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Mobile RFID Tracking System

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Abstract— **This paper describes the design of an RFID Kids Tracking System. It is designed to track a moving child in a wide area, such as a park or mall, using RFID technology. The proposed system has hardware and software components. The hardware architecture consists of an RFID active tag, RFID tag reader, web server and database server. The web server and database server are located in the master station. The tag readers are distributed around the open area, e.g. park. The tags are programmed with kid's profiles and are worn by the kids. Communication between the tag reader and the web server is done via wireless LANs. The software architecture consists of a communication driver that handles all communication functions done at the master station, an Application Programming Interface (API) that handles and analyzes the data, a friendly GUI and a database that saves all readings and client information.**

Keywords-component; ***Radio Frequency IDentication (RFID), RFID object tracking, Wireless system, Supply-Chain mangment, Tracking Alogrithem***,

I. INTRODUCTION

In recent years, Radio Frequency Identification Systems (RFID) gained a great interest in industry and academia. This interest has lead to the use of RFID technology in a variety of applications such as factory automations and integrations [1], B2B and B2C networks [2], smart parking lot access [3], material tracking information systems [4], libraries management systems [5] hospital management systems[6], Pharmaceutical manufacturing [7],supply-chain management [8] and Airline baggage Identification [9]

The basic architecture of an RFID system consists of a tag that includes an antenna and a chip, a reader equipped with antenna and a transceiver, and a workstation to host the Middleware and database.

There are several frequencies that are used for RFID. Table 1 shows the frequency range and the typical application for each range [10]. The detection range could vary from few Centimeters to 100 Meters.

Table 1: RFID operation frequency ranges and related applications [10].

Frequency Range	Description	Typical Applications
< 135KHz	Low Frequency, Inductive coupling	Access Control & OEM applications
13.56 MHz	High Frequency, Inductive coupling	Access Control, Library books,
868 - 870 MHz 902 - 928 MHz	Ultra High Frequencies (UHF), Backscatter coupling	Supply chain tracking
2.40 t- 2.483 GHz	SHF, Backscatter coupling	Asset tracking Highway toll tags Vehicle tracking

The objective of this project is to design and implement an RFID-based reliable and efficient solution to track lost kids in a large open area. The system allows users (e.g. security officers) to monitor the position of "tagged kids" from a sufficiently large distance by implementing an application that reveals the position of a kid at anytime and anywhere in the coverage area.

II. SYSTEM FUNCTIONAL REQUIREMENTS

The system functional requirements are described according to their priority. The priority value (high, medium, or low) will be indicated at the end of each requirement description between round brackets.

A. Hardware Requirements (High Priority)

- The system requires the usage of RF (Radio Frequency) active readers with an omni-directional antenna that provides a circular coverage area of at least 30 meters, or uni-directional antenna that provides a straight coverage area of 100 meters.
- The system requires the usage of RF active readers able to communicate with the main station using 3 different communication mediums: serial cable, LAN cable, and WLAN antenna.
- The system requires the usage of RF active tags with a built-in battery.
- The system requires the usage of RF active tags that are neither affected by the human body temperature nor the human body water.

B. Readings and Measurements (High Priority)

The system shall be able to provide the user with the following information, at any time, when required:

- Reader ID and Tag ID, detected at anytime by any reader.

C. Detecting the Child (High Priority)

The system shall be able to detect the child if s/he is in the coverage area of a reader.

D. Interface Requirements (High Priority)

- The system shall have an Application Programming Interface that will open the serial port between the reader and the PC.
- The system shall have an Application Programming Interface that will enable readers and will enable tags.
- The system shall contain a graphical user interface that will allow the user to monitor the covered area

E. Adding new user (High priority)

- The system shall be able to add a new user to the system.
- The user shall be able to specify the new user's name, his middle name, last name, age and his parent's phone name.
- The system shall be able to assign a new tag number to the new user from the pool of unassigned tag numbers.

F. Deleting user (High priority)

- The system shall be able to delete a user from the system by specifying his tag number.

