Full-Scale Testing and Performance Evaluation of Passive RFID System for Positioning and Personal Mobility

Krishnaraj.D[1], Sathish.K.R[2], Tamilselvan.S[3],Kumarganesh.S[4]
UG (ECE) Students[1, 2 & 3], ASP[4], ECE, Paavai Engineering College

Abstract

The Location of a person in a bounded area can be attained by Wi-Fi Positioning System (WPS). WPS is used to identify the person or object which is equipped with inside the human habitation area using radio waves collected by smart devices. The proposed system focuses to track an individual person in an environment. The location of the person can be achieved by Radio Frequency Identification (RFID) transponders. The RFID trackers accomplish with the Unique Device Identification (UDI). The procedure is deployed using an RFID sensor based application which pinpoints the location of the personnel inside architectural frameworks. The position co-ordinates in the indoor area can be using the Wi-Fi technology. The mechanism is split into two sections - Data Collection and Position Identification. The data collection combines the location information acquired from the sensor technologies. The identification of an individual with RFID transponders which results in the tracking the person. The location information obtained from the sensors are without time constraints and is updated in the RFID readers and databases including the time when they read. Design and development of the application from connecting to the sensor devices, distance estimation between the sensor devices and the person, retrieval of the exact position information are deliberated. The mechanism of the finding location of a person is executed in with position estimation algorithm.

Keywords: *RFID, WPS, communication, GSM, spread spectrum, UDI.*

I. INTRODUCTION

Radio frequency (RF) technology is used in many different applications, ware houses, companies, educational institutions and automatic identification systems. RFID stands for radio frequency identification and describes the use of radio frequency signals to provide automatic identification. Unlike the electronic article surveillance (EAS) systems used for theft detection, RFID provides a unique serial number for identification of an object. RFID is used in the Mobile Speed pass system to pay for gas without going into the store, in automobile immobilizer systems to prevent theft by uniquely identifying a key with an embedded chip, in Fast Lane and E-Z Pass toll road systems to automatically pay tolls without stopping, in animal identification, in secure entry cards to secure access to buildings, and in the supply chain to manage the flow of pallets, cases, and items. RFID technology was invented in 1948, but it was not commercialized until the 1980s. One of its first known applications was during World War II, when it was used by the British radar system to differentiate between friendly and enemy aircraft with attached radio transponders.

Most media accounts of RFID are actually about one form of RFID, the electronic product code (EPC) system. Initially, RFID was being used to identify objects in the MIT robotics laboratory but was found to be useful for managing the supply chain. The electronic product code (EPC) was developed by the Auto-ID Center at MIT and is now being managed by EPCglobal Inc. EPCglobal Inc. is a nonprofit global standards organization commercializing the Electronic Product Code (EPC) and RFID worldwide. It is one important form of RFID used by retailers to manage the supply chain. EPC has standardized chip designs and protocols to enable the mass production of low-cost passive RFID tags in the 860-960 MHz range. EPC technology is more or less equal to the uniform product code (UPC) barcode identification used to provide information about the product to which the EPC tag is attached except that it can be read at a distance and does not require line-of-sight aiming like the barcode system. In this WPS replaces GPS technology in the indoor premises.

II. LITERATURE REVIEW

In this radio frequency identification(RFID) tag overcome the problem of existing intrusion RFID traces, this paper proposes a method of intrusion detection by combining the Markov chain technology and probability statistics technology[2]. We use this method to calculate the threshold that is used to determine whether the tag event is a cloning tag intrusion one. Current research focuses on RFID intrusion detection under the condition of complete RFID traces, such as encryption algorithm improvement, tag authentication protocol improvement, and track and trace technology in RFID supply chain. RFID traces are occasionally to be incomplete, which causes the above methods to be inefficient. Our method proposed in this paper is the solution to incomplete RFID traces which makes up for the study of RFID intrusion detection research.

