AN INTELLIGENT RFID BASED HOSPITAL EMERGENCY ANNUNCIATION SYSTEM

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***Abstract*--In large hospitals handling emergencies on a day-to-day basis, it is very important to locate and ensure the availability of medical specialists in a timely manner. This is especially significant in situations where doctors will have to keep the mobile phones in 'switch-off' state in a few patient-sensitive areas. In this paper, an RFID based system has been developed to determine the location of medical specialists inside the hospital and also to make automatic annunciations only to the required locations. The RFID based application developed in this work and the associated database for a structured storage of entities aid in easy and efficient functioning of the overall system. The system developed is very robust and flexible enough to handle changing environment.**

Keywords—RFID, kNN algorithm, Administrator console, Doctor Database

I. INTRODUCTION

The use of modern technologies in Hospital Management has been a focus of research in the last decade all over the world. Especially in developing countries like India, the need for such technologies in hospitals is very pronounced in view of high volume of patients that are serviced in large government and private hospitals. There has been a focussed effort in integrating technologies such as sensor networks, RFID, WiFi, Bluetooth, etc for efficient day to day hospital related activities.

The research work carried out in [1] addresses the problem of medical asset tracking. The authors of this paper design an RFID based medical asset tracking system that works in situations where the availability of RFID readers is limited. The optimal placement of readers is designed for best coverage. Min Chen et al [2] propose a 2G-RFID technology for e-healthcare management system. Encoded rules are dynamically stored in the RFID tags, as against the conventional storage in a server database. The system performs actions on demand dynamically for different situations. The paper integrates the Body Sensor Network that collects patient data and the 2G-RFID system that improves diagnosis and handling of on-the-fly action demands.

The authors in [3] present a framework for an RFID based patient tracking and mobile alert system that integrates RFID technology, WiFi, Bluetooth and SMS. The paper also addresses an automated document management mechanism for a smooth and easy patient record retrieval. A problem of concern in hospitals is the missing or misplaced equipment. A manual inventory of the equipment location will tend to create issues when they are not readily locatable in emergency situations. Also, maintenance of a variety of equipment is also difficult when they are not systematically locatable. A technology proposed in [4] using passive UHF RFID to detect equipment in large hospitals seems to be a practically viable option.

There is still a tremendous opportunity to use RFID and allied technologies for a smooth and efficient functioning of various units in large hospitals. This paper proposes one such system where the location of the concerned medical expert in the hospital in an emergency situation is determined and automated annunciation to alert the doctor on the requirement of his presence in a particular unit is done. The key functionality of the scheme is as follows:

- First level Patient diagnosis by a duty doctor in an emergency ward
- The operator side of the application would chart out the list of doctors best suited to treat the patient.
- 2D-Localization of doctor's precise location using the KNN Algorithm is carried out using the information provided by RFID tags (on doctors' ID cards) and RFID Antennas located in prime locations of the hospital.
- Intelligent processing of the location information and subsequent annunciation only in the speaker system located closest to the place where the concerned doctor is present. The speakers are operated from a central server and they play digitized messages.

A sample floor map of a section of a hospital is represented in Fig. 1. The numbering of blocks is in accordance to the order of flow of control in case of an emergency.

