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A REAL TIME HEALTH CONTROL AND LOCALIZATION OF PILGRIMS IN EL HAJJ :BSN APPLICATION

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ABSTRACT

As an emerging technology, WSN (Wireless Sensor Networks) composed from a large number of small, low data rate and inexpensive node that communicate in order to sense or control a physical phenomenon. WSN have a lot of applications like disaster management, health, military and security, and enormously attracted the community of researchers and has fueled the interest in sensor networks during the past few years. Sensors are typically capable of wireless communication and able to solve several problems in numerous domains. During the Hajj season, the organizers faced a lot of problems related to the health of pilgrims and their position in the area of El Hajj. At this time, the proposed works are focused on the identification of pilgrims lost, using the implementation of RFID (Radio Frequency IDentification). The latter solution, is as expensive equipment, requires adding tags to pilgrims. Those tags are limited to read data from those passives tags. Further work is limited only to the location of pilgrims. However, the aim of this paper is to discuss and propose a system which allows monitoring of pilgrims. Indeed, this allows, using a BSN (Body Sensor Network) as a particular application of wireless sensor network, for the localization of pilgrims lost and control, in real-time, the health status of those who fall into critical situation with diseases that could threaten their health and life. In this system, the agents in El Hajj, dispatched to several areas of Hajj and have devices that install applications to monitor and locate pilgrims, periodically, by reading sensors measurements in addition to their localization with adequate and theoretical technique. This solution, present a model for an area, and which can be duplicated for the full area of El hajj. It also facilitates the intervention and localization, in real time, of pilgrims who are away from their camps and to save their life.

Keywords: *Hajj, WSN, Localization, Body Sensors*

1. INTRODUCTION

Hajj (pilgrimage) is a huge gathering of Muslims on the earth. It is characterized by a place of their meeting and the kind of rituals they perform. This generates a series of challenges for the authorities to control the crowd and identify individuals. Therefore, the season of El Hajj becomes more difficult, especially when the whole crowd is the same movements at the same times do essentially the same thing. This spiritual gathering causes a lot of challenges and problems in relation to the conduct of rituals of El hajj. This is face to the increasing demand for good organization, security and control, the Hajj task remains one of the big challenges that Saudi authorities are facing each year. To this end, the authorities and officials are introduced to minimize these difficulties, especially those which may affect their health and life. Being different, some difficulties which may be mentioned are:

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

2. RELATED WORKS

[1], the authors propose a prototype RFID-based Pilgrim Identification System, tested with a group of 1000 pilgrims from.

This experiment proved to be very successful in demonstrating the effectiveness of RFID system in removing bottlenecks of the traditional authentication system. This work needs more investigation, especially for improvement of antennas design, selection of readers' location, and communication frequency are also to be tackled. The same author [2], describes a developed system (fig.1) for pilgrim

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tracking and identification using a mobile phone. The system consists of software that can be downloaded to the mobile phone of every pilgrim upon arrival to the Kingdome of Saudi Arabia. In add, the RFID tag can be programmed and be placed in inside the mobile. The mobile uses the Internet or SMS to send location information to a server managed by Hajj authority and to a server managed by the guide of the group that the pilgrim belongs to.

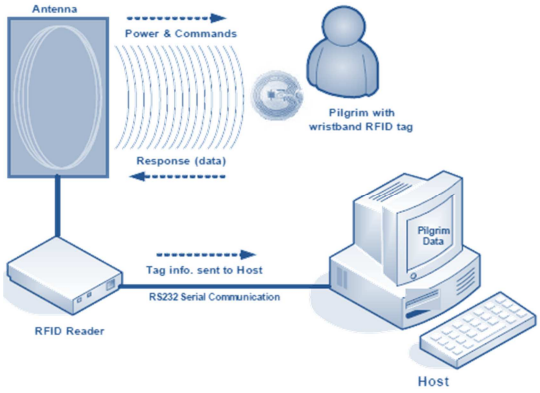

Figure 1: RFID System For Pilgrim Identification

[3] Lists a project build by the use of WSN; they made WSN Stations as emergency fixed stations. These stations are spread around the holy mosque to support local rescues and aid the retrieval of missing pilgrims. Each station has a button switch to press if the pilgrims get lost or if they need to request services. The last work is focused on the problems of missing people and helping those in need of urgent medical services with absence of any health control.