Existing localization technologies face several challenges indoors because of their sensitivity to the environment. In this paper, we present an indoor localization system based on Low Frequency (LF) Radio-Frequency Identification (RFID) as a reliable and low-cost solution, which is less affected by challenging indoor conditions [3]. The presented system makes use of LF (125 kHz) magnetic fields for reliable localization in multipath and Non-Line-of-Sight (NLOS) environments. The objective of this paper is to analyze two-dimensional (2D) positioning estimation performance of LF-RFID based localization system in comparison with the localization systems based on Ultra-High-Frequency (UHF) and Ultra-Wideband (UWB) technologies. We present results for 2D localization tests for these three systems in a challenging indoor environment of area 315 square meters. The presented system, which is implemented using off-the-shelf components, achieves a mean positioning error of 1.53 m with a standard deviation of 0.91 m for 352 position estimations while keeping the positioning error below 2.82 m for 90% of the cases.

One of the main potentials for improved bulk reading speed in UHF RFID systems is collision recovery. Channel state information (CSI), which is difficult to achieve using existing UHF RFID standards [4]. In addition, these methods neglect the rate tolerance, i.e. the unknown bit-rate of the tag replies. In this paper we will show that this rate tolerance can be used for improving the performance of RFID readers. We also show that we can further improve the performance if we furthermore artificially stimulate this rate tolerance. Using our approach we also do not face the difficulty of unknown CSI. Our new approach is compatible with the existing EPCglobal Class-1 Gen-2 RFID standard. Simulation results indicate that the new approach is able to reduce the time for reading a bulk by 8% compared to a Maximum Likelihood (ML) receiver. Using additional rate tolerance stimulation, this gain increases up to 25%. Furthermore, we can easily combine our approach with multiple antennas for improved performance, without any significant effect on the complexity of our decoding algorithms.

Fall detection and remote health monitoring system of human can be analyzed by reading the human activities and recognizing by the passive RFID [7]. Existing system based on computer vision or wearable sensor technologies present several significant issues such as privacy (e.g., using video camera to monitor the elderly at home) and practicality but no more development in past years (e.g., not possible for an older person with dementia to remember wearing devices). In this paper, we present a low-cost, unobtrusive and robust system that supports independent living of older people. The system interprets what a person is doing by deciphering signal fluctuations using radio-frequency identification (RFID) technology and machine learning algorithms., we develop a compressive sensing, dictionary-based approach that can learn a set of compact and informative dictionaries of activities using an unsupervised subspace decomposition to deal with noisy, streaming, and unstable RFID signals. In particular, we devise a number of approaches to explore the properties of sparse coefficients of the learned dictionaries for fully utilizing the embodied discriminative information on the activity recognition task. Our approach achieves efficient and robust activity recognition via a more compact and robust representation of activities. Extensive experiments conducted in a real-life residential environment demonstrate that our proposed system offers a good overall performance and shows the promising practical potential to underpin the applications for the independent living of the elderly.

In many radio frequency identification (RFID) applications, one of the essential systematic functionalities is to quickly detect missing-tag event in case of misplacement or other incorrect operations [7]. Detecting the missing tags by anonymous multi-category RFID systems without revealing the tag privacy. The main objective is to minimize the detection time while satisfying the required detection reliability of each category. Firstly, we propose to use a multi-hash technique to sequentially detect the missing tags category-by-category, called Segmented Sequential Detection Approach (SSDA), in which the frame segmentation is adopted to reduce the detection time. Then, we propose an Enhanced Segmented Sequential Detection Approach (ESSDA) to further improve the detection efficiency by deactivating the identified existing tags. We conduct extensive simulations to illustrate the effectiveness of our proposed two missing tag detection approaches.

III. PROPOSED SYSTEM

Wi-Fi technology is linked to WPS to achieve the target location using RFID transmitters and Wi-Fi enabled RFID readers. The criteria of the proposed system are as follows .The person is equipped with an IEEE 802.11b RFID tag .The IEEE 802.11b tag will be recognized by the nearest Wi-Fi enabled RFID reader. The reader transmits the location information to the is mapped to the indoor map. The location co-ordinates are updated on the servers .Server updates the databases of the entity and can be accessed only be authorized end users.

A. RFID Transmitter

In the RFID transmitter section which it contains the tag, RFID reader, and controller and Wi-Fi module when the tag is read by the reader it sends the information to the local server where the server iswithin the range of Wi-Fi frequency. Where the functional block of the receiver section is shown in the figure.1.