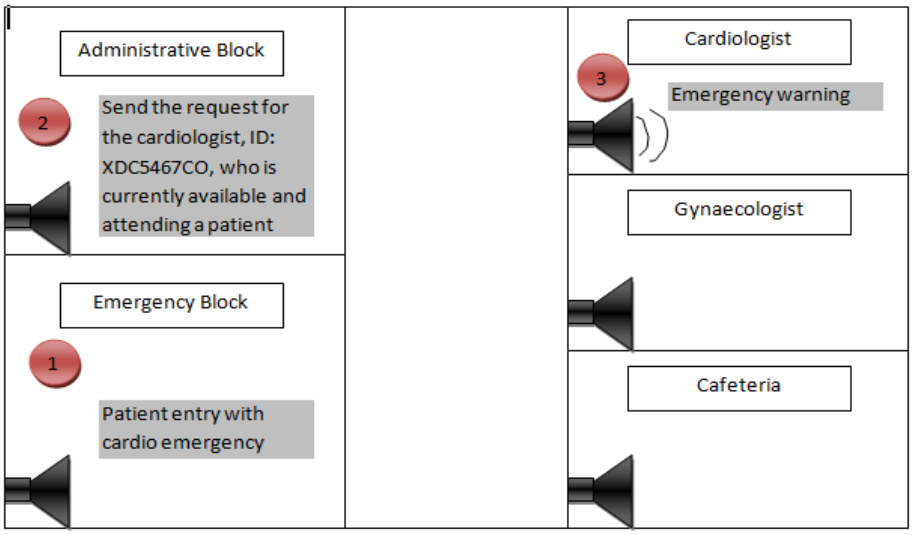


Fig. 1. Floor Map of an Example Hospital System with RFID Antennas

II. LOCALIZATION ALGORITHM

A. KNN (k Nearest Neighbour) algorithm

Reference tags are placed at predetermined positions (fixed positions, based on a strategy to maximize the accuracy of estimation of tag positions). Thus, the coordinates of the reference tags are known. A database of virtual reference tags with minimal interference is created to start with. The database encompasses every detail like the tag ID, PC bit, Time stamp, milli-second counter, Date & time and tag RSSI for reference tags. The database is updated periodically as brought out in Section III. The RSSI for the queried tag is obtained from the database once the user sends a query containing the tag ID. The

Euclidian RSSI (referred to as E in Eqn. 1) of the unknown tag with respect to each of the reference tags is calculated, using Eqns. 1 & 2, where R represents the reference tag RSSI and U, the unknown tag RSSI.

For a single reader system:

$$E = R - U \quad (1)$$

For multiple readers (say *n* in number):

$$\mathrm{E} = \sqrt{\sum_{i=1}^{n} (Ri - Ui)^2} \quad (2)$$

where summation is carried out for all the *n* readers.

Among all the above computed RSSIs, k minimum values are taken for further consideration (the very reason to term the algorithm as kNN). The best case would be to take k as 4. The centroid of these k values defines the location of the unknown tag.

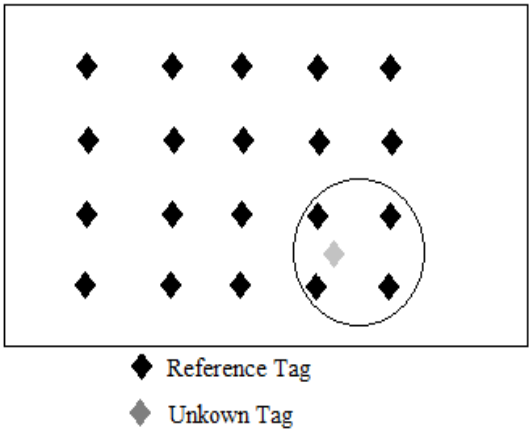


Fig. 2. Reference – Unknown Tag Positions for kNN Algorithm implementation

In Fig. 2, a layout of the combination of reference tags and the unknown tags is provided. The circle in this figure depicts a scenario where the position of the unknown tag is estimated using the coordinates of four reference tags.

Algorithm 1: Localization Pseudo-Code

BEGIN
Input: A = {($\mathbf{x}_1$, c_1), . . . , ($\mathbf{x}_N$, c_N)}
$\mathbf{x}$ = (x_1, . . . , x_n) new instance to be classified
For each labelled instance (xi , ci)
{ calculate d($\mathbf{x}_i$,$\mathbf{x}$)
Order d($\mathbf{x}$i , $\mathbf{x}$) from lowest to highest,
(i = 1, . . . ,N)
Select the K nearest instances to $\mathbf{x}$: $A_K(x)$
}

III. SYSTEM DESIGN

Fig. 1 shows the layout of the end-to-end system. The four sub-systems developed for the purpose of intelligent doctor tracking and annunciation are briefly explained here:

A. RFID System

The basic RFID infrastructure for the project involves mounting antennas connected to the RFID reader at pre determined locations. The antennas are suitably mounted such that they provide maximum coverage in the designated area of patient movement. Also important from the operations viewpoint is that the interference between the signals from closely located antennas are to be minimum. The readers are networked and are connected to the internet either wired or in a wireless manner. *The RFID Reader – Antenna tracking system is shown in Fig.3.*

Administrator Console:

