Optimization of RFID Real-time Locating System

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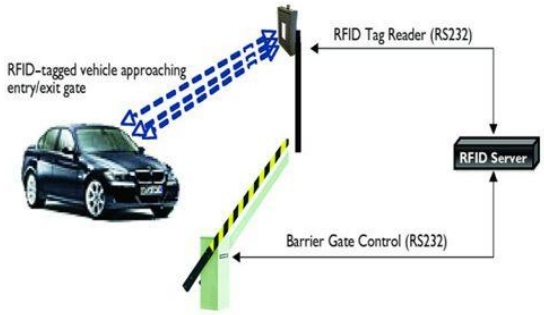
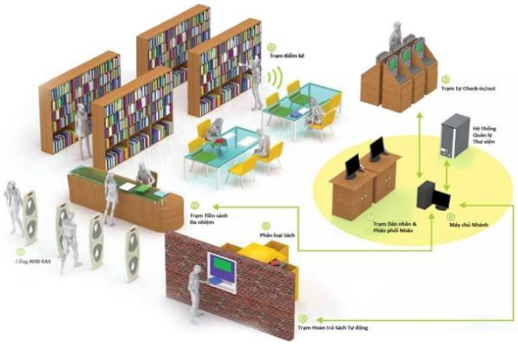
Abstract —Radio frequency identification (RFID) wireless technologyis used for tracking, locating and identifying items, person or an animal through radio waves without line of sight. Efficiency of RFID can be enhanced by integrating with wireless sensor network (WSN) and zigbee mesh network. Integrated system can get richer information of real-time locating system (RTLS) of items characteristics and sensing their environmental parameters like temperature, noise and humidity etc. The system make life easier at various fields. It can prevent theft of automobiles, tolls collection without stopping,tracking library books,no checkout lines at grocery stores, managing traffic and hospital system, tracking corporate campuses and airports, mobile asset tracking, warehousing, trackingmanufacturing, logistics and supply chain management.The proposed system optimized by using particle swarm optimization intelligence technique which solves the RFID network planning issues such as tag coverage, load balance, economic efficiency and interference between readers.RFID wireless integrated system increases productivity, accuracy and convenience in delivery of service in supply chain at optimum level.

Keywords:RFID, WSN,RTLSand Zigbee.

INTRODUCTION

Radio frequency identification (RFID) wireless technology is used for automatically tracking, locating or identifying the objects, person or an animal through radio waves without the need of line of sight. Its main advantages are; items can be tracked through human body, clothing and non-metallic materials also has ability to track moving objects. This technology has been used in various fields such as preventing theft of automobiles, tolls collection without stopping, no checkout lines at grocery stores, managing traffic, easy scanning to entrance in buildings, hospital management, animal tracking in farm management, automating parking, controlling access of vehicles to gated communities, corporate campuses and airports, mobile asset tracking, warehousing, providing ski lift access, tracking library books, manufacturing, logistics, and supply chain management etc [1] as shown in Fig. 1.RFID technology is superior to barcode technology because its user does not need to know where the object is and does not need to get close to scan it. Since tags can be read at a distance and do not require line-of-sight, they lend themselves to many more applications across the supply chain; which holds a promise of significantly improving business operational efficiencies and increasing the visibility of the business objects [2]. RFID tags are just high-tech and intelligent barcodes, attached to items to allow them to be tracked through the supply chain and makes life easier at supermarket checkouts [3].





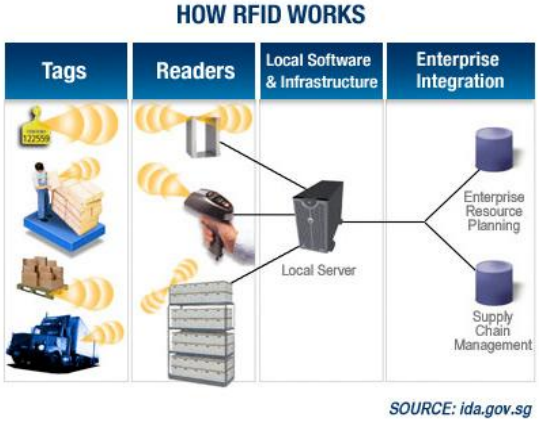


Fig. 1. Various RFID applications [35]

