A Proposed RFID Model Based on GIS for Improving the Medical Services in Hospitals

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Abstract – The importance of healthcare to individuals and governments and its Growing costs to the Economy has contributed to the emergence of healthcare as an important area of research for scholars in Information systems (IS) and other disciplines have much to improve the quality of care. In addition to the embedded role of information technology (IT) in clinical and diagnostics equipment, information systems are uniquely positioned to capture, store, process, and communicate timely information to decision makers for better coordination of healthcare at both the individual and collective levels. Since the Geographic Information System (GIS) makes it possible to integrate different kinds of geographic information, such as digital maps, aerial photographs, satellite images and global positioning system data (GPS), along with associated tabular database information. So emerged the importance of this paper which describes a proposed Radio Frequency Identification (RFID) model based on GIS for hospitals to improve medical services quality.

Keywords – Geographic Information System (GIS), Global Positioning System Data (GPS), Indoor Positioning Systems (IPS), Location Based Services (LBS), Radio Frequency Identification (RFID).

I. INTRODUCTION
Radio Frequency Identification (RFID) is a method for remotely storing and retrieving data using devices called RFID tags or transponders. An RFID tag is a small object, such as an adhesive sticker, that can be attached to or incorporated into a product. RFID tags are composed of an antenna connected to an electronic chip. These chips transform the energy of radio-frequency queries from an RFID reader or transceiver to respond by sending back information they enclose. Also, a computer hosting a specific RFID application or middleware pilots the reader and processes the data it sends. RFID has great characteristics it is possible to scan tags in motion and since radio waves can pass through most solid objects, the tags don't need to be in direct line of sight of the RFID reader [1]. Having labeled or tagged objects being identifiable in ubiquitous and flexible manner is already a good start. Building a network out of these objects, so that with a unique number one can easily retrieve information about them, would enable much more interesting use cases. In order to make the dream of a seamless global network of physical objects come true [1].

Geographic Information System is a system designed for storing, analyzing, and displaying spatial data is the use of hardware, software, people, procedures, and data [2].

So a Geographic Information System (GIS) can be defined as a computer-based system for the digital entry, storage, transformation, analysis, and display of spatial data. Although we often restrict our concept of spatial data to maps (e.g., land use, vegetation), spatial data also include images (e.g., satellite data), point observations (e.g., rainfall), or tabular data associated with geographic areas (e.g., census records). Thus, in addition to maps alone, a GIS must be capable of handling other types of data, all within a spatial frame of reference [3]. This means that a GIS user will expect support from the system to enter (geo-referenced) data, to analyze it in various ways, and to produce presentations (maps and other) from the data. Many kinds of functionality should come with this: support for various kinds of coordinate systems and transformations between them, many different ways of 'computing' with the geo-referenced data, and obviously a large degree of freedom of choice in presentation parameters such as color scheme, symbol set, medium et cetera [4]. The basic functionality of GIS packages can be viewed as data transformations. From the initial loading of the data through its analysis to visualization as a thematic map merely requires GIS functions to appropriately transform data from one form to another [5].

A GIS provides facilities for data capture, data management, data manipulation and analysis, and the presentation of results in both graphic and report form, with a particular emphasis upon preserving and utilizing inherent characteristics of spatial data. The ability to incorporate spatial data, manage it, analyze it, and answer spatial questions is the distinctive characteristic of geographic information systems [6].

II. APPLICATIONS OF RFID IN HEALTHCARE
RFID applications in healthcare could save important resources that can further contribute to better patient care. RFID applications could reduce the number of errors by tagging medical objects in the healthcare setting such as patients’ files and medical equipment tracking in a timely manner. RFID further improves the situation for patients’ care by integrating medical objects involved throughout the patients’ care. RFID based timely information about the location of objects would increase the efficiency and effectiveness of paramedical staff leading to improved patients’ experience [7].

