TRACKING OBJECTS USING RFID AND WIRELESS SENSOR NETWORKS

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Abstract

RFID (Radio Frequency Identification) and Wireless sensor network (WSN) are two important wireless technologies that have wide variety of applications and provide unlimited future potentials. RFID is used to detect presence and location of objects while WSN is used to sense and monitor the atmospheric environment. Integrating RFID with WSN not only provides identity and location of an object but also provides information regarding the condition of the object carrying the sensors enabled RFID tag. Radio frequency identification is another identification system that uses radio frequency for object and location identification. In recent days, RFID has provided cost effective solution for object identification in areas like parcel distribution, airline luggage identification, security enabled smart keys and etc. To identify a moving object within a wireless space that does not wireless capabilities, the only possible solution is to integrate wireless networks and RFID. Integrating these two technologies would provide low-cost solution for object identification and tracking for wide range of applications. RFID is a means of storing and retrieving data through electromagnetic transmission. It can be widely used in military, environmental monitoring and forecasting, healthcare, intelligent home, intelligent transport vehicles, warehouse management, and precision agriculture. This paper presents a brief introduction of RFID, WSN, and integration of WSN and RFID.

Keywords: *RFID, Wireless sensor, sensor network, object tracking.*

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1. INTRODUCTION

Radio frequency identification is another identification system that uses radio frequency for object and location identification. In recent days, RFID has provided cost effective solution for object identification in areas like parcel distribution, airline luggage identification, security enabled smart keys and etc. To identify a moving object within a wireless space that does not wireless capabilities, the only possible solution is to integrate wireless networks and RFID. At present, wireless sensor networks and radio frequency identification are both emerging technologies with great potential in seamless applications. Integrating these two technologies would provide low-cost solution for object identification and tracking for wide range of applications. RFID is a means of storing and retrieving data through electromagnetic transmission using an RF compatible integrated circuit. It is usually used to label and track items in supermarkets and manufactories. RFID systems consist of two main components: Tags and readers. A tag has an identification (ID) number and a memory that stores additional data such as manufacturer name, product type, and environmental factors such as temperature, humidity, etc. The reader is able to read and/or write data to tags via wireless transmissions. Sensor networks are widely employed in environment monitoring, biomedical observation, surveillance, security, etc. WSNs are different from RFID networks. WSNs are usually employed to monitor objects in interest areas or to sense atmospheric environments while RFID systems are used to detect presence and location of objects which have RFID tags.

2. WIRELESS SENSOR NETWORK

WSN is one of the most rapidly evolving R&D field for microelectronics. The sensor network is composed of large number of sensor nodes that can be deployed on the ground, in the air, in vehicle, inside building. A sink node aggregates some or all the information. Since sensor energy cannot support long range communication to reach a sink, multi-hop wireless connectivity is required to forward data to the remote sink. Each of the distributed sensor nodes has the capability to collect data, process them, and route them to sink node. Router nodes are deployed in sensor field to forward data from sensor nodes to remote sink node[1]. . It utilizes a component-based architecture that enables rapid implementation and innovation while minimizing code size as required by the memory constraints in sensor networks. It includes network protocols, distributed services, sensor drivers, and data acquisition tools. Sensing, computing, and communication can now be performed on a single chip, further reducing the cost and allowing deployment of large numbers of nodes. Available MEMS include pressure, temperature, humidity, strain gauge, and various piezo and capacitive transducers for proximity, position, velocity, and acceleration and vibration measurements.

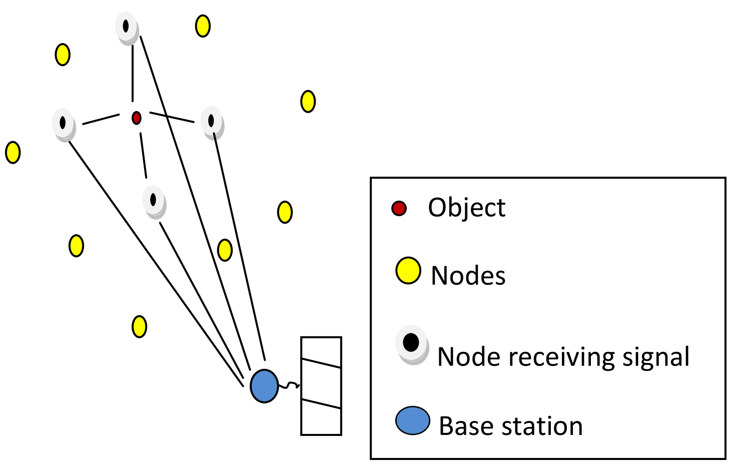


Fig-1: Locating objects in a Wireless Sensor Network [11]

The figure shows that the nodes will identify the objects which have RFID tags. All the nodes will send the information to the base station Power efficiency in WSN can be accomplished in three ways: low duty cycle operation, local/in-network processing to reduce data volume (transmission time), and multi-hop networking to reduce requirement for long range transmission since signal path loss is an inverse exponent with range or distance.