[4], propose an integrated solution to the problem of pilgrimage transportation control while tracking the shuttle-bus from its starting point till its final destination. The application identifies a particular bus by the RFID tag fixed on it. Passengers boarding or getting down the bus are identified on the basis of RFID cards they have and finger identification.

[5], Yamin proposed a framework (Fig.2) which combines database and wireless technologies, by collecting pilgrim information's since her visa application, after the arrival and during the Hajj process; for this, the author propose a mobile reader and scanner.

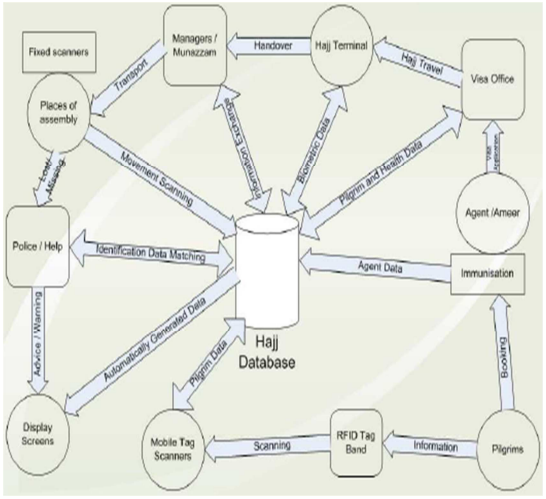

Figure 2: Framework For Hajj Management

3. WIRELESS SENSOR NEWORKS

3.1. WSN: Roles and Applications

Micro-electromechanical systems, embedded technology, sensor technology and wireless communication technology has become more sophisticated and progressive, to promote wireless sensor networks (WSN) generation and development, WSN become the current research in the field of IT hot, and has been widely used in many fields. Actually, this technology is omnipresent in application that requires communication with their components to transmit relevant quantities or values like light, temperature, humidity and more.

A WSN, sensor nodes are organized into fields "sensor fields" (fig.3). Each of these nodes has the ability to collect data and transfer them to the gateway node (called "sink" in English or sink) via a multihop architecture. Well then transmits this data via the Internet or satellite to the central computer "Task Manager" to analyze and make these decisions.

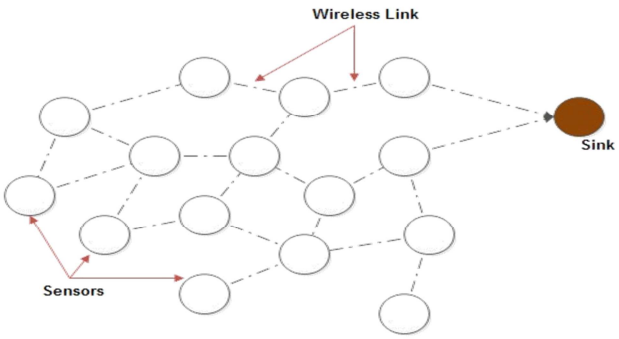

Figure 3: Sensor Field Architecture

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Their applications are mainly related to conduct surveillance and remote control of the events of sensory (or physical) several different such as temperature, pressure, light, sound. These devices (motes or sensors) are able to capture and collect information sensitized in the environment monitoring , and then you send it wirelessly from one sensor to another in cooperation with each other to a the base station (sink), which is a computer that collects information from wireless sensors scattered, processed and analyzed. Due to their importance, sensors are used in many domains like military, rescue and ambulance, in nuclear reactors conducts a periodic surveillance, transport (plane and car) VANETs (Vehicle Ad hoc Networks), animal control, natural disasters (earthquakes and volcanoes) for the purpose of surveillance.