RFID tags talks to a networked system to track every product that you put in your shopping cart. Imagine going to the grocery store, filling up your cart and walking right out the door. No longer will you have to wait as someone scan each item in your cart once at a time. RFID tags will communicate wirelessly with an electronic reader that will detect every item in the cart and rings each up almost instantly. The reader connected to a large network that will send information of your products to the retailer and product manufacturers. The bank will then be notified and the amount of the bill will be deducted from the account. It results no lines, no waiting. The proposed integrated system can be used for identifying, sensing and real-time information exchange of items in various application areas such as manufacturing, logistics, asset tracking and supply chain management. The system gives richer information of item's identification, location and their environmental parameters like temperature, moisture content, noise and light etc.

RADIO FREQUENCY IDENTIFICATION (RFID)

Radio Frequency Identification (RFID) system was first developed in 1948 and it undergoes several development changes. Radio frequency identification (RFID) is the method of automatically tracking, locating or identifying people, animals or an objects through radio waves without line of sight in real time visibility of enterprise operations. The system works on different frequencies such as (LF, HF, UHF and Microwave) according the requirement. It has three basic components such as (tag, reader and middleware). It works as the RFID device "tag" is physically attached to the objects that is to be identified at later time. RFID reader transmit radio wave signals through their antenna, tags in the range of radio wave at a distance attached to the objects will transmit response back through their attached antenna to identify the object instantaneously, and then data transmit to communication infrastructure which updates the information of business software as shown in Fig. 2.[4]. RFID system is generally used in the indoor environment for various applications such as asset tracking, ticketing, logisticsas well as indoor positioning. It reduces out-of-stocks items by providing visibility into the location of goods with RFID tags [5].

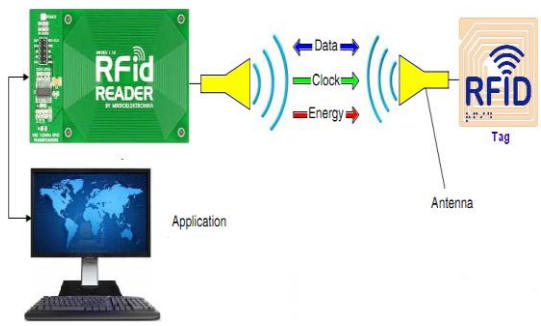


Fig. 2. RFID System [36]

Radio frequency identification (RFID) system components are described as follows.

Tag (transponder): It is a microprocessor chip consists of an integrated circuit with memory. It contains information about object could be (serial No; Model No; Date, size, color and price) for identification purpose and distinguish from others or to track the movement of object. It has unique identification EPC (Electronic Product Code) which sticks to a real world object [7]. It can be classified according three catagories.

1. *Accordign to design or technology:*RFID tagmay be passive, semi passive and active.
2. *According to memory:*It contains read only and other is read/write.
3. *According to method of communication between tag and reader:*It contains induction and other one is propagation.

Various tags according to different application requirements are shown in Fig. 3.

Fig. 3. RFID system components and their types[4]

Readers (interrogator/transceiver): It is the device which talks with tags. A reader may support one or more antennas; it can read and /or write data to an RFID tag. Its types are classified according to memory (read only, read-write) and by fixation (hand held, vehicle mounted, post mounted and hybrid) as shown in Fig. 3.

Communication infrastructure (Middleware): It includes the physical network communication technology, wired and /or wireless that carries and store data; it also has controller, sensor, enunciator, actuator, host and software system.

WIRELESS SENSOR NETWORKS

A wireless sensor network (WSN) consisting of a number of sensor nodes that can be arrange at various locations according to need e.g. on the Land, inside buildings, in the atmosphere, underground, under water, in automobiles, or even on human bodies. It has processing, sensing and communicating capabilities [8]. Sensor nodes working like small computers. Smart