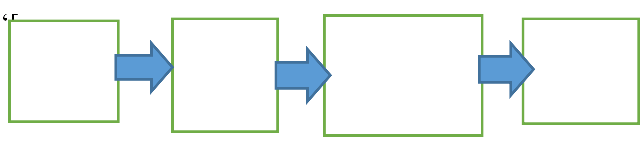

Figure.1.Block diagram of RFID transmitter.

PIC is a peripheral interface controller which it has a frequency range of 10 MHz with five ports, which it sends the information to the local server via Wi-Fi module, this controller has 33 pins for I/O port, 2pins for clock to speed up the process, one pin for Reset and 4 pins for power supply.

B. RFID Control section

RFID control section contains server with IP address, PC with local server and database which is updated by the controller. Where distance measurement is one of the parameter to find the location of the entity.

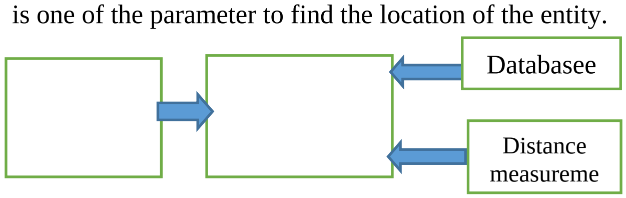

Figure.2. Block diagram of RFID control section

The functional diagram of the RFID control section is Figure 2,when the information of the tag which is updated to the server then it display in the local server in PC.we can also measure the distance of the person with help of database uploaded.

C. RFID

The tags, readers, communication protocols, computer networks, and databases are included in RFID. A typical RFID system being standardized by EPC global is shown in Figure.3. The tag is a miniature chip containing product information with an affixed radio antenna. The tag is attached to an item or its packaging and contains a unique serial number called an electronic product code (EPC). The EPC is used to uniquely identify the pallet, case, or item. For low-cost tags, a reader transmits a radio signal to the tags to energize them so that the tag can transmit its EPC. A reader can be either stationary in a fixed state or handheld. There are communication protocols that define the exchange of messages from the tag to reader and reader to tag. The readers are connected to a computer network so that they can be queried by a management system. Then the management system can query a database determined by the EPC to find out more information about the item to which the tag is attached.

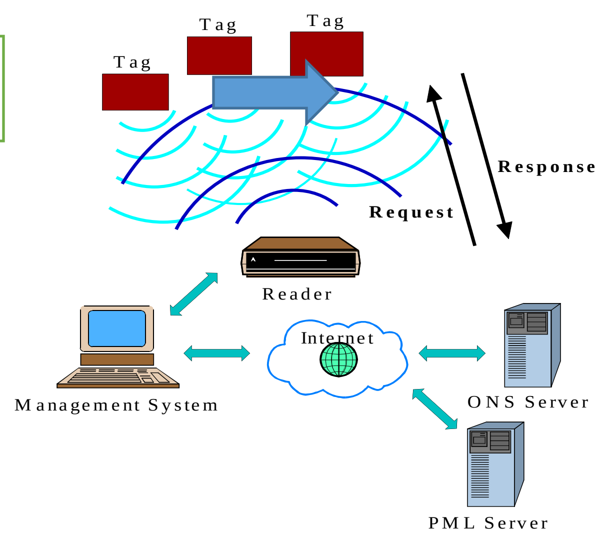

Figure.3.RFID system

A reader, also known as an interrogator, is a device used to query one or more tags within its range and communicate with them. It consists of one or more antennas that emit radio waves and receive signals from one or more tags. The reader sends a request as an interrogating signal for identification information to the tag. The tag wakes up and responds or broadcasts with the respective information by sending an encoded modified signal, which the reader decodes, forwarding it to the data processing device. A data processing device aggregates the information from multiple tags and processes data. It provides a distributed database of information about items identified by tags and is positioned between readers and enterprise applications. It can provide a variety of computational functions on behalf of applications. The EPCglobal and International Standards Organization (ISO) standardization groups have a standardized communication protocol stack for the physical and data link layers of the open systems interconnect (OSI) model between the readers and the tags. The data link layer includes the local wireless communication that occurs between a reader and the tags within its read field. The physical layer standard describes the specific radio frequencies and whether tags and readers are communicating in half or full duplex mode. EPCglobal has standards for systems operating in the high frequency (HF) band of 13.56 MHz and for the ultra-high frequency (UHF) bands from 860 to 960 MHz the focus in EPCglobal is the UHF band because it is used in the supply chain. Communications between readers and in-house or third party databases are not standardized, but determined by individual implementations. Inter-company communications are not standardized. Each company or organization uses EPC information service (IS) to communicate EPC related information with other organizations and business partners. EPC is a data repository used to store information about an item in the supply chain.