3.2. WSN: Challenges And Contraints

The main factors influencing the architecture and constraints of sensor networks can be summarized as follows:

- *Fault Tolerance*: Some nodes may generate errors or stop working because of a lack of energy, a physical or interference.
- *Scale*: The number of nodes deployed for a project may reach one million. Such a large number of nodes generates a lot of transfers inter nodal and requires that the well "sink" is equipped with lots of memory to store the information received.
- *Production costs*: Often, sensor networks are composed of a very large number of nodes. The price of a node is critical in order to compete with a network of traditional surveillance. Currently a node does not often costs much more than $ 1. For comparison, a Bluetooth node, already known to be a low-cost system, costs about $ 10.
- *The environment*: The sensors are often deployed en masse in places such as battlefields beyond enemy lines, inside large machines, the bottom of an ocean, fields biologically or chemically contaminated.
- Therefore, they must operate unattended in remote geographic areas.
- *Network topology*: The deployment of a large number of nodes requires maintenance of the topology. This maintenance consists of three phases: Deployment, Post-deployment, and Redeployment of additional nodes.
- *Material constraints:* The main constraint is the physical size of the sensor. Other constraints are that energy consumption must be reduced so that the network will survive as long as possible, it adapts to different environments (extreme heat, water, ..), it is very durable and autonomous since it is often deployed in hostile environments.
- *The media transmission:* In a sensor network, nodes are connected by a wireless architecture. To allow operations on these networks worldwide, the transmission medium must be normalized. We mostly use the infrared (which is license-free, robust to interference, and inexpensive), Bluetooth and ZigBee radio communications.

3.3. Body Sensor Networks(BSN)

BSN is a special Body Area network (BAN) whitch considered as a technology that emerges as the natural byproduct of existing sensor network technology and biomedical engineering. Professor Guang-Zhong Yang was the first person to formally define the "Body Sensor Network" (BSN) with publication of his book Body Sensor Networks in 2006 [6].
BSN technology represents the lower bound of power and bandwidth from the BAN use case scenarios. Actually, This kind of structure, usually, use cellular network (3G) or WSN infrastructure to transmit data concerning patient to the base station and to the doctor (fig.3).

Wireless sensing and communication have the potential for large applications in medicine. Body Sensor Networks are a specific and medical application of wireless sensor networks intended to operate in a pervasive manner for on-body applications [7]. Using this technology, it is possible to obtain measurements of heart rate, oxygen saturation, pressure, and temperature, with small, non-invasive sensors; we expect that, over time, an increasing array of sensors with sophisticated capabilities will become available.

Practically, BSNs for healthcare monitoring appears in several network applications operating in a variety of different environments including a hospital operating room, an elderly

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health clinic or a personal home setting and also in special area in hajj environment or in Kumbh Mela in India. Each of these environments varies substantially from one to another.

Because of this, BSN framework must be adaptable and distributed to accommodate for such different settings. Due to this, we must appropriately structure the network in terms of number of sensors, and select relevant features in the BSN. Several benefits of the use of BSN can be exploited to monitor and control persons in real time and in their position.

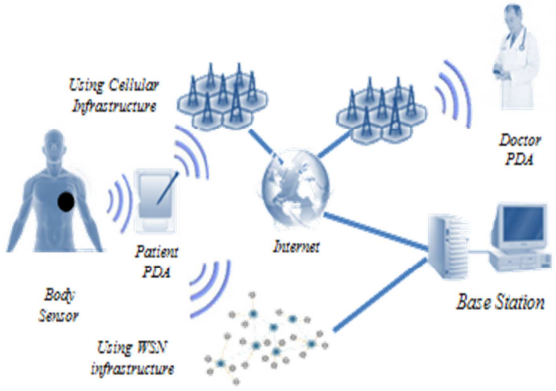

Figure 3: Sample Of Existing BSN Architectures

4. THE LOCALIZATION CHALLENGE IN WSN

Node localization is a complicated and important problem for wireless sensor networks (WSN). The aspects of this problem that have challenged the research community can be summarized as follows:

- *Assumptions* - The node localization problem remains a difficult challenge to be solved practically. To make the problem practically tractable, its complexity had to be reduced, by making simplifying assumptions. As a result, many localization schemes proposed solutions that are based on assumptions that do not always hold or are not practical. Examples of such assumptions are: circular radio range, symmetric radio connectivity,
- additional hardware (e.g., ultrasonic), lack of obstructions, lack of line-of-sight, no multipath and flat terrain.
- *Localization Protocol Design* - The problem of localization in WSN is further complicated by the large number of parameters that need to be considered when designing a localization system for a particular WSN deployment. Among these parameters are: the deployment method for the sensor network; the existence of a line-of-sight between sensor nodes and a remote, central point; the time required by the localization scheme; the presence of reference points (anchors) in the network, and the density; the cost for localization, represented by additional hardware (form factor) and energy expenditure (messages exchanged or time necessary for localization).

Sensor network localization algorithms estimate the locations of sensors with initially unknown location information by using knowledge of the absolute positions of a few sensors and inter-sensor measurements such as distance and bearing measurements.

Sensors with known location information are called anchors and their locations can be obtained by using a global positioning system (GPS) [8], or by installing anchors at points with known coordinates. In applications requiring a global coordinate system, these anchors will determine the location of the sensor network in the global coordinate system. In applications where a local coordinate system suffices (e.g., smart homes), these anchors define the local coordinate system to which all other sensors are referred.

Because of constraints on the cost and size of sensors, energy consumption, implementation environment (e.g., GPS is not accessible in some environments) and the deployment of sensors (e.g., sensor nodes may be randomly scattered in the region), most sensors do not know their locations. These sensors with unknown location information are called non-anchor nodes and their coordinates will be estimated by the sensor network localization algorithm.

Several measurement techniques in WSN localization can be listed depending on their localization technique like:

- *AOA: Angle-of-arrival measurements,*
- *TDOA : Distance related measurements*
- *RSS : Received Signal Strength*

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- *POA: Power of Arrival (PoA) detection systems:*
- *FOA: Frequency of Arrival (FoA) detection system*

5. CONTRIBUTION AND PROPOSED ARCHITECTURE

5.1. Problem statement

El Hajj is a gathering place of millions of pilgrims from around the world. Around the grand mosque of El Hajj, hundreds of pilgrims are lost each year while away from their camps and their families during the rituals of El Hajj. Others who have health problems may arise in severe situations, especially in large crowds and congestion, causing death in some cases.

Even before efforts in health services by local and international authorities, unfortunately, it is difficult to monitor and intervene in time to save lives. As reported in the related works, numerous existing applications using RFID are focused just on the identification of pilgrims and listing their information.

Others focus only on the localization of pilgrims lost. At this moment, none of these applications treat health monitoring of pilgrims in real time. It is in this context, we propose a hybrid architecture based sensor networks using BSN and able to locate lost pilgrims.

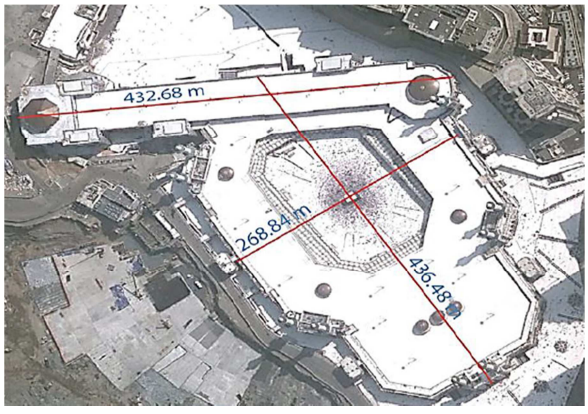

Figure 4: The Grand Mosque Dimensions

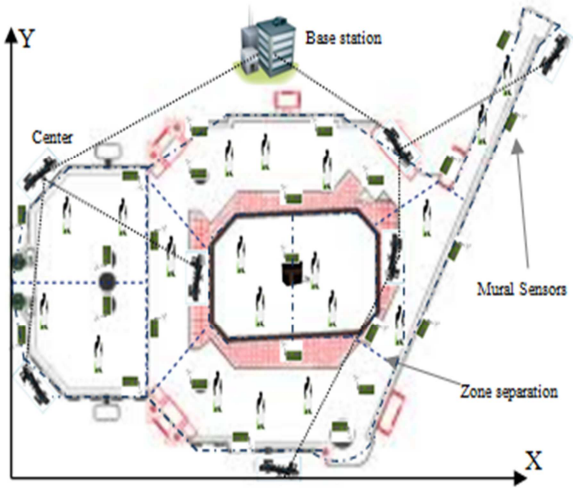

Figure 5: Sample Of Mural Sensors Deployment And Zone Repartition.

