# Near Field Communication

## *Overview and Applications*

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***Abstract*** **- Near Field Communication (NFC) is a special category or a case of RFID (Radio Frequency Identification) Technology. The modern age NFC was introduced in 2004 and since 2014 after 10 years of invention it has picked popularity mainly because of cheap hardware, extensive use of smart phones and boom in Internet of Things technology. I have explained in this report about NFC and the implementation that I have done and at last some future work that can be done to extend the use of my application.**

***Index Terms*** **– NFC, RFID, Android.**

### I. INTRODUCTION

***NFC***

Near Field Communication (NFC) as its name suggests is a shorter range subset of RFID (Radio Frequency Identification) technology. It has gained popularity as the rising development in today's technical world. What this wireless communication technology offers is a low bandwidth with high frequency allowing data transfer in range of centimeters.

13.56 MHz is the frequency where NFC operates. It can provide speed up to 424 kbps. NFC tags communication and data exchanges are based on standards like ISO 14443 A, MIFARE and FeliCa. It provides high comfort level and ease of use as there are no further configuration steps required to initiate a session to share data. [1]

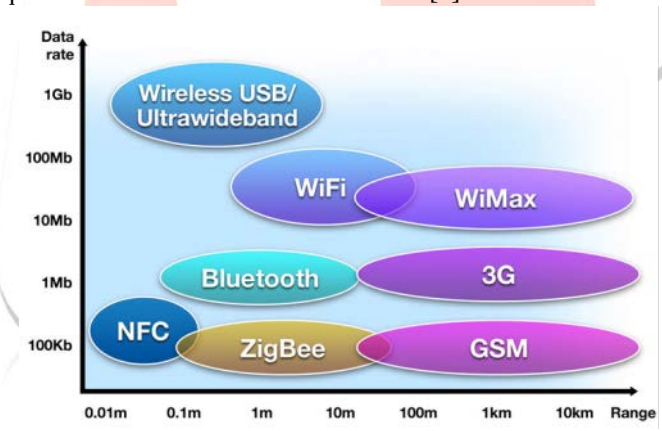



*Figure 1. Comparison of various wireless standards*

Reading from NFC tags is very easy as you just need to bring NFC tag closer to NFC reader and it will start reading from it without providing any connection details. Concept of inductive coupling is used in this architecture. It is also compatible with Bluetooth and Wi-Fi.

***RFID***

RFID emerged somewhere around in 1980s. Charles Walton invented an object using RFID in 1983. It basically enables a one-way wireless communication that is typically between two devices, i.e. a powerless RFID tag and a powered RFID reader. RFID reader which is enabled with battery supply is responsible for generating long-distance Radio frequency waves using which RFID tag will get induced and generates its own electricity based on the strength of electromagnetic field received. [1]

| RFID Frequency Band | Scan Distance |
|---|---|
| 120-150 kHz (Low Frequency, LF) | Up to 10 cm |
| 13.56 MHz (High Frequency, HF) | Up to 1 m |
| 433 MHz (Ultra High Frequency, UHF) | 1-100 m |
| 865-868 MHz & 902-928 MHz (Ultralight High Frequency, UHF) | 1-2 m |
| 2450-5800 MHz (Microwave) | 1-2 m |
| 3.1-10 GHz (Microwave) | Up to 200 m |

*Figure 2. Classification of RFID frequency band*

RFID can be scanned from a distance of 100 meters without being in line of sight and that's why it is being used everywhere for asset tracking such as in a warehouse or airport and wild animal movement tracker or livestock identification. As shown in the figure RFID is categorized in various frequency ranges from 120 kHz to 10 GHz spectrum.

NFC works at High Frequency RFID band that is 13.56 MHz the reason why this spectrum is accepted globally is because it is unlicensed and hence anyone can use it freely for transmitting and intercepting data.

***NFC vs. RFID***

RFID uniquely identifies using radio waves. NFC is a subset of RFID technology. NFC is a branch of High-Frequency RFID. Both RFID and NFC operate on 13.56 MHz frequency. NFC is designed to be a secure form of data exchange, and an NFC device is capable of being both an NFC reader and an NFC tag. This unique feature allows NFC devices to communicate peer-to-peer.

| | NFC | RFID | IRDA | BLUETOOTH |
|---|---|---|---|---|
| Set-up time | <0.1ms | <0.1ms | ~0.5s | ~6s |
| Range | Up to 10cm | Up to 3m | Up to 5m | Up to 30m |
| Usability | Human centric Easy,Intuitive ,fast | Item centric Easy | Data Centric Easy | Data Centric medium |
| Selectivity | High, given, security | Partly given | Line of sight | Who are you? |
| Use cases | Pay, get access,share,initiate service, easy set up | Item tracking | Control & exchange data | Network for data exchanga,headset |
| Consumer experience | Touch,wave,simply connect | Get information | Easy | Configuration needed |

*Figure 3. Comparison of NFC, RFID, Infrared and Bluetooth*

***NFC Forum***

It was launched in 2004 by leading companies in the field of semiconductors, communication and electronics as a non-profit organization. The forum educates market about NFC and promotes its usage. They build specifications, standards and maintain interoperability between devices and services. They have around 200 global partner companies who are working towards modular NFC device architecture and much more.