D. Tags

There are two broad categories of RFID tags: active and passive. The characteristics of active and passive tags are summarized in Table.1 each type will be described in separate sections.

Table: 1 Comparison of Passive and Active Tags

Characteristics	**Passive RFID Tag**	**Active RFID Tag**
Power Source	Provided by a reader	Inbuilt
Availability of power	Within the field of reader	Continuous
Signal Strength (Reader to Tag)	High	Low
Signal Strength (Tag to Reader)	Low	High
Communication range	< 3meters	>100 meters
Tag reads	< 20 moving tags @ 3mph in few seconds	>1000 moving tags @ 100mph in 1 sec
Memory	128 bytes	128 Kbytes
Applicability in supply chain	Applicable where tagged items movement is constrained	Applicable where tagged items movement is variable and unconstrained
Expense	$0.05	$10.00-$50.00

i. Active Tags

Active tags have their own transmitter and power source to transmit the information stored on the microchip. They operate at 455 MHz, 2.45 GHz, or 5.8 GHz, and they typically have a read range of 60 feet to 300 feet (20 meters to 100 meters). An active tag generally gives it a longer read range from the battery supply power. The tradeoff is greater size, greater cost, and a limited operational life that may yield a maximum of 10 years, depending upon operating temperatures and battery type.

Transponders and beacons are the two types of active tags. When the signal received from a reader the active transponders response. These are used in toll payment collection, checkpoint control and in tracking cargo. Depends on the range of reader only transponders conserve the life of the battery. Due to tracking of the precise location of an asset the beacons are mostly used in real –time locating system (RTLS). At the time pre-set intervals signals emits from the beacon with its unique identifier. It could be every three seconds or once a day, depending on how important it is to know the location of an asset at a particular moment in time. Active tags generally cost from $10 to $50, depending on the amount of memory, the battery life required, any on-board sensors, and the ruggedness. A thicker, more durable plastic housing increases the cost.

ii. Passive Tags

Passive tags do not have a power source, but simply reflect back or backscatter the energy coming from the reader antenna. Passive tags are consequently much lighter than active tags, less expensive, and offer a virtually unlimited operational lifetime. The tradeoff is that they have shorter read ranges than active tags and require a higher-powered reader. Passive tags operate at low, high, and ultra-high frequencies. Low-frequency systems generally operate at 124 kHz, 125 kHz or 135 kHz. High-frequency systems use 13.56 MHz Ultra-high frequency (UHF) systems operate at approximately 900 MHz and 2.45 GHz. The tags used in the supply chain operate between 860 and 960 MHz and are the most common.

E. RFID Frequencies

RFID systems operate on different frequencies depending on the application. Ten such frequencies are defined and are shown Table.2 Four classes of frequencies used in RFID system are: Low Frequency (LF) with frequency range of 30 KHz to 300 KHz, High Frequency (HF) with frequency range of 3MHz to 30MHz, Ultra High Frequency (UHF), and Microwave Frequency above 1 GHz. These frequencies have specific ranges known as industrial-scientific–medical (ISM) or short-range device (SRD) frequency ranges. RFID systems operate on different frequencies so they will not interfere with existing radio frequency systems.

Table: 2 RFID Frequency Ranges

Frequency Band	Description
< 135 KHz	Low frequency (LF)
6.765 – 6.795 MHz	High frequency (HF)
7.4 – 8.8 MHz	High frequency (HF)
13.553 – 13.567 MHz	High frequency (HF)
26.957 – 27. 283 MHz	High frequency (HF)
433 MHz	Ultra-high frequency (UHF)
868 – 870 MHz	Ultra-high frequency (UHF)
902 – 928 MHz	Ultra-high frequency (UHF)
2.4 – 2.483 GHz	Super-high frequency (SHF)
5.725 – 5.875 GHz	Super-high frequency (SHF)

F. RFID Reader

RFID tag with an information is obtained by reading with a device called (Radio frequency identification) RFID reader shown in Figure.3, which is used to track individual person's mobility and objects. Radio Frequency waves are used to transfer data from the tag to a reader. RFID tags are work within the frequency range of the reader, in order to be read. RFID technology useful to identify the single object or person in crowd or the object surrounded by several objects in a quickly and easy manner because of that tags enabled fast identification.

