International Journal of Research in Advent Technology (E-ISSN: 2321-9637) Special Issue
National Conference "NCPCI-2016", 19 March 2016
Available online at www.ijrat.org

Smart Objects: Indoor Positioning using RFID

Ashwin Shukla[1], Vineet Sinha[2], Ayush Solanki[3], Vishal Tripathi[4] and Dr. Kailas Patil[5]
Department of Computer Engineering, VIIT, Pune, India[1,2,3,4],Savitribai Phule Pune University[1,2,3,4]
Dean, R &D, Vishwakarma Institue of Information Technology (VIIT), Pune, India[5]
Email: shuklashwin@gmail.com[1],vinssins09@gmail.com[2]

Abstract-We keep misplacing things that we use in our day-to-day life, like watch, keys, spectacles, important documents etc. It can be difficult to locate them in time. The aim of this paper is to create smart objects that communicate unobtrusively and give their locations to the user whenever requested. Objects are embedded with smart RFID tags. The RFID tags can provide their approximate location to the user. The first objective of the paper is to create a location sensing system based on RFID tags and wireless communication infrastructure. The second objective is to design and implement an efficient power management algorithm. A sleep-wake scheduling algorithm is designed to ensure efficient power management of the devices. We have also performed a location awareness proof of concept test to analyze the viability of the approach.

Index Terms-Pervasive Computing, RFID, Object Tracking, Indoor Positioning.

1. INTRODUCTION

There are few facts regarding people misplacing their stuff on a daily basis. On an average, we spend 6 minutes looking for our keys in the morning (IKEA). The average office employee spends 1.5 hours a day (6 weeks per year) looking for things (OrganizedWorld.com). The average American wastes 55 minutes a day (roughly 12 days a year) looking for things they own but can't find (Newsweek). Hence we propose a system that will help finding our daily use objects easily using a pervasive system environment and wireless communication.

2. BACKGROUND

2.1. *Motivation*

Elderly people keep misplacing objects of daily uses such as glasses, keys, etc. and it is very difficult for them to find such objects in time. Also, sometimes we need to keep track of some important documents lest misplacing them. There is a need to have a system that will enable us to sense the location of such - and similar - objects in the indoor environment.

2.2. *Observations*

The existing solutions in the field of object tracking and positioning include GPS, RFID, infrared, Bluetooth and wireless LAN [1],[2]. GPS is not useful in indoor positioning, owing to the problem of satellite penetration. Bluetooth is a mature technology, however Bluetooth tags have limitation in terms of range, power and data transfer rates. Also, Bluetooth tags are rather bulky in size. Infrared cannot penetrate through most obstacles and hence positioning a tag hidden behind or under a surface deems impossible in this case [3].

The proposed system uses a hybrid approach. It uses RFID to sense the location of objects in a room and the data is sent to a central node over Wi-Fi.

2.3. *Goal of Proposed Research Work*

Our goal is to create a location sensing system based on RFID tags and wireless communication infrastructure that communicate unobtrusively and give their locations to the users whenever requested. Objects are embedded with smart RFID tags which can provide their approximate location to the user.
We'll be looking forward to design and implement an efficient power management algorithm which will make the product last longer.

2.4. *Objectives of the Proposed Research Work*

Create a prototype of the system using Passive RFID Tags. Upon successful implementation, design an efficient power-management algorithm.

2.5. *Contributions*

(1) Develop a localization algorithm based on RSSI values obtained from individual RFID readers.
(2) Upon successful implementation, design an efficient power-management algorithm.
(3) Provide a mathematical model for the placement of RFID readers based on the area of the room.

3. RELATED WORK

A lot of work has been done in the field of indoor positioning using RFID. We have studied a number of localization algorithms in this regard, and they can be classified in three families: distance estimation, scene analysis and proximity [4]. The distance estimation family of algorithms uses properties of triangles to estimate the target's location.

3.1. *Localization Techniques*

The triangulation approach consists of measuring the angle of incidence (or Angle of Arrival - AOA) of at least two reference points. The estimated position corresponds to the intersection of the lines defined by the angles. The range measurements techniques use Received Signal Strength (RSS), Time of Arrival (TOA), Time Difference of Arrival (TDOA), or Received Signal Phase (RSP). The scene analysis approach consists of two steps. First, information about the environment is collected and then, the target's location is estimated by matching the online measurements with the environment. Two main techniques in this are: k-Nearest-Neighbour (kNN) and probabilistic methods. Proximity approach relies on dense deployment of antennae. When the target enters in the radio range of a single antenna, its location is assumed to be the same that this receiver. When more than one antenna detect the target, the target is assumed to be collocated with the one that receives the strongest signal.

Other approaches in this field include Bayesian localization algorithms [5] and Received Signal Strength factors [6].

The Bayesian Localization system supposes that a person equipped with an RFID-LPS device is located at an unknown position x, and receives RF signals in a given time interval. The goal is producing an optimal estimate x of the current position of the user from that information [5].

3.2. *Placement of Readers*

As observed in [6], four RFID readers are required for the system to work efficiently. Each of the four RFID readers will record the specific RSSI of the tag within a cell. An average value of a specific position point's RSSI to each of the four readers is calculated. The average RSSI is used to form a Look-Up Table (LUT). Upon completion of data collection and construction of the LUT, the system can be used to determine the position of the object affixed with a passive tag. Euclidean distance is employed to compare its average RSSI obtained from the four readers and the values in the LUT.

4. SYSTEM ARCHITECTURE

The proposed system architecture consists of three modules, namely, Gateway server, microcontroller and RFID reader module.