Each RFID reader has its own online administrator console, a platform used to manage each reader's antennas and their respective settings such as antenna power rating, read mode, memory type, etc. Access to administrator consoles is available through a unique IP address for each of the readers. Once the infrastructure for the localization is set into place, the setup is powered up. The unique IP addresses associated with each of the readers are used to access the respective Administrator Consoles. Readers are configured to run periodic scans for tag detection. The periodically collected data comprising tag IDs, RSSI, time stamp, etc is regularly fed to an application that keeps updating the database for virtual and real reference tag RSSIs. The periodic database update helps in making the system adaptive to changing scenarios, especially when the obstacles and objects in the system significantly alter the RSSI signals.

Fig. 3. Antenna-RFID Network Model

B. Doctor's Location Estimation

This module processes the RSSI at the readers and uses the localization algorithm (explained in Section II) to arrive at the exact location coordinates of doctors available in the hospital premises. The database is updated continuously to provide the doctors' location at any given point in time.

C. Doctors' Location Database

The main focus of the front-end application is to provide the operator with a suitable listing of doctors for a particular emergency based on their real time position co-ordinates for a quick notification to the specified doctor of his requirement. A well structured database has been designed using MySQL which is flexible enough to accommodate changes in it and to add or modify administrative details. The location coordinates of doctors are continuously updated in the database using the doctors' RFID tags.

The specifications for the database tables as are follows:

- Three tables corresponding to 'Doctor', 'Injury' and 'Patient' are created.
- The doctor table has the following columns – Doctor Id, doctor name, speciality 1, speciality 2, x and y co-ordinates (current location filled by the processing module). The x and y co-ordinates hold the real time positions of the doctors which are derived from their respective RFID tags.
- The injury table has 'injury name' as its field, which maps directly to the speciality fields of the doctor table.
- The patient table holds the patient Id, patient name, the injury type and the doctor ID (ID of the designated specialist)

D. Annunciation System

This module comprises a set of well-coordinated speakers that are centrally operated from an automated controller. The speakers are fixed at different locations in the hospital premises to cover all the areas. It is ensured that the speakers do not disturb the general quiet functioning of the hospital and at the same time, make announcements in an effective manner to communicate the medical expert's requirement in a particular ward/location via the annunciation system.

IV. HOSPITAL ANNUNCIATION : A CASE STUDY

This section deals with the system developed and its usage. Fig. 4 gives the layout of a representative hospital scenario. The layout has speciality wards, surgery and the annunciation system comprising the speakers. The sequence of activities carried out by the overall system are as follows:

Stage 1: Patient Entry

When a patient arrives with a specific medical condition, the hospital staff makes an entry of the this condition in the front end application (Fig. 5).

