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Performance Improvement in Hospital Management using RFID and ZigBee Technologies for Tracking and Monitoring Patients and Assets in Saudi Arabia

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Abstract— This paper outlines a developed framework for presenting and visualising data from RFID and ZigBee technologies. The data is gathered from sensors that track and monitor the location and statuses of patients, medical staff and medical equipment by using visualisation concepts to assist in creating, transforming and sharing knowledge to improve hospital management performance and help and to support decision making in the Saudi Arabian healthcare sector.

Keywords: **Tracking and Monitoring; Patients and Assets; Decision Making; Saudi Arabia; Healthcare System, Efficiency**

I. INTRODUCTION

Tracking patients' movements through the hospital helps caregivers work more efficiently by providing them with real-time information on patients and updates about laboratory, orders, and other notifications that are crucial to their workflow and patient safety (Drazen & Rhoads, 2012). Patient tracking provides information to improve the flow of patients in the outpatient departments, emergency department (ED) and the inpatient setting by increasing the number of acute care transfers coming into the facility (Mchugh & Dyke, 2011). The benefits of implementing patient tracking include, but is not limited to, increased throughput, decreased average length of stay, improved recording of treatment costs (charge capture), fewer ambulance diversions, and higher patient satisfaction ratings (Drazen & Rhoads, 2012). In addition, patient tracking and monitoring improve patient flow by tracking patients, assets, or staff members. This paper proposes a novel Smart e-Health framework for tracking and monitoring patients and assets, for healthcare decision support in Saudi Arabia. Attention is given to the use of RFID and ZigBee technologies.

II. SAUDI ARABIA HEALTHCARE CHALLENGES

There is increasing concern about the underutilisation of and performance e-health systems in Saudi Arabia. This has been indicated by The Saudi Arabia Government Health Reform Committee where a lack of proper health informatics systems was ranked as one of the top challenges facing the Saudi health services. One of the current and existing challenges in Saudi Arabia's healthcare sector is patient misidentification. About 4% of the reported patient incidents were related to patient misidentification in a Saudi Hospital from a recent study (Aljadhey et al., 2014). The long waiting queues of patients is another challenge as research shows average patient waiting time in outpatient clinics in the Middle East Region is 161 minutes (Mohebbifar et al., 2014). Poor patient flow increases the possibility of harm to patients, and raises healthcare costs by failing to make the best use of skilled staff time (De Silva, 2013). Also, It is estimated that the total number of people aged 60 and above by 2020 will be over 2.5 million which will be expected to need more effort and resources (Yusuf, 2014). Cost increases, low efficiency, poor risk management, high inventory etc. are some of the expected consequences of these challenges (Genpact, 2013).

III. TRACKING AND MONITORING FRAMEWORK MAIN COMPONENTS

A. e-Health system

E-health refers to the use of digital data transmitted, stored and retrieved electronically in the health sector, in support of healthcare, both at the local site and at a distance (Almuayqil et al., 2015). Smart e-health is a term that refers to the use of ICT in the healthcare field. According to Park & Kim (2013), Smart e-health is the management of health and medical services through the use of information technology where people are using it whenever, and how ever, safely and freely. A Smart e-health system collects patients' data and monitors their daily health condition through sensing devices (Mukherjee et al., 2014).

B. RFID

Radio Frequency Identification (RFID) is a fast developing technology that uses radio waves for data collection and transfer (Kim, 2012); it can capture data efficiently and automatically without human intervention. RFID is believed to be the next generation innovation for automatic data collection and asset tracking. The technology is attractive in its obvious advantages over other identification technologies such as bar coding (Yao et al., 2010). The RFID is used to follow a product through the supply chain and clinical workflow. The RFID reduces the amount of time involved in locating or tracking, thereby making the process less cumbersome (Ajami & Rajabzadeh, 2013).

