Near Field Communication

Its Applications and Implementation in K.S.A.

BY:
Mohammad Umair Yaqub – Undergraduate (Senior)
Umair Ahmad Shaikh – Undergraduate (Senior)

Advisor: Dr. Mohamed Mohandes

Date: 13th February 2012
Abstract

Near Field Communication Technology (NFC) is a form of very short range contactless communication for distances up to 4 cm (theoretically 20 cm). NFC is the descendant or an evolved form of Radio Frequency Identification (RFID). Although technically its working principal is based on RFID, it is more similar to Bluetooth in applications since it allows communication between active devices. Currently, it has applications mostly in the field of contactless electronic payment. In this report, we briefly discussed the history of NFC and its theory of operation. We described some of the applications in brief detail and gave examples of how they have been implemented in other technologically advanced countries. We then proceeded on to offer suggestions how NFC can be used to enhance services in Saudi Arabia. Our case study was based on a small scale system; one that involves providing university campus services (with K.F.U.P.M. as the subject). The services we worked on include Automated Attendance, e-Wallet, Access Control, and NFC based Smart Posters. Furthermore, we discussed the feasibility and analyzed the implementation of these NFC systems in the Kingdom. We also analyzed the scope for a mobile payment system in the Kingdom of Saudi Arabia. Finally, we suggested how ideas from our NFC based campus services, the previous Hajj services project by Dr. Mohandes, and the proposed mobile payment system can all be combined for large scale implementation in KSA.
Near Field Communication:
Its Applications and Implementation in K.S.A.

Table of Contents
1. Introduction ........................................................................................................... 1
   1.1. What is NFC? ................................................................................................. 1
   1.2. History of NFC ............................................................................................. 1
   1.3. Background .................................................................................................. 2
   1.4. Theory of Operation ..................................................................................... 3
   1.5. Communication Specifications ....................................................................... 4
   1.6. Applications .................................................................................................. 4
2. Objective ............................................................................................................... 6
3. University Services using a NFC System ............................................................. 7
   3.1. Methodology .................................................................................................. 7
   3.2. Discussion ..................................................................................................... 13
      3.2.1. Feasibility ............................................................................................... 13
      3.2.2. Advantages ............................................................................................. 13
      3.2.3. Disadvantages and How to Overcome Them .......................................... 15
      3.2.4. Future Direction .................................................................................... 16
   3.3. Results and Testing ....................................................................................... 17
4. Conclusion ............................................................................................................. 18
Acknowledgment ...................................................................................................... 18
References ............................................................................................................... 19
1. Introduction

1.1. What is NFC?

Near Field Communication or NFC is an emerging technology for electronic devices which allows them to communicate with each other by simply touching or bringing them very close to each other. This act of communication is called ‘to tap and go’ or ‘tap-in’. Using NFC, communication could take place between two active devices such as cell phones or even between a NFC device and a passive (or unpowered) ‘tag’. Currently, NFC has applications mostly in the field of contactless electronic payment. Examples include Electronic Point of Sales (EPOS) terminals at shopping centers and ticketing systems in public transport such as buses and trains. 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 or Wi-Max. [1]

1.2. History of NFC

NFC is a descendant or an evolved form of Radio Frequency Identification (RFID). Before studying NFC, certain features and specifications of RFID must be studied. RFID involves tracking or identifying objects by a ‘reader’ through information stored on electronic ‘tags’ using special RFID software called middleware. For communication, RFID technology uses frequencies in the radio range of the Electromagnetic (EM) spectrum; which are in the range of 3 kHz – 300 GHz. RFID can trace its roots back to World War II where a Russian inventor developed a covert audio spying device for the Soviet army in 1945. However, it wasn’t until 1970’s that the first true RFID device was invented which was a radio transponder with memory. From 1973 and onwards, real competition developed for research in the field of RFID. The term RFID was first used in a patent that was awarded to Charles Walton in 1983 for a “Portable radio frequency emitting identifier”. From then on, many applications have been found for RFID. [2] [3]
The work on NFC was started by Phillips and Sony in 2002 and they complemented it by developing the first NFC forum along with Nokia. Since then, the NFC forum has more than 150 members and research is being conducted by many companies and academic organizations in this field. NFC can also be called the 2nd generation or ‘2G’ RFID. A lot of NFC-enabled phones now exist in the market and many applications have been or are being developed. [4]

1.3. Background

Although NFC based applications run in a similar manner to Bluetooth on mobile devices, the working principal behind Near Field Communication is based on RFID, . Therefore it is essential to study the basics of RFID before discussing the technical details of Near Field Communication. As mentioned earlier, RFID system contains 3 essential parts which are the reader, tag, and middleware. We will briefly describe how these components work in sync.

