

# An RFID-Based Pilgrim Identification System

Mohammed Mohandes, Maan Kousa, Ahmed A Hussain

**Abstract** — *Every year Muslims from all over the world gather in the Holy city of Makkah in the Kingdom of Saudi Arabia for pilgrimage called the Hajj. With the increased number of pilgrims every year (over 2.5 million pilgrims performed the Hajj in January 2006), the problems and difficulties facing the pilgrims and the Hajj authorities have also been on the rise – especially in crowd control and the prevention of accidents. A significant number of pilgrims die due to both accidents and natural causes, and a large number get lost in this extremely crowded gathering. The authorities are faced with the problem of identifying the dead and injured pilgrims and as well as helping those who get lost during the Hajj.*

*In this paper, we present a solution based on RFID technology to help the Hajj authorities in the identification of pilgrims as well as in crowd control. We have developed a prototype Pilgrim Identification System that employs a wristband RFID tag, an RFID reader and Graphical User Interface application running on a PC. A wristband RFID tag worn by a pilgrim that stores pilgrim data can be used for identification, as a Hajj permit, to access medical history during an emergency, and as e-purse.*

**Index Terms**—RFID, transponder, Hajj, crowd control

## I. INTRODUCTION

RFID is an electronic tagging technology that allows an object, place, or person to be automatically identified at a distance without a direct line-of-sight, using an electromagnetic charge/response exchange. Typical applications include labeling products for rapid checkout at a point-of-sale terminal, inventory tracking, animal tagging, timing marathon runners, secure automobile keys, and access control for secure facilities [1].

In the last few years RFID systems have experienced a surge of deployment (due to the drop in cost). Inventory tracking is now necessary on an unprecedented scale to support growing consumer markets at low operating costs and to remain price competitive despite the relatively high labor cost in the developed countries. Furthermore, the components

used to build the tags and tag readers have become more sophisticated as currently, they provide greater functionality, longer reading range, and higher speed of data transfer. As a result, a number of influential organizations such as Wal-Mart, GE, U.S. Department of Immigration, and the U.S. Department of Defense, recognize the capabilities of RFID to improve operational efficiencies [2]. Since tags would most often be attached to large number of inventory items, the tags need to be inexpensive. Some analysts say a tag must cost less than 5 cents for the technology to be truly competitive. Currently, RFID tags are in the 50-cent range, which can be reduced significantly for very large quantities. Further drop of the cost of RFID tags provides the ultimate incentive for deployment of the technology.

RFID tag technology is the natural successor of barcode tags. The benefits of RFID tags, compared to barcode, are:

- Ability to read and write multiple RFID tags at once using anti-collision technique
- No line of sight required during the read or write processes
- Can be read through various materials allowing the label to be embedded inside the product
- Ability to update and rewrite information to the label over 100,000 times
- Endures harsh industrial environment (dirt, heat, cold, moisture)
- Fast data transmission between the tags and readers
- Inbuilt encryption offering unparalleled security
- Reusable in many applications
- Can have extended capacity to hold enough information about an individual. Thus, does not need life communication network for its operation. This is particularly important during Hajj season as these networks are already overloaded.
- Can be embedded in a convenient form like wrist working watch, thus gets necessary acceptance and buying-in from the public.

Hajj (Pilgrimage) is undoubtedly the most crowded gathering of Muslims on earth. It has unique characteristics with regard to the people who attend it (pilgrims), the place they meet in, and the kind of rituals they perform. These characteristics result in a set of challenges to the authorities and organization departments in controlling the crowd, and identifying the personalities. The authors believe that RFID

This work was supported in part by the King Fahd University of Petroleum & Minerals.

Mohammed Mohandes is with the Department of Electrical Engineering, KFUPM, Dhahran, KSA, 31261 (phone: +966-3860-4709; fax: +966-3860-3535; e-mail: mohandes@kfupm.edu.sa).

