RFID Technology and Crowded Event Management

Mohammad Yamin, Masoud Mohammadian, Xu Huang, Dharmendra Sharma
Faculty of Information Sciences and Engineering, University of Canberra ACT 2601 Australia
Mohammad.yamin@canberra.edu.au, Masoud.mohammadian@canberra.edu.au
Xu.Huang@canberra.edu.auDharmendra.Sharma@canberra.edu.au

Abstract

Efficient management of large crowded events is always a challenge. Successful Management of such events largely depends on the use of technologies. There are many business cases where the use of latest technology can vastly improve their management. In recent times, many types of identification and sensor devices, including RFID tags, have been developed. Such technologies, combined with appropriate backend database systems, can be used to improve the crowd and event management. Hajj, an annual pilgrimage to Mecca, is a very large and unique gathering, which attracts millions of pilgrims for two or more weeks. Despite tremendous advancement of technology and its availability, Hajj continues to be managed manually. There are many aspects of Hajj which are worth researching. The aim of this paper is to identify appropriate technologies which can be used to improve the management of large gatherings such as those of Hajj and Kumbh gatherings in India.

1. Introduction.

This paper demonstrates the use of RFID and sensor technology to improve the management of crowded events like the Hajj. Management of the annual pilgrimage to Mecca, known as the Hajj, is a very complex task. Hajj takes place every year and is managed by the Saudi government. About four million people travel to Mecca using air, sea and road transport. The Hajj also involves frequent travels between spiritual cites. The added complexity in Hajj management is due to mandatory and multiple activities on the same day and the same locations. Because of the limitations of facilities and their manual management, millions of people are denied permission to perform Hajj. A detailed account of Hajj activities, problems and suggested solutions, including a conceptual design of Hajj database can be found in [3], [4], [12], [13] and [14].

In this paper, we first provide an in-depth introduction of the technologies which can be applied to improve crowded events like the Hajj. This will be followed by a discussion of some specific aspects of pilgrim surveillance, tracking and identification problems and the application of the technology to solve the problems.

Many ubiquitous sensors and scanning devices available today are very useful in effectively tracking and monitoring body movements. However, as required for the Hajj, we examine these technologies in the context of very large congregational crowds and the mandatory nature of certain rituals within a specified time-frame. For example, all pilgrims (four millions or more) are required to travel to several destinations and return back to perform a number of the Hajj rituals within the space of 36 hours. A number of improvements in the Hajj Management, including a future Hajj Management Framework, are discussed in [13] and [14].

In the present context, in many situations, information about pilgrims will be collected from ubiquitous sensors. Many of these operate invisibly, from the early active badges [2] to the now common radio-based sensors like Wi-Fi and Bluetooth, low cost radio-frequency tags and associated RFID readers as well as ultrasound devices as in the Cambridge BAT [10] and in the Cricket system [11]. In addition, many other sensors, such as cameras, pressure pads and microphones may sense people. To model a person's location, a system must interpret the data from such sensors to model aspects of the pilgrim that are associated with location.

2. RFID

The basic operating principle for RFID is summarized as follows: the reading device transmits wireless signal to a tag, and the tag is activated by obtaining energy from the electromagnetic wave received, and the activated tag transmits to the reading device of its own identification information. At this time, where response signal is transmitted by using the electromagnetic wave received as the energy source, it is classified into manual electronic tag, and otherwise,

978-0-7695-3514-2/08 $25.00 © 2008 IEEE
DOI 10.1109/CIMCA.2008.233

if the response signal is transmitted from a battery as power source, it is classified into the active electronic tag. Some of the specifications follow:

- No battery or long battery life –2 years
- Secure ID number storage & reading
- Small scratch-pad read-write memory for systems.
- Tag Communications correlated to item/targets
- Tag response can be FSK, AM, OFDM, BPSK, QPSK and QAM
- Swept frequency and frequency hopping