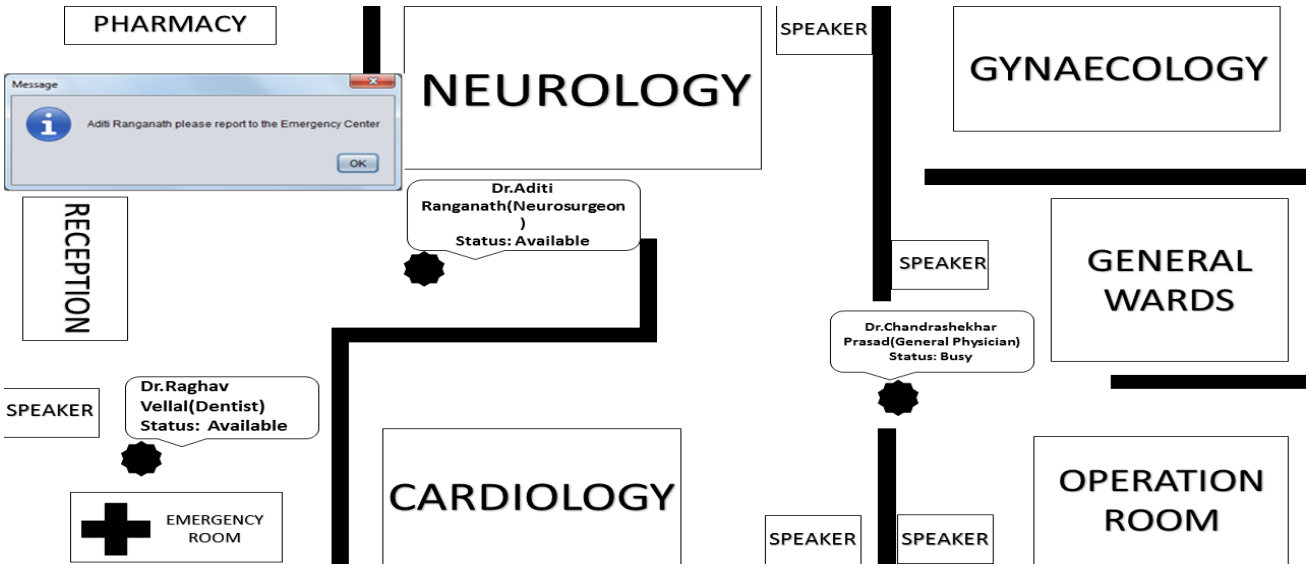


Fig. 4. A Representative Hospital Layout

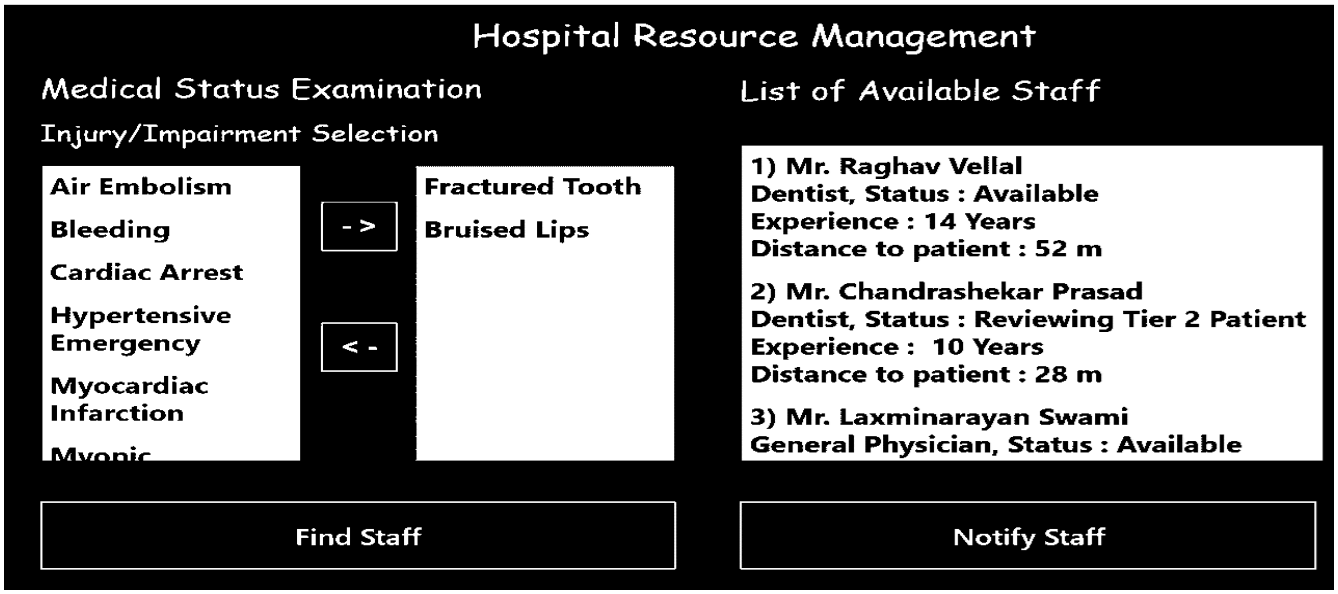
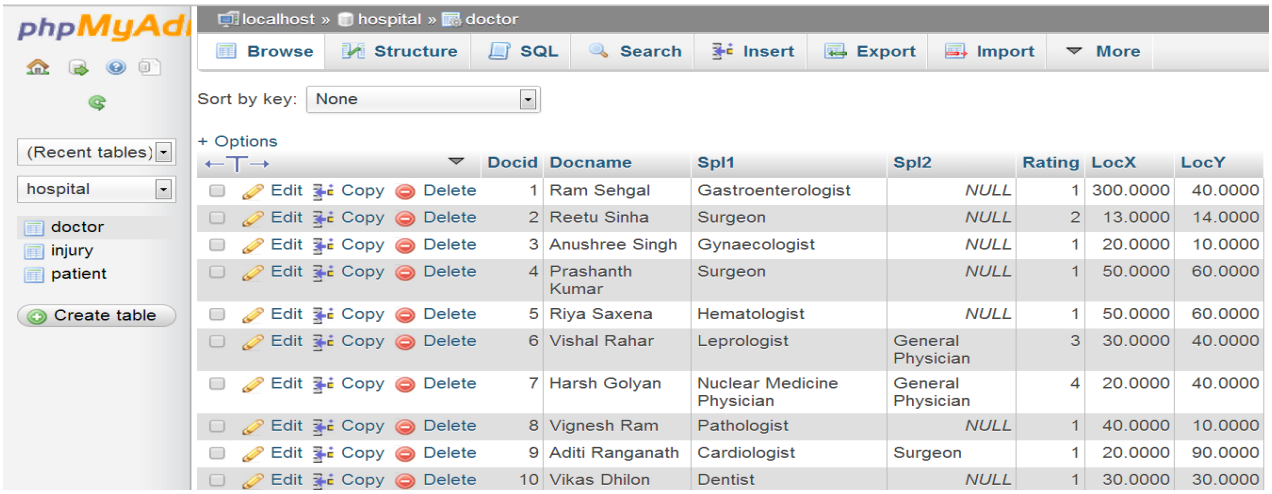


