Survey Paper on RFID: Radio Frequency Identification

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Abstract – RFID (Radio Frequency Identification) is highly developing technology in new days. It is also known as "internet of things". Internet of Things is identified as one of the main pillars to next-generation Internet. Two technologies supporting this technological advancement are Radio Frequency Identification and Wireless Sensor Networks. They are used to automatically identify people, objects, and animals, as well as monitoring environmental parameters, and area monitoring. But in past years, RFID technology was not used that much because of lack of standardization and high costs. Latest technologies have brought costs down and standards are being developed. Today RFID is mostly used as a medium for numerous tasks including managing supply chains, tracking livestock, preventing counterfeiting, controlling building access, and supporting automated checkout. The use of RFID is limited by security concerns and delays in standardization. This paper describes RFID technology like how it works, its architecture, its applications in today's world and also comparison with the other identification technologies. It offers the promise of reduced labor levels, enhanced visibility, and improved inventory management. There are many types of tags and reader available in market for different types of applications. Because each tag has some strength and weakness. This paper describes the different types of RFID tags. RFID has many application in many fields like in retail industry, agriculture, vehicle management, underwater applications, healthcare, smart homes and for security and safety purpose etc.

Key Words: RFID, Tags, Readers, RFID applications, Reading range etc.

1. Introduction

RFID terms as Radio frequency identification, It is wireless communication technology. Radio waves are used to automatically identify, track, and authenticate items or people by the RFID technology. RFID not a new technology. RFID firstly used in world war 2nd to identify the friendly aircrafts. The name of the application used in World war 2nd was IFF (Identification Friend or Foe) [2]. But in the present days RFID technology used in new advancement with in many public or private sector. RFID is an automatic identification like smart cards, bar codes, and voice recognition etc. used in machines to identify objects. But unlike barcodes line of sight is not required for operation of RFID. So RFID is better than barcodes due to it has greater read range, large storage capacity, and capability to reprogrammable and without line of sight [1]. So RFID is a technology that using radio waves to transmits the identity of any object or item. This is the technology that automatically identify item, object or people and the capture information without data entry is store into computer. RFID technology is used over 60 year but its uses in industry and public sector from year 2003. Now these days RFID is used for many application like in retail industry, vehicle management, defence and agriculture etc. RFID is faster technology. RFID is well established and versatile technology. If the performance of RFID is considered then the main factor are fast identification, scalability, reliability etc. Because the RFID technology is used mainly in real time system and in real time system time, cost, memory and mobility is most important. So in real time system we can't ignore these factors. RFID used the term EPC (Electronic Product Code) that differentiate the one object from others. The EPC is the unique number and it stores the information about the object.

2. Brief History [3, 4, 5]

Decades	Events
1940-1950	Radar refined and used. Major Second World war development effort. RFID invented in 1948.
1950-1960	Start laboratory experiments and explorations of RFID technology. .
1960-1970	Development of the RFID theory and application field trials.
1970-1980	Explosion of RFID development. Test of RFID ace. Early adoptions of RFID implementations.
1980-1990	Commercial applications of RFID enter in mainstream.
1990-2000	Emergence of standards. Great advancements. Take part in daily life.
2000	RFID explosion continues.
2003	Establishing EPC
2005	Wal-Mart's RFID pilot

3. Basic Components of RFID

RFID basically has three main components. That is:

Fig. 1 Basic components of RFID

3.1) RFID Tags: RFID Tags are the building block of RFID technology. Tag component is emits the radio signals. RFID tags is combination of microchip and antenna. Each RFID tag is contains a unique identification number which is stored in the microchip of tag. This microchip is built with the integrated circuit, sensors, I/O ports and embedded logic on a silicon chip. Tags antenna is used to transmission of radio waves. Sometimes RFID tags is also known as transponder. RFID tags available in different shapes and sizes according to which environments and applications they will be used.
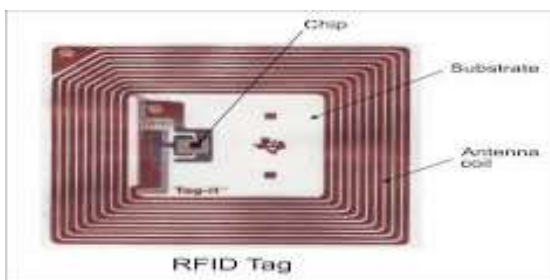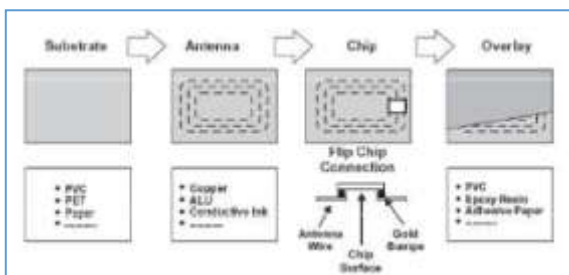

Fig. 2 RFID Tag

Fig. 3 Components of RFID tag

3.2) RFID Readers: RFID Readers act like the heart of the RFID technology. Reader is main component that is responsible for functioning and controlling the RFID system with particular frequency. Reader consists of an antenna, decoder and a transceiver. The transceiver used to receive the radio signal, then

decoder is used to decode the analog signal to digital form and antenna is used emit/picks radio signals. The reader range is depends upon the how much frequency is used, basically reader range is some inch to 200+ feet .After decodes the radio waves into bit stream, it gives the information to the host computer or device controller.

Handheld Reader   UHF Reader   Active Reader

Fig. 4 RFID readers

3.3) Host controller: Host computer is used to use the information for further processing or application depends upon which type for application it is used. Host also called system software that are combination of four components. That are:
Edge interface: Establish communication and retrieve data from reader is the responsibility of the edge interface.
Middleware: Filtering, counting of tags, controls and manage the reader is responsibility of the middleware.
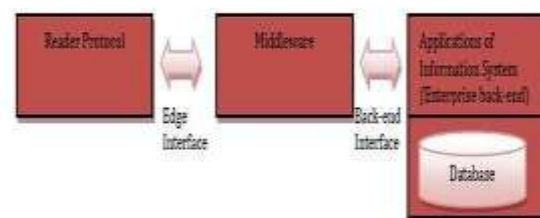Enterprise back end interface.
Enterprise back-end.

Fig. 5 Components of host

4. Functioning of RFID Technology

RFID is wireless technology that transmits the identification of any object using radio waves. So RFID tags is the device that emits the radio signals and the RFID reader picks these signals, convert into the bit stream and send to the host computer for further processing. The reading range of the reader is depends upon how much frequency are used for communication.
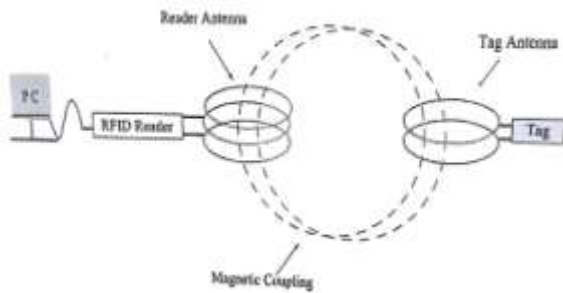
Fig. 6 Functioning of RFID

5. TYPES OF TAGS

Mainly three types of tags. That are:
- Active tags
- Passive tags
- Semi-passive tags

5.1) Active tags: Active tag has own power supply. Active tag used this power to integrated circuits and to transmit the data to the reader. Active tag has on-board electronics and antenna. Active tags are more expensive compared than passive tags. Its range is 10 to 100 meters.
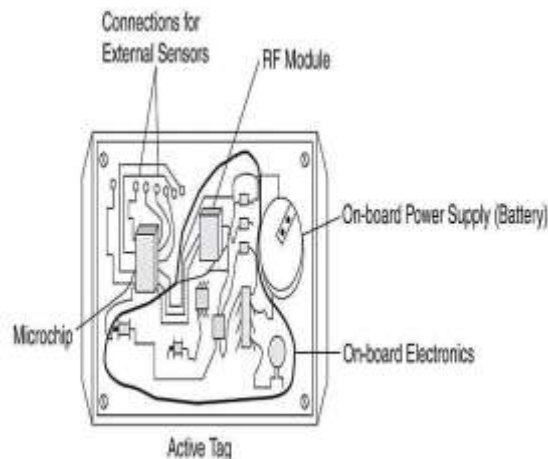