5.2. The proposed BSN Architecture

The BSN architecture of the pilgrim health control system is designed in a hierarchical tree. The main component here is the Pilgrim equipped by Body Sensors considered as mobile sensor. We note here, that just pilgrim declaring that they suffer from health problem (Cardiac, Imbalance in pressure, temperature…) who must be equipped by these sensors. Murals and fixed sensors in several placement of the area of the Grand mosque are used to achieve data to the centres.

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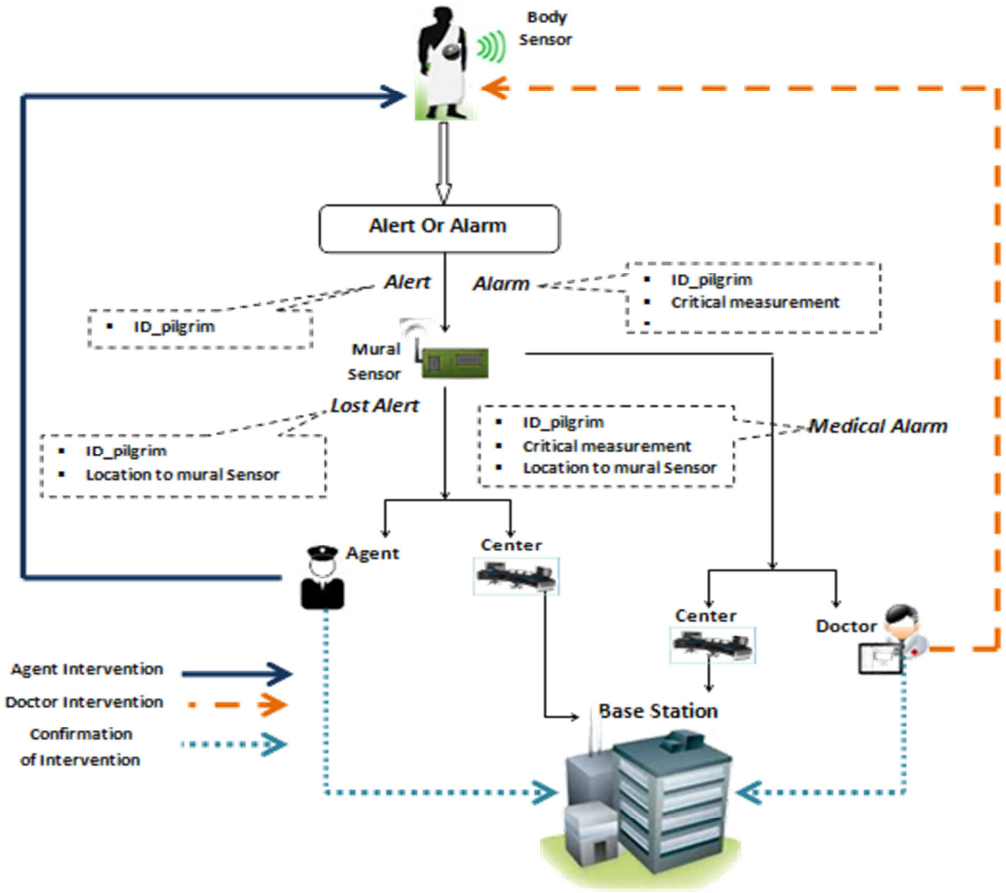

Figure 6: Illustration of pilgrim Alert/Alarm

Those centres transmit valid request to base stations and to agents of their zone. The Grand Mosque area is subdivided to seven zones (Fig.5), each zone content a computer center that collect periodically measurement achieved by mural sensors. Taking in consideration the WSN rang and dimensions of the Grand mosque (fig.4), those sensors are fixed and deployed to cover all area of the grand mosque, and referenced to absolute bi-dimensional reference (Fig.5).