RFID applications in healthcare could include: Supply chain applications. This includes high-cost items like pacemakers, defibrillators, and artificial joints. The supply chain for these items is complex, and they are often supplied on consignment. They also require a high degree of traceability from the supplier to the patient. Patient
safety applications may include improved patient identification using RFID tags in patient wristbands. Also, Quality assurance applications may include improved instrument tracking for infection control purposes. Some vendors supply RFID-enabled trays that can be tracked through central sterilizing departments [8].

Assets tracking applications like tracking of blood Bags Transfusion Blood Bags for transfusion are an important field of application for RFID in Healthcare. If fact blood and plasma and blood products are stored at low temperature for cry preservation this causes ice on the bags surface. Therefore optical based Identifications technologies like barcode are useless for this scope [9].

III. RFID AS LOCAL POSITIONING SYSTEM

It is an accurate positioning technology which can identify the movement and location of personnel and goods to provide real time information that supports Location Based Services (LBS). To offer a low cost indoor positioning solution for locating large number of items, passive tags are chosen rather than active ones. To study the effectiveness of using passive RFID as the positioning technology, experiments are conducted in a laboratory under a controlled environment [10].

According to one RFID vendor, a large, multi-hospital healthcare provider is installing a real-time location system that uses hybrid Radio Frequency tags, combined with infrared (IR), to pinpoint the exact room in which an asset is located. The health-care provider has performed a beta test of the RF-IR system in which each hospital room is fitted with a Room Locator, an IR transmitter designed to send a location-identifying code [11].

To employ RFID for positioning and tracking of objects, one strategy is to install RFID readers at certain waypoints (e.g. entrances of buildings, storage rooms, shops, etc.) to detect an object when passing by. For that purpose an RFID tag is attached to or incorporated in the object. This concept is employed for example in theft protection of goods in shops and in warehouse management and logistics. A second approach for using RFID in positioning would be to install RFID tags at known locations (e.g. at active landmarks) especially in areas without GPS visibility (e.g. in tunnels, under bridges, indoor environments, etc.) and have a reader and antenna installed in the mobile device carried by the user. When the user passes by the tag the RFID reader retrieves its ID and other information (e.g. the location). In the case of cell-based positioning, i.e., Cell of Origin (CoO), the maximum range of the RFID tag defines a cell of circular shape in which a data exchange between the tag and the reader is possible. Using active RFID tags the positioning accuracy therefore ranges between a few meters up to tens of meters. For 3-D positioning range measurements to at least three tags are necessary. The ranges from the antenna of the reader to the antenna of the tag are deduced from the conversion of signal power levels into distances [12].

Data from RFID systems provides a three-dimensional view (product, spatial and temporal) of an item at a minimum; the tag ID identifies the product, the reader provides the location where the tag was read and the time when the tag was read. Each data dimension can be used individually or in aggregate to track items [13].

IV. INDOOR GIS AND GEO-LOCATION

Use Geographic Information System GIS integrates software and hardware for collecting, managing, analyzing the data and showing all forms of geographically information in a computer-based system. It helps to analyze data visually and look patterns, trends, and relationships that might not be visible in tabular or written form. A GIS is different from other information systems, because it integrates common database operations such as query and statistical analysis with the advantages of visual and geographic analysis through maps [14]. Thus, GIS with the aid of control server, solid waste bin can be detected and monitors [14].

Indoor positioning is a technique that provides the continuous real-time location of objects or people within a closed space through measurements [15]. It is primarily used in retail floors, warehouses, factories, and offices to monitor and track people, equipment, merchandise, etc. Contrary to self-positioning systems such as GPS, indoor positions are calculated on a distant server using the information transmitted by mobile tags [16]. Indoor positioning systems (IPS) may have different configurations. For example, tags may transmit movement information directly through a wireless network or may be read by scanners as they pass by. In the latter case, tags possess no processing capabilities and are unable to calculate their own position. Also, different radio frequencies can be used for indoor positioning: namely, ultrasound, a wireless LAN based signal such as wireless fidelity (WiFi) or Bluetooth, and cellular network signals. Finally, to be completed, the process of indoor positioning usually requires data analysis (e.g., validation, spatial analysis, geo-statistics, data mining) to extract patterns and trends as well as to provide accurate and timely knowledge to managers [17].