The NFC Forum's Sponsor members are: Intel, NXP Semiconductors, Qualcomm, Samsung, MasterCard Worldwide, NEC, Sony Corporation, Broadcom Corporation, Google Inc., STMicroelectronics, and Visa Inc.


*Figure 4. Sponsors of NFC Forum*

## II. NFC Operating Characteristics

As discussed earlier being a wireless communication technology it operates on short-range radio frequency. It is capable to form a peer-to-peer network for data communication. 13.56 MHz band is unlicensed in all the countries.

The technology works when NFC enabled devices brought within close proximity i.e. a small distance around 4 to 20 cm. It can provide transfer data rate of up to 424 Kbps. It also allows data transfer in the chunks of 106 Kbps and 212 Kbps. It can provide a bandwidth of approximately 2 MHz [2].

| Data Rate (Kbps) | Active Device | Passive Device |
|---|---|---|
| 106 | Modified Miller, 100%, ASK | Manchester, 10%, ASK |
| 212 | Manchester, 10%, ASK | Manchester, 10%, ASK |
| 424 | Manchester, 10%, ASK | Manchester, 10%, ASK |

*Figure 5. RF signal coding and data rates in NFC*

## III. NFC Standards

ISO (18092), ECMA (340) and ETSI are popular NFC standards. It supports smart cards like Mifare and Felica. NFC has two standards: NFCIP-1 and NFCIP-2. NFCIP-1 is defined in the ECMA-340 standard. This mode is intended for peer-to-peer data communication between devices which is divided into two variants: active and passive mode.

NFCIP-2 is specified in ECMA-352 which defines how to automatically select the correct operation mode when starting communications [3].

### Modes of Operations

***Active Mode***

NFC device operating in active mode generates its own carrier frequency, resulting its own RF field for transmission purpose. It is equipped with a power supply for operation. Active NFC device act as an initiator in communication. Two active NFC devices can alternatively generate RF field to form a two-way communication link to transfer data. NFC device operating in passive mode would not be able to generate its own carrier frequency.

***Passive Mode***

Passive device acts as a target. Initiator device produces RF field for communication and Target device use inductive coupling for responding them back. Target device modulates to initiator's RF field, for replying back to initiator. Target device uses power from initiator's generated RF electromagnetic field and saves energy. Resultant, Passive device can be provided a small battery for its operation to restrict energy sources consumption.

### Modes of Communications

***Peer-to-peer***

Peer-to-Peer mode is defined for device to device link-level communication. This mode is not supported by the Contactless Communication API. Peer-to-peer mode is a simple or classic mode of NFC operation. It allows data transfer at a rate of up to 424Kbps. It works on NFCIP-1 protocol, whose protocol's detail and electromagnetic properties are standardized in ISO 18092 and ECMA 320/340.

***Reader-writer***

Read/Write mode allows applications for the transmission of NFC Forum-defined messages. This mode is not secure and supported by the Contactless Communication API. NFC device can also operate as Reader/Writer for tags and smart cards. In Reader/Writer mode, NFC active device act as an initiator and passive tag act as target. This mode allows data transfer rate of 106 Kbps.

***Card emulation***

NFC Card Emulation mode allows the NFC-handset behave as a standard smartcard. This mode is secure and is supported by the Contactless Communication API. In emulation mode, NFC device emulates ISO 14443 smart card chip. These smart chips are integrated in mobile devices and get connected to NFC module for communication to occur.

## IV. NFC APPLICATIONS

Now-a-days most of the high range smart phone provides NFC chips. This has created an unprecedented interest for application developers to take advantage of it and make it useful in many domains. Some of the most popular ones are ecommerce and security. Peer to peer transfer has also found its usages. Some of the applications are as listed below:

- Mobile Payments (m-payments)
- Credit Cards Replacement
- Advertising
- Educational purpose
- Electronic Ticketing
- Visiting Cards
- Parking Lots
- Key less Entry
- Device Pairing

***eShakti cards in Bihar***


*Figure 6. Smartcards in Bihar*

***Janmarg (BRTS) cards in Ahmedabad***


*Figure 7. Janmarg Travel Card*

***Security Applications***

In cases where authentication is needed for physical access such as starting a vehicle or to enter a room or turn on a machine it can be useful.

***Google Wallet***

1. Unlock / Wake up phone. No need to start application.
2. Hold the back of your phone against the payment terminal.
3. If asked for a PIN on the terminal or your phone use Wallet PIN.

4. The terminal might ash or beep to show your payment was made.

## V. IMPLEMENTATION

I made an android application using Xamarin framework which converts C# code to native APIs. This application can read and write from NFC tags. Though there are many applications available on play store to read and write data but they are not open source. I made another lightweight apk file which simply checks whether the phone has NFC hardware or not which was made in eclipse and that is coded in Java.

The idea was to read and write tag and then process that read data to perform some operation like opening the door, turning on any appliance or just manipulating data with web service.

I have also made use of android apps available on play store to read and write data to NFC tags which supports variety of tags from different manufacturers and can write variety of data to perform many different applications. Following section represents the screenshots of those applications.