Figure.4.RFID Reader

G. Reader Anti-Collision Protocols

RFID systems of earlier applications had readers far apart, but applications of recent time like global supply chain have readers in close near vicinity that can interfere with the operations of other readers and cause reader collisions. The readers overlap and signals from readers interfere with one another occurs due to reader collision. Reader collision can be resolved by keeping the readers out of the read zone of the other readers. In addition, frequency division multiplexing (FDM) can be used. In FDM, different frequencies are assigned to readers over time so that no two readers can transmit at one time. But this technique can increase the duplicate reads of tags because tags having minimal functionality cannot differentiate among different readers. Therefore, some filtering mechanism is required by the management system to filter out the duplicate reads. An extra feature of sessions to provide multiple readers coordinated access to tags by EPC global class1generation-2 tags.

IV. DISTANCE ESTIMATION

The distance estimation is calculated using the Received Signal Strength Indicator. RSSI calculates the strength of one device communicating to another device. The signal strength is calculated in dB (decibels with power reference to mill watts). The value is measured between 0 to -120. The signal is stronger at 0 and very less at -120. IEEE 802.11b tags communicate to Wi-Fi enabled RFID readers in an indoor environment. The area is prone to be bounded with the intervention of walls and other objects. Due to the interference of the physical substances, the signal strength might differ from place to place. The calculation of the differing signal power can be accomplished with Free Space Path Loss (FSPL) technique. FSPL depends on two parameters namely - frequency of wireless signals and wireless transmission distance. FSPL can be calculated using the equation (1),

$$\text{FSPL (dB)} = 20 \log10 (d) + 20 \log10 (f) + K \quad (1)$$

The terminologies used in equation (1) are distance (d), frequency (f) and k (constant dependent on the distance between d and f). The equation (1) can be rewritten assuming distance (d) is calculated in kilometers (km) and frequency (f) is calculated in Megahertz (MHz).

FSPL (dB) = 20 log10 (d) + 20 log10 (f) + 32.44 (2)

Using the Fade Margin Equation, Free Space Path Loss can be calculated as

FSPL = Tx Power − Tx Cable Loss + Tx Antenna Gain −Rx Cable Loss − Rx Sensitivity − Fade Margin (3)

Combining equation (2) and (3),

FSPL can be rewritten as Distance (km) = 10 (FSPL − 32.44 − 20 log10 (f)) 20 (4) Fresnel Zone is the space around the visible Line of Sight (LoS) that radio signals are broad-casted after the signals leave the antenna. Fresnel zone is mandatory in Wi-Fi Location Positioning to estimate the distance of the IEEE 802.11b transponder and the middleware. About 60% of the area should be free from obstacles in order to estimate the distance accurately in Fresnel Zone. The loss will be shown in 20% of the Fresnel Zone blockage and the loss will be more significant above 40%. The value 32.44 is considered assuming the distance will be calculated in kilometers (kms) and frequency (f) is calculated in Megahertz (MHz)

Assuming with Fresnel Zone can be calculated with

FSPL r = 17.32 ∗ d /4f (5) The terms in equation (5) depict radius (r), distance (d) and frequency (f).

RSSI Distance estimation measurement at an unknown node (target) from a fixed position of an IEEE 802.11b RFID readers. The distance (d) is estimated from the RSSI using Log Normal Shadowing Model. The constant ranges from 0 to 5. The accuracy of critical (n) to the distance estimation is independent of the indoor location.

RSSI (d) = −10n log10 (d) − C (6)

The variables in the equation (6) are path loss exponent (n), environment constant (C).

