Emerging Applications in RFID Technology

Praharshin M. Senadeera\textsuperscript{1}, and Numan S. Dogan\textsuperscript{2}

Abstract—Radio Frequency Identification (RFID) is an emerging technology which has wide range of applications. This technology has helped to accelerate various processes in different industries, without the requirement of line of sight compared to the traditional bar-code technology. The latest technological developments in various industries have open new avenues to many new applications of RFID, should drive excellent growth through the end of this decade and beyond. This paper introduces the principles of RFID, and reviews the emerging applications of RFID.

Keywords—RFID, Tag, Antenna, on-chip antennas.

I. INTRODUCTION

Radio Frequency Identification (RFID) is a quickly growing technology which place an important role in identification such as health care, aviation industry, library shelf management, supply chain management, vehicle identification and weapon management[1-4]. Main vendor chains such as Wal-Mart and Target have mandated that all suppliers introduce RFID[5]. RFID is a term use in systems which transmit the ID of a particular object through wireless technology.

There are many advantages in RFID compared to bar code technology. One of the advantages is that the reader can read or write tags data without the line of sight. In addition the information of a tag can be rewritten, but it is unchangeable in the bar code system. Also the RFID reader has the ability to read multiple RFID tags simultaneously[6]. Compared to barcodes, RFID tags are applicable in insensitive environments, such as outdoors, higher temperatures and around chemicals [7-9].

In 1948 RFID work was published initially in a paper “Communication by Means of Reflected Power” by Harry Stockman. The progress of RFID was initiated in 1960s. The first US patent for an active RFID tag with rewriteable memory was received by Mario W. Cardullo in January 23, 1973[10, 11]. The major development of RFID came in 1970s and early 1980s. After this major expansion, researchers, developers and academic institutions including Los Alamos Scientific Laboratory and the Swedish Microwave Institute Foundation showed a greater extent of interest to RFID technology[12]. In this paper Section II & III present the RFID system, RFID frequencies and emerging technologies and trends in RFID. Finally Section IV presents the conclusion.

II. RFID SYSTEM

Typical RFID system is made of three major components: RF tag[13], RF antenna[14], and a RF reader. The functionality of the system is as follows. Initially, a signal of radiation is emitted from the RF antenna. The signal will be identified by a tag located in its coverage area. Then the tag’s internal chip retransmits a signal to the antenna[15].

A. Tag

The tag is also recognized as the transponder. The tag sends the unique ID and data to the reader for processing when the tag is interrogated by the reader. An integrated circuit (IC) is a common component in most of the tags [8]. Fig.1 shows a block diagram of a passive RFID tag.

![Fig.1 Block diagram of a passive RFID tag](image)

B. Antenna

The last component to integrate is the antenna in the RFID tag to develop a completely integrated single-chip wireless system. Antenna provides a way of communication and energy to correspond with the tag. It is very important for the communication of data between the reader and the tag. Block diagram of an Antenna is given in Fig.2.

Dr. Praharshin M. Senadeera\textsuperscript{1} is attached to the Department of Electrical and Electronics Engineering, University of Peradeniya, Peradeniya, Sri Lanka author’s e-mail: pmelaka@gmail.com

Professor Numan S. Dogan\textsuperscript{2} is attached to the Department of Electrical Engineering, North Carolina Agricultural and Technical State University, Greensboro, NC 27411 USA
C. Reader

RFID reader can write and read data in the RFID tag. The reader is also referred to as the interrogator. Another responsibility of the reader is to communicate with the host computer [17].

Electromagnetic energy is used as a medium for sending information in RFID technology. The two main elements of RFID system is the reader and the tag. These are connected to a host computer which controls the reader. The basic theory is that the reader retrieves data over the air from the RFID tag. [9]

The fundamental operation of RFID system the data transfer between a reader and a tag is shown in Fig.3.

The reader and the tag communication mainly depend on the application requirements such as the cost, size, speed, accuracy and the read range. One of the important parameters in an operation of the RFID tag is the operation frequency between the reader and the tag. This frequency selection depends on the relevant application requirement such as speed, accuracy, environmental situations, and specific applications standards and regulations [16].

Depending on powering techniques, RFID tags can be divided into two categories, passive or active. Since the passive tag do not have a battery it can communicate with the reader when sitting in an electromagnetic field only. However the active RFID tags consisting of a battery can power the integrated circuits and transmit the response signal to the reader.[6]

Brief explanation of types of RFID tag is given below. Active tags (battery-powered), semi-active tags, semi-passive tags (battery-assisted), and passive tags (battery-free)[4].

I. Active tag

A battery is essential for an active tag for its operation. It can supply power to sensor enabled RFID systems and supports longer communication distance because they have a dedicated power supply. Since these tags have an in-built battery they can respond to a weaker signal from the RFID reader. The main disadvantages of active tags are the short battery life, large volume, and high cost [9]. The range of active tag is of 300 meter from the reader.