The Body sensors send alarms when exceeding a threshold of critical measurements (fig.6), by avoiding sending regular or periodic data, which causes more consumption of energy. This alarm is also sent to the doctor charged in the area. We note here that the agents and doctors in the area are equipped with information reader's (Medical Alarm, Lost Alert) from the centers. Pilgrims lost can activate an alarm button, which sends an alert to the nearest wall sensor.

The latter, inform both the center and agent of the area to which it belongs (fig.6).

In another part, leaders of the camp may contact the base station or centers for any absence of pilgrims from his group, at that time; an alert is broadcasted in the network to locate the pilgrim. Indeed, murals sensors play an important role by searching neighboring sensor pilgrim sought: the sensor that find it, can locate it in relation to its reference, and then indicate its position to agent and center of concerned area (fig.7).

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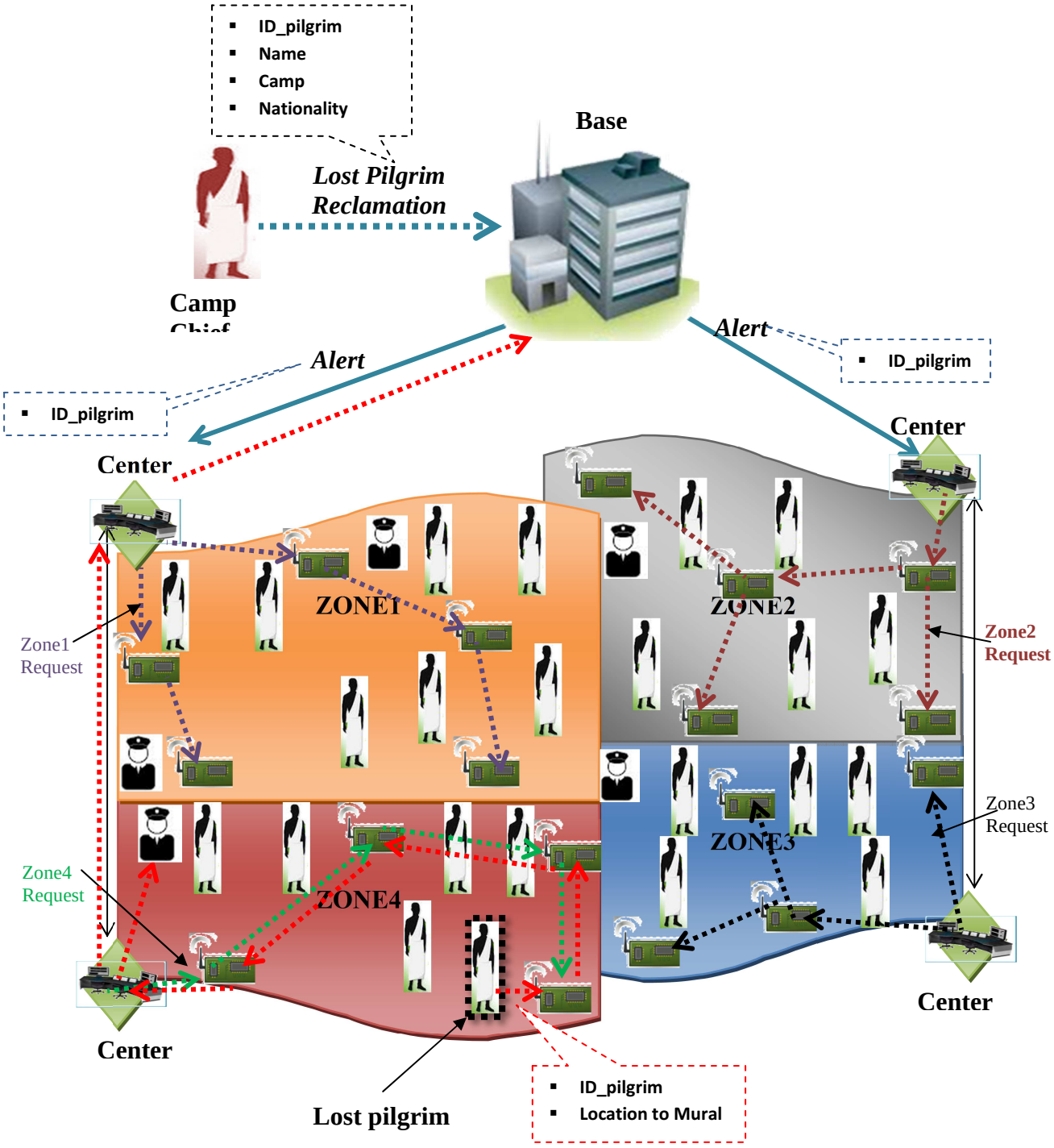