The RFID reader is also called an interrogator or an initiator. It is a device that continuously propagates Radio Frequency (RF) signals and waits for a tag to response. Readers can be stationary (fixed RFID) or moving (mobile RFID). Tags, also called transponders, are just basically 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 can be stored in any small device or object according to their applications easily due to their small size. A good example is tags stores on rental cars or criminals for tracking purposes. They can also 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 is allowed to pass through whereas student
cards are rejected. This depends on the frequency, modulation, encryption, etc. and this decision is made by a form of middleware installed on the reader. [5]

1.4. Theory of Operation

NFC tags are designed just like an RFID tag to be used at 13.56 MHz and therefore the tag design is similar. At this frequency range, RFID tags mostly use the theory of Strongly Coupled Magnetic Resonance. This is basically where 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. Please note that this phenomenon is valid only for loop antennae that are placed very near to each other.

In this type of system, the antennae can be represented by inductors where for a passive device the energy is provided by the magnetic field of the reader. From EM and transformers, we know that two coupled coils can be replaced by an equivalent transformer circuit as shown in Figure 1a. This circuit and the whole electronic system in Figure 1b can be analyzed to design the parameters which will provide coupled resonance at 13.56 Mhz. [7][8]

![Figure 1 a) Antenna circuit and its equivalent](image1)
![Figure 1 b) A full NFC/RFID system at 13.56 MHZ](image2)
1.5. Communication Specifications

As mentioned before, NFC can be considered a special case of RFID. It operates at a frequency of 13.56 MHz, which is one of the unlicensed frequencies. Unlicensed frequencies are commonly used in medical application or industrial applications concerned with personal devices such as Bluetooth, wireless devices and micro-wave ovens (2.45 GHz). The allocated Bandwidth in the 13.56 MHz band is 14 kHz so the communication has to be in the range 13.553 – 13.567 MHz. However, in NFC the envelope of the spectrum may spread up to 1.8 MHz using ASK modulation. [6]

In NFC, there are two communication modes and three supported data rates and coding/modulation schemes used. In passive mode, the initiator sends an RF signal and the target device uses the power generated by the propagated EM field. On the other hand, in active mode, both devices have their own power supply and use it to alternately generate their own RF field for communication. The three supported data rates are 106, 212 and 424 Kbit/s (maximum) which is much lower to the Bluetooth V2.1 data rate of 2.1 Mbit/s. Almost all configurations use Manchester with 10% ASK except for active devices operating at 106 Kbit/s. The coding and modulation schemes are summarized in the following table:

<table>
<thead>
<tr>
<th>kbit/s</th>
<th>Active Device</th>
<th>Passive device</th>
</tr>
</thead>
<tbody>
<tr>
<td>424</td>
<td>Manchester, 10% ASK</td>
<td>Manchester, 10% ASK</td>
</tr>
<tr>
<td>212</td>
<td>Manchester, 10% ASK</td>
<td>Manchester, 10% ASK</td>
</tr>
<tr>
<td>106</td>
<td>Modified Miller, 100% ASK</td>
<td>Manchester, 10% ASK</td>
</tr>
</tbody>
</table>

*Table 1: Frequency versus Voltage at sensitivity of 25% and 60% [1]*

1.6. Applications

NFC can be used to improve existing RFID and Bluetooth applications/devices and it can be used for applications which were not possible using previous technologies. We can divide the applications into two categories: identification and information exchange. Identification includes authorization and authentication such as in contactless credit/debit payment systems, keyless entry (e.g. hotel suite doors),
security clearance or authorized access (e.g. garages, rooms, labs, etc.), medical tags, e-passports, and similar technologies. Data transfer or ‘beaming’ applications include game download, device configurations such as routers, handing out or taking contact information for mobile phones, social networks, business cards, etc., and many other similar ones. [9][10]

For identification, there are quite a few countries which have implemented such systems or are in the process of doing so. For payment systems the best example is Google developing a special version of its Google Wallet to be used in the 2012 London Olympics. Another application is ticketing systems for public transport. Recent examples include the German city Frankfurt where the regional transit authority has merged its ‘tap-in’ payment system with the national railway operator to allow commuters to access travel information and schedules. In South Africa, a joint venture between Aconite and Procama has overseen the implementation of a transit (train) payment system using NFC-enabled phone.[11][12] In the medical field, NFC can be used not only to ID patients, but their diagnosis can be instantly filed by a doctor on a remote storage location. This is done by using existing RFID tags placed on hospital bracelets only for identification purposes. Such a system was successfully implemented in Pakistan recently to treat and monitor infants diagnosed with pneumonia.