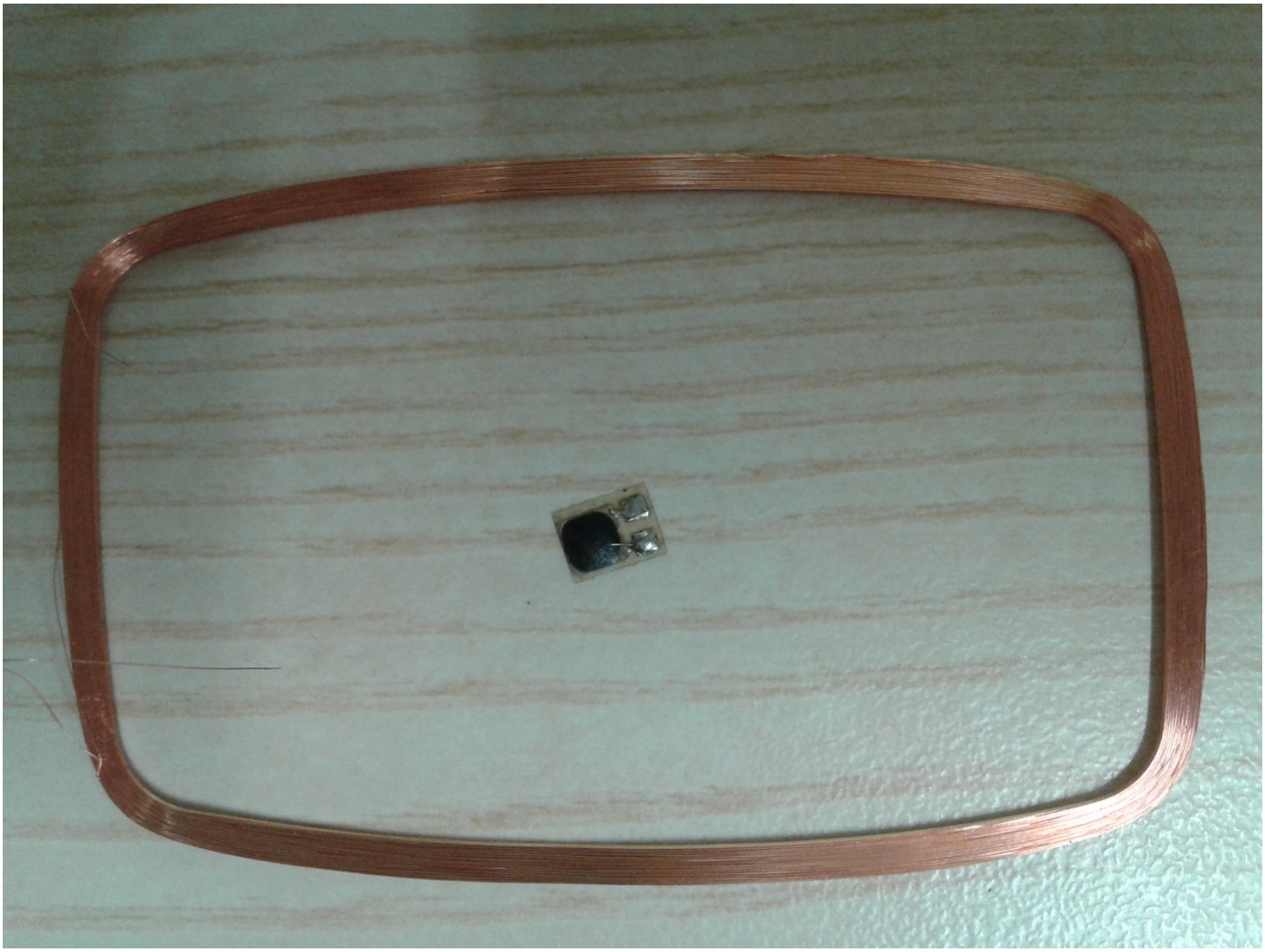


*Figure 8. Inside RFID Tag*

