automatically identifies you to the toll reader, even at top speed, which bills you later. Some airlines use RFID tags to efficiently track and control large loads of baggage. And RFID appears in so-called smart passports and credit cards, as well as identification badges that let employee's access secure areas.

RFID often works well at distances of many feet; otherwise, you'd have to veer your car dangerously close to a toll gate in order to make sure the reader accepted your payment. And RFID is a one-way communication system, in which data flows from tags to the reading equipment.

NFC technology is a newer, more finely honed version of RFID. It operates at a maximum range of about 4 inches (10 centimetres) and can be set up for one- or two-way communications.

Let's start with a one-way NFC data transfer. Using your NFC smartphone, you can tap NFC smart tags that might appear in everything from promotional movie posters and political flyers to museum tour placards. Smart tags are a lot like RFID tags; they're simply tuned to work with an NFC reader instead of an RFID one.

Working of NFC and RFID

NFC technology is actually embedded in a chip which can be installed in your smartphone, tablet or your palmtop. The working of NFC technology is very simple. All you need to do is to buy an NFC embedded smartphone. There you will find a simple form in the phone where you have to enter all the credit card or bank account details. After activating it, you can do your shopping with your smartphone. At the time of payment, you need to swipe your phone at the required place. There also exists a forum known as Near Field Communications Forum that is committed to make the technology better. This forum also works for the sharing and pairing between NFC devices. This

technology is so robust and powerful that it can behave like your ID card, key card, and also your credit card. With NFC, your phone is very versatile.

RFID is more popular than near field communications because it has a wider spectrum of uses. The mechanism of RFID depends upon the radio frequency. All its features are activated by using radio waves. A radio frequency can be active or passive or sometimes both but the NFC technology always work upon passive frequency. The expected working range of near field communication is in few centimetres while for RFID, it is in meters. One present use of RFID technology is the tracking of animals in reserved wildlife forests and parks. It is also used for tracking your car and used by detectives to track criminals. RFID mainly works by forming tags. Bluetooth and NFC both are short range technology for sharing and receiving. However, NFC requires less power than Bluetooth. Also, there are various threats attached to NFC like eaves-dropping, relay attack, lost properties, walk-offs, and data modification.

The NFC is an essential extension of RFID. However RFID has a wider covering range and for NFC, as the name suggests, its transmission is restricted to a small range. Near field communication technology can't be used for security purposes as it is confined up to a few centimetres whereas RFID has wider applications. Nevertheless, one of the great features of NFC is that near field communications can be installed in portable devices like smartphones.

1.2   **About NFC**

NFC is a short range wireless technology that has been developed by Philips Electronics and Sony Corp in 2004. As can be inferred from the name, NFC is a connectivity technology that allows interconnection among devices within a range of about 10 centimetres.

Quick and simple operations together with a high security make this technology suitable for secured communications like monetary transactions, private data collection, and ticketing and generic information exchanges.

NFC's main advantage is its intrinsic security level, ensured by the limited communication range of the technology that, together with a single P2P connection, will limit any interception possibilities. On top of the intrinsic security, NFC technology supports advanced cryptography, which makes NFC-based systems suitable for financial and other kinds of secure transactions.

The market driver for NFC technology is, and still will continue to be, mobile handsets, where the technology is expected to be integrated soon on a wide scale, reaching about 220 million units by the 2014 time frame.

Characteristics of NFC technology:

- It is based on Magnetic Coupling.

- Low interference from devices due to secluded band width & low proximity.

- Instant (no pairing required unlike Bluetooth).

- Low power consumption of energy as it uses energy produced by magnetic coupling.

- Operates at frequency of 13.54 MHz with data transfer rates of 106/212/424kbps.

- Easy to swipe device or can be easily brought near a TAG. No authentication time required after initial setup.

- No training will be required and card will act as passkey.

- Many companies, services & users are now working & developing this technology.

- NFC technology is secured by various protocols.

1.2.1 Various Modes of NFC

- **Card Emulation mode**- In card emulation mode, an NFC phone behaves much like a passive NFC tag, which allows information on the phone to be read at a terminal for applications such as e-ticketing and subway passes.

- **Reader/Writer mode**- In reader/writer mode, an NFC phone can read and/or write NFC tags.