V. RESULT & DISCUSSION

The positioning phase is retrieves the location of a particular tag on to the local server. The phase implements triangulation algorithm to pinpoint the location on server. The tag movements are determined using the IEEE 802.11b enabled RFID reader and plotted using the floor maps. The information is updated in databases of the entity. The authenticated end users can view the information. Tag is detected as it is enters the range area of the Wi-Fi Access Points. The tag can also be detected simultaneously by the multiple Access Points if the range is shared by numerous readers. In table 3 tabulated how fast the reader responsible when the tag is read ,where in the table 3 the processing time of the proposed system is also compared with the existing system ,so it shows that proposed will eliminate the time delay.

Table.3. Speed Performance

SYSTEM	PROCESSING TIME
Person.1	40
Person.2	45
Person.3	30
Person.4	24
Proposed system	15

The position is retrieved once in 5 seconds and previous location co-ordinates are checked. The table row is updated as the new position is traced. The table row is retained when there is no change in the location co-ordinates and the current time is updated. The map view of the simulation results positions the current location of the UDI of the Tag - 2F02035733139D4 on the radio map. The implementation of the triangulation algorithm is depicted on the indoor plan. The system performance which is compared with proposed system is shown in Figure.5

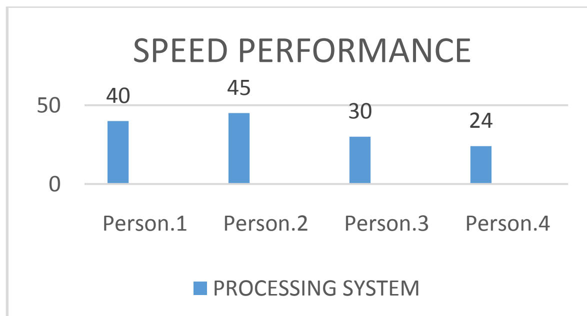

Figure.5.Speed Performance

After the tag is read the information update to the local server, the tag with unique identification code also enabled with the GSM module which sends message about the tag bearer where he is located. The simulation result of the system accuracy are saved in table view, where it is shown in the table.4,and also plotted the graph for the compared system accuracy with proposed system shown in the figure.6

Table.4.System Accuracy

SYSTEM	ACCURACY	
	LATITUDE	LONGITUDE
Person.1	13.0030590	77.699948
Person.2	13.0030590	76.994537
Person.3	13.0030590	77.748012
Person.4	13.0030590	77.699480
Proposed system	13.0030590	77.7006836

Using WPS in this system will enhance the accurate location of the persons where it will give the better results when compared with other system.

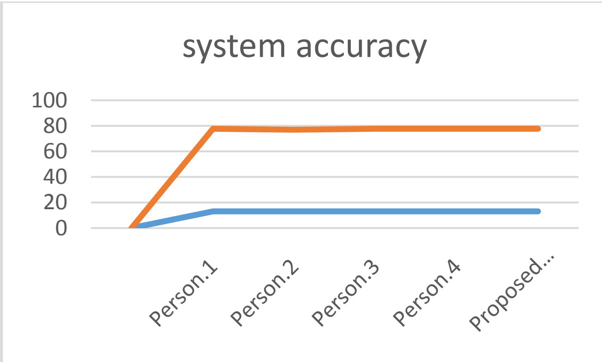

Figure.6.System accuracy

The multiple Wi-Fi Access Points nearest to the Tag - 2F02035733139D4 are retrieved using RSSI and distance relation algorithm. The map highlights the triangulation execution by the nearest Wi-Fi Access Points. The current location of the entity is pinpointed at the intersection point.

VI. CONCLUSION

The design and development of location identification using RFID with Wi-Fi Positioning Systems is an enhanced mechanism for tracing an individual in any indoor environment and outdoor. The method is developed using RFID transponder and IEEE 802.11b enabled RFID reader. The outcome of the RFID tag movements are displayed as the location and location co-ordinates on the radio map. The triangulation implemented. The server displays the locations elevated by the entity with latitude, longitude, date and time. The table is updated every five seconds. The authorized user is assisted with the location information of the entity from the current date and to the data of the last 6 months. The user can specify the date and time of a day to know the details of the specific object of the particular period. The time span can be specified but the limitation cannot exceed the last six months of the current date. The option 'Find by Particular Date 'can be employed by an end user to know where the entity was positioned at the said date. The technology can be exercised by anyone as the process is effortless, saves time and proves to be favorable to the human civilizations. Future work for this system is to reduce the size of the reader and sensing of the tag should be improved.