Fig. 7 Components of active tag

5.2) Passive tags: Passive tags has no internal battery power. The microchip of passive tag is sleep mode, until the tag is in the reader range. Reader sends the electromagnetic waves to wake up the microchip. So passive tag is sleep mode and active only when it comes into the reader range. Passive tag is less expensive compare then active tags. The range of the passive tag is just a meter.
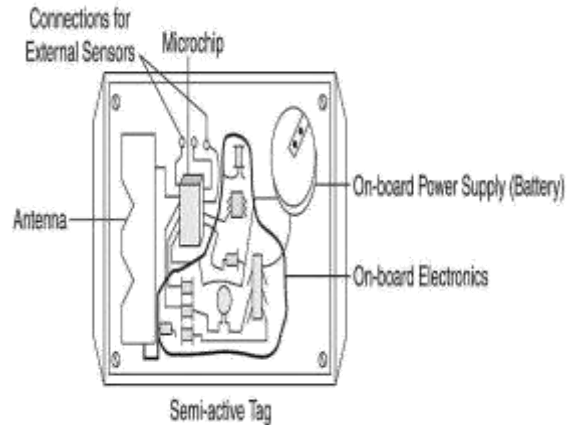

Fig. 8 Components of passive tag

5.3) Semi-passive tags: Semi-passive tags are lay between active and passive tags compared to both price and capabilities. It is term both as semi-passive or semi active tag. Semi-passive tags use a battery to power the signal, but only respond when they range of the reader. Thus provide the energy efficiency of the RFID system. In the end, semi-passive tags in the reader zone will not be continuously activated until their battery are exhausted.
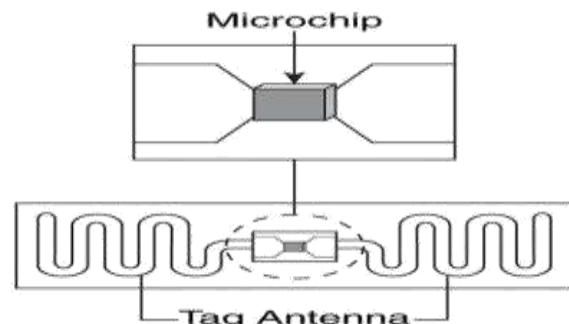

Fig. 9 Components of semi-passive/semi-active tag

6. Modes of Operation On RFID Tags

We can differentiate the tags using mode of operation. There are basic three types of operations that are performed on tags. That is follows:
- Read only tags
- Read/write tags
- WORM tags

6.1) Read only tags: Read only tags that only permit the permission to read the tag only. Because these tags are programmed that stored a unique identification number that only for read only purpose, it can't be changed. Read only tag are cost effective due to it uses less memory for storage.

6.2) Read/write tags: Read/write that gives the permission for both read and write operation when it

is in the reader range. Read/write tag contain the more memory in comparison than read only tags

6.3) WORM tags: WORM tags are WRITE ONCE READ MANY tags. We can say that it is write once and afterwards it becomes read only tags.

7. Some Terminology of RFID Technology

7.1) Different frequency ranges: RFID tags used different types of frequency bands according to which types of environment and application in it working. Because radio waves act differently at the different frequencies, so it is must require that choose the right frequency band for your application. Frequency refers to the size of the radio waves & it is used to communicate between RFID systems components. Basically it used four types of frequency bands.
That are follows:

➢ LF: Low Frequency.
➢ HF: High Frequency.
➢ UHF: Ultra High Frequency.
➢ MF: Microwave Frequency.

Low Frequency (LF): Low frequency is in between 125 -134.2 KHz. Mainly it is used by passive tag. The communication range is typically from 10 cm to 100 cm maximum. It is allowed field strength transmission power is 72dBμA/m maximum. It is mainly used in animal identification, food traceability, tree implant, item tracking application. LF performs better in liquids and underwater applications. But LF signals requirements long antennas and more costly the higher frequency bands.