V. INDOOR GIS IN HEALTHCARE

Geographic information systems are usually associated with outdoor locations; the movement of goods through a supply chain, locations of utility poles, or the analysis of business prospects. But, as people with GIS training or who are interested in health informatics will want to know, the technology is expanding into indoor mapping, which is great news for the health care industry [18]. Location systems are seen as a promising technology for tracking people and objects to improve efficiency and quality in the healthcare domain [19]. The health care industry already uses GIS in a number of ways, whether analyzing the spread of contagious diseases, managing the provision and delivery of service to communities, or looking at the links between health and where people work or live. All that is outward facing, treating location as something that surrounds health care facilities; the notion of indoor is becoming important in the world, whether involved in
building security, interior navigation, retail analysis, or, now, health care. GIS software leader ESRI recently joined the In-Location Alliance, a trade association of companies that are focused on accurate indoor location services, and it has offered indoor mapping for years [18].

VI. A PROPOSED RFID MODEL BASED ON GIS

This proposed RFID model based on GIS is a tracking system for the medical equipment’s and medical Staff’s locations that combined RFID Passive chips with optical sensors and readers to enable the management to fully track and allocate the target objects in the hospital through centralized data of each registered equipment and medical staff whether identification data or tracking data to improve the access time to these equipment or staff at the right time and display their locations graphically using the GIS interface.

![Image of Proposed RFID Model Based on GIS](image)

The proposed model is based on reading the tag Id of the target object by the nearest rfid reader then sends information about the reader and the tagged object to the backend rfid database thru rfid middleware application which is managing such processes, also readers Id and their physical locations data are predefined in the rfid database.

When the user search for any tagged object location like medical staff or equipment the model checks the current active reader which is near to the target tagged object and display information about its location using GIS graphical interface on the hospital floor plan map.

The proposed model as shown in Fig.1 composed of the following:

A. RFID Module

RFID readers represents the allocation and identification phase, composed of card and tag tags or transponders which will be attached to the target objects we need to track, a computer hosting a specific RFID application or middleware pilots the reader and processes the data it sends see Fig.1.

B. GIS Module

The Interface phase display the target objects’ location on the hospital floor plan Map includes: floor plan maps of the hospital, a computer hosting a specific GIS application and software, predefined spatial data of the Hospital buildings see Fig.1.

C. Software Package

Software package deals with Database Management System and RFID Middleware that collects the information from the RFID readers and sends it to the backend database.

D. Main Server

The main server(s) includes the central databases for RFID Database and GIS Database and all the transaction update and database stored procedures and functions.

VII. A PROPOSED RFID FRAMEWORK BASED ON GIS (ARCHITECTURE–COMPONENTS)

A Proposed RFID Framework based on GIS describes briefly how does the integrated system between RFID System and GIS work? In this framework the RFID system by its functions will be responsible of collecting the active objects ids and the active RFID readers IDS and update to GIS database by the locations of these objects, while GIS by its functions will be responsible of treating spatial data and present the output in understating form (map) see Fig.2. Here is a simulation of a working mechanism:

1) Users generate RFID tags and setup it to the target objects using RFID interface.
2) User setup RFID readers and inserts its information using RFID Middleware.
3) User inserts a related spatial data and maps using GIS interface.
4) When RFID tag passes through the reader range zone.
5) The stored data transmitted to the RFID database system to store the ID of the active reader and the ID of the target object thru the RFID middleware.
6) RFID database stored procedures and triggers will fire and update the GIS database with the current active location for an object using the Structure query language SQL thru the database link to be an input to the GIS database.
7) GIS & SDB functions are used to abstract and extract an important data and knowledge.
8) Data transformation is a critical step in which Vector data is related to from attribute data tables.
9) The final step will use visualization techniques and GIS interface to present the result in an understanding for (map) to the user.
Also, the integration will achieve a good result and the value of geographical data will become more valuable. This proposed framework can be used to achieve a lot of tasks and extend the basic functionalities of traditional GIS to include modeling and simulation capabilities in aiming to improve the presented medical services quality.