There are also many systems in place for data transfer. The first example involves advertisement posters in Sydney University campus by Unilever to promote their
Lipton Ice Tea product by allowing users to ‘like’ it via Facebook and offering other services like coupons.[14] In application download there are further examples. For example, in Singapore their second largest transit operator SMRT Corporation is launching NFC-enabled media hubs through their iMobSmrt product. They have implemented this service in some of their most high-traffic stations. Many services such as news, music, travel guides and maps as well as bookings are possible.[15] In Denmark, a joint venture between NFC Danmark and Nokia sees the launch of smart posters that allow instant download of Nokia apps and games.[16] In the social networking arena, Japanese site MIXI allows users to share wide variety of information about any object containing NFC tag. Book information can be shared by just waving the phone like barcode and there is a check-in feature like Facebook places where NFC tags are stationed at various points in a city to allow users to ‘check-in’ by tapping their phones.[17]

Figure 3: Demonstration of the above given examples

2. Objective

Until now, we have discussed the various ways in which Near Field Communication is already being used all over the world. From this point onwards, the focus of the report will shift towards the Kingdom of Saudi Arabia, how NFC systems can be implemented here and whether they will be feasible. The best place to start such an implementation would be in the universities of the Kingdom. The simple justification for this choice is that universities usually form a major portion of the most technologically advanced areas in a country. Since we are K.F.U.P.M. students,
we will be focusing on our university. The objectives to be accomplished in this project are as follow:

- Do a literary survey on the technology of Near Field Communications, its theory, its specifications, and its applications. This has already been done in the previous section of Introduction.
- Propose and design a NFC based university system. This system would incorporate the following services:
  - Student/Faculty/Staff identification
  - Security Access to Buildings, Class Rooms & Labs
  - Automated class attendance
  - University e-wallet for various provided services

3. University Services using a NFC System

This section is the main part of our report. It describes a complete NFC system in detail which can be implemented in the Kingdoms’ many universities. For this project, we shall take our own university, King Fahd University of Petroleum & Minerals (K.F.U.P.M.) as the subject.

3.1. Methodology

The student/faculty/staff members will be equipped with a NFC enabled smartphone. The mobile application development will be done using the Google Android platform. Google is a major backer of Near Field Communication technology and as such has provided many flexible APIs (Application Programming Interface) which will aid us in this. Google provides an Android Software Development Kit which combined with the popular Java based eclipse IDE (Integrated Development Environment) and the Android Development Tool (ADT) plugin will help us greatly in the development of the software. Another web-based system will also have to be developed to oversee and monitor this system. This would be the system used by the
administrators and instructors to check student activities etc. Students would also be given access to this system so they can check their semester progress or check their e-Wallet balances. [18]

```java
void resolveIntent(Intent intent) {
    // Parse the intent
    String action = intent.getAction();
    if (NfcAdapter.ACTION_TAG_DISCOVERED.equals(action)) {
        // When a tag is discovered we send it to the service to be save. We
        // include a pendingIntent for the service to call back onto. This
        // will cause this activity to be restarted with onNewIntent(). At
        // that time we read it from the database and view it.
        Parcelable[] rawMags = intent.getParcelableArrayExtra(NfcAdapter.EXTRA_NDEF_MESSAGES);
        NdefMessage[] msgs;
        if (rawMags != null) {
            msgs = new NdefMessage[rawMags.length];
            for (int i = 0; i < rawMags.length; i++) {
                msgs[i] = (NdefMessage) rawMags[i];
            }
        } else {
            // Unknown tag type
            byte[] empty = new byte[0];
            NdefRecord record = new NdefRecord(NdefRecord.TNF_UNKNOWN, empty, empty, empty);
            NdefMessage msg = new NdefMessage(new NdefRecord[] { record });
            msgs = new NdefMessage[] { msg };
        }
    // Setup the views
    setTitle(R.string.title_scanned_tag);
    buildTagViews(msgs);
    }
    else {
        Log.e(TAG, "Unknown intent "+ intent);
        finish();
        return;
    }
}
```

Figure 4: Sample code of reading a NFC tag [19]