- **Peer to Peer mode**-In peer-to-peer (P2P) mode, two NFC enabled devices such as a phone and a terminal, actively exchange information with each other for payment and other purposes. For P2P mode, though, the two devices need to make actual physical contact in order to start communicating, and hence, tap and pay as a new way to pay.

- **Bluetooth Handover** – Many companies are using NFC technology to pair Bluetooth headsets, media players, and speakers with a tap of NFC devices

- **Wi-Fi Handover**- The same principle can be applied to the configuration of Wi-Fi networks e.g. Cafe shops.

1.2.2 Unique features of NFC

NFC provides a range of benefits to consumers and businesses, such as:

- **Intuitive**: NFC interactions require no more than a simple touch

- **Versatile**: NFC is ideally suited to the broadest range of industries, environments, and uses.

- **Open and standards-based**: The underlying layers of NFC technology follow universally implemented ISO, ECMA, and ETSI standards

- **Technology-enabling**: NFC facilitates fast and simple setup of wireless technologies, such as Bluetooth, Wi-Fi, etc.)

- **Inherently secure**: NFC transmissions are short range (from a touch to a few centimetres)

- **Interoperable**: NFC works with existing contactless card technologies

- **Security-ready**: NFC has built-in capabilities to support secure applications

1.2.3 Security Aspects of NFC

- Hacker needs to be really close to the device to hack it.

- NFC SIM cards storing a consumer's payment credentials and the payment applications are certified according to security standards. These standards are defined by financial services' authorities and are comparable to CHIP-N-PIN security.

- Consumers can also request the PIN to be entered for all payments Consumers can choose to authenticate transactions by entering a PIN code on the payment applications, even for small amounts providing the end-user with complete control over protection features.

- Secure over-the-air technology for remote management enables immediate remote blocking of the payment application. This works in a similar fashion to blocking a bank card in opposition mode.

- Besides this, there are standards followed by over 160 companies given in NFC-forum.

1.2.4   NFC-forum standards

- **NFC Data Exchange Format (NDEF)** defines a common data format between NFC-compliant devices and tags

- **Record Type Definition (RTD)** specifies rules for building standard record types

- Five specific RTDs (Text, URI, Smart Poster, Generic Control, and Signature) are used to build standard record types

- **Connection Handover** defines how to establish a connection using other wireless communication technologies

- **Logical Link Control Protocol (LLCP)** defines a protocol to support peer-to-peer communication between two NFC-enabled devices

- **Digital Protocol** addresses the digital protocol for NFC-enabled device communication, providing an implementation specification on top of the ISO/IEC 18092 and ISO/IEC 14443 standards

- **NFC Activity Technical Specification** explains how to set up the communication protocol with another NFC device or NFC tag

- **Simple NDEF Exchange Protocol (SNEP)** supports peer-to-peer communication between two NFC-enabled devices, which is essential for any NFC applications that involve bi-directional communications

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- **Operations Specifications** for Four Tag Types (1/2/3/4) enable core interoperability between tags and NFC devices

1.2.5 Types of NFC tags

Various types of NFC tags are given below:

Tags	Read/Write	Lockable	Memory	Transfer rate	Price
Tag 1	Read/Write	Yes	96 Bytes	106 Kbps	Low
Tag 2	Read/Write	Yes	48 Bytes	106 Kbps	Low
Tag 3	Read only	Yes	2 Kbytes	212 Kbps	High
Tag 4	Read only	Yes	32 Kbytes	106/424 Kbps	High

- **Tag1**: Users can make it read only. It is expandable up to 2kbytes. It is very cost effective & widely used for personal use.

- **Tag2**: Users can make it read only. It is expandable up to 2kbytes.

- **Tag3**: It is used in complex systems such in an organizations as it is very costly.

- **Tag4**: NFC tags are pre-configured at manufacture and they can be either read / re-writable, or read-only.

Type 1 and type 2 tags are dual state and may be either read/write or read-only. Type 3 and Type 4 tags are read-only, data being entered at manufacture or using a special tag writer.

2. <u>Comparative Analysis of various short range mobile communication technologies</u>

2.1 <u>Various parameters for comparison</u>

This table shows comparative analysis of various short range mobile communication technologies which are currently being used for mobile based payments. Thus, QR code and barcode are included although they are not used for payments but play an important role in bridging with payment channel.