3. WIRELESS CONNECTIVITY

The major advantage of wireless connectivity over wire connections is that they offer more desirable features like easy installation, easy accessibility, enhanced user friendliness, and easy adding new devices to existing networks. Wi-Fi can support many devices (max. 128) within one network, can transmit data up to 30m distance, needs more power, and cost is more than Bluetooth or ZigBee. Bluetooth was developed as a wireless protocol for short-range communication in WPAN as a cable replacement for mobile devices. Bluetooth ends to be utilized for lower-end, cheaper product that works on low power and enables data up to the rate of 1Mb/s[2]. Its range is only 10m and it supports up to 8 devices. The search for cheaper system opened the door for new standard called ZigBee Standard. The name of ZigBee has come from domestic Honey Bee, which uses Zigzag type of dance to communicate. IEEE802.15.4 operates in 2.4GHz ISM band and support data rate up to 250kb/s at the ranges from 10 to 70m. ZigBee is designed to complement Bluetooth and Wi-Fi. It allows large number of nodes (more than 65,000). The application layer provides a framework for distributed application development and communication. Application layer deals with data gathering, information processing, etc. ZigBee is a low power network which can operate for years on a pair of AA batteries, short time delay (from the sleep state to wakeup state requires 15ms and to connect to a network needs 30ms)[3]. ZigBee could be used in light switches, heating, ventilation, air-conditioning, electrical, gas, and water metering, irrigation, industrial plants.

4. RFID TECHNOLOGY

RFID is an effective automatic identification technology for variety of objects. The most important functionality of RFID is the ability to track the location of the tagged item. Based on power source, RFID tags can be classified into three major categories: *active* tags, *passive* tags, and *semi-passive* (*semi-active*) tags. An active tag contains both a radio transceiver and a battery that is used to power the transceiver. A passive tag reflects the RF signal transmitted to it from a reader or a transceiver and adds information by modulating the reflected signal. The passive tag does not use any battery to boost the energy of the reflected signal. Every passive tag contains an antenna needed to collect electromagnetic energy in order to wake up the tag and to reflect (backscatter) the portion of the energy back to the reader. In addition, tags have transmitter/receiver circuits, power generating circuits and the state machine logic[4]. Similar to passive tags, semi-passive tags use the radio waves of senders as an energy source for their transmissions. However, a semi-passive tag may be equipped with batteries to maintain memory in the tags or power some additional functions. Active tags are more powerful than passive tags/semi-passive tags. RFID tags can also be classified into two categories: tags with read/write memory, and tags with read-only memory[5]. The tags with read/write memory are more expensive than the tags with read-only memory. RFID tags operate in three frequency ranges: low frequency (LF, 30–500kHz), high frequency (HF, 10–15MHz), and ultra high frequency (UHF, 850–950MHz, 2.4–2.5GHz, 5.8GHz).20 LF tags are less affected by the presence of fluids or metals when compared to the higher frequency tags. RFID is an effective automatic identification technology for variety of objects. The most important functionality of RFID is the ability to track the location of the tagged item. Based on power source, RFID tags can be classified into three major categories: *active* tags, *passive* tags, and *semi-passive* (*semi-active*) tags. An active tag contains both a radio transceiver and a battery that is used to power the transceiver. A passive tag reflects the RF signal transmitted to it from a reader or a transceiver and adds information by modulating the reflected signal. The passive tag does not use any battery to boost the energy of the reflected signal. Every passive tag contains an antenna needed to collect electromagnetic energy in order to wake up the tag and to reflect (backscatter) the portion of the energy back to the reader. In addition, tags have transmitter/receiver circuits, power generating circuits and the state machine logic. Similar to passive tags, semi-passive tags use the radio waves of senders as an energy source for their transmissions. However, a semi-passive tag may be equipped with batteries to maintain memory in the tags or power some additional functions. Active tags are more powerful than passive tags/semi-passive tags. RFID tags can also be classified into two categories: tags with read/write memory, and tags with read-only memory [5]. The tags with read/write memory are more expensive than the tags with read-only memory.