As we mentioned in the objective, this proposed NFC system would assist in automated attendance, as an identification and security clearance device and as an e-wallet. Now we will tackle each of these areas separately.
The key to the academic success of a university is punctuality of the classes. The taking of the attendance wastes around 5-10 minutes of important teaching time. This proposed system has the potential to replace all the manual attendances still taken in classes and eliminate this waste.
For this part of the system, the instructor would simply take his NFC enabled phone or an RFID reader and place it in an accessible place for students in the class. As the students enter the class, they would use their NFC enabled phones, passing it close to the instructor’s and thus recording their attendance. In case the student does not possess an NFC-enabled phone, the existing ID cards based on MIFARE contactless smart card technology used here in K.F.U.P.M. can be upgraded to make it compatible with NFC. Later, after the class, the instructor simply uploads the data to the web server. NFC smart tags could also be placed in classrooms to check the attendance. The web-server monitors the attendance of each student. This also allows students to easily view where their absences stand. [18]
Another important part of this proposed system is the university e-wallet. This e-wallet would be able to pay for food, stationary, printing, and other university services. This system would have a NFC reader installed in their computer or other Point of Sale system. The cashier would simply calculate the cost and key it into the system. The student or other university personnel would simply bring out their NFC phone and hold it close to the reader. A pin code would be required known only to the holder of the e-Wallet. As a confirmation, a SMS receipt would be received by the consumer. Other university services could be automated in a similar manner. In fact, a partial electronic payment system already exists for printing services which can be updated to incorporate NFC. This preexisting system could easily be used as the basis for the new e-wallet database.[18]

Another interesting idea is the aforementioned identification and security clearance system. All universities in the kingdom have a database system to manage the faculty, staff, and students. Linking this database to the world-wide-web will
allow this data to be accessed everywhere and anytime. Along with certain authentication using a user id and a pin, the person may access his id details. This information would also be transmitted through Near Field Communication. In places such as the library, the user would simply bring his phone close to authenticate his ID and issue books or other library items. In places such as lab and offices, the professor of staff personnel may use his NFC-enabled phone with the NFC reader that would have to be placed outside every class to authenticate and enter the room, laboratory or office. Similar functionality could be added to other offices such as the security department or at the main university where identification is often a problem.

The only feature not discussed yet in this section is NFC’s ability to ‘beam’ data. Smart tags can be installed in various places in the university which preprogrammed data which students or other NFC users may download by bringing their NFC device close. The main use of this is Smart Posters. In a university, there are hundreds of different events happening all over the campus. Most of these events use poster placed upon various bulletin boards across the various buildings to advertise themselves. With smart posters, these flyers can be embedded with a small NFC smart tag. People passing by may use their phones to download the poster and other event information directly to their devices. Currently, in King Fahd University of Petroleum and Minerals, QR codes are used. These QR codes are similar to barcodes and usually contain a web link. The main advantage of using NFC smart tags over QR codes is that the information is transmitted and received then and there. This downloading process usually requires, a data connection with an expensive data plan in the mobile device which not every mobile user possesses. There is no need to access the information and separately download it in case a Wi-Fi connection is not available,
3.2. Discussion

3.2.1. Feasibility

So far, we have introduced NFC technology, illustrated applications, discussed its potential in the Kingdom and given an example of an NFC system which can provide campus services in a typical Saudi university (KFUPM). Now, we will focus our attention on why NFC is the way forward with regards to proximity communication technologies. NFC enabled phones are already readily available in the Kingdom. Research in Motion, a major backer of NFC and also creators of the highly popular BlackBerry Smartphone have included NFC in all their new phones. Furthermore, it is expected that in 2014 30% of all mobiles will be NFC enabled.[20] This combined with the large number of BlackBerry users in the Kingdom provide positive signs for the feasibility of services based on NFC in Saudi Arabia.

We will discuss the advantages of NFC compared to other existing technologies such as Bluetooth and RFID (Infra-Red will not be discussed in detail because it is obsolete; however it is listed in table of comparison) and the reasons it can prove to be more successful. Finally, we will also mention the drawbacks and competition faced by NFC and how they can be overcome.