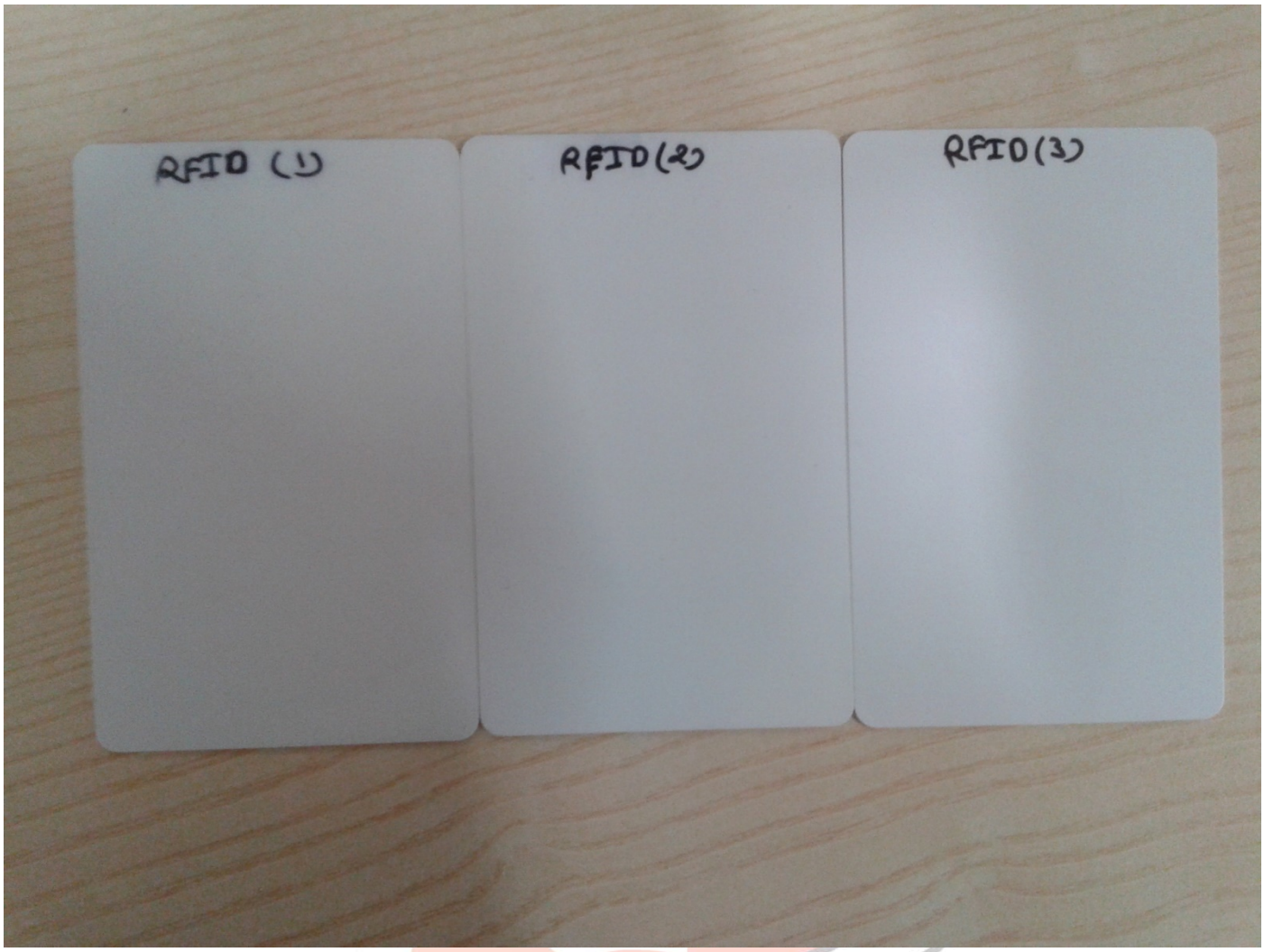



*Figure 9. RFID Tags Used by Me*