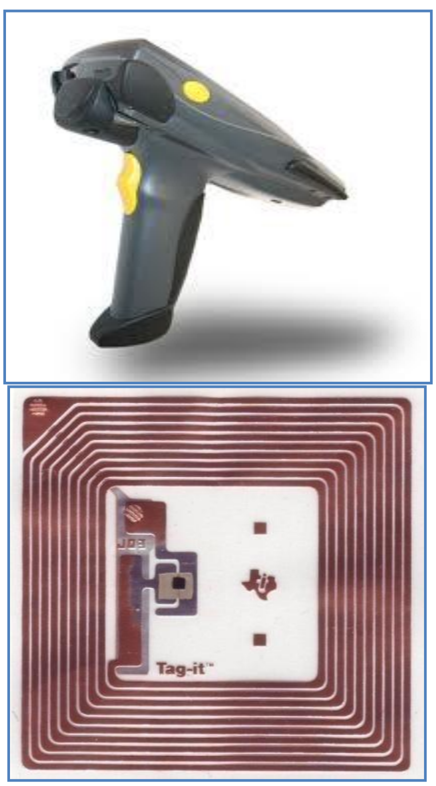


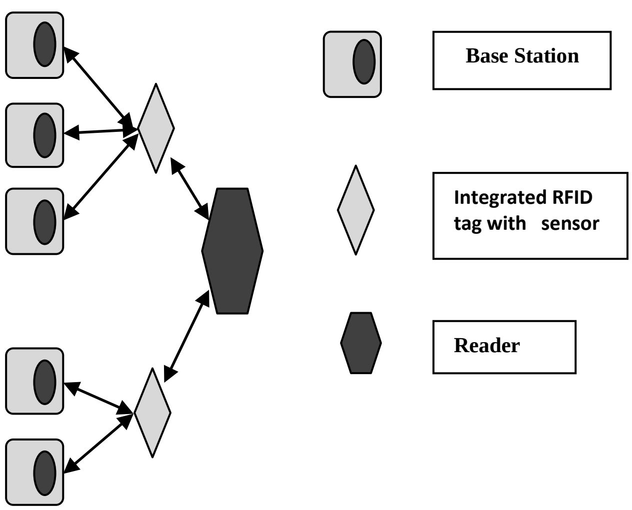
Fig-2: RFID Reader and RFID Tag[11]

The above figure shows the RFID reader and RFID tag. They are fast enough for most applications and are also cheaper than any of the higher frequency tags. However, low frequency tags have shorter reading ranges and low reading speeds. Typical applications of LF tags are access control, animal identification and inventory control. The most common frequencies used for LF tags are 125–134.2kHz and 140–148.5kHz. HF tags have medium transmission rates and ranges but are more expensive than LF tags. Typical applications of HF tags are access control and smart cards. RFID smart cards, working at 13.56MHz, are the most common members of this group. However, UHF tags are severely affected by fluids and metals. These properties make the UHF tags most appropriate in automated toll collection systems and railroad car monitoring systems. UHF tags are more expensive than any other tag. The typical frequency of UHF tags are 868MHz (Europe), 915MHz (USA), 950MHz (Japan), and 2.45GHz. Frequencies of LF and HF tags are license exempt and can be used worldwide while frequencies of UHF tags require a permit and differ from country to country. The active tag enables higher signal strength and extends communication range up to 100-200m. Active RFID tag is capable of two-way communication where a passive tag is read only. RFID reader is able to read and/or write data to tags via wireless transmission. RFID uses backscatter technique and operates in UHF band between 865-956MHz[6]. It allows range between 3-4m using 30cm long reader antenna and 10cm long tag antenna. RFID has been widely applied in supply chain tracking, retail stock management, tracking library books, parking access control, airlines luggage tracking, electronic security keys in cars, automatic toll collection, theft prevention, and healthcare.

5. INTEGRATION OF RFID WITH WSN

RFID systems and WSNs have extensively been used in the supply chain for inventory control, product tracking, and asset monitoring, while wireless sensor networks are used for space and environment monitoring. Nevertheless, the integration of RFID systems with sensor networks open new directions [9].

From the figure we can explain that the each rfid tag attached with WSN. The base station will communicate with the RFID tag, with the help of RFID reader. Furthermore, integrated RFID and WSN technologies allow for the automatic condition and tamper detection from a distance without direct and manual inspection in a convenient, inexpensive and less error prone way. RFID systems are able to accurately identify objects, but often sometimes provide unreliable information concerning the location of an object. Sensors on the other hand, present many advantages in recognizing the location of an object but they are unable to identify it. The efficient integration of RFID and WSNs offers great advantages in accurate location tracking. There is a great range of possible integration approaches of RFID and WSNs in the supply chain management. The proposed scheme integrates wireless sensor nodes and RFID readers. More precisely, a wireless sensor node is connected to a host (i.e. ordinary PC) in which an inventory of tagged products is maintained in a database. Another wireless sensor node is integrated in an RFID reader (reader node). A user of the host node is able to perform queries on the database which are later relayed to the reader node via the WSN[8]. The query is then transmitted to the RFID reader and the required data is retrieved. The communication is bidirectional. Thus, data can be sent from the reader to the host device using the same interface. The basic idea of integration of RFID with WSN is to connect the RFID reader to an RF transceiver, which has routing function and can forward information to and from other readers. Users are able to read tags from distance 100-200m that is well beyond normal range of readers. Integration of RFID and WSN can provide RFID to work in multi-hop to extend application of RFID to operate in a wider area.



6. CONCLUSION

Tracker has a lot of potential in helping facets of our personal and work environment. If we bring the RFID solution together with the WSN, it will open a gateway to many more applications. WSN with RFID solution can help provide safety to people and cargo. Along with this it will also help in increasing the efficiency of a system. RFID technology in combination with WSN has a promising future since reading range becomes much larger. It opens up a larger number of applications in which it is important to sense environmental conditions to obtain additional information about surrounding objects.

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