RFID contains the information with respect to entire process of production, distribution, keep, consumption and abolition to be attached on the tag of product, and is equipped with self-antenna, and can read the information with a reader device, and is used totally by integrating with an information system by means of connecting with satellite or mobile communication network. RFID has high rate of recognition, and possibility expandable to other communication network so that vital studies and applications in diverse field, including the distribution and circulation of goods, defense science, and food/ safety have been doing. The operational principal of RFID is that generating the signal containing the peculiar information of product tag, and letting the controlling system obtains the information of tag recognized and analyzed through an antenna. The active electronic tag has the advantage able to reduce the power needed to reading device, and to let the recognizable distant be farther, whereas because the power source device is required, the running time is restricted, and is expensive in comparison with manual type. Recently, RFID is been applied into wide range of: the management of chain supplies by a company, tracing on the freight in air port or sea port, pursuing for men or equipment in hospital, inventory management of grand mart, tracing on goods bought by consumer, and pursuing lost child in school, or public park. In this way, the information inputting from RFID reader may be used for far more available purposes beyond simply chasing goods, freight, equipment or a man. The table 1 summarizes the characteristics and example applications of each band.

Table 1: RFID frequency bands and applications

Frequency Band	Characteristics	Typical Applications
Low 100-500 kHz	Short to medium read range Inexpensive low reading speed	Inventory control Car immobilizer
Intermediate 10-15 MHz	Short to medium read range potentially inexpensive medium reading speed	Access control Smart cards
High 850-950 MHz 2.4-5.8 GHz	Long read range High reading speed Line of sight required Expensive	Railroad car monitoring Toll collection systems

Figure 1: Smart Shelf with RFID


Figure 2: RFID tag

Low frequency tags can be read by an interrogation unit (within 4 feet) at a maximum relative speed of approximately 20 miles per hour, while high-frequency tags can be read at a distance of 250 feet and at a relative speed in excess of 150 miles per hour. Figure 1 shows a "smart shelf" where each item on this shelf has a tag as shown in Figure 2. Therefore any item status will be always known to the manager via the backend database.

A reader can be set up and a tag can be read by the reader, and then the data can be sent to the backend database for management. Figure 3 is of a gate reader and can be used to monitor the goods passed by the gate installed with a RFID reader.


Figure 3. RFID reader gate


Figure 4. Sensor for environment

There are other technologies such as GPS, Wi-Fi, WiMAX, and Bluetooth, speck (2003), ICE (2006), etc. We shall briefly introduce some popular members. In Figure 4 there is a wireless sensor that can send out the detected data such as temperature, humility, etc. and then passes the data to the distributed nodes, and then the accumulated data will be sent to the central database.

Fig. 5: GPS tracking


Fig. 6: ATMEGA 128L

It is well known that Bluetooth is another wireless technology that has been used by the original founding members: Ericsson, Intel, IBM, Nokia, Toshiba, etc. and some promoters such as 3Com, Agere (was: Lucent), Microsoft, Motorola. Their typical characteristics are: 2.4 GHz ISM band, 79 (23) RF channels, 1 MHz carrier spacing, Channel 0: 2402 MHz … channel 78: 2480 MHz, G-FSK modulation, 1-100 mW transmit power, Frequency hopping with 1600 hops/s, Hopping sequence in a pseudo random fashion, determined by a master Time Division duplex for send/receive separation.

Different wireless technologies differ from each other on the natures, such as energy cost, distance, bandwidth, rate, etc. Therefore, different applications should choose different wireless technology. In next section we shall discuss a few cases of Hajj processes, where some of these technologies can be used to improve the administration and management.

3. RFID Applications for Improving the Current Hajj Management.

There are two kinds of pilgrims namely, overseas pilgrims (who apply for the travel visa) and the local pilgrims (who only attend mandatory rituals of Hajj). In both the cases, we propose that the pilgrims should be provided with an ID in the form of a RFID tag (as shown in Figure 2) and wireless smart "wrist strap" as shown in Figures 5. For this technology to work, of course, the entire travel route of the Hajj should be mapped to the GPS system.

3.1. Pilgrim Processing at Saudi Ports

On arrival and departure, each pilgrim is required to fill a paper form and stand in a long queue for the purpose of their immigration processing. This process may take several hours, sometimes up to a full day, because of the large number of pilgrims and their slow processing. To expedite the processing at the ports, each pilgrim, at the time of their grant of visa, should be provided with a RFID tag, as shown in Figure 2, which should be linked to the backend database. To read the tags, the gates at the ports should be installed with RFID readers. As the pilgrims pass through these gates, the reader would pick the data by the ID embedded in the RFID from the backend database. In this way each person can get immigration clearance without any delay. When a person who is without RFID or with false tag, passes through the gate, the RFID reader system would take action, such as automatically close the gate, light winking, or even electrical action, depending on the ranked status. After authenticating a pilgrim at the immigration processing, a "smart watch" as shown in Figure 5, should be provided to each pilgrim. This watch would contain authenticated data matching with that stored in the backend database, which would connect to the RFID system.