3.2.2. Advantages

One of the main advantages NFC has over Bluetooth is that it is compatible with existing RFID technologies. As mentioned earlier, a significant percentage of Saudi population is expected to own NFC enabled phones by the time most NFC systems will be ready for large scale implementation. However, this does not include all of the population so the integration of NFC systems would be smoother if the current and previous systems are compatible. For example, KFUPM access control uses contactless smart cards (MiFare Classic) which can be integrated with an NFC based system. Another advantage is less setup time because in Bluetooth you have to search for, pair a device, and select a ‘dummy’ security code; all of these steps are redundant in an NFC system.
We have repeatedly mentioned that NFC is derived from RFID. Despite this fact, there is an extremely important benefit: NFC can be used for transferring information between two active devices which have memory. Consider the e-poster system; if an RFID transponder was used to read the tag, it will not be useful to the interested parties. However, when an active device such as a mobile phone is used the information can be read and stored for future reference. In addition, NFC is a very directive form of communication due to its extremely short range. For example, if we use existing RFID for payment, the reader may detect the tags carried by 2 or more people standing in the queue which can lead to errors. On the other hand, this situation is highly unlikely using NFC due to the short distance.

Below is the table comparing NFC and other technologies:

<table>
<thead>
<tr>
<th></th>
<th>NFC</th>
<th>RFID</th>
<th>IrDa</th>
<th>Bluetooth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set-up time</td>
<td>&lt;0.1ms</td>
<td>&lt;0.1ms</td>
<td>~0.5s</td>
<td>~6 sec</td>
</tr>
<tr>
<td>Range</td>
<td>Up to 10cm</td>
<td>Up to 3m</td>
<td>Up to 5m</td>
<td>Up to 30m</td>
</tr>
<tr>
<td>Usability</td>
<td>Human centric</td>
<td>Item centric</td>
<td>Data centric</td>
<td>Data centric</td>
</tr>
<tr>
<td></td>
<td>Easy, intuitive, fast</td>
<td>Easy</td>
<td>Easy</td>
<td>Medium</td>
</tr>
<tr>
<td>Selectivity</td>
<td>High, given,</td>
<td>Partly given</td>
<td>Line of sight</td>
<td>Who are you?</td>
</tr>
<tr>
<td></td>
<td>security</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use cases</td>
<td>Pay, get access, share, initiate service, easy set up</td>
<td>Item tracking</td>
<td>Control &amp; exchange data</td>
<td>Network for data exchange, headset</td>
</tr>
<tr>
<td>Consumer experience</td>
<td>Touch, wave, simply connect</td>
<td>Get information</td>
<td>Easy</td>
<td>Configuration needed</td>
</tr>
</tbody>
</table>

Table 2: Comparison between NFC and other technologies [21]

Above all, the main advantage of NFC over both RFID and Bluetooth is better security, at least in the physical layer of the network. The fields for RFID and Bluetooth are generated over a wider area than NFC so it makes them more susceptible to interference and jamming. More importantly, this increases the immunity of NFC to interception which could be lethal to certain applications such as payments. Furthermore, due to the short distance communication occurs so quickly
that it becomes very hard for hackers. For any sort of attack, the exact time of data transfer needs to be predicted which is practically impossible. The table above summarizes the differences between the technologies (including Infrared) and it is clear that NFC holds the edge.

### 3.2.3. Disadvantages and How to Overcome Them

Although we have explained how NFC has inherent security, attacks are still possible and threats possible. Interference (similar to denial of service) and interception (man-in-the-middle) can be countered simply by encryption. Another type is called spoofing where a hacker alters the programming of a tag on say a poster. This is a problem because if the poster links to a URL, attackers can program tags to direct to their website which may contain harmful content or steal vulnerable information stored on the phone’s NFC tag. This attacked can be easily countered by tags containing digital signatures which cannot be spoofed. Another issue is privacy where people say NFC tags can be used for tracking but this is rare because the tag is in operation only when a certain application is being used. Moreover, encryption at the application layer deals with this problem.[22][23]

There are other issues related to the implementation of NFC systems. First of all it faces competition; Bluetooth Low Energy can perform all the applications described above at a faster rate. The advantage NFC holds over it is its lack of compatibility with previous RFID technologies and the headache of setup required. Another challenge like all new products or service, NFC has to convince it is safe and effective way of identification, access control and data beaming. Last but not least, there is the problem of walk-out which is a technical word for losing your mobile phone. The only way to counter is that there should be a security code or password to open the NFC App which is not required in Bluetooth applications.
3.2.4. Future Direction

The example provided for an NFC system implementation is only with regards to a university campus. This choice was made because it is the most suitable place to start. However, university and the education sector only make a small percentage of the commercial world of K.S.A. The long-term aim is to provide services for the whole kingdom of Saudi Arabia. An excellent start to this is the Hajj Pilgrim Tracking and Identification system created by Dr. Mohammed Mohandes from the Electrical Engineering Department in K.F.U.P.M. This designed system allows the pilgrim to identify him or herself at checkpoints, shop using the e-Wallet, and download guidance maps from particular access points.[20] Looking into the future, this Hajj system and our University system could be combined and expanded to build a nationwide identification, tracking and other government services’ system. This system could combine all government IDs including Driving Licenses, Vehicle Registrations, National IDs, and Insurance Papers into one simple to use application for the mobile.