REFERENCES

[1] K. Deepika and J. Usha, "Investigations & implications on location tracking using RFID with Global Positioning Systems," 2016 3rd International Conference on Computer and Information Sciences (ICCOINS), Kuala Lumpur, Malaysia, 2016, pp. 242-247

[2] C. Senthil Kumar, Y. Raj Kumar,"Bus Embarking System for Visual Impaired People using Radio-Frequency Identification" International Journal of Electronics and Communication Engineering (SSRG - IJECE),Volume 4 Issue 4 2017.

[3] LI Peng1,2, WANG Zhen1, XU He1,2, ZHU Feng1,2 and WANG Ruchuan1,"Intrusion detection methods based on incomplete RFID traces"2017Chinese Journal of Electronics Vol.26, No.4, July

[4] Vighnesh Gharat1,2,3, Elizabeth Colin2 , Geneviève Baudoin1 , Damien Richard3 "Indoor Performance Analysis of LF-RFID based Positioning System: Comparison with UHF-RFID and UWB" 2017 International Conference on Indoor Positioning and Indoor Navigation (IPIN), 18-21 September 2017, Sapporo, Japan

[5] Shilpa Bhatt, Deepak Dhadwal, Ayush Bhatt,"RFID: Review & Comparison of Tree Based Tag Collision Resolution Algorithms",International Journal of Electronics and Communication Engineering (SSRG - IJECE),Volume 2 Issue 3 2015.

[6] Hamed Salah, Hazem A. Ahmed, Joerg Robert, Albert Heuberger Friedrich-Alexander "Multi-Antenna UHF RFID Reader Utilizing Stimulated Rate Tolerance"2017 IEEE Journal of Radio frequency identification.

[7] Nisha Singh , Nitika Sharma,"A Survey on Various Indoor Localization Techniques in Wireless Sensor Networks",International Journal of Computer & Organization Trends (IJCOT),Volume - 4 Issue - 5 2015.

[8] Vijaykumar V R, Member, IEEE, Raja Sekar S, Elango S and Ramakrishnan S "Implementation of 2n – 2 k -1 Modulo Adder Based RFID Mutual Authentication Protocol"2017 IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS

[9] Honglong Chen, Member, IEEE, Guolei Ma, Zhibo Wang, Member, IEEE, Feng Xia, Senior Member, IEEE, Jiguo Yu, Member, IEEE "Probabilistic Detection of Missing Tags for Anonymous Multi-Category RFID Systems"2017 IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY

[10] Lina Yao, Member, IEEE, Quan Z. Sheng, Member, IEEE, Xue Li, Tao Gu Senior Member, IEEE, Mingkui Tan, Member, IEEE, Xianzhi Wang, Member, IEEE, Sen Wang, and Wenjie Ruan "Compressive Representation for Device-Free Activity Recognition with Passive RFID Signal Strength "April 2017 IEEE TRANSACTIONS ON MOBILE COMPUTING.

[11] You Li, Yuan Zhuang, Haiyu Lan, Xiaoji Niu, Naser El-Sheimy, "A Profile-Matching Method for Wireless Positioning", Communications Letters IEEE, vol. 20, pp. 2514-2517, 2016, ISSN 1089-7798.

[12] H. Ryden, A. A. Zaidi, S. M. Razavi, F. Gunnarsson and I. Siomina, "Enhanced time of arrival estimation and quantization for positioning in LTE networks," 2016 IEEE 27th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC), Valencia, Spain, 2016, pp. 1-6.

[13] T. Nowak, M. Hartmann, L. Patino-Studencki and J. Thielecke, "Fundamental limits in RSSI-based direction-of-arrival estimation," 2016 13th Workshop on Positioning, Navigation and Communications (WPNC), Bremen, Germany, 2016, pp. 1-6. [5] Yuan Zhuang, You Li, Longning Q

[14] K. Deepika and J. Usha, "Identification of UHF Gen 2 RFID privacy and security issues," 2015 International Conference on Radar, Antenna, Microwave, Electronics and Telecommunications (ICRAMET), Bandung, 2015, pp. 82-86.