High frequency (HF): Higher frequency is in 135.6 MHz frequency. Passive and semi passive tags both can use high frequency band. The communication range is 10 cm to 1.5 m. It is allowed field strength transmission power is 60dBμA/m. It is used mainly in temperature measuring, animal identification and cold chain tracking etc. applications. HF used shorter antennas compare than LW. But it has some limitations.

Ultra-high frequency (UHF): Ultra high frequency is in range 860 – 930MHz. It is mainly used by active tags. The communication range is from 3m to 10m. It is allowed field strength transmission is 10-100mW. It is mainly is used in farm machinery, intermodal transformation and crop monitoring. It is greater range compare than LF and HF. It is less problems with metal and liquids. But it has limited battery power

Microwave frequency (MF): Microwave frequency in 2.45 GHz. Microwave frequency covers the 10 meters distance. The capacity of data transfer of this specific frequency is up to 100 Kbits per second. Microwave frequency cannot penetrate water or metals. Applications area of microwave frequency in highway toll collection and in vehicle fleet identification.

7.2) Reading Range: Reading range of RFID system is depends upon many factor like the frequency bands, the size of antennas, power of the reader and which type of tag is used. When the lower frequency bands is used then the reading range is low. But higher frequency band gives the result, increase the reading range. Active tags have more reading range power in comparison with passive tags. But the higher frequency bands is not good for human health.

Hardware design is major factor of reading range of RFID system. It maximizing the reading range. So it is necessary that the hardware design is properly maintained. There are some hardware design factor that is responsible for reading range of reader.
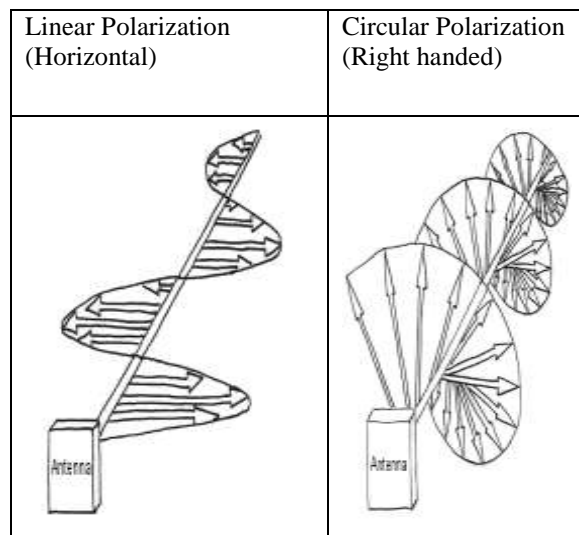That are following:

Linear Polarization (Horizontal)	Circular Polarization (Right handed)

Fig.10 Linear and Circular Polarization

Antenna Gain: If we are want to more reading range, use the higher gain antennas and if we want to short range, the lower antennas gain. One question about the short read range is arises in everyone mind that is: why would to want short reading range? The answer is sometimes the tags are nearly located to the reader and less is amount. So using this we want save the power of reader to accessing the tags.

Antenna Polarization: Polarization means that the type of electromagnetic field is generating by the antennas. Mainly two different types of polarization, linear polarization and circular polarization.

Linear polarization refers that radiation along a single plane, it may be horizontal or vertical. Fig: Polarization

But in the circular polarization the radiation power is splits into two axes and spins the field so as it is cover the many planes as it possible

Choice of the polarization is depends upon the plane type. Like if all the tags are in same plane and the same height, then the liner polarization is give better results. But if the tag orientation is different then consider the circular polarization system. Linear polarization is better than the circular polarization.

Tag size/orientation or angle/placement: The reading range of the reader is effects by the tag size, orientation and placement. The rule of thumb is that if tag is small the reading range is small and if the tag is large the reading range is also large. Its main reason is that every tag contain antenna so if the antenna is large it will broadcast the farther than small antenna. According to the tag orientation or angle, to get the best reading range make sure that each and every tag is fully facing the antenna when linear polarization is used. Tag placement refers that choose the right tag, according to the object type. Example some tag especially for metal objects and in liquid objects.