II. Semi-active tag

The semi active tag consists of a small battery helps to keep the microchip alert to make a tag response quickly. The power supply to the semi-active tag is done by an internal battery which enables to operate the circuit of the microchip and to transmit a signal to the reader.

III. Semi-passive tag

The main difference between the Battery Assisted Passive (BAP) or the semi-passive tag and the passive tag is the BAP is able to provide a larger reading range and readability. The circuit of the microchip in the BAP tag powered by the battery reflects the radio waves generated by the reader whereas a passive tag uses some of the readers signal to power its microchip. The BAP tag reflects back more of the reader’s radio waves.

IV. Passive tag

RFID reader is responsible to power the passive tag. The advantage of the passive tag is that they can be manufactured at a very low cost than the battery powered tags because they do not require a battery. When the passive tag is within the radio frequency field, it’s power is supplied by the electromagnetic waves sent by the reader. The microchip can send back the information on the same wave when the power of the microchip meets the minimum voltage. The battery is not required for Passive tags to communicate with the reader because they use the transmitted power from the reader. The range of passive tag is about one meter.

III. RFID FREQUENCIES

Operating frequency of the reader and the tag is a very important aspect of an RFID system. Operating frequency defines the rate of data between the tag and the reader.

Lower operating frequency usually means slower data rate. Operating frequency also determines the tag size in addition to the data rate. As an example high operating frequency means smaller antenna and tag size. RFID operating frequencies mainly divided into three categories. They are namely, low frequency(LF), frequencies less than 125KHz, high frequency(HF), frequencies less than 13.56MHz, and ultra-high frequency(UHF), frequencies less than 900MHz)[16].

A. Emerging Technologies and Trends

The RFID users seek diverse characteristics of tags depending on their application especially cheaper tags than the existing ones and interoperability between systems.

RFID manufacturers tend to create products to fulfill the demands of consumers. Identification systems for the medical aviation, railway and shipping industry, animal identification, timing of sporting events, control of highway toll collection,
smart cards, vehicle identification, electronic shelf management in libraries, control of production lines, and food safety are some of the new developments that use RFID technology today.

- Health care and Pharmaceutical industry

Improve patient safety and decrease operational costs due to human errors are the main challenges hospitals are facing today. The deaths are between 44,000 and 98,000 deaths per year according to the estimation of The Institute of Medicine (IOM) and urgent need to improve the patient safety in U.S. hospitals[6].

One of the critical parts in healthcare is the Identification. It has a significant role such as patient identification, medicine identification, and different kind of devices, materials, equipment, objects and instruments need to be identified as well. Registration, tracking and monitoring are among many targets in healthcare that need identification. Identification errors in patients or drugs can lead to deadly accidents due to manual handling procedures. Therefore it is crucial to implement RFID technology in vital healthcare procedures [18].

The patients have a wide variety of benefits through RFID technology because it can be computerized in home care and improved procedures. It can also improve the hospital procedures that are currently carried out manually. Some of these procedures include advanced automatic databases and guide pathways.

RFID tags bring important benefits for the patients with special needs. It can be used to guide blind or visually impaired patients to protect them from accidents. RFID technology can be used effectively to alert emergencies during surgical procedures and blood transfusion.

RFID technology in management of Severe Acute Respiratory Syndrome (SARS) affected patients was tested in a hospital in Taiwan. They used the technology to locate and monitor such patients. When a new SARS infection occurred the Location based Medicare Service System (LBMS) also raised an alarm. Therefore the RFID technology plays an important role in healthcare industry to assure the safety of patients [18].

- Aviation industry

The aviation industry has been searching advanced methods for accurate baggage handling than the existing methods since 1999. The read accuracies of RFID tags are about 98 percent compared to 85 percent in barcode baggage tags[19].

One of the most important industries that need implementation of emerging RFID technology is the Aviation industry. Boeing and Airbus are looking for implementing RFID technology on commercial aircraft parts. RFID could provide major benefits for the entire aviation industry.

The traditional methods that airlines use to identify baggage are tags with a bar code, and baggage tags or stickers with a corresponding ticket issued to the passenger. At present the aviation industry uses RF reader and RF encoded baggage tags that are either attached to or made a central part of a passenger bag compared to the bar coded tickets.

RFID transponders are capable of tolerating rough environmental conditions in an airport and help in remote management of bag tags [7].

- Personal asset tracking

One of the emerging applications of RFID is tracking of personal belongings such as bags, keys, wallets, passports, jewelry, wrist watches, sunglasses, books, medicine, portable flash drives, mobile phones, PDAs, laptops, Ipads, mp3 players, calculators, etc. RFID tag can be attached to all these items separately. The owner can carry the reader which communicates with the tag attached to each personal item. The owner will be notified, when any of these items is out of range of the RFID reader [20].