Technology	NFC	Blue tooth	QR Code	Bar code	Wi-Fi/3G	
Frequency	13.56 MH	2.4 GHz	-	-	2.4 GHz	
Transfer Rate/Data retrieval	106/212/ 424 Kbps	2Mbps	Quick	Quick	Network/ Signal strength	
Range	10cm	10m	1m	1m	Worldwide	
Interference	Low	High	Direct View	Direct View	High	
Size	Small Size (30mm*10 mm)	-	Small Size (20mm* 20mm)	Small Size (20mm* 10mm)	-	
Information transferred/ Stored	Less	More	More	Less	More	

Can be attached to odd object	Yes	-	Print	Print	-
Data Modify	Yes	Yes	No	No	Yes
Durable	Yes	-	No	No	-
Passive/ Active	Passive/ Active/ Battery Passive	Active	Passive	Passive	Active
Contactless	Yes	Yes	Yes	Yes	Yes
Line of sight	No	No	Yes	Yes	No
Secured	Yes	Partially/ Hack able	No	No	Hack able
Cost	Initial cost	Hardware cost else cost free data exchange	Low	Low	High
Simple to manufacture	Complex	Complex	Yes	Yes	Complex
Device Switching	Yes	Slow	Yes	Yes	Slow
One touch	Yes	No	Yes	Yes	No
Security Standards	Very High	High	Low	Low	High
Power Consumption	Low	Very high	No	No	High
Simple	Easy to use	Complex	Software	Software	Complex
Software Requirement	No	No/ Preferable	Yes	Yes	Yes
Availability	Few	Huge no. of devices	Yes	Yes	Yes

Ways of communication	Two way	Two way	One way	One way	Two way
Uses	Task oriented	Task oriented	Branding/ Marketing	Branding/ Marketing	Everything

2.2   NFC v/s Bluetooth

Bluetooth: A wireless short range data transfer technology which transmits data between two mobile devices via radio waves. The specialty of this technology is, it transmits low signals of about 1 mill watt to avoid interference with other devices on the transmission path. As the signals are feeble, it can't travel long distance and it is the reason why data transfer won't take place when two Bluetooth-enabled devices are held at greater distances. With no line of sight communication mandatory, using this technology connecting different devices in distinct rooms is never a tough option.

NFC vs. Bluetooth (standard)		
	NFC	**Bluetooth**
History	2004, initiated by Nokia, Sony, Philips	1994, created by Ericsson
Technology	Radio waves; frequency-hopping spread spectrum	RFID combined with smartcard infrastructure
Standards	ISO, ECMA, ETSI	IEEE Global Standard
Users (in %)	200 million	2 billion

Communication frequency	13.56 MHz	2.4 GHz
Data transfer rate	424 kbps	1–3 Mbps
Power consumption	Very Less	Less but a bit high compared to NFC & consumes a lot of power when left turned on.
How it works	No pairing required for data transfer	By pairing two devices within a short distance you can transfer data
Accessibility	Tap screen to transfer data (highly intuitive)	Search devices, select the one and start data transfer (no intuitive)
Ease of use	Very easy	Bit difficult compared to NFC
Data exchange over distance	Within 4 cm	Within 32 feet or 10 meters
Data transfer ability	Very fast	Fast
Multi-device connectivity	2 Devices at the same time	Connects up to 8 devices at the same time
Cost-effectiveness	Initially expensive & cheap maintenance cost	Initially expensive but zero maintenance cost
Convenience	High	Not as high as NFC
Social networking ability	Yes	No
Payment transaction	Yes	No

Security	Intermediate; neither high nor low (allows for anti-virus installation)	Low (no option to enhance security)
Benefited Sectors	Electronics, Healthcare, Transport, Payments, Access Control, etc.	Sports & Fitness, Medical, Health & Wellness

The latest development in Bluetooth technology, Bluetooth low energy (BLE), is targeted at low power consumption and uses even less power than NFC. As the technology increases, Bluetooth and NFC technology may continue to work together, relying on each other to help users meet their data transmission needs.

IHS expects NFC technology to be implemented in the car and coexist with today's more mature and diffused technologies, such as Bluetooth and Wi-Fi. As a result, Bluetooth and NFC will be complementary technologies.