Another good example is the Electronic Point of Sales terminals (EPOS) where customers pay using NFC phones. This system consists of two major parts. The first is NFC enabled payment terminals (PayPass terminals) provided by the banks and the other part is towards the consumer or customer. The best example of this is the Google Wallet application written for NFC equipped Android phones. Google Wallet is a mobile payment system developed by Google that allows its users to store credit cards, loyalty cards, and gift cards among other things, as well as redeeming sales promotions on their mobile phone. Payments can be made fast and convenient by simply tapping the phone on any PayPass-enabled terminal at checkout. Google
doesn't charge users or merchants for access to Wallet, and makes money by offering sponsored ads to their users. [24]

Implementation of this technology would be relatively simple in the Kingdom of Saudi Arabia. As in other countries, POS terminals are provided by the banks themselves in conjuncture with MasterCard and Visa. In return, the bank charges a small monthly fee for each terminal and 2% of whatever is paid using their machine. Banks in the kingdom have usually proven to be slow on the acceptance of newer technologies. Contactless smart-card payments still haven’t shown up in the market. Even though most consumers already have the new smart-card ATM/Debit/Credit cards, the POS machines have yet to show up in the market. For the complete nationwide implementation of a NFC capable payment system, the first step would be for banks to offer the new machines at competitive rates to the old ones.

### 3.3. Results and Testing

This project is currently in an early testing phase being overseen by Dr. Mohandes. Currently, the testing is being done behind closed doors. Testing of each module will be done separately. In later stages, small batches of students will be given access to the system to see how it performs in real-life. Early results show great promise for this university campus services system. A demo of some of the developed services will be given during the presentation session.
4. Conclusion

Overall, we described Near Field Communication technology as a very short range wireless communication. We mentioned that it is an evolved form of RFID but its applications are run similar to Bluetooth. In that context, we briefly discussed the history and background which included the basic working principles of RFID. We then proceeded to discuss in details the theory of operation, standards and some of the specifications involving modulation schemes and coding.

Then we listed many applications where NFC can be utilized and gave examples of other countries that have implemented such systems. Finally, we arrived at the major part of the report which was to investigate how these systems can be implemented in KSA and justify their presence.

Firstly, as a case study we considered a university as a good place to start the implementation of NFC based services. Since we are KFUPM students we chose our university as the subject. We described how an attendance and e-payment system can be implemented using modules provided by Dr. Mohandes. We also gave a sample code of reading an NFC tag. Then we proposed 2 new features which are e-posters and access control using an NFC enabled mobile device. After that, we discussed the feasibility of NFC in Saudi Arabia and in general. Due to the expected widespread availability of NFC phones in the kingdom, we can safely believe the application will prove to be a success. As for NFC, we saw how it offers more benefits than drawbacks compared to existing technologies. At the end, we suggested how in the future NFC can be used in the Kingdom to improve the customers’ shopping and pilgrims’ Hajj experiences and all systems implemented on nationwide scale.

Acknowledgment

We would like to thank Dr. Mohandes for the valuable help and material he provided us without which we would not have been able to complete this report.
References

[7] C. Patanier¹, H. Witschnig¹, D. Rinner², A. Maier¹, E. Merlin¹, E. Leitgeb² “High Speed RFID/NFC at the Frequency of 13.56 MHz”, 1.NXP Semiconductors 2.Institute of Broadband Communications, Graz University of Technology 3.Fachhochschule Technikum Karnten
[13] Adam Marcus*, ***Guido Davidzon,Denise Law*, Namrata Verma*, Rich Fletcher*, ***Aamir Khan, Luis Sarmenta*, “Using NFC-enabled Mobile Phones for PublicHealth in Developing Countries”, *Massachusetts Institute of Technology, **Massachusetts General Hospital Laboratory of Computer Science, ***Interactive Research and Development, Karachi, Pakistan
[23] Paranjape, J. (n.d.). Mobile contactless payments security using “nfc - near field communication” technology. University of Southern California,