Maan Kousa and Ahmed A Hussain are also with the Department of Electrical Engineering, KFUPM, Dhahran, KSA, 31261 (e-mail: [makousa@kfupm.edu.sa](mailto:makousa@kfupm.edu.sa), [ahussain@kfupm.edu.sa](mailto:ahussain@kfupm.edu.sa))

can be an ideal solution for crowd control and personal identification at Hajj season. This work suggests some ideas on how this technology can be applied, and presents a pilot project in this context.

This paper is organized as follows. In section 2 we present RFID Technology and Architecture. Section 3 highlights the main characteristics of Hajj season and the challenges they pose. In Section 4 we introduce the proposed solution. We wrap up in Section 5 with main conclusions.

## II. RFID TECHNOLOGY

### A. Architecture

An RFID System consists of the following three components as shown in Fig. 1:

- RFID tag or transponder
- RFID reader or transceiver with a scanning antenna
- Data processing subsystem

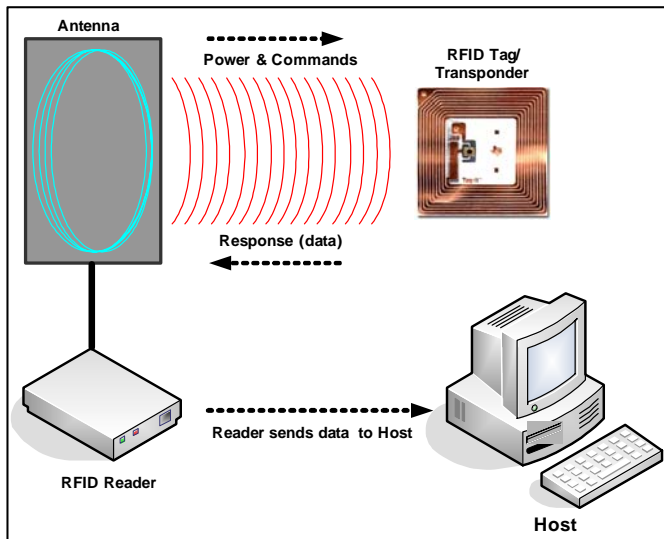


Fig. 1. A Typical RFID System

An RFID reader consists of an antenna, transceiver and decoder, which sends periodic signals to inquire about any tag in vicinity. On receiving any signal from a tag it passes on that information to the data processor that may be part of the reader itself. The data processing subsystem provides the means of processing and storing the data.

The scanning antenna puts radio-frequency signals in a relatively short range. The RF radiation does two things; it provides a means of communicating with the transponder tag (the RFID chip) and (in the case of passive RFID tags) it provides it with the energy to communicate. This is an absolutely key part of the technology; RFID tags do not need to contain batteries, and can therefore be made simple, cheap and remain usable for very long periods of time. The scanning antennas can be permanently affixed to a surface; handheld antennas are also available.

### B. Types of RFID Systems

Operating frequency is the determining factor for the type of application an RFID system is best suited for. These frequencies include high frequency (850-950 MHz and 2.4-5 GHz), intermediate frequency (10-15 MHz) and low frequency (100-500 kHz).

- **High-frequency** RFID systems are suitable for applications requiring a longer read range such as supply chain, inventory, assembly lines, toll-collection systems and railroad car and container tracking.
- **Intermediate-frequency** RFID systems are just now beginning to emerge in the financial transaction processing areas of smart card use.
- **Low-frequency** systems have short reading ranges and lower system costs. They are most commonly used in security access, asset tracking, and animal identification applications.

As you move up in frequency, tag and reader costs move up as well. Tags at 125 kHz operating frequency have ICs costing tens of cents as compared to 2.4 GHz tag ICs costing several dollars.

### C. RFID Tags

An RFID tag is composed of an antenna, a wireless transducer and an encapsulating material as shown in Fig. 2 [5]. These tags can be either active or passive. While the active tags have on-chip power, passive tags use the power induced by the magnetic field of the RFID reader. Thus, passive tags are cheaper but with lower range (<10m) and more sensitive to regulatory and environmental constraints, as compared to active tags.