2.3   NFC v/s QR Code

Quick Response codes, or QR Codes, are two dimensional barcodes that originated with Japanese automakers as a way of sharing information or data. Just as a grocery store clerk scans a barcode on packaged or canned items that reveals information regarding manufacturer, price, and quantity. QR codes contain information that is accessed through scanning. Smartphones enabled with a QR scanner applied over the code unlocks the data and information from each code. At grocery stores, USB barcodes are one dimensional, and their ability to hold information is limited. QR codes are two-dimensional; therefore, they enable a user to store much more data than a bar code. Many marketers utilize QR codes in their campaign strategies and store information such as web addresses or files in their codes. Though these have numerous benefits to businesses and webmasters, they pose several security risks that must be taken into account.

- Denso Wave created the first QR code in 1994 for the auto giant Toyota.

- QR codes are open source; developers do not need to worry about copyrights when using them

- QR codes may hold up to 7,089 characters of numeric content and up to 4,200 characters of alphanumeric content.

NFC tags and QR codes in essence perform the same function; they store small amounts of information such as a web address (URL) or ID. They do however perform this function in very different ways and understanding these differences will allow you to make the right choice.

1. **User Experience**

   NFC: NFC-enabled mobile phones work straight out of the box and do not require any additional software. Simply tap an NFC tag from your home screen and the web link or command will launch automatically.

   QR: Mobile phones require an app in order to use QR codes. To scan the QR code you must first access an app and then align your camera to the code.

Winner: NFC tags offer a more slick and intuitive user experience.

2. Cost

NFC: NFC tags are available for £0.20 ($0.30) each for an order of 1000 tags.

QR: QR codes only cost as much as the print and can therefore be included within existing print media at no extra cost.

Winner: QR codes are the cheapest option.

3. Size

NFC: NFC tags are typically 10-30 mm in diameter and are very thin at just 10-20 microns (0.01-0.02 mm).

QR: QR codes must be at least 20mm × 20mm to ensure they can be scanned without error.

Winner: Both have a comparable size.

4. Product Integration

NFC: NFC tags scan be scanned without a direct line of sight and therefore can be integrated within products and/or hidden from view. Special on-metal NFC tags must be used when the tag is placed within 5 mm of a metal surfaces.

QR: QR codes must be printed visibly onto each product. Particular care must be taken when printing on 3D products.

Winner: NFC tags are better suited for product integration.

5. Print and Customisation

NFC: NFC tags are available with full colour custom print and can be hidden behind printed media and/or within products.

QR: QR codes must be visible and can only have very limited customisation in order to maintain their performance.

Winner: NFC tags allow for full colour custom print and branding.

6. Availability in Mobile Phones

NFC: As of May 2013 NFC is available in mobile phones from 9 out of 10 of the world's major manufacturers. It is estimated that there will be 500 million NFC-enabled phones in the market by 2014.

QR: QR codes can be used by all existing smartphones.

Winner: QR codes can be read by all smartphones.

7. Programming

NFC: NFC tags are easy to encode using mobile apps available on NFC-enabled phones. Our recommendations are NXP Tag Writer for Android, NFC Interacter for Windows Phone 8 and NFC Shortcuts for Blackberry. NFC tags are also rewritable and therefore allow for task launcher applications such as NFC Task Launcher.

QR: QR codes can be freely generated online from a wide range of websites.

Winner: Both are easy to programme however only NFC tags are rewritable.

8. Security

NFC: NFC tags have a fixed manufacture ID number and specialist tags can also support encryption to hide the programmed data.

QR: QR codes offer no security.

Winner: NFC tags are the only option when security is required.

2.4   NFC v/s 3G/Wi-Fi (Cloud Payments)

Cloud wallet consists of an app on a smart phone. The cloud wallet concept will be very familiar to PayPal customers. The idea is that users register for the service (or receive the service from their operator), and then use the service for one-click check-outs in e-commerce. This may in some cases include a stored value or prepaid account to draw funds from your bank and use as cash in the cloud wallet. These wallets are evolving from existing services from the likes of PayPal and Telefonica. In POS retail situations, the cloud wallet requires cardholders to enter a PIN into their wallet app from the receipt to complete the transaction. This is arguably clumsier than the NFC solution, but has seen much higher transaction volume initially because merchants do not have to change their POS infrastructure.