G. Display Child's location (High priority)

- The system shall be able to state whether the child is in the coverage area of one of the readers or not.
- The system shall be able to state whether the child is in the area covered by two readers or more.
- The system shall be able to mention which reader(s) detected the child.

H. Tracing route (Low priority)

- The system shall be able to show the route taken by the child by plotting the last detected positions and connecting them.

In addition to the above functional requirements, non-functional requirements such as system, process and external requirements were studied and have been taken into account.

III. System Harware Archeticture

To satisfy the above system functional and non-functional requirements, the RFID tag and tag reader were selected. The wireless access point that links the tag reader with the monitoring station and database server were also selected. Figure 1 shows the system hardware architecture. Multiple tag readers were added to enable the system track the child while s/he is on the move.

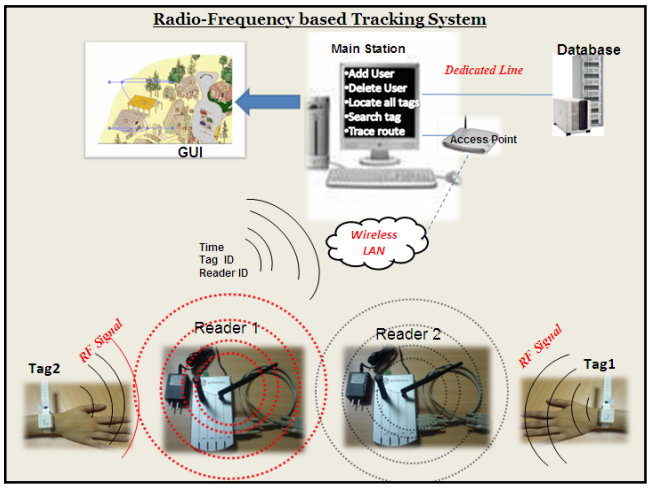

Figure 1: Hardware Architecture

IV. Software Archticutre

The software architecture is designed as modules namely: communication, API, user visualization, and database module. The function of each module is summarized as follows:

- Communication module that handles all the communication fuctions that are done at the Master side. It utlizes the a wirless access point and it performs the following functions:

  - *Analyze the connection between the Station and the reader (Master and Slave)*
  - *Prepare the station(Master) packets (command)*
  - *Send the packets (command)*
  - *Receive the reader (Slave) packets (responds)*
  - *Analyze the reader (Slave) packets (responds)*
  - *Update the database.*

- The module functions at the reader (Slave) side performs the following:
  - *Prepare the slave packet (commands)*
  - *Send Packet (commands)*
  - *Receive tags Packet (responds)*
  - *Analyze tags Packets (responds)*
  - *Receive station (Master) Packet (commands)*
  - *Analyze reader (Master) Packet command and act.*

- Dedicated line communication over the access point performs the following:
  - *Prepare the reader (Slave) packets (responds)*
  - *Send Packets (responds) to the station (Master)*
  - *Send Packets (commands) to the tags*
  - *Receive station (Master) Packets (commands)*
  - *Receive tags Packets (responds)*
  - *Analyze reader (Master) Packet (commands)*
  - *Analyze tags Packets (responds)*

- Application Programming Interface (API): a software that handles data and analyzes the readings performing the following functions:
  - *Enable and disable tags.*
  - *Trend Analysis Software: a software that handles data and analyzes the readings performing the following.*
  - *Get the status of the tags.*

- User Visualization Software: Visualization software that communicates with the communication driver embedded within and shows the data in a visual format in real-time every single click on any button.
  - *Show the information of the tags that the user gathered from the database.*
  - *Plot the specific tags on the map as different colored points.*
  - *Trace the route of specific tags on the map of the place as different colors lines with flags showing the information of the tag user.*

- Database: Oracle Database that saves all readings and information in tables and queries for fast access. Seven main tables were developed to manage the system:
  - Tags Table, used to keep information about the tags *themselves*
  - *TagUser Table, used to keep information about the tag users*
  - *Readers Table, used to keep information about the readers and their location*
  - *Detects Table, used to keep information about the tags, their users and the times when they were detected.*
  - *Datasheet Table, used to keep track of location for each tag using RSSI*
  - *Exdatasheet Table, used for overlapping scenario*
  - *RSSITable Table, used to keep the RSSI values for each tag.*