sensor nodes are low power devices equipped with one or more sensors, a processor, memory, a power supply, a radio, and an actuator. A variety of mechanical, thermal, biological, chemical, optical, and magnetic sensors may be attached to the sensor node to measure properties of the environment like (pressure, temperature, sound and light etc). The size and cost of a sensor can vary depending on requirement of system and resources such as energy, memory, computational speed and bandwidth. A sensor network normally have ad-hoc network, forward data packets through the base station to the end user [9,10]. WSN nodes can deploy in remote and hostile regions. So the algorithms and protocols need to be robust and fault tolerant to maximize the life time of WSNs. Integrating RFID-WSN with zigbee and IOT; can track an object identification and provide richer information about the environmental parameters of objects, as well as their locations [11, 12, 13]. In addition, various types of WSN network available, such as ad-hoc, peer-to-peer, star, and mesh. The application domain depends upon its technical features including bandwidth, possible number of nodes, power usage and data transfer rate. RFID and WSN applications in supply chain management (SCM) have contributed to reduce inventory, business process, and reworks by improving the prevention of omissions and errors, and the timely exchange of information occurring through the whole SCM process that bridges from manufacturing to inventory, shipping, delivering, and installation.

ZIGBEE (WIRELESS MESH NETWORK)

Wireless communication technologies generally operate in frequency bands that are shared among several users, at different RF schemes. In particular for WiFi, Bluetooth, and more recently ZigBee [14]. These technologies are used to extend the range of RFID reader [15]. They all three operate in the unlicensed 2.4 GHz Industrial, Scientific and Medical (ISM) band [16, 17]. Table 1. Shows the comparison of wireless technologies [18].

Table 1.Comparison of wireless technologies

	ZigBee	Wi-Fi (802.11n)	Bluetooth
Data Rate	20,40 and 250 Kbps	up to 150Mbps	1Mbps
Range	10-3000m	70-250m	10-100m
Frequency	868MHz, 900-928MHz, 2.4GHz	2.4 & 5 GHz	2.4GHz
Complexity	Low	High	High
Battery Life (days)	100 to > 1000	1 to 5	1 to 7

ZigBee is well suited for WSN. It is used for locating, identifying and sensing objects in an indoor environments [19]. ZigBee used as the leading wirelessly networked, sensing and control standard for consumer, commercial and industrial areas. The communication can occur at 2.45 GHz with maximum air data rate of 250 Kbps. ZigBee is a very attractive technology for implementing low-cost, low-power consumption wireless control networks requiring high flexibility in node placement. IEEE 802.15.4 standard can benefit from an increasingly large wireless network built around the standard. IEEE 802.11 transmitters designated as WiFi transmitters they are now largely spread in both residential and office environments [20]. It is essential that those technologies coexist peacefully to allow each user of the band to fulfill its communication goals [21].Zigbee protocol IEEE 802.15.4 wireless mesh network integrated with active RFID system used for increasing the read range of tracking of RFID readers via mesh routing with zigbee coordinator through zigbee router, which allows data packets to travel across multiple nodes in a network to forward data from initial point to the end position to enhance the coverage of the RFID reader communication range; so that out of range items can be tracked easily without additional RFID readers [22, 23,24].Integrate RFID, Zigbee mesh network and WSN include various sensor node like (pressure, temperature, sound and light, infrared sensors, laser scanners and other information sensing device), according to the agreed protocol, objects connected to the Internet in order to achieve intelligently identifying, sensing, positioning and multi-hop communication and manage a network for information exchange [25].Internet of things (IOT) system develop an architecture platform as shown in Fig. 4, the system using RFID, ZigBee and WSN to establish the IOT. Information sent by each node to the key points of things and finally, computer display and update information about items identification, location and their characteristics [26].

RFID NETWORK PLANNING (RNP) OPTIMIZATION

In large-scale deployment environment, the RFID network planning (RNP) includes the set of objectives are tag coverage by readers, load balance on readers, economic efficiency and interference between readers.To solve the RFID network planning issues by controling the variables like coordinates of the readers, the number of the readers, and the antenna parameters setings of the system. The multi-dimensional nonlinear optimization problem with a large number of variables and uncertain parameters can be solved by the most successful nature inspired computation techniques includes evolutionary algorithm (EA) and swarm intelligence (SI). In this paper only particle swarm optimization intelligence technique used. Swarm intelligence is inspired by the collective behavior of social systems (such as fish schools, bird flocks and ant colonies), and has became an innovative computational way to solving hard optimization problems [27-32]. Currently, SI includes four different algorithms, namely particle swarm optimization (PSO), ant colony optimization (ACO), bacterial foraging algorithm (BFO) and artificial bee colony (ABC).