The cloud camp is winning at the moment. For NFC technologies to take off, the infrastructure needs to be in place. This will probably take two years at least, given that merchants must upgrade their point-of-sale terminals and consumers upgrade their mobile devices.
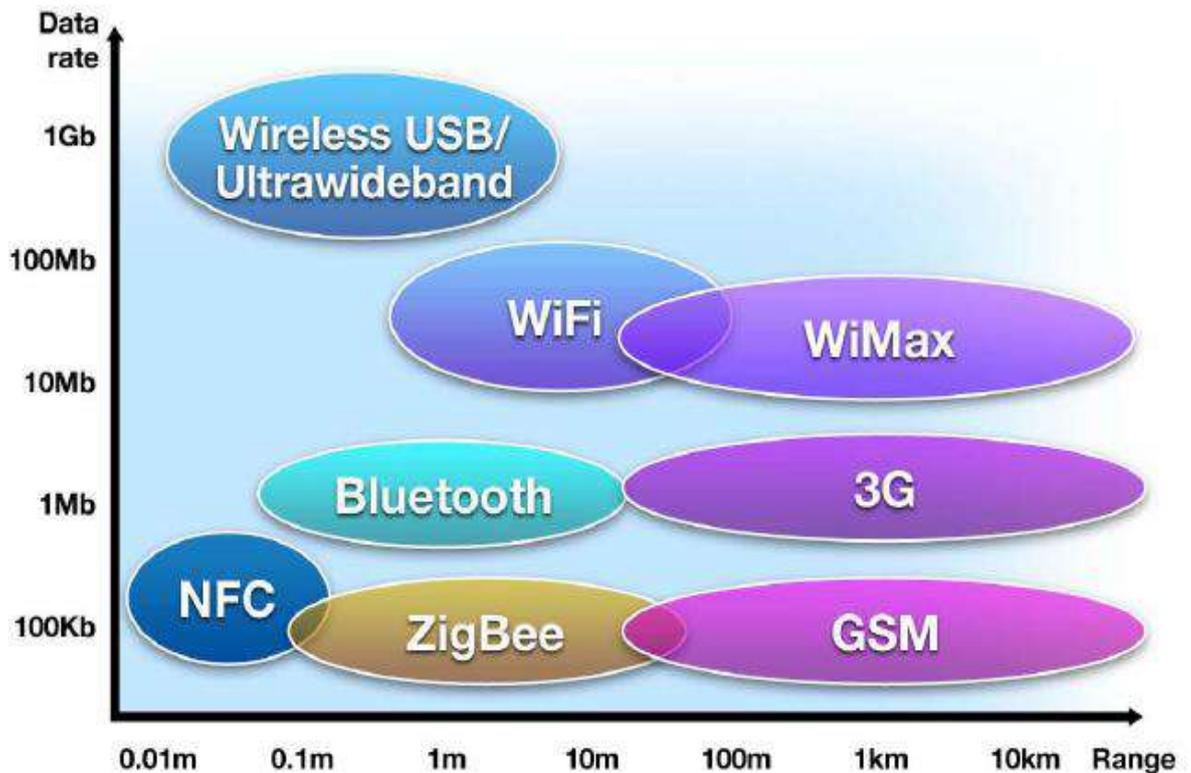
2.5   Cons of NFC

Based on various comparisons done with various technologies there are a few concerns we need to take care before we adopt this technology.

- Initial infrastructure cost is very high as it needs to replace existing technologies.

- NFC technology is in development stages & its benefits are not fully tested

- Sometimes NFC requires the use of Wi-Fi & 3G connection to complete a task.

- There are very few devices available which are NFC enabled.

- One Access point creates bottleneck.

- Consumers may get confused.

- Overnight update of NFC payments leaves merchants unpaid which is unlike debit cards where payment is done right away.

- Many companies' have to agree that it will actually work in long term.

- **Eavesdropping-** With the use of a patch loop antenna it is possible to place a receiver close to the target and disguise it. This is much like ATM skimming in that it needs to be near the location however in this case no contact with the device or reader is required.

- **Data modification -** It is easy to destroy data by using a jammer. There is no way currently to prevent such an attack.

- **Relay attack**-Because NFC devices usually include ISO/IEC 14443 protocols, the relay attacks described are also feasible on NFC. For this attack the adversary has to forward the request of the reader to the victim and relay back its answer to the reader in real time, in order to carry out a task pretending to be the owner of the victim's smart card. This is similar to a man-in-the-middle attack.

- **Lost property-**Losing the NFC RFID card or the mobile phone will open access to any finder and act as a single-factor authenticating entity. Mobile phones protected by a PIN code acts as a single authenticating factor. A way to defeat the lost-property threat requires an extended security concept that includes more than one physically independent authentication factor.