This system will help people to secure their belongings. It will also help the owner to locate his/her items in the event of misplace or theft. The time stamp can provide the information of the lost item to the owner such as when the object was detected to be missing. The advantage of this personal identification system is that owner can finds the lost item right away if he/she realizes the alert immediately. On the other hand if the owner realizes the alert at a later time he/she has the facility to backtrack it.

- Smart cards

People identification and travel documents are the newest approaches of RFID technology. The disadvantages of this approach are the problems associated with privacy and security. The development of electronic passports, licenses and identification cards using the IC technology facilitate ample storage space, and computational power[21].

- Library shelf management

Library management system helps to track items in a library where there are large number of books, CD’s and others. It also helps to track new orders, bill paid and clients who have borrowed. This system is very important to a library to maintain a good coordination of all the details of items for better management of the library. The arrangement of the books on the shelves should be in order otherwise it will hard for the user to find require books.

RFID tag containing specific information can be attached to each and every book in a library. This system allows the reader to interrogate each book and notice the location of the book to the user. It will help to locate misplaced books [22].

- Supply chain management

Traditionally RFID systems are used in supply chain management where it is able to track and trace the product location at different points in the chain. When RFID tags are attached to products, they provide continuous tracking information throughout the supply chain. These capabilities of
RFID tags makes them much more popular candidates in supply chain management[23].

- Food safety

RFID technology can be used in diverse sectors in food industry including processing, storage and distribution. It also can be used to identify physical contamination of food items. This wireless sensor network technology coupled with RFID can be used to develop new RFID sensors which can be used in various food industries [8].

- Transportation

Primarily RFID tags are used to increase the number of transactions both in private and public sectors. Plastic cards embedded with RFID tags are used to replace the paper tickets. When a passenger enters a train, bus or a metro they are checked because their cards have a passive rewritable chip. Most of these cards have passive and partly rewritable chips[23]. At present in transportation industry RFID is used for electronic vehicle registration and identification, electronic toll collection and car parking etc.

- Vehicle identification

One of the emerging applications of RFID is the implementation of RFID System on Roads (RSR). It supports the future smart vehicles. RSR consists of RFID tags, RFID readers, Information Processing Units (IPU), and Information Sharing Units (ISU). RFID tags are contributed on road surfaces, and RFID readers are installed at vehicles. These smart vehicles obtain the information from implanted sensors and RFID tags, which will be processed by IPU and then broadcast to the other vehicles[24].

- Weapon management

For the management of weapons UHF band of RFID can be used. This reduces the wrong identification of the gun and minimizes the cost of registering and evaluating the use of a weapon and most significantly identifying a handgun without the line of sight[25].

IV. CONCLUSION

RFID technology is used in many industries such as medical, aviation, library shelf management, vehicle, animal, and personnel identification and weapon management. It is essential to improve research and development and implement RFID applications in fast growing markets. Limitations of current RFID tags should be identified in order to improve the technology and to fulfill the future expectations and challenges. This includes a development of new low cost smaller tags with on-chip antennas with small form factors. These new improvements will enable using RFID technology in emerging areas such as insect tracking. The realization of on-chip antennas on a single chip will improve the operating frequency of RFID tags to microwave and mm-wave ISM bands. Packaging and assembly costs will be reduced by developing single chip RFID tags resulting in small form factors. To meet the current demands of the emerging industries, the future research should direct towards developing and implementing low cost, smaller size and higher performance RFID tags.

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Praharsin M. Senadeera (M’13) Melaka
Senadeera was born in Kandy, Sri Lanka,
where he completed his elementary and
secondary education at Kingswood
College, Kandy. This author became a
member (M) of IEEE in 2013. Melaka has
received two Bachelor’s degrees in Sri
Lanka and USA of which the first one is in
Physical Science from the University of
Peradeniya, Sri Lanka, 1998 and the
second one is in Computer Science from
Wright State University, Dayton, Ohio,
USA, 2001. He earned his Master’s degree in Electrical Engineering from
Wright State University, USA in 2005.

Melaka worked as an Electrical Engineer in several companies in Sri
Lanka and USA including Tandon Lanka (Pvt) Ltd, Sri Lanka and M2Micro,
USA. He has also worked as a Java/XML/XSL developer at Bearing Point,
Fairfax, Virginia, USA and at Perot Systems, Fairfax, Virginia, USA.
Currently he is working as a Senior lecturer in Department of Electrical and
Electronics, University of Peradeniya, Sri Lanka.

Dr. Melaka received several scholar awards at North Carolina
Agricultural and Technical State University including the award for scholarly
accomplishment and academic excellence by the International Students and
Scholars Office (ISSO) consecutively from 2009 to 2012. He has been a
recipient of the Wadaran L. Kennedy 4.0 Scholars award granted by the
School of Graduate Studies in 2009, 2010 and 2011. Melaka is a member of
Phi Kappa Phi honor Society. Melaka presented his findings in a number of
national and international conferences. He has authored several scientific
papers which remain published in IEEE.