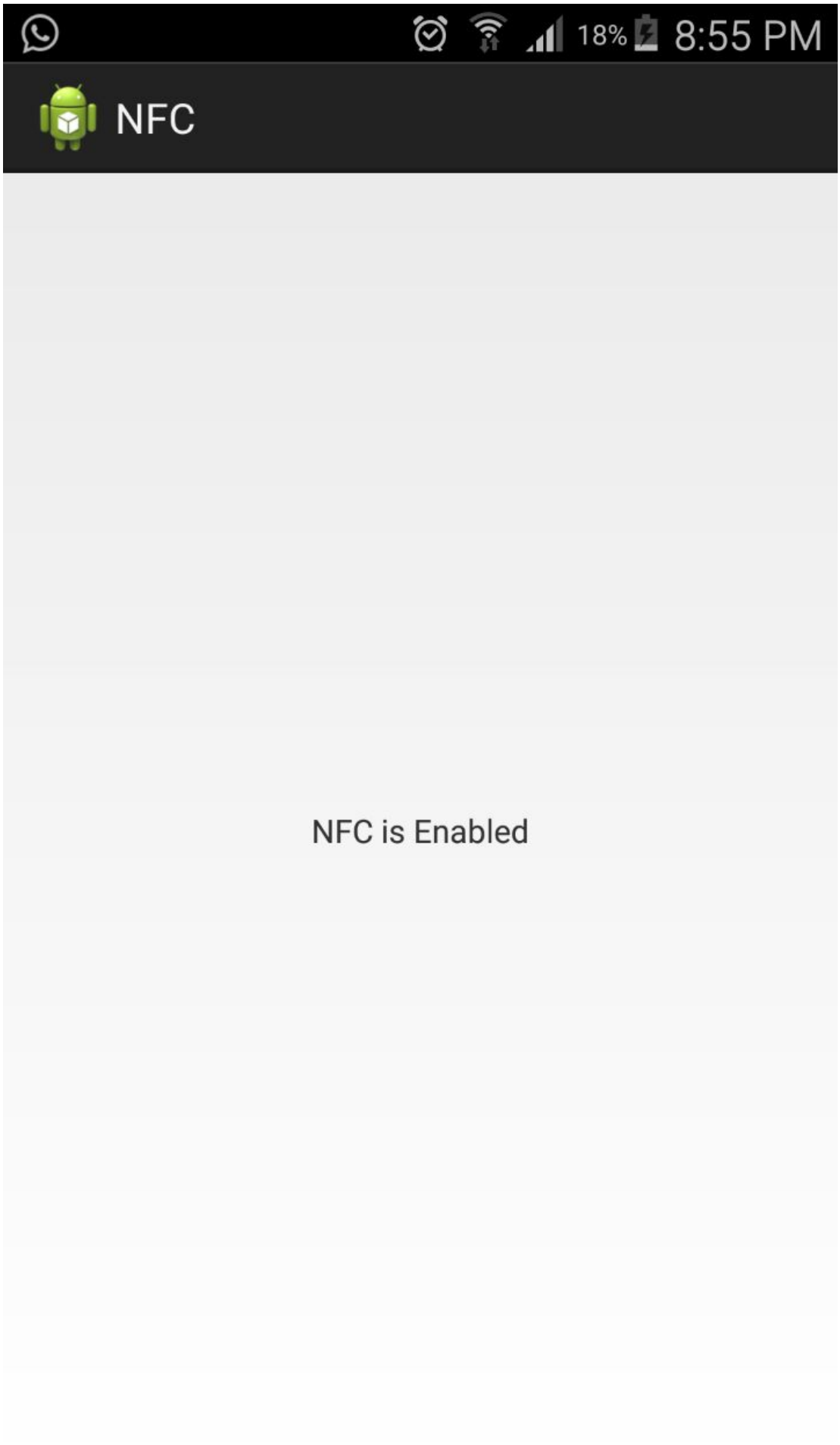
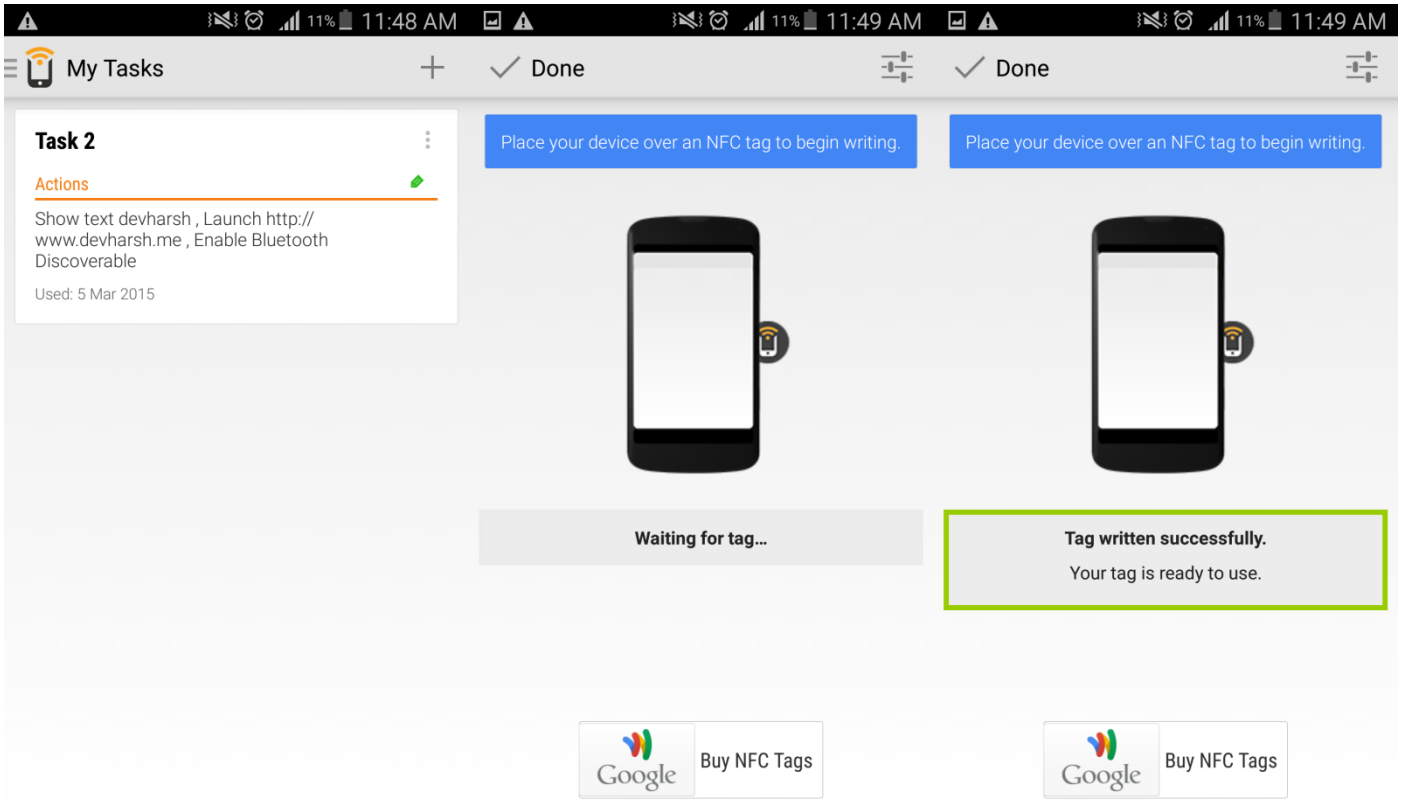