3. <u>Applications of NFC</u>

3.1   <u>Various uses of NFC technology</u>

- **Walmart** is using NFC tags to keep up with information of clothes such as keeping count, locating the required item. These tags can be removed for the customer after purchase

- **Smart Mirrors** are being used in trial rooms of various clothing stores. These detect tags and give suggestions on compatibility of clothes and also suggests matching shoes as well as other accessories.

- **Smart sponge System** is being used in various hospitals where all the surgical items like cotton, bandage, and instruments are equipped with tags. They are also provided with a device that detects if any instrument is left inside the body during surgical process.

- **Smart toilets** have tags which can perform various functions like flushing, keep a tab on water usage, all using your smart device.

- **Vehicle tire** can also use NFC tags along with sensors to measure air pressure and temperature and send that data to mobile phone in your car.

- **In Baja Beach Club,** while wearing a swimming costume you can't carry wallet & debit cards, thus people are implanted with NFC tags on their arms. They can pay using these tags as well as get access to VIP lounges.

- **Edible RFID Tags** along with sensors are used to measure blood levels and other health parameters via NFC detectors which can pass through human body.

- **Smart dust** detect dust particles as well temperature and humidity.

- **Online shopping** uses your NFC enabled phone to pay online via NFC reader attached to your laptop.

- **Museum of London** is already using NFC tags to give various kinds of information to visitors.

- **Blind people** can have NFC tags at the bottom of stick and use it to travel various locations.

- **Brand Table** has NFC tags so that you can select menu of various restaurants and order using Bluetooth handover.

- **NFC** tags are also put in bonds, documents, jewellery to avoid counterfeit notes, check illegal transactions, and stop hawallah system and to stop illegal money laundering.

- **Expensive** items like Diamond, Gold Bars also have NFC tags to keep track of them.

- **Wine tap at noodle towers** is an Alcohol mall that gives suggestion on various recipes of wines

- **Entrance door and cars -** Wi-Fi, mobile profile, GPS, playlist of your mobile can be triggered.

- **Temperature tags** are used for perishable items like fruits, ice creams which are imported worldwide.

3.2 Various uses of RFID technology

- **Golf balls** are equipped with RFIDs so that they can be easily traced in golf ground.

- **Mexican kidnappings -**Some rich people are implanted with active RFID chips so that they can detected over long distances.

- **Indian Elephants & expensive plants** are implanted with RFID which can be detected over various kilometres and to stop illegal smuggling of them.

- **RFIDs for mobile payments-**Mobile phone are equipped with smart memory cards which are used as a pass key to pay.

- **Inventory security** – To keep track of various items.

- **Some Casinos** have RFID tags inside chips to prevent cheating.

- **Vehicle control** – I-key is used to open car doors.

- **Security Cards -** Contactless security cards are widely used.

- **Product tracking-** Courier services use RFID to keep track of the packages over various transit stations.

- **Promotion tracking –** Some companies use it to ensure that the discounted products reaches the customer.

- **Public transport-** Buses and metro trains use contactless cards and tokens.

- **Passports** are also embedded to keep track of the travellers.

- **Sports-** Runners are provided with tags to record their time and info where there are many participants and keeping a record of participant is difficult e.g. Marathon.

3.3   NFC in India

- **NFC India Summit – It's not just about payment** is held every year in the month of May in Mumbai. Various companies come to discuss technology, marketing strategy, etc. Earlier it mainly focused on technology such as how devices should be manufactured for Indian customers and what are the standards that need to be followed, however, this year it focused on how to commercialize NFC in Indian market. Marketing strategies were discussed. It predicted that by 2015, 375 million people in India will be using NFC.

- **Yebhi.com** launches Virtual stores in collaboration with café coffee day. Consumers can go to café coffee day stores and choose clothes, gain information regarding product & payment methods all using NFC tags. It reduces labor cost as well as less space.

- **Chennai, Hyderabad, Bangalore metro** are going to use NFC based cards for payment. Delhi metro has also tested NFC based payment.

- **MP government** is using NFC tags for tourism purposes which would help tourists with all the information required.

- **PVR-Blackberry** have started NFC payment application where movie goer can purchase tickets easily from NFC readers at PVR cinemas.

- **E-Shakti cards** are used to implement virtual banks. These are being tested in east Bihar where NFC card acts as Debit card, credit card, and passbook.