Fig. 5. Injury entry menu



	Docid	Docname	Spl1	Spl2	Rating	LocX	LocY
Edit Copy Delete	1	Ram Sehgal	Gastroenterologist	NULL	1	300.0000	40.0000
Edit Copy Delete	2	Reetu Sinha	Surgeon	NULL	2	13.0000	14.0000
Edit Copy Delete	3	Anushree Singh	Gynaecologist	NULL	1	20.0000	10.0000
Edit Copy Delete	4	Prashanth Kumar	Surgeon	NULL	1	50.0000	60.0000
Edit Copy Delete	5	Riya Saxena	Hematologist	NULL	1	50.0000	60.0000
Edit Copy Delete	6	Vishal Rahar	Leprologist	General Physician	3	30.0000	40.0000
Edit Copy Delete	7	Harsh Golyan	Nuclear Medicine Physician	General Physician	4	20.0000	40.0000
Edit Copy Delete	8	Vignesh Ram	Pathologist	NULL	1	40.0000	10.0000
Edit Copy Delete	9	Aditi Ranganath	Cardiologist	Surgeon	1	20.0000	90.0000
Edit Copy Delete	10	Vikas Dhilon	Dentist	NULL	1	30.0000	30.0000

Fig. 6. Doctor database

Stage 2: The Server System

The front end application forwards the requisite names to the server, which refreshes its database on a continuous basis for current location of the doctors (Sec. III.B). Fig. 6 shows a snap shot of the Doctors' database for a particular scenario.

JDBC (Java Database Connectivity) has been used to establish the database connection with the front end and the server.The two main queries used are:

- Selecting the injury associated with the emergency case.
- Retrieving a list of doctors who specialise in treatment for the given case.

Hence, by using a simple yet flexible database design, it is seen that every incoming emergency is attended to at the earliest time thereby, creating an effective response system in the hospital resulting in minimizing the time to attend to emergency situation.

Stage 3: Final Announcement

In the final stage, announcements made through the system have to reach the concerned doctor (through a speaker system located close to his present coordinates). In the present prototype for a proof of concept, a text box pop up is implemented to convey the emergency message as shown in Fig. 4. But in actual hospital deployment, the annunciation system replaces this text box pop up.

VI. CONCLUSION

Timely addressing of patient needs in emergency situations is of highest priority in large hospitals. In this paper, an intelligent hospital annunciation system has been developed using RFID technologies. The RFID based localization to determine the locations of doctors in the hospital, the database design to store the details in an organized way and the design of an efficient annunciation system have been effectively carried out. The system designed and developed in this paper is novel and is easily deployable in large hospitals.

As a future research, the reader network system can be optimized by employing soft computing techniques such as genetic algorithms. This can enhance the performance of the whole system.

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