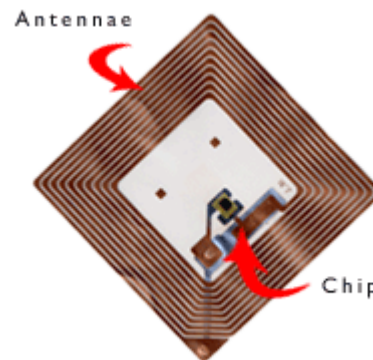


Fig. 2. Components of an RFID tag (Source: Texas Instruments)

The vast majority of RFID tags or transponders use a silicon microchip to store a unique serial number and usually some additional information

Passive RFID tags do not have a transmitter; they simply reflect back energy (radio waves) coming from the reader antenna. Passive RFID tags do not require batteries, and can be much smaller and have a virtually unlimited life span.

Active tags have their own transmitter and power source, usually—but not always—a battery (active tags could draw energy from the sun or other sources). They broadcast a signal to transmit the information stored on the microchip.

Wristband tags for human identification and access control as shown in Fig. 3 have been used in this project.



Fig. 3. Wristband RFID tags

#### D. Applications of RFID

Applications fall into two principal categories: firstly, short range applications where the reader and tag must be in close proximity (such as in access control) and secondly, medium to long range applications, where the distance may be greater (such as reading across a distribution centre dock door). A sample of applications is shown below:

- Security, ticketing and access control
- Supply Chain Logistics & Retail
- Asset Tracking and Traceability
- Lifetime item identification
- Medical applications
- Animal and specimen identification
- Airline baggage handling
- Vehicle access control.

### III. HAJJ: THE ANNUAL ISLAMIC PILGRIMAGE

#### A. Introduction

Every year Muslims from all over the world gather in the Holy city of Makkah in the Kingdom of Saudi Arabia for pilgrimage called the Hajj. The Hajj is obligatory on all adult Muslims at least once in their lifetime if they can afford it. It brings several million Muslims from all over the world speaking hundreds of different languages and belonging to different countries and cultures. More than 2.5 million pilgrims performed the Hajj in 2006.

The following observations are unique to the Hajj gathering:

#### Crowd

Muslims are obliged to perform Hajj once in their lifetime. Many of them love to perform it more than once. It is performed on specific days of the year (8<sup>th</sup>- 13<sup>th</sup> of the 12<sup>th</sup> Hijri month) in designated boundaries (Makkah, Mina, Muzdalifa and Arafat). The whole crowd makes the same

movements at same time doing essentially the same thing.

The authorities for Hajj try their best to limit the crowd flooding to the area by assigning quotas for pilgrims from other countries, and limiting the visits of people within the country to one every five years. Yet the number of pilgrims is in the range 2-2.5 millions.

#### Large Number of Elderly Pilgrims

Many Muslims decide to perform Hajj when they are old. Moreover, many countries, in attempting to adhere to the quota, give preference to the elderly. Added to the crowd and exhaustion they face, a significant number of them are exposed to falling sick or even losing their lives.

#### Language Barrier

Pilgrims in Hajj season are, literally, coming from all countries on earth, with no exception. They speak different languages. It is a serious issue when it comes to helping the lost or treating the patients.

#### Dress Code

The uniform of the pilgrim consists of two pieces of garments, one is rolled around the lower part of the body and the other is put on the shoulder. There are no pockets to carry the belongings. Although pilgrims are allowed to put on a belt with small pockets, most of them do not prefer to carry valuable documents because of concerns to lose them in the crowd.

As a result of the above issues, the authorities face tough challenges every year, in spite of their continuous efforts to ease them. These challenges are explained in the following sections.