- **Identitis**-**Mobile and retail stores –** They are specialized in selling NFC tags, devices, reader/writer.

- **Nokia/Samsung** have launched a wide range of NFC enabled mobile phones in India.

- **Atuch.com** – Specializes in smart posters, NFC posters.

- **Nearyoutech.com & airnc.com** – They specialize in selling tags, posters, readers, as well as programming for personal purposes. They also provide with consultancy services for NFC technologies.

4.   Upcoming Alternative Technologies to NFC

4.1   Table: Upcoming Technologies

Technology	Wi-Fi Direct	Digital Wallet	Induction Wireless	Advanced Infrared	Ultra Wideband	Zig-Bee
Range	20m	World wide	3m	100m	Few Metres	134m
Transfer Rate	250 Mbps	Depends on network	204 Kbps	10 Mbps	100 Mbps	28Kbps 250Kbps
Frequency	2.4 GHz	Network	11.5 MHz	3.3*10^5 GHz	3.1-10 GHz	889MHz & 2.4 GHz

These are the various technologies that can replace NFC in near future.

4.2 Wi-Fi Direct

Wi-Fi direct is a set of protocols that enables devices which allows users to communicate without use of an access point and to transfer data at typical Wi-Fi speeds. This is the closest one to replace NFC as it is already available on various devices. It has a wide range of about 20m.

4.3 Digital Wallet

It refers to various payments done via applications without use of a new technology present in mobile devices like Airtel Money, Google wallet. It also includes sms banking, mobile banking etc.

4.4 Induction Wireless

It uses magnetic field to communicate with other devices. Currently it is used for wireless charging of mobile devices.

4.5 Advanced Infrared

Wireless arrays of high-powered IR LEDs are used to send signals in different directions. Array of photo detectors and super-sensitive receivers to pick up the diffused IR within the networking space. It has a transfer rate of 10mbps.

4.6 Ultra Wideband

It can penetrate walls, body, and even ground. It is used by U.S. military to send signals in a restricted area. They operate at a frequency range between 3.1 GHz – 10 GHz.

4.7 Zig-Bee

Zig-Bee is the low cost cousin of Bluetooth. And is used for short range remote control operations. It works at the same frequency as Bluetooth i.e. 2.4 GHz with a range of 134m at a transfer rate of 250kbps. It can connect up to 254 devices at one time. It has another variant for low end devices which works at 889MHz with a transfer rate of 28kbps. It is used for specific purposes like video games home appliances, consumer appliances. It consumes less power and is inexpensive.

5. Conclusion and future scope

5.1 Observations & Suggestions

It has now been established by the current study that NFC is the next big thing in the payment sector along with the existing technologies. Based on various comparisons done and cons discussed there are few ideas that can be implemented to make NFC more secure, so that we can easily adopt this technology in our lives:

- **NFC tag** can be attached to a wrist watch to make payments as one would not remove it and it always stays with the owner. It is better than mobile phone as hacker can easily use mobile phone but if he uses his watch he might get caught easily.
- **NFC tag** can also be put on rings. Now a days NFC tag size is decreasing and such small tags are available.
- **NFC** should be combined with other technologies to make it more secure like QR code authentication. It solely depends on the user.
- **NFC** can also use Wi-Fi authentication such as devices should be in same network which belongs to that closed group.

In my view the future will be such as follows:

- Travis wakes up in the morning and puts his NFC phone near tag placed on the bed. It enables Wi-Fi connection, puts back his mobile phone to normal from silent mode and starts up the music system with his favourite playlist of songs as it already knows that it is morning time.
- When he leaves home, he activates the tag which switches his home Wi-Fi network as well as switches off his music system.

- He enters his car using NFC phone as well as triggers GPS connection, opens map application on the phone, and starts his car playlist on the music system. Phone goes into dock mode and air conditioner adjusts itself according to the user.
- At the train station, he uses his phone to enter the turnstile. Inside he sees a smart poster regarding a concert in the evening. Gains all the information and pays using 3G by the link given by NFC tag. He receives all the ticketing details via SMS. In train, he heard someone's ringtone and asks for the same which is transferred to him within seconds implementing peer to peer network without need of setting up of Bluetooth connection.
- He enters office using his mobile phone as ID card implementing card emulation and phone goes into office mode.
- He buys his lunch using sodexo coupons stored in his phone.
- In meeting, all the members exchange their digital contact card using NFC technology.
- In the afternoon, he wanted to buy a wrist watch from an online store but there was a problem with network connectivity in his phone so he borrows NFC reader from his boss and connects it to his laptop via USB and authenticates the NFC phone to make the payment.
- In the evening after the concert, he goes to a restaurant with his wife, after that goes for shopping and uses his NFC phone for payments.
- Finally while coming back via train he lost his phone and thus immediately contacted the concerned authorities to disable NFC phone via over the air technology.