3.2. Withholding of passports

Currently, at the time of arrival, after the immigration clearance, pilgrims' passports are collected by the Hajj Management officers, known as Munazzam. These passports travel with the pilgrims in the custody of the Munazzam and are given back at the port of exit at the time of their return journey. This step is taken seemingly to facilitate the check point processing and to prevent infiltration of pilgrims to the other parts of the Kingdom of Saudi Arabia. However, during this process, some passports are misplaced, in which case the pilgrims are required to travel to get a new travel document from their diplomatic mission in the kingdom's capital Riyadh, about 800 KM from Mecca. This system would be redundant once the RFID and "smart watch" systems are introduced. At the checkpoints, the validity of a pilgrim can be automatically verified by pilgrim's RFID tag and the "smart watch". There can be no mistake because of the double checking by the two systems. As for the return journey, the passport would already be authenticated, the boarding card could also be provided instantly by combining the immigration check-out and the airline check-in together to make the whole process smooth. In case of the illegal migrants, the biomedical data of pilgrims like blood, DNA, skin colour, face natures; etc would enable easy identification of illegal migrants.

3.3. Movement of pilgrims between Jeddah and Mecca

At present, there are major delays (several hours) in sorting out the pilgrims to their assigned Munazzam, organizing their bus travel to and from Mecca, and manual processing of pilgrim passports at the check

points between Mecca and other cities. In the proposed framework, individual checking based on the "smart watch" can be conducted at bus station by installing the RFID readers, which can also be installed at the highway check points. Also as the "smart watch" has the tracking function, this can offer the individual location, even in the moving bus. Anyone with health problems or risks to others can be monitored by the medical system linked with the Hajj management system.

3.4. Overcrowding and stampedes

During the last decade, there have been some incidents of stampedes and fires resulting in the loss of hundreds of precious lives. The Hajj management has taken technological measures, which has prevented fires since 1997. Despite widening of facilities at Mina, the tent city, the possibilities of stampedes occurrence are still very real. This is because overcrowding during some mandatory rituals continues to be a challenge to the organizers. The possibilities of future terrorist attacks cannot be ruled out. In order to monitor any large accidents, fires, terrorist attacks the sensors likes "ATMEGA 128L" (see Figure 6) can be deployed. By doing so, the temperature, humility, explosion, etc can be detected and the control system can take responding reactions. Normally there will be 80 meters per one sensor to be deployed coving all the area where overcrowding occurs. As the whole area would be installed with the surveillance systems, the managers would be able to continuously monitor the situation and take the preventive measures.

3.5. Identification Problem

There are a number of activities where overcrowding cannot be avoided. Whenever a stampede or a fire occurs, identifying badly mutilated bodies becomes a challenge. Another result of overcrowding is that thousands of pilgrims are disintegrated from their groups or relatives for days or weeks (and some of them may never found). Currently, reuniting the pilgrims with their groups may take considerable time due to poor identification mechanisms in place. In cases when pilgrims are lost and do not know their place of stay, there is no way of finding their details, without seeking the help from the Munazzam. On the other hand, if pilgrims do not return to their bases, there is absolutely no technology in place to track them. As discussed, the RFID and "smart watch" systems supported by the backend database would be able to track the missing persons, and find all the other details. As the biometric scans for each pilgrim would also be stored in the backend database, it would help identification in case the loss of the RFID tags and 'smart watch'.

3.6. Well being of pilgrims

At present, there is no health or age consideration for granting the Hajj visa. Most pilgrims get their visa on the basis of inoculation against certain diseases. As no data is collected about the blood groups or health status of the pilgrims, there is no system in place to monitor aged pilgrims or the ones with disabilities or those with potentially harmful bacteria like HIV. The problems of the hospitals are compounded when dealing with medical emergencies. In order to prevent diseases and make Hajj a health safe event, every pilgrim should undergo full medical checkup and the data be stored in the backend database. Once the people with health risks are identified, they can be monitored throughout the pilgrimage by the established RFID and "smart watch" system. The PDA can be linked with the "smart watch" system, by which the person can clearly see the situation and also the PAD can talk to the "smart watch" system to send the "SOS' signal to the central control station so that the medical aid can be organized on an urgent basis. Since the systems would know the exact location of the patient, there would be no delay in sending the medical help.