#### B. Problems during the Hajj

While it is a great spiritual experience for all the pilgrims, at the same time it poses great challenges of all sorts for the authorities responsible for facilitating the Hajj. Despite all that is done to facilitate the Hajj, the following are some of the common problems faced by the pilgrims and the authorities alike due to the issues listed above:

- Identification of pilgrims (dead or injured)
- Medical Emergencies
- Guiding lost pilgrims to their camps.
- Loss of identity documents
- Crowd control



Fig. 4. Pilgrims in Makkah during Hajj

#### ***Identification of pilgrims (dead or injured)***

Due to the crowd, age factor and sometimes unfortunate accidents, the death toll in Hajj season is on the high side. Many of the dead are on their own, carrying no documents. Every year at the end of Hajj season, authority are confronted with tens of bodies of pilgrims that are never identified or claimed. This problem is not easy to solve as it is not known when and if any of these bodies will be claimed in the future. Moreover, it puts a moral obligation on Hajj authorities to identify and inform the families of these pilgrims of the sad demise of their loved ones. Pilgrims are considered as guests of the Kingdom until their safe return home.

#### ***Knowing the medical record of patients***

Tens of thousand of pilgrims are brought to hospitals and clinics for emergency treatment. Doctors always complain that would they knew the medical record of the patient they would be more efficient in treatment and utilization of the limited resources available during this period. Unfortunately, this is never the case. Even worse, due to the language barrier they may not be able to do basic investigations with the patient to

find any information that may help them in the diagnosis.

#### ***Guiding Lost Pilgrims to their camps***

Large numbers of pilgrims report on the hour to Help Kiosks to help them find their camps. It is not always easy to find a speaker of the lost pilgrim's native language. Without papers showing their location and contact numbers, and sometimes without a common language to communicate, it becomes almost impossible to help them.

This puts a tremendous pressure on the security officers who are taking care of pilgrims.

#### ***Loss of Important Documents***

With the special cloth of Ihram, it is highly likely that the pilgrim may lose some of his identification papers, like Passport, Residence Permit, and national ID in addition to money or credit cards. With lost passports the return of pilgrims to their home countries is delayed which imposes additional burden not only on the pilgrims but also on the authorities.

#### ***Crowd Control***

Crowd control has become a major problem with many pilgrims dying in accidents and stampedes in congested places during the Hajj, especially, in Mina. These accidents happen due to insufficient planning and management of available space as well as due to crowd behavior. The authorities have recently experimented with techniques to control the flow of the crowd to the most congested area of Al-Jamarat. The authors are currently conducting some research on using RFID for this purpose, as well as controlling access of vehicles to the Hajj zones.

## IV. RFID SOLUTION

### ***A. Introduction***

RFID offers an effective, convenient and economical solution to the Hajj problems described above. A wristband RFID tag that can be worn at all times can be provided to each pilgrim. This tag when presented to an RFID reader the information stored in the tag can be retrieved and displayed on a handheld portable unit. The following is some of the information that can be stored in a tag:

- Personal details - like name, address, blood type, nationality, etc.
- Medical condition
- Contact information of the pilgrim's Hajj group
- E-purse that can be loaded with optional amount of money

### ***B. How it Works***

RFID may help in crowd control by allowing the authorities to estimate the number of people at specific locations where there is a risk of accidents taking place. Combined with the efforts of the security personnel it may be possible to ease the flow of pilgrims at key points resulting in proper utilization of space. RFID readers can be installed at key entry and exit points to ping wristband RFID tags and thus get fairly

accurate estimate of people passing those points. This will help the security personnel in controlling the entry of pilgrims in high risk areas.

The utilization of the wristband can allow the pilgrims to leave their IDs on safe places like hotels safe deposit boxes. Moreover, if an ID is lost, it is possible to retrieve the information needed to produce a replacement of the lost ID with the presence of wristband tag. Information stored in the tag on the medical condition of the pilgrim can be very useful in case of a medical emergency. Having access to the medical condition of the patient in the emergency room from the tag he holds on his wrist may help save the life of the patient and improve efficiency of the medical team. The tags will also help in guiding the pilgrims who get lost - besides helping in the immediate identification of pilgrims who die during Hajj.

With the new rules that each local or external pilgrim should obtain a permission to perform Hajj, the permission certificate can be the wristband itself. The presence of the tag can be detected at a distance and does not require visual reading by the security officers. For example, the officer can read tags from a distance and find out if all passengers of a car have permission to perform Hajj. This is because RFID tags do not require line of sight or contact with the reader for the information to be transferred. This would increase efficiency and deter violators in a way to achieve the objectives of Hajj authorities to control the number of pilgrims every year and make it easier for authorized pilgrims to perform their once in life time Hajj.