5.2   Conclusion

Along with this study, a demonstration of NFC technology was done using two NFC enabled mobile devices. Tags were programmed using applications available at google play store which were used to show how GPS, Wi-Fi, Bluetooth, playlist can be triggered. Further, peer to peer communication was established between two devices and data was transferred.

NFC technology will grow immensely as more and more merchants and customers are seduced by its power and flexibility. Merchants will be able to keep better track of their inventory and check out customers as they approach the register, or process items being purchased in mass.

Customers will benefit by faster checkouts, shorter and quicker lines, and the eventual elimination of needing to carry a wallet at all.

Although customers will benefit a great deal, merchants will be the biggest beneficiaries of this new technology. Initially there will be some cost in the implementation of NFC tags and NFC readers, but the benefits in their ability of tracking their merchandise, seeing payments instantly post to their accounts, being able to do a store scan from a single location, will reduce doing inventory to within seconds instead of days.

NFC will benefit everyone from the consumer to the merchant to the financial institutes. As long as security can keep pace with the hackers NFC will change the way everyone does business and in a very productive, profitable, and enjoyable way.

5.3   <u>Payment methods by 2025</u>

Future kinds of currency

The nature of cash will change. In 2025, many people will use PayPal, electronic vouchers, virtual currency such as BitCoin and others yet to enter the market. Although PayPal is used to facilitate transactions in other real currencies, there is no fundamental reason why it could not have been a currency in its own right, and PayPal could still develop one. These kinds of electronic payment need not depend in principle on other forms of currency.

Global electronic currency

Many people would prefer currency that is accepted globally, since it would avoid many of the expensive currency exchange costs currently present in travel. Corporations have advantages over governments here, both in geographic presence and trust, so we may well see a few corporate currencies, backed up by alliances of large companies rather than governments. These could work with existing payment mechanisms such as PayPal, or they could incorporate their own mechanisms and compete with PayPal.

Miniaturisation

Electronic devices will continue to shrink in size (except of course where they need to be large for some reason).Digital jewellery will emerge, and ultimately, this might even result in the disappearance of phones in the form we have them now. Many tiny pieces of jewellery such as lapel pins, rings, badges, necklaces, even ear or nose studs will carry out a wide range of electronic functions, so phones could be replaced by a range of jewellery with specific functions.

Fingerprint security enhancement

Fingerprints could safely be used as a simple biometric part of such a system, and if the added security is via electronics on the fingernails or a ring on the same finger, it would be totally unobtrusive. It would still be possible for a mugger to steal the ring and take a fingerprint but the use of one-time codes makes it easy to cancel it. Adding the accelerometer and the third security token of gesture recognition would make it.

- **By 2025**, most of the major battles will be over and people will be able to spend their money electronically anywhere without worrying about what kind of devices or whether there is a good signal there.
- **Even in 2025**, there will still be times where coins and notes will remain useful, so they will stay in common use too. The ongoing battles with fraudsters over security and among competing businesses and products for market share will ensure that it will take much longer than 2025 for electronic payments to approach full market penetration.

5.4   Payment methods by 2040

Technology won't stop developing in 2025, but it becomes more and more uncertain. As we start to use the skin as a platform and link into the nervous system, and even start to make direct links into the brain, whole new realms open up for payments. It may be possible to pay just by thinking the intent to pay, or snapping your fingers. Thought recognition is feasible, but this is an excellent example of the level of uncertainty in the far future. How reliable it will be, and how much we can learn to control our thoughts to make it useful remain to be seen. It is possible to read a PIN by thought recognition even in 2013. Security concerns could potentially wreck such

payment methods in the long term. Also in the further future, there is much more scope for radically new inventions to change the whole field. So, although 2025 is close enough that we already know most of the technologies that will have enough time to play out properly, that simply isn't the case for 2040 or beyond.

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