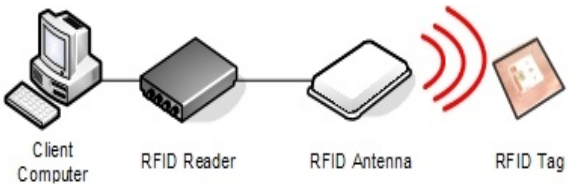

Figure 1: Basic Components of RFID System

C. ZigBee

ZigBee is a global communication Wireless Sensor Network (WSN) that provides a short distance, low speed, low power consumption communication with a longer battery life (Wang & He, 2011). ZigBee Alliance industry was established in 2001 and formally named ZigBee in 2007. ZigBee is an IEEE 802.15.4 standard design for data communications between a large numbers of consumer devices for industrial usage and is designed for Wireless Personal Area Networks (WPANs) application (Alliance, 2008).

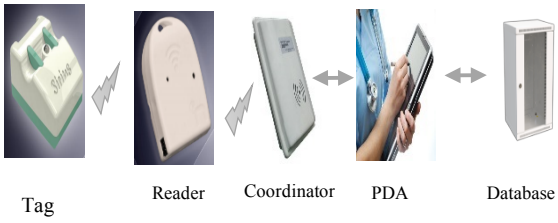

Figure 2: ZigBee Network Components

D. RFID and ZigBee

RFID and ZigBee can both be used for tracking certain objects: RFID will provide a faster scanning speed for large volumes of tags, and ZigBee can provide almost unlimited network scale with lower output power, which is a significant benefit for healthcare applications particularly in operating tracking and monitoring in an environment containing people (Hui et al., 2014). Using such emerging sensor technologies which automatically scan and use non-contact and non-intervention for tracking objects, users will be able to receive real-time information and visualization of objects such patients, staff and equipment location throughout the hospital which will improve the management information systems and provide more effective decision support systems (Alharbe et al., 2015).

E. Visualisation

There are several factors associated to the term visualisation and its inclusion within our research. A key success factor in our work will be the gathering of patient, medical staff, equipment, and location related information, and then secondly the displaying of this information in an effective succinct visual format (Demšar et al., 2015). It is critical that in order to represent these four issues the correct form of visualisation is used to effectively summarise the

information. Key factors required to address this will include the specific hardware viewing device / platform and given media choices to that device.

Assuming that the viewing device is a television or large monitor display would suggest most information relay will take place on the display itself. Information will therefore need to be represented to show a spatial environmental (location information layout) representation with patients, medical staff, and equipment integrated on top of this as a dynamically represented layer of information. For this layer further key decisions will need to be taken as to the graphical style of visualisation employed to aid readability efficiency and reduce misinterpretation in drawing the viewer's attention to situations that require address (highlighting) (Schoffelen et al., 2015). There will also need to be consideration as to interaction mechanisms used, such as how would medical staff interact with the displayed information (e.g. via interaction which is remote or via direct manipulation) (Khan & Khan, 2011).

Figure 3: Live Tracking and Monitoring through the Visualisation Concept

IV. TRACKING AND MONITORING FRAMEWORK

At present, there is no automatic, non-intervention, real-time system in operation in Saudi Arabia for allowing either monitoring patient tracking, bed allocation or medical equipment tracking within a hospital environment, nor is there tracking of patient files and staff through the various hospital processes and the physical areas associated with them (Alharbe et al., 2013). In order to improve hospital efficiency, this paper is presenting a developed framework to present and visualise the gathered data from RFID and ZigBee systems about patients, medical staff, medical equipment locations and status, by using visualisation concepts to assist in creating, transferring and sharing knowledge to help and support decision making in Saudi Arabia healthcare sector. The proposed framework will be at a strategic-level, and will be developed by using knowledge management concepts in relation to visualisation to identify an appropriate managerial decision support framework in order to identify locations of patients, medical staff, and medical equipment to improve efficiency, and decision support systems to meet the needs of Saudi Arabian healthcare sector.