Some types of RFID wristbands can't be unlocked once fixed and requires cutting the band. This will guarantee that the wristband will not get lost or disposed. There is a possibility to collect the wristbands upon finishing Hajj activities. The collected RFID tags could be re-programmed and installed in new wristbands to be used for upcoming Hajj seasons.

The wristband tag can be a real working watch; this should remove the fear and sensitivity of pilgrims and their reluctance to wear such tags. Other paper wristbands did not find the full cooperation from pilgrims in the past.

## V. PROTOTYPE RFID PILGRIM IDENTIFICATION SYSTEM

### A. Introduction

We have developed a prototype Pilgrim Identification system to demonstrate the advantages of using RFID technology during the Hajj. It has a Graphical User Interface that communicates with an RFID system that consists of an RFID reader and a set of RFID wristband tags. The reader is used to read a unique ID number (UID) stored in the wristband tag which is then sent to the PC. The system is shown in Fig. 5.

The user interface program which has been developed using Visual Basic 6.0 reads the pilgrim's tag UID from the reader. The reader is connected to the PC using an RS232 cable (via the serial the port). Upon receiving the UID, the Visual Basic application decodes the UID and then performs a search

operation in its local database for a matching UID. Once a match is found, the pilgrim's data is displayed on the computer screen. Pilgrim data is stored in a local database which is accessed by the Visual Basic application.

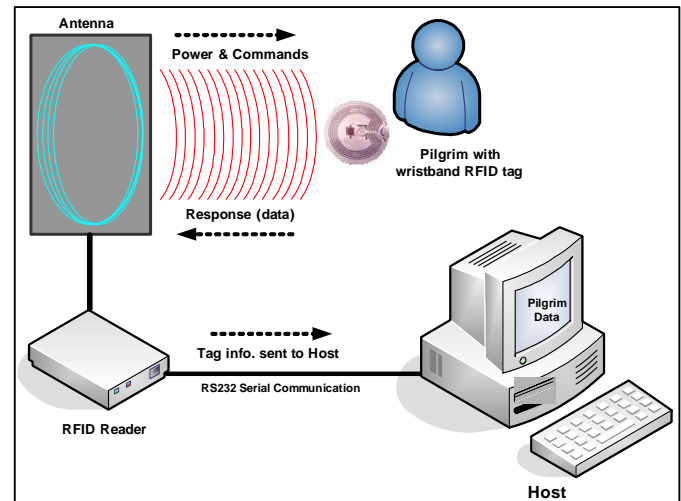


Fig. 5. RFID Pilgrim Identification System

In the practical application, the pilgrim data will be written (encoded) into the RFID tag itself instead of accessing it from a database. This allows instant access to pilgrim's information by reading it directly from the tag without the need to connect to a network or for portable handheld readers to carry the database of several million pilgrims.

### B. Description of System Interface

This section describes the user interface that has been developed using Visual Basic. Screen-shots of various forms are also shown.

#### *Login Form*

The user is first presented with a "Login" form which ensures that only authorized users can access the system. The Login form is shown in Fig. 6a below:

Fig. 6a. PIS Login Form

In this form, the program asks the user to enter his user name and password. There are two types of users: normal users and administrator users. The normal users have limited access to the program. They can read tags and search, open database and access settings menu. On the other hand, the administrator users have full access to the program. They can add, edit and delete data. They can also add new system users.

#### **Main Menu Form**

An authorized user is presented with the Main Menu which has different options for running the system. The Main Menu form is shown in Fig. 6b below:

Fig. 6b. Main Menu Form

This form allows the users to access different features in the program. For normal user, he can access the User Menu and

can select Read Tag, Search and Open Database options. He can also access Settings Menu to select Serial Port number and to change his password.

On the other hand, the administrator user has all features of normal user with some additional features. He can add new data, edit and delete data and add or remove new users. There is also logout option to close the program and go back to the login form.