V. System Implemeation and Testing

The system is designed to track kids in public parks, playgrounds, shopping centers, etc. It was assumed that the system is to be used it to track kid's mobility in Dubai Global Village which is an international exhibition attracting people from many countries. Families with their kids visit the village at scale of 40000 to 50000 visitors per day. The village security office receives hundreds of lost kid cases on a daily basis. Given the large size of the park, the security officers find a hard time locating the lost kids.

The system operates by initially having each parent fill an application form with the kid's details such as name, age and parent's phone number at the park entrance. The kid's information is entered into the database and the kid is given an RFID tag to wear through-out his stay at the park. The parent can leave his/her ID as a temporary deposit for the RFID tag. Note that the security officer enters the RFID tag number in the kid's profile that's stored in the system database.

Wireless RFID readers are installed around the village. Once the parents lose their kid, they have to report it to the master station (or any security station). The tag number corresponding to the kid is retrieved from the database and the tag-readers are asked to locate the lost kid. Note that the readers are continuously transmitting the locations of all kids in their surroundings. Each reader covers a radius of 30 meters. In order to be more accurate when locating the lost kid, we developed an advanced algorithm that can identify the kids position within a 10 meter range. The algorithm is based on three different methods: (1) Receive Signal Strength Indication (RSSI), (2) the time delay of a signal and (3) overlapping areas mechanism. We implemented and evaluated all three methods and concluded that the overlapping method is the most accurate.

An area of 105^2 meters was used to test the system. Two scenarios were tested using three and four readers, respectively. Figures 2 and 3 show the readers distribution.. It was found that the three-reader scenario accuracy is 75% whereas the four-reader scenario accuracy is 95%, therefore the four-reader scenario was adopted. It is worth mentioning that for testing purposes, the prototype is used the RS232 instead of wireless access point.

VI. Conculsions

An RFID based kids tracking system was developed and tested. Results show that the overlapping method accurate. It is recommended that the system be tested in the real park.

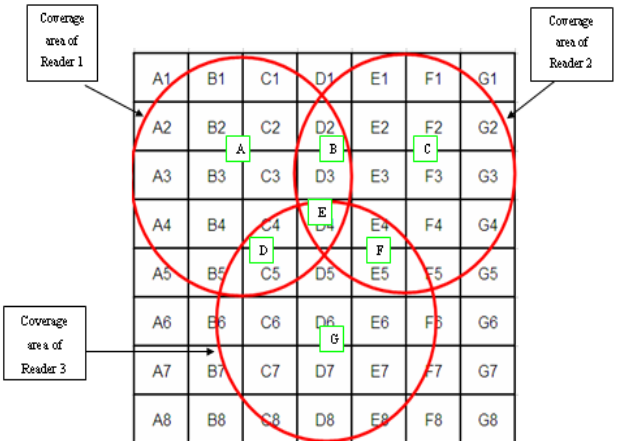

Figure 2. Three reader arrangement

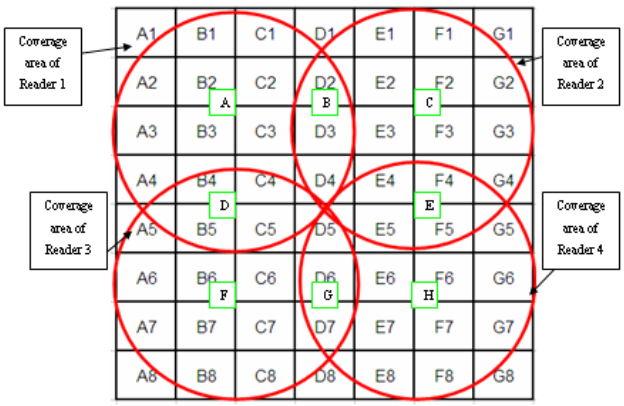

Figure 3. Three reader arrangement

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