Figure 7: Illustration of reclamation of Pilgrim Lost

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For pilgrim localization, the mechanism adopted is focused on broadcasting a ID_pilgrim request which refers to body sensor ID. The broadcasting is limited to the area (zone) of the mural sensor. The concerned ID sends a Replay to the near mural sensor. The latter, by routing mechanism, inform both agent and the center. We note her that the mural sensor that finds the ID, is considered as a reference by his position to locate the pilgrim lost.

5.3. Localization Technique

In the literature, several techniques are listed to locate a sensor, taking in consideration the optimization of the energy consumed to find this sensor; we can list AOA, TDOA, POA [9]. Analytical method was listed in [10], this technique is adopted for large objet, and dedicated to transport domain and need a directional antenna for every sensor.

In this work, we use a fixed sensor in walls of El hajj areas, those sensors are considered as reference knowing their position. As mentioned in the figure 8, we consider a mural sensor as reference who receive alert/alarm from the pilgrim sensor, the fixed sensor send this request to Agent/Doctor. The last receiver sends a request message to the pilgrim sensor in order to calculate the distances D1, D2 and D3 using (1) and (2) where C_1 and C_2 are defined in [10].

$$e_{ij}^{s} = C_1 + C_2 d_{ij}^{2} \quad (1)$$
$$e_{ij}^{r} = C_1 \quad (2)$$

We also use the AOA technique [9], by the triangularization method and using three other fixed mural sensors as references, to know the angle between the fixed sensor and pilgrim. The measure, can easily used to deduce X_{pi} and Y_{pi} where i=1, 2. We note that the direction (φ_i) looked is from the agent/doctor to the pilgrim.

Calculating D_2, D_3, can simply deduce that the pilgrim is same where on the circle C_2 and same where on C_3. The intersection between the two circles gives two probable positions (P_1 or P_2). To compute the direction φ_i to the pilgrim, we calculate it to the X_{AD} position of Agent/Doctor: an analytical demonstration is given by the equations (3), (4) and (5).

$$X_0 = |X_{pi} - X_{AD}| \quad (3.1)$$
$$\Delta_i = \sqrt{(|X_{pi} - X_{AD}|)^2 + Y_{pi}^2} \quad (3.2)$$

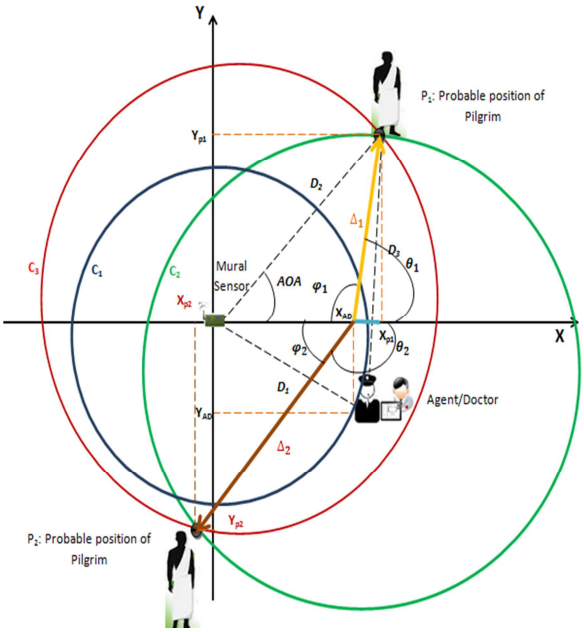

Figure 8: Localization Technique Illustration

Hence $cos(\theta_i) = \frac{Y_{pi}}{\Delta_i}$ and $\theta_i = Arcos\left(\frac{Y_{pi}}{\Delta_i}\right)$ (4)