#### **Read & Search Form**

This form allows for searching and displaying pilgrim data. It can be opened from the User Menu. It is shown in Fig. 7 below.

Fig. 7. PIS Read and Search form

In this form, the user has two ways to find the information of a pilgrim. He can use the search option and can search either by the name of a pilgrim or by the passport number. Also, he can use read tag option. This option will allow the program to read the tag number from the RFID Reader and immediately search for this tag. The user can also print the form by using the print button provided on the form.

#### **Add New Data Form**

This form is used to add pilgrim data to the database. It is only accessible to a user with administrative privileges. It is shown below in Fig. 8 below.

There are other forms in the User Interface which have not been shown here. These forms deal with maintenance operations (Edit, Delete) that can be performed on the pilgrim data as well as user who access the system. These forms are only available to the administrator. There is also a Change Password form.

**Add New Data**

**Read Tag**  
Tag No. #E00780E561879226

**Personal Information**  
Name   
Passport No.   
Birthday  /  /   
Nationality  Language   
Social status  Sex  Blood   
Medical Cond

**Home Address**  
Country  City   
P.O. Box  Postal   
Phone No.

**Address in Makkah**  
Hamla Name   
Address

**Emergency Phone**  
Phone No.   
Fax No.

**Picture**  
  
Picture Link

Fig. 8. PIS Add New Data form

## VI. CONCLUSION

Hajj season poses many challenges for the authorities. The main challenges have been introduced in this work based on official reports, interviews with key officers and the authors' personal experience. Using advanced technologies is very promising in tackling these challenges. In this work we have demonstrated the use of RFID technology to ease some of these challenges.

## ACKNOWLEDGMENT

This work has been conducted under KFUPM Funded Project xxx. The authors are grateful to KFUPM for the support.

## REFERENCES

- [1] Klaus Finkenzeller, RFID Handbook, Radio-Frequency Identification Fundamentals and Applications, Wiley, 1999.
- [2] [http://www.rfidgazette.org/2004/07/japanese\\_childr.html](http://www.rfidgazette.org/2004/07/japanese_childr.html)
- [3] [http://www.rfidgazette.org/2004/04/denmarks\\_legola.html](http://www.rfidgazette.org/2004/04/denmarks_legola.html)
- [4] Applied Digital Inc. <http://www.adxs.com/index.html>
- [5] Texas Instrument's Tag-it Transponders <http://www.ti.com/rfid/docs/products/transponders/transponders.shtml>
- [6] Texas Instrument's Tag-it Transponders <http://www.verichipcorp.com/content/solutions/verichip>
- [7] John R. Tuttle, "Traditional and Emerging Technologies and Applications in the Radio Frequency Identification (RFID) Industry", 1997 IEEE Radio Frequency Integrated Circuits Symposium

**First A. Author** (M'76–SM'81–F'87) and the other authors may include biographies at the end of regular papers. Biographies are often not included in conference-related papers. This author became a Member (M) of IEEE in 1976, a Senior Member (SM) in 1981, and a Fellow (F) in 1987. The first paragraph may contain a place and/or date of birth (list place, then date). Next, the author's educational background is listed. The degrees should be listed with type of degree in what field, which institution, city, state or country, and year degree was earned. The author's major field of study should be lower-cased.

The second paragraph uses the pronoun of the person (he or she) and not the author's last name. It lists military and work experience, including summer and fellowship jobs. Job titles are capitalized. The current job must have a location; previous positions may be listed without one. Information concerning previous publications may be included. Try not to list more than three books or published articles. The format for listing publishers of a book within the biography is: title of book (city, state: publisher name, year) similar to a reference. Current and previous research interests ends the paragraph.

The third paragraph begins with the author's title and last name (e.g., Dr. Smith, Prof. Jones, Mr. Kajor, Ms. Hunter). List any memberships in professional societies other than the IEEE. Finally, list any awards and work for IEEE committees and publications. If a photograph is provided, the biography will be indented around it. The photograph is placed at the top left of the biography. Personal hobbies will be deleted from the biography.