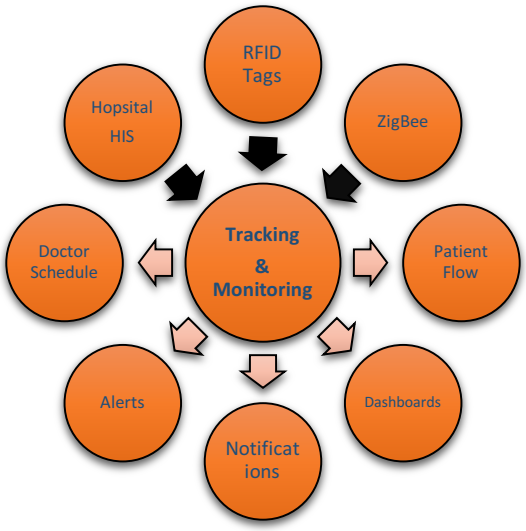

Figure 4: Tracking and Monitoring Framework Components

The proposed framework consists of tags (RFID or ZigBee tags) that are fitted on the object or person which need to be tracked and a network of sensors, and receivers installed throughout the targeted area (Hospital) that locate the position of the tags in real-time. This information is then presented and visualised on a screens accessed from the nurses', line managers', senior management and all other related care givers' workstations (Arden-Close et al., 2015). Systems that track patients this way track patient locations, times, characteristics (e.g., fall risk, selected diagnoses), and status (e.g.,

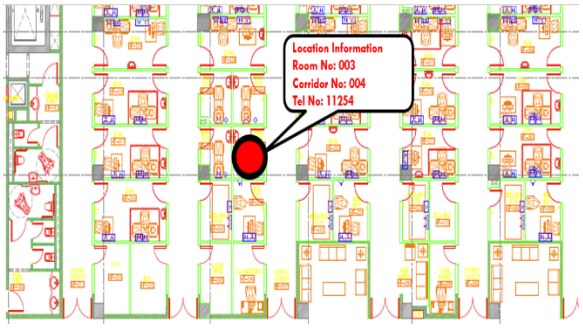

Figure 5: Objects Live Tracking and Monitoring

waiting for x-ray, ready to be discharged) (Drazen & Rhoads, 2012). This real-time information is typically overlaid onto a diagram of the floor layout of a specified unit. All health caregivers can refer to this 'Screens' for the latest and updated status, location, and indicators for each patient. Patient tracking systems communicate with the hospital's information systems, including the bed management system, through the automated exchange of messages using the hospital standard. This provides data to decision makers, which enables them to make informed decisions about patient admissions and placements (Drazen & Rhoads, 2012). Bed managers can see which units have available beds and what the expected waiting times are for rooms to be cleaned and prepared for new admissions.

Also, notifications can be set to alert caregivers when patients have waited too long relative to some predefined service standard, or when a laboratory result is ready (Tim & Ken, 2009). The availability of detailed information at a glance improves throughput by reducing the cost of looking up information (e.g., instead of calling to check if an

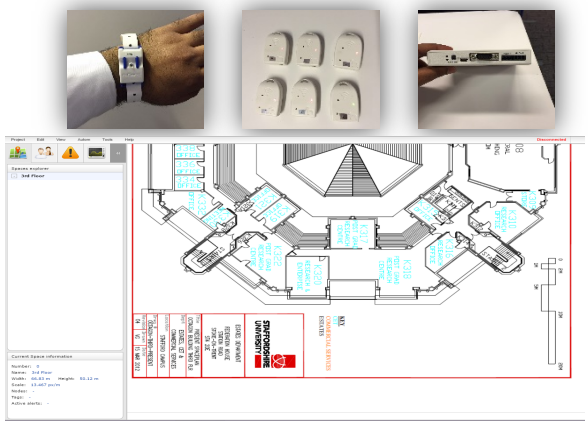

Figure 6: Experiment of Live Tracking and Monitoring

order is ready, a nurse sees an icon appear when the order becomes ready).

V. RESEARCH EXPERIMENTS

The research team carried out experiments in a laboratory environment to make sure this worked perfectly. The system contained 2 tags (type: n-Core Sirius Quantum), 8 readers (type: n-Core Sirius D), 1 coordinator (type: n-Core Sirius A), 1 computer working as a server, Polaris n-Core platform (Web Based Tracking System) as tracking application. The topology was designed as a mesh network. The designed system was able to locate the tag within less than 50 cm and monitor the movement of the tracked object moving continuously and accurately.

VI. CONCLUSION AND FUTURE WORK

The paper outlined the potential for use of RFID and ZigBee technologies in Saudi Arabian healthcare facilities to improve performance and patient experiences. The paper describes how the technology can be implemented and the benefits of its use. Further work will focus on transformation of operational management information on patient, staff and asset movements to support Knowledge based Decision Support Systems (KDSS) thereby improving performance and patient experience.

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