Reader Setting: It is the ability of RFID reader to control the how much power send through the cables of antennas. So check your reader sensitivity setting. Because lower sensitivity ignore the weaker signals thus result is decreased the read range. But max sensitivity take the weak signals so that reading range is increase. By default it is maximum. Lastly we can say that for quickest and easiest method to maximize the read range, it is necessary that reader is high sensitivity and contain full power.

Cable length, Adapter and Multiplexers: If we use the long cables for antennas than it lower the reading range. Also use of adapters and multiplexers insert the additional overhead of your RFID system. For maximize the read range it is ensure that, connect the antennas to the reader with shorter cables and we should avoid the use of extra adapters and multiplexers. If it is required the use of longer cables then ensure that only use of high rated and good quality cables.

Environmental factors: Environmental factors also effects the reading range of the reader like rain, dust particles, metal, florescent lighting and water etc.

7.3) Selection of reader: Reader is the brain of the RFID system. It is very important to select the right RFID reader because each reader has its unique features. When we select a RFID reader considered these features. Here I discuss three main factors about selection of reader. That are following:

Region of operation: Each country has its own rules and standards. So it will be necessary to select the RFID reader that operate within the bound of country boundation and standards. Otherwise it will be the violation of the rules of the country.

Antenna ports: The numbers of the read points requirement is depends upon the application. The amount of the antennas is directly depends upon the number of antennas that a reader can be support. So in selection process of reader the reader ports is considered. Reader typically in 2-port, 4-port and 8-port. But sometimes using the multiplexers, the reader ability to extend up to 32 RFID antennas.

Method of Communication: Sometimes if the application does not require the need to be placed on a network, then if directly connect to the host computer via an: RS-232 cable, Ethernet cable and USB cable.
If the application requires the networks, then the Ethernet or Wi-Fi can be used. So using these two method of communication is used and the collected information is accessed by the host software. Second method is cost effective.

8. Application of RFID Technology

Now these days, RFID technology used in daily life. Some applications are following.

8.1) RFID System in Smart homes: Now these days RFID technology used in smart homes [6]. In RFID homes, RFID used to locating the missing items of homes, identify and check validity of the person which enters in the home, lighting control for when person enters in the room light is on and when he exit lights automatically off. Due to this wastage of energy is minimum. RFID homes have also personalized music system like when person enter in room music is on and when he exit that room and enters in other room same track is running without pausing it from same position. RFID system also used for security and safety purpose.

8.2) RFID system in Agriculture: It is no doubt that agriculture is the soul of the any country. Agriculture is the base point of the life. So now these days advancement also in the field of agriculture [6, 7]. RFID, sensor and their networks play the important role in the area of agriculture [8, 9]. In the field of agriculture it contributes as Precision agriculture (PA), Variable Rate Technology (VRT), Precision Framing, Global Position System Agriculture, Information Intensive Agriculture, Agriculture Site Specific Crop Management, Framing by inch [10]. Some applications area also are: animal identification and tracking [11] and viticulture.

8.3) RFID system in Healthcare: RFID used in medical as it used to identify patients or drugs, monitor blood preservations or for medical communication [6, 12, 13, 14, 15]. RFID integration with sensors networks used in body area also refers as Body Sensor Networks. Sensor are used to measure blood pressure, body temperature, breathing activity etc. RFID system also identify the patient and staff record and also used for information about items and equipment used in hospital. Example some hospital the put the RFID tag on new born baby to uniquely identify, safety and security purpose. This alert the hospital, if any unauthorized person attempt to take the baby outside of the hospital. RFID technology very helpful to the visually impaired people to unfamiliar public locations, paths and destinations [12].

8.4) RFID System in Retail Industry: RFID technology play a very important for retail industry [14]. Some area where RFID mainly used are supply chain management, tracking objects and security in retail industry.