18%
8:55 PM
NFC
NFC is Enabled

*Figure 10. Application to check whether NFC is supported*



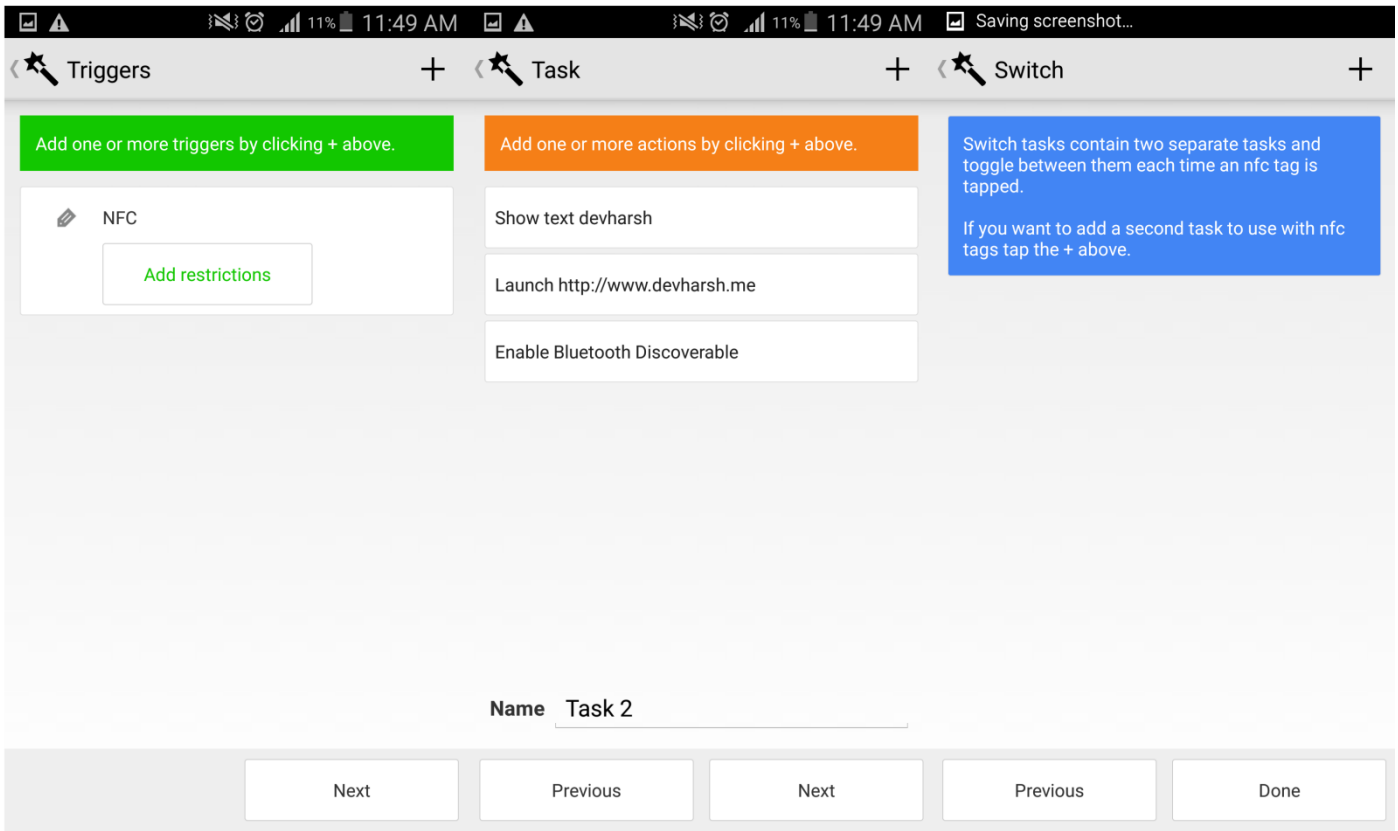




*Figure 11. Triggers application is used here to write three actions:*

*1) Display text "devharsh"*

*2) Enable Bluetooth*

*3) Open website [www.devharsh.me](http://www.devharsh.me)*

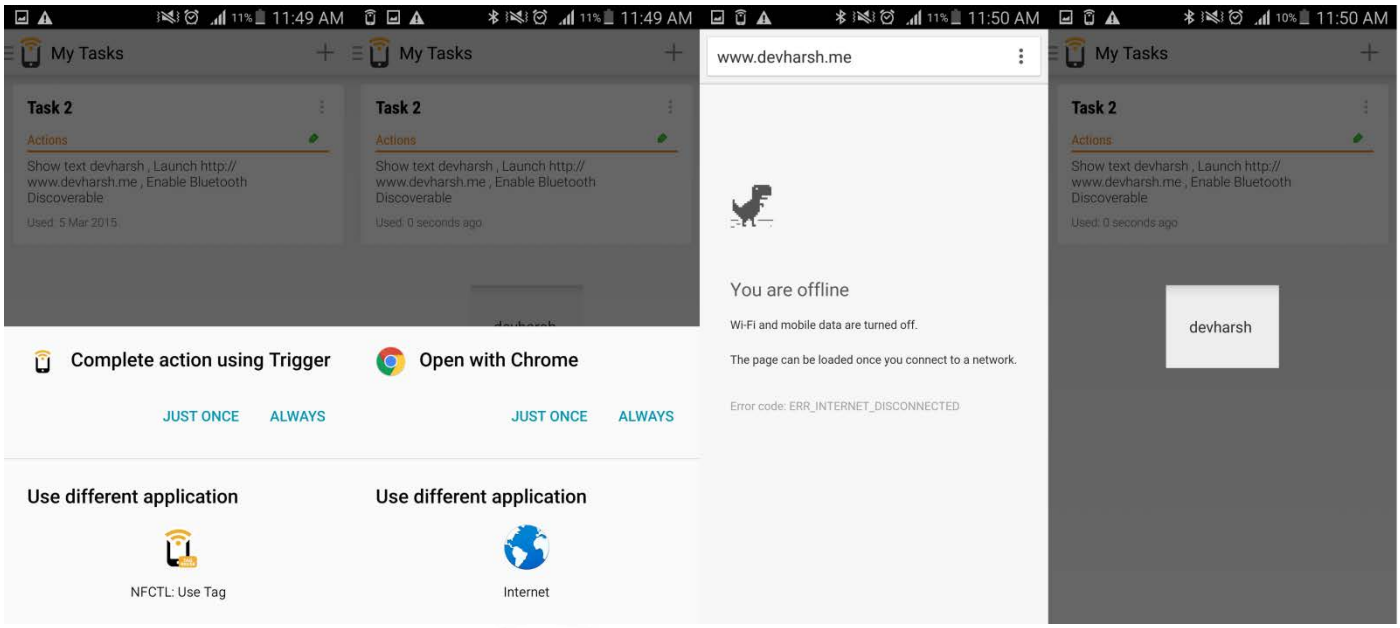



*Figure 12. 'Triggers' application to launch actions by reading tags*

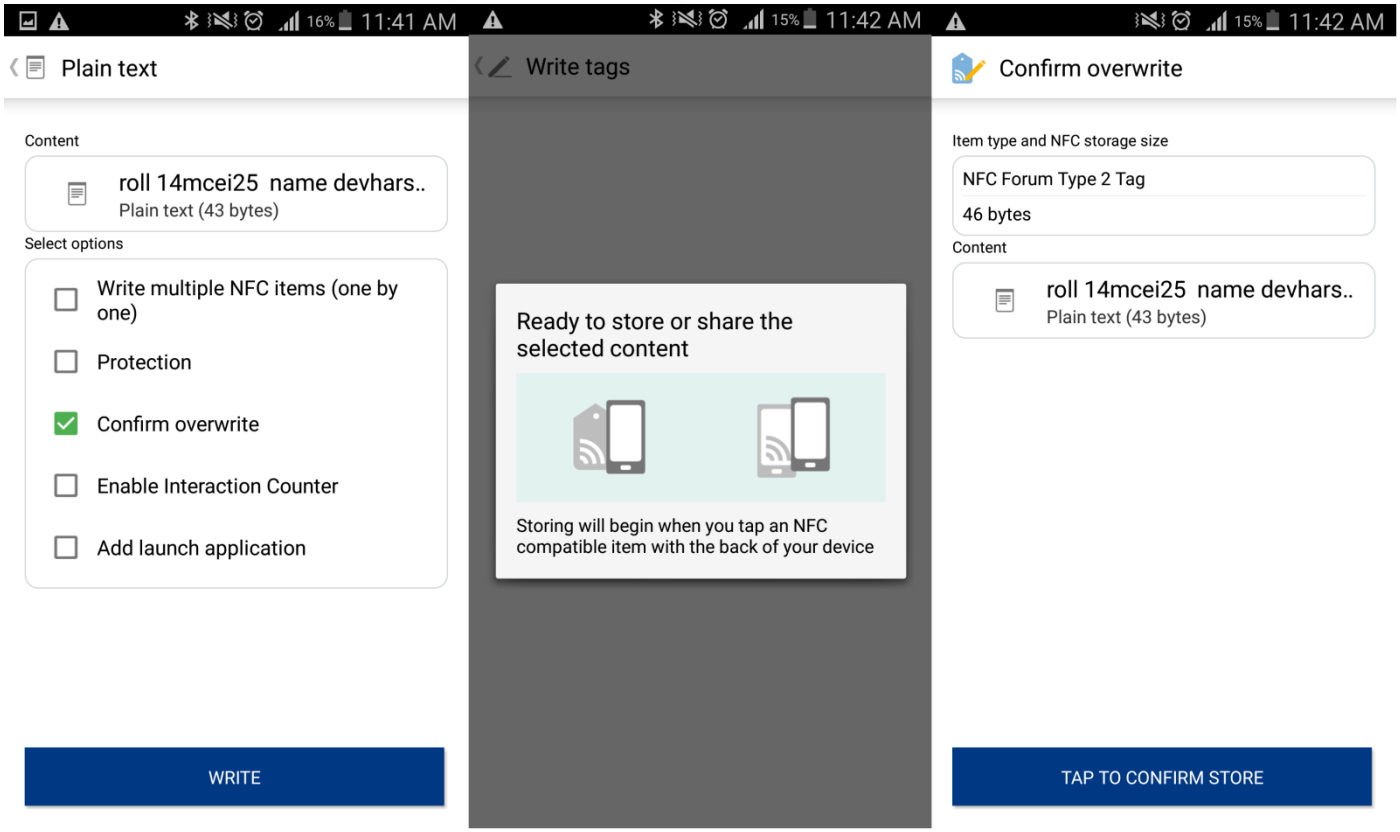



*Figure 13. 'TagWriter' by NXP is used to write text data*

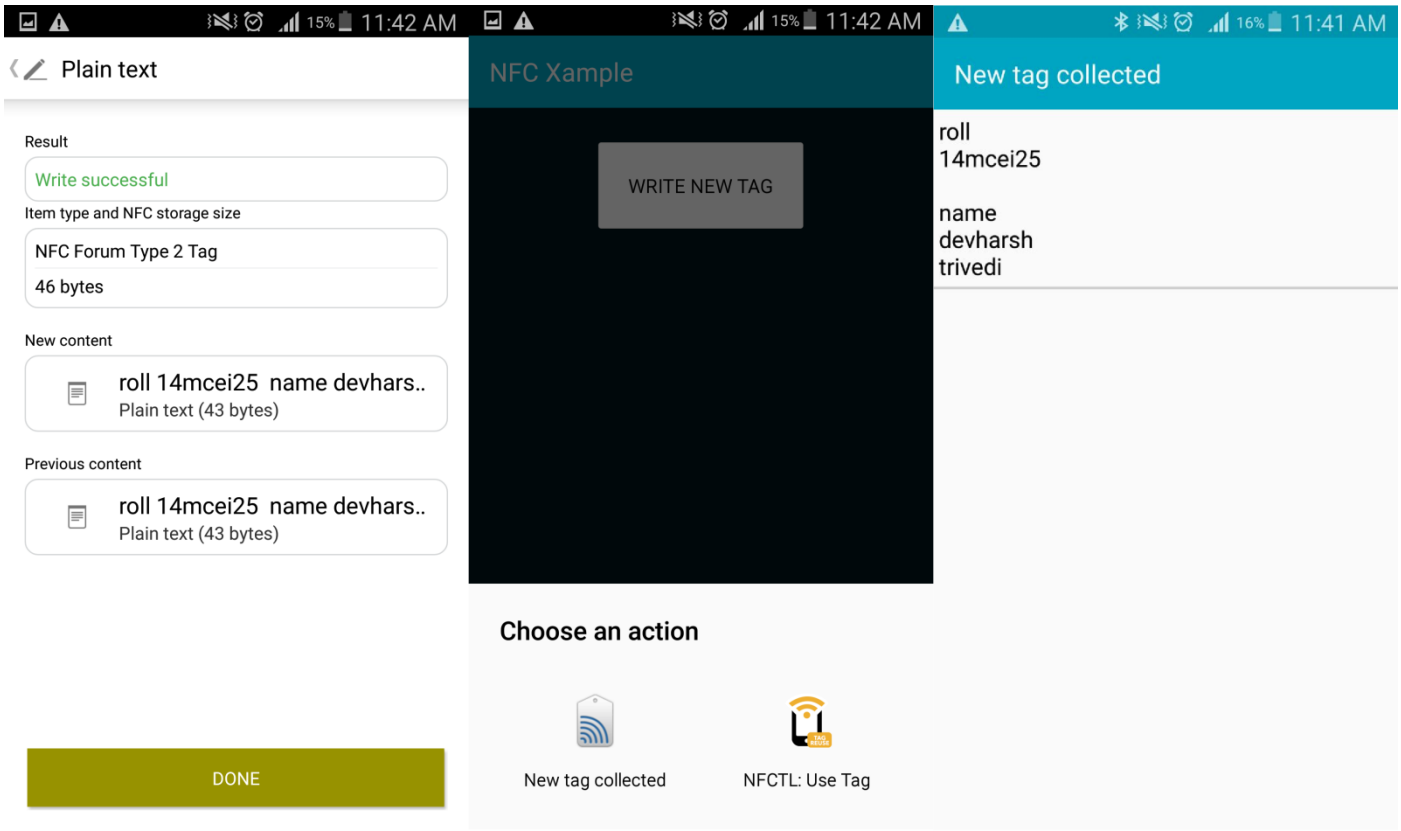



*Figure 14. Application designed by me to read and display data from tags*

## VI. Security Threats and Solutions

***Eavesdropping***

It is a wireless communication interface so eavesdropping is a big issue. A secure channel must be established. Diffie-Hellman can be used for key exchange to generate a symmetric key which further can be used with AES or 3DES encryption. [4]