4. Conclusions

In 2008 hundreds of people lost their lives in the tragedy at Jodhpur temple in India [12]. Also in 2008, many people were crushed and trampled to death in the Naina Devi temple stampede [1]. With thus use of technologies discussed in this article, these lives could have been saved. Apart from the Hajj, there are other hot spots where anything can happen anytime. For example, the Kumbh [7], [8] and [9] of India attract huge number of people (an estimated 1500 million over the period of four weeks). But even the Kumbh organizers do not use the sensor technologies which could help avoid catastrophic incidents. There are many other facets of Hajj which can be better managed with the help of sensor technology.

Many of the unresolved issues with people management at large congregations (such as Hajj and Kumbh) are due to the lack of information and infrastructure. Technology can provide information at the right time and the right place but cannot eradicate the need for suitable facilities. To prevent disasters such as stampedes, walkways and places of congregation may need to be expanded. Alternative methods (like rail link) between places of assemblies need to be explored. Another important factor that

plays significant role in the management of the hajj is the perception of event-timing of certain rituals. There are significantly different views as to start and end times of some events of the Hajj. Many pilgrims believe that the symbolic stoning at Mina should take place between the noon and the sunset, a span of about five hours. A simple simulation based on 2000 people performing this ritual in one minute would result in 25 hours required for three million people.

5. Acknowledgements

The inspiration for this work has come from the personal experiences of one of the authors gained during his pilgrimage to Mecca in 1998 and 2004-2007. The authors acknowledge the help and information provided by the King Abdullah Research Centre for Pilgrimage, Mecca. The authors would also like to thank the Saudi Arabian Cultural and Educational Mission in Canberra, Australia.

6. References

[1] 2008 Naina Devi temple stampede, Last accessed 18 October 2008, from http://en.wikipedia.org/wiki/2008_Naina_Devi_temple_stampede

[2] Addlesee, M., Curwen, R., Hodges, S., Newman, J., Steggles, P., Ward, A. and Hopper, A.: 2001, Implementing a sentient computing system. IEEE Computer 34(8), 50–56.

[3] Hajj [2006]. Last accessed 22 November 2006, from http://en.wikipedia.org/wiki/Hajj#Performing_the_Hajj

[4] Hajj in Pictures (2008). Last accessed: 16 September 2008 from http://www.ummah.net/hajj/pics/

[5] Hajj and Eid–ul-Adha (2008). Last Accessed 16 September 2008 from http://www.ummah.net/hajj/

[6] Kumbh Mela, From Wikipedia, Last accessed 16 September 2008 from http://en.wikipedia.org/wiki/Kumbh_Mela

[7] Kumbh Mela 2007, Last Accessed 16 September 2008, from http://www.kumbhamela.net/

[8] Kumbh Mela Pictured from Space. Last accessed 16 September 2008 from http://news.bbc.co.uk/1/hi/sci/tech/1137833.stm

[9] Naina Devi temple stampede, 2008, Last accessed 16 September 2008 from http://en.wikipedia.org/wiki/2008_Naina_Devi_temple_stampede

[10] Want, R., Hopper, A., Falco, V. and Gibbons, J.: 1992, The active badge location system, *ACM Transactions on Information Systems* **10**(1).

[11] Priyantha, N.B., Chakraborty, A. and Balakrishnan, H.: 2000, The Cricket location-support system. In: MobiCom '00: Proceedings of the 6th Annual International Conference on Mobile Computing and Net

[12] Scores die in India temple crush, Last Accessed 16 October 2008, from http://news.bbc.co.uk/2/hi/south_asia/7643373.stm

[13] Yamin M, A Framework for Improved Hajj Management and Future Research, ENTIC Bull, Vol. 2/08, 2008

[14] Yamin M, Wireless Systems to Manage Large Congregations, Proceedings of Keynote Addresses and Invited Lectures, 2nd International Conference on Wireless Communications and Sensor Networks (WCSN), IIIT Allahabad, December 17-19, 2006