The proposed framework consists of the following components:

A. Central Database Component

Central database component is the main counter for the base database and related objects:

1) RFID Database

Rfid is the first component of the architecture it contains data about all tagged objects like object Id and description, also it includes data about rfid readers like reader Id, location and data about the current active objects, database stored procedures, database triggers which are used to update the geo-database with the spatial and attribute data.

2) Structure Query Language (SQL)

SQL is used to communicate with the Database and build a simple and complex queries, build database stored procedures and triggers, build database links between RFID and geo database.

3) RFID Database Management System

Database management system is an extension of the conventional database management system (DBMS). It is used to manage the rfid database.

4) Geo-database

Geo-database where both spatial and attribute data are stored and managed. Several geo-databases will be available from RFID database.

5) Spatial Database Management System

The spatial database management system (SDBMA) is an extension of the conventional database management system (DBMS). It is used specially to manage spatial.

B. GIS Components

This part is related to the functionalities of GIS. GIS has a set of functions and tools which support spatial analysis.

These functions may be measurement functions, vector analysis functions, overlay, buffering, visualization functions or query functions. All these functions should be integrated together and joined to the proposed framework to be complementary with the proposed model.

C. RFID Component

Rfid component consists of:

1) RFID Basic Functions

The proposed model used a set of RFID functions like reading RFID tag Id, check the current active reader Id and store such information in the RFID database.

2) RFID Middleware

RFID is a main component of RFID components it’s the middle layer between the RFID devices and RFID database, it's a software package responsible for setup the new RFID readers and managing them. It performs the filtering, aggregation, and counting of tag data, reducing the volume of data prior to sending it to backend database, Fig.3 shows the concept of the Middleware.

D. Communication System Component

The communication system permits the user to enter his/her query and to retrieve the results. It is also responsible of the communication between the movement and transformation of data between RFID components and GIS components.

E. Visualization Techniques and GIS Interface Component

As the aim of integration is to facilitate the understating of result so this part is essential as a communication language between user and the system. GIS visualization function is used to present the spatial results of searched object. A map is usually the result of any geographical project so all needed tools for producing the map should be included in the model. Then user interface can be developed by any programming language to provide an easy way for the interaction between user and these components.

Though the unique advantages and flexibility of RFID and GIS is the good news, the technology is still not yet widely understood or installed in the Healthcare environment, RFID, its application, standardization, and innovation are constantly changing. Its adoption is still relatively new and hence there are many features of the technology that are not well understood by the general
populace. Developments in RFID technology continue to yield larger memory capacities, wider reading ranges, and faster processing. The interest in RFID as a solution to optimize further the automation and tracking of items and goods are gathering momentum at an increasing pace. The Integration between RFID and GIS still also new and it needs more researches and it will add more value to the medical information system.

VIII. CONCLUSION

This paper has aimed to build a proposed model using the combination of RFID and GIS to enable fast medical staff and equipment tracking. So the proposed model achieved the goals as followings:

1) The proposed model consists of RFID passive chip that stores the object data which transmitted to the database when it becomes nearby the reader zone that represents the identification mode, and the GIS software represents the graphical layout interface.
2) Both RFID and GIS data is related to same object, but it saved separately and can work independently.
3) This independency provides a system with an effective performance where the object can identify it by using his Tag that holds the passive chip.
4) This model could perform its main target based on actual contact to RFID reader.
5) Also this model could work over Local Area Connection.
6) The proposed model has been chosen on the appropriate criteria that divided into technical, integration criteria to ensure the success of this project.

According to these results the specification of building the model has been chosen to cover all needed details to achieve the target of tracking methods and accuracy.

REFERENCES


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