Hence the direction to the pilgrim is:

$$\varphi_i = \pi - \theta_i \quad (5)$$

The values of φ_i serves to give the orientation and the direction to the lost pilgrim. The agent or the doctor, who uses a PDA, is oriented to the pilgrim, from the X_{AD} as the initial point of the origin of direction to the destination.

As mentioned in figure 8, we have two possibilities of position of pilgrim, by the intersection of two circles. Using this technique, and to locate the real position in huge density of pilgrims in Hajj season, we consider the dichotomic approach discussed in [11], which use Dicho_AODV as a protocol with a specific RREQ (Route Request) mechanism based on discovery of destination on the right at first, the, on the left.

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As described in the model (Fig.9), the agent/doctor equipped by an ipad, which content information about lost and patient pilgrim and also gives directions to them.

6. CONCLUSION

This paper outlines a solution to one of the most problems in El hajj season related to the health, the control and localization of lost and special patients of pilgrims. The presented work were control the health of patients and locate the lost pilgrims in order to intervene in time to save lives and guide the lost pilgrims to their camps. This solution uses the BSN and the WSN technologies to control and achieve data to the base stations. A analytical localization technique is presented to locate both lost pilgrim and the patient in critical situation. An architecture and analytical study proposed here, in the perspective of an implementation and in-depth study in the environment of great mosque and with the authorities, for the development and deployment of this solution.

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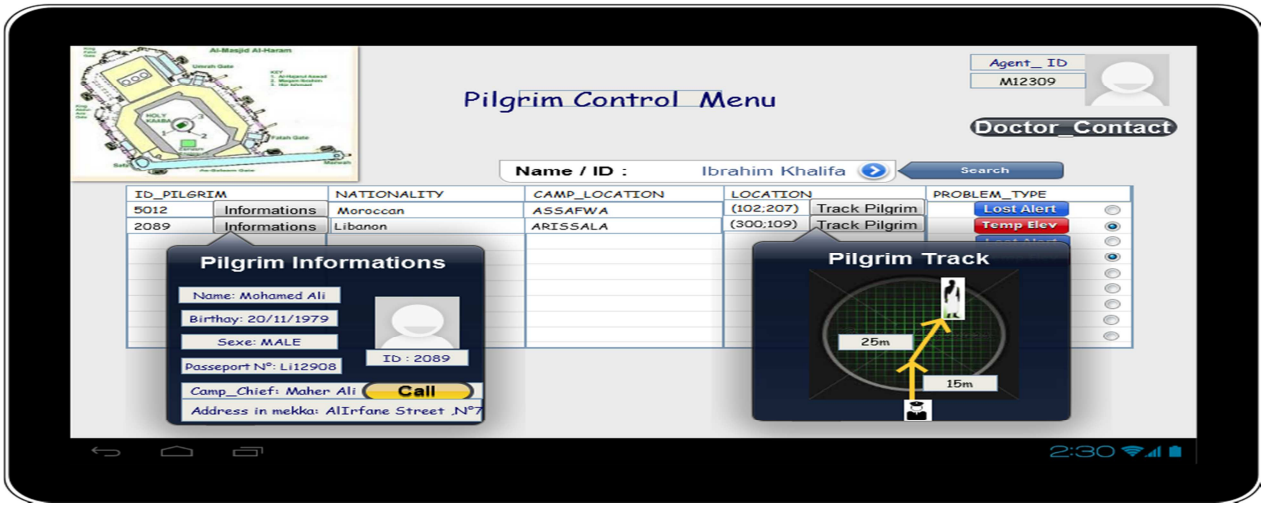

Figure 9: Model Of IPAD Pilgrim Control Application