***Data corruption***

Instead of eavesdropping an attacker may disturb the transmitted data. This can be detected by checking RF field as the power needed for corrupting data is higher than detected by NFC.

***Data modification***

It is different from data corruption as in this case attacker wants receiver to get the malicious data. It can be prevented by regularly checking RF field by active sending device or a secure channel should be used.

***Data insertion***

Attacker sends his own data along with the data transmitted by both parties. The best solution is to minimize the delay. The attacker cannot be faster than the active device in this case. A secure channel can also be used as remedy.

***Man-in-the-middle attack***

Attacker can easily implement this attack by generating his own electromagnetic field to induce the receiver. Practically this attack is not possible but it is good habit by sender to listen to RF field before sending data to check for any disturbance present in the channel.

## VII. Conclusion

NFC is a short range version of RFID which makes it immune to few attacks by default. It is highly interoperable with existing technologies and cheaper hardware has made its use more popular. Many applications are being used for payment and physical access. NFC does not provide protection against threats itself so encryption should always be used.

## VIII. Acknowledgment

I would like to thank Dr Sharada Valiveti for guiding me to explore NFC to produce some working application which I have done at some extent. I would also like to thank Prof Vipul Chudasama for letting me use Akash Tablet provided by IIT Bombay and Mr Paras Jain for allocating RFID tags when I needed. At last I would like to thank my classmate Ms. Nidhi Trivedi (14MCEI27) for providing me her NFC enabled Samsung android smart phone to test the application.

**REFERENCES**

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