In supply chain management, RFID used from supplier to the customer delivery. From supplier RFID system give the information about how many productions is needed, then products distribute to the retailer and from retailer it distribute to the shopping malls etc. In this process RFID maintain the record about each product like how many items are produced, how many sold, which items near to expire, any item contain discount or not, product name, company, and weight etc. Using RFID tech in retail industry provides many advantages like lower labor requirement, lower chance of out of stock, faster payments, faster checkouts, better information and reduced inventory requirement.

Mainly RFID replace the bar code system which scan the each and every product and then provide the bill. In some situations when thousands of peoples in malls, and each people purchase hundreds of items, bar codes system is very time consuming and tedious task. Because RFID technology not use the concept the light of sight.

Security provide the better mechanism to handle the theft in malls. Using RFID technology there are the minimum chance to theft in the malls.

8.5) RFID System for Security and safety purpose: Now these days security and personal identification is very important and necessary for many organizations. A main benefit of RFID technology is the identification cards to control the building access [14]. Many organization used the RFID tags embedded in the ID cards, which ensure the validity of the person for the entrance. Using the RFID cards it is easy to record the person identification, information about the exit time and presence of the

particular area of building. Now days some country also used the e-passport and National cards using RFID.

8.6) RFID System in Vehicle management: RFID technology is also used in the vehicle management [17]. Now these days the RFID locking system. RFID locks the car with unique password which is not easy to crack. When any unauthorized key is used to unlock the car it gives the alarm and doesn't open. So therefore reducing the chance to stolen the vehicle. If any person successful to open the door, the car system is enough smart, it identify the vehicle is unlocked any unauthorized way, it automatically off the oil system of the car.

If vehicle and roads using the RFID technology, the accidents chance is low. Because when many vehicle is running on the highway, RFID system help the drivers to ensure their speed, positions and directions. So that the drivers limit the speed and direction to avoid the touching lane lines, road edge, center lines and maintain the distance from other vehicle on the road. RFID system also used the GPS so the traveller go through the shortest path so that time and money is not wasted.

8.7) RFID System in Railway: Using RFID technology in railway, the ticketing system be automated [18]. Because ordinary ticket can be fake ad use of paper, which is damage easily. So using RFID in railway, firstly all passengers have RFID cards, which contain the all information about the passenger like name, age, gender, photo, card id and credit balance. The checker have the card Reader to swipe the card and enter the destination code, so that the payable amount can be deduced from credit balance.

RFID System show the detail of arrival or departure information about the rains. RFID system also used to locate the position and location of trains, operation and maintenance, train axle temperature measurement, train inspection system, wagon monitoring system etc.

8.8) RFID system in underwater: RFID technology also used in underwater for animal tracking, pipeline monitoring used to carry oil. This system is used to monitor the condition of pipelines [19]. Navy also used RFID technology for the underwater navigation of the vehicle.

9. Comparison of RFID with Barcode

If we compare the RFID with other technologies that used for identification and data carrying purpose like barcodes. We observe that RFID technology is more efficient, with high data capacity, more robust and low cost.

Barcode is a system that scan the data of the item and identify it. Reading of the data lone of

sight is required. So it makes it the very time consuming system because when the thousands or more items, it is very time consuming and tedious task. But RFID system has higher range and better durability in comparison with barcode system. RFID tags also provide the facility Read/Write update of the items. So RFID system is more robust, reliable and with low cost.

10. Challenges and Limitations

- ➢ Harsh environments
- ➢ Collision problem
- ➢ Huge volumes of data
- ➢ Reading range
- ➢ Fault detection and isolation
- ➢ Physical limitations
- ➢ Lack of uniformity in global standards
- ➢ Cost
- ➢ Lack of skilled personnel

CONCLUSION

In this paper, RFID technology, its architecture and various applications has been analyzed. It is easy to enjoy the advantages of RFID, such as large memory space, long service life, because it is rewritable. It can also do a non-contact reading within a short time. All these features make RFID quite suitable for the management and operation of various application, such as RFID Tracking System for Vehicles, Safety Driving Support System and RFID system for security and safety purpose etc. The standardization of RFID is developing rapidly, and its practical applicability will surely give RFID a wider use in various applications.

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