For our prototype, we have used EM-18 RFID reader module, which works on the High Frequency (HF) band (13.56 MHz), and Arduino UNO as the microcontroller. In the server gateway, we have used MySQL for an underlying database and XAMPP suite for network support.

The system application starts with the user requesting the location of a particular object from the Web UI provided by the server gateway.

The reader modules that sense the requested passive RFID tag in their range send the received signal values to a central server through Arduino. The central server then calculates the Received Signal Strength Indicator

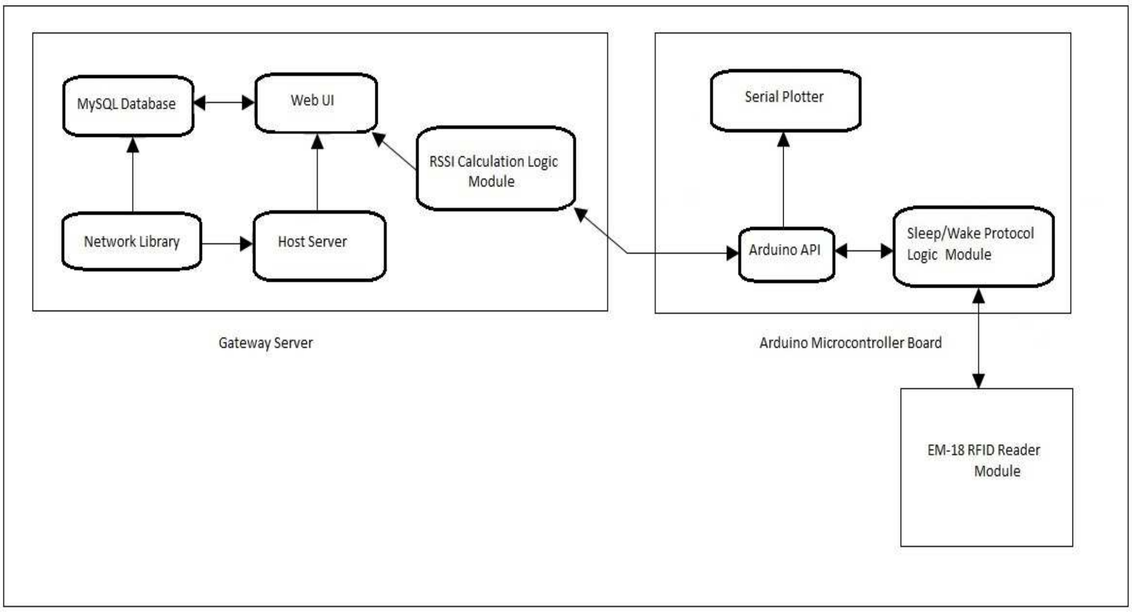

Fig. 1. System Design Architecture

(RSSI) and based on the generated RSSI value, returns the distance of the object from the reader.

The microcontroller regulates the power consumption by the reader module by implementing an efficient power management algorithm. This is done with the help of the Sleep/Wake Protocol Logic module. Under the algorithm, the reader module wakes up and senses the location of required object only when necessary and thus reduces unnecessary power consumption. Out of the Passive RFID power management protocols studied for this paper, we found that our proposed algorithm successfully reduces power consumption by a significant margin.

The server gateway is responsible for calculating the Received Signal Strength Indicator and hosting the Web UI. Whenever the user logs into the system, the gateway creates a secure tunnel between the server and the user's device. This addresses the issue of intrusion on the home Wi-Fi bandwidth. The gateway uses a database to verify the user identification and store the RSSI values.

The Web UI provides the user with a log-in screen, location of the object, and its approximate position in the room. It also provides the user with an inventory of available tags and the objects they are assigned to.

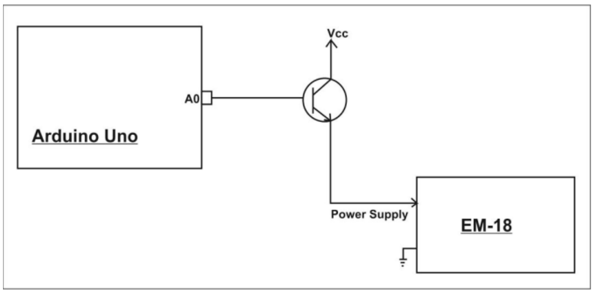

Fig. 2. Sleep and Wake Circuit Implementation Diagram

5. CONCLUSION

Thus, we conclude by saying that we have implemented an indoor positioning system using RFID and Wireless LAN, using which we can find the location of objects of our daily use as well as important documents. We have implemented a proof of concept model for the same, and have shown that the proposed system can be implemented on a full-scale using UHF RFID reader modules.

REFERENCES

[1] Mathieu Bouet, Aldri L dos Santos (2008): RFID Tags: Positioning Principles and Localization Techniques.
[2] Hakan Koyuncu and Shuang Hua Yang (2010): A Survey of Indoor Positioning and Object Locating Systems, International Journal of Computer Science and Network Security.
[3] Dr. Rainer Mautz(2002):Indoor positioning technologies, Technical report.
[4] Fernando Seco, Christian Plagemann, Antonio R Jimenez and Wolfram Burgard (2010): Improving RFID-based Indoor Positioning, International Conference on Indoor Positioning and Indoor Navigation (IPIN).
[5] S L Ting, S L Kwok, Albert H C Tsang and George T S Ho. (2000): The Study on Using Passive RFID tags for Indoor Positioning.
[6] Philipp Vorst, Jurgen Sommer, Christian Hoene, Patrick Schneider, Christian Weiss, Timo Schairer, Wolfgang Rosentiel, Andreas Zell and Carle Georg (2008): Indoor Positioning via Three Different RF Technologies.