Integration of RFID with WSN and zigbee network also RNP according the following steps:

*First step:*RFID tags either active or passive or sensor attached with each item which needs to be tracked and update information of items in the tags memory.

Second step: PSO algorithm is used for solving RNP issues by optimizing the strategic location of RFID readers, number of redears and antenna parameters settings of each reader. Resulting the minimum number of readers at best locations identified which reduces the overall cost of the system.

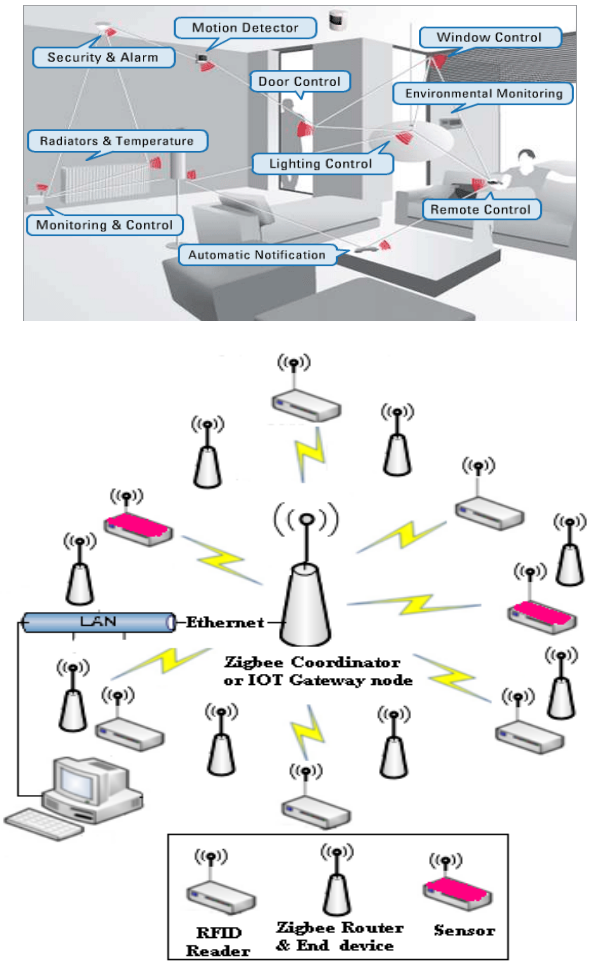


Fig. 4.Integrated system architecture

Third step: The RFID readers are equipped at each section or stage depending upon the proposed area and requirement as shown in Fig. 4.

*Fourth step:*ZigBee end node (module) attached with large-scale active RFID system based on multi-hop deployment using dual radio frequency to overcome the range of radio areas that do not reach signals from the RFID reader.

Fifth step: Wireless sensors are attached with RFID tags wherever required to monitor the parameters like temperature, light and humidity etc.

Sixth step: Finallythe RFID-WSN system is established and communicates by using ZigBee network. RFID reader located at each section of the proposed area communicates with the ZigBee coordinator through ZigBee routers. The routers also have RFID readers associated with it. The Fig. 4 shows the system which implements in all stages of the proposed area. ZigBee coordinator connected to the Ethernet interface link to LAN. The LAN is connected with computer software Labview GUI system which is used to update the real-time information of items identification, location and their environmental parameters like temperature, humidity, energy usage and noise etc [33, 34].

Benefits of the proposed system are to reduce inventory, costs, and waste also improve flow of production, save time and improve environmental performance at real-time information interchange.

CONCLUSIONS AND FUTURE WORK

By integrating RFID-WSN with zigbee wireless mesh network make our life easier. Integrated system have great potential to identify, locate and sensing the characteristics of items in the system at real time locating system (RTLS). RTLS reduce human error, optimize inventory management, increase productivity and information accuracy at indoor heterogeneous network. Moreover, the power consumption of the system has to be minimized to have a longer battery life. This is achieved by low power hardware design and minimizing the data transmission. The range of tracking of RFID reader can be enhanced with zigbee coordinator through zigbee router; so that out of range items can be tracked easily without additional RFID readers.

For Future work the Global Positioning System (GPS) integrated with the above system can monitor indoor as well as outdoor real time tracking, identifying and sensing with greater visibility also reduce the time span.

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