IoT: Applications of RFID and Issues

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Abstract: - Radio Frequency Identification is assists computer based systems to identify various objects, record data and information and control them by using radio waves. RFID reader is connected to the Internet, which has the capabilities of identification, monitoring and tracking of tags attached with objects in real time. IoT and RFID are dependent upon each other as RFID is indispensable for IoT. I am going to discuss role of RFID technology into IoT. Later, I will discuss the most challenging issues RFID faces for implementation in IoT.

Keywords: - RFID, IoT, applications, issues, security, privacy

1 Introduction

RFID is self-regulating technology which is used for various systems to help them carry out their functions on the basis of objects identification, data recording and various objects controlling. An emblematic RFID systems consists of two parts: tags (transmitters/responders) and readers (transmitters/receivers). The tag contains a microchip which is attached to an object, under tracking, and it works as identifier of that object. On the other hand, RFID reader exchanges information with RFID tag regularly by using radio waves [1]. The biggest advantage of RFID technology is automatic object identification, data capturing and cost reduction across wide scale of business activities. The RFID technology had got momentum in the past decade due to the cost constraint in its implementation across variety of businesses. RFID will bring many opportunities which will innovate the entire world politically, economically and geographically. RFID readers, distributed throughout the world, follow correct routing protocols to connect to the Internet. After this, a reader can exchange information for identification, tracking and monitoring of objects on the basis of tags they carry. On the other hand, IoT means particular identifiable objects which we call “things” and their virtual presentation in IoT architecture. RFID is prerequisite for successful functioning of IoT systems. Objects in everyday life can be radio-tagged so that they could be identified and their information could be stored in real-time databases for research, analysis, planning and many more purposes[2].

2 IoT and RFID technology

2.1 Internet of Things

Internet of Things is worldwide infrastructure which would connect virtual and physical object, disregarding distance among them, on the basis of data exploitation and routing capabilities[3]. Typical services and required applications would be developed owing to object identification, sensors and their capabilities. Autonomous data capture, network connectivity, interoperability among devices, sensors and applications and event transfer are few of its benefits. IoT architecture is composed of three layers: service layer or application layer, network layer and perception layer as depicted in Fig.1. The perception layer contains actual information and it is considered the core of the IoT. This layer is responsible for collecting and perceiving information about objects existing in physical world by applying sensors, wireless sensor networks, tags, RFID systems, cameras, GPS, intelligent terminals, EDIs and readers-writers. The network layer is also called transport layer consists of access network, core network and produces data transmission capability which includes, GPRS, WSNs, WiFi, WiMax, Ethernet etc. The most critical responsibility of this layer is to provide efficient and reliable infrastructure to support upper layer and large scale industrial applications in used.
The service layer or application layer consists of two sub layers: data management sub-layer and application service sub-layer. The functions of data management sub-layer are, but not limited to, complex data processing, cloud computing technologies, market to market service, quality of

service, geomatics and facility management and so on[4]. The main functions of application service sub-layer are transforming information into contents, providing appropriate users' interfaces for upper level applications deployed on enterprise level like supply and management, disaster recovery, agricultural management, environment monitoring etc.

2.2 RFID systems

Each RFID system consists of RFID tags, readers and application systems as shown in the figure below.

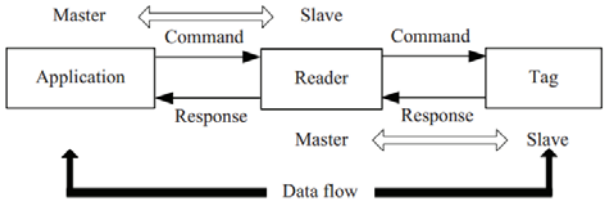

Fig 1. RFID system and its main components

- RFID Tags also called as transponders, can be active or passive, are connected to various objects for identification or counting purposes. Active tags have high functionalities due to excellent battery power, their features of communicating with other tags in the environment and starting a dialogue on their own with other readers. On the other hands, passive tags are not intelligent at all. They do not have their own power source because tag reader provides power to them. Its components are microchip and coiled antenna used to store data.
- Reader is also called transmitter having radio frequency interface module and control unit as its main components. It performs the functions of tags activation, structuring communication sequence with activated tags and data transferring among applications, software and relevant tags.
- Application systems is also called data processing system and may be an application, database. The application is responsible for starting all readers and tags and functions.

RFID is reliable and quick method of detecting, controlling and tracking various objects electronically. It works in the following way: RFID uses radio transmission to transmit signal to RFID tag, and the tag replies back with a unique identification code to data collection reader which is connected with information stored in a host computer for analysis purposes.

2.3 RFID Tags

RFID tags are available in many sizes, capabilities and shapes. Which tag would be deployed into system depends upon business and technological requirements of the organization [5]. The antenna, integrated circuit printed circuit board or substrates are main components of RFID tags. The antenna initiates transmission and receiving of radio waves signals for communication. It is also a coupling mechanism where energy can be transmitted in the form of electromagnetic radiation. This is the most typical style of communication between reader and tag. Depending upon the distance between antenna and reader, the antenna can also power up other components of a tag. The brain of the tag is called integrated circuit which is a collection of various components. Its functions are equivalent to that of a multiprocessor found in any computer or smart phone. The sole function of an integrated circuit is transmission of unique identifier of tag. Moreover, it can also collecting information if tag has any peripherals and their information area also sent along with unique identifier.

The printed circuit board is used to accommodate the tag. It may be flexible or rigid and is made of various materials depending upon the functionality of the tags, deployment environment, purpose and size of the tag. Tags are made with appropriate standards called a class. Six classes have been defined by EPCglobal so far as under:

- Class 0/class 1: Provides very fundamental radio frequency passive capabilities. The difference between these two classes is programming: class 0 is by default factory programmed, class 1 is not factory programmed as users' can program according to their own specifications.
- Class 2: Possesses capabilities of encryption and RF memory read-write
- Class 3: Contains on-board batteries for longer power and it also provides long range broadband communications.
- Class 4: It consists of active tags, peer-to-peer communication and various sensors.
- Class 5: Contains readers only and also activates other tags in environment.

No built-in power sources ares added into passive tags. Readers use radio frequency to power up readers and normally fall into class 0 to 3 range. Class 4 states active tags only which contain their own internal power source to provide energy for specific time period for various operations. Class 5 deals with active tags and readers only that can read data from various tags.

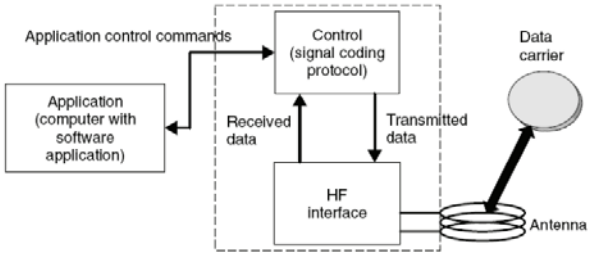

Fig 2. RFID reader having HF interface and control unit as its main components

2.4 RFID Reader

RFID readers are also known as interrogators because their responsibility is querying the tags for identification purposes whenever any tag enters in their read-range [6]. After reading any tag, it offers data to any relevant application which need for decision making purposes. Readers have very complex capabilities as they can be scaled down to two basic functional blocks: high frequency interface and control system which consists of a transmitter and receiver. The entire system can be controlled by an external application interface through various commands. The control unit performs the functions of communication with application software and execution of related commands for that application software, controlling transponder communication in a master-slave fashion, as shown in figure 2, and coding and decoding of signals at transmitter and receiver ends. Depending upon the complexity of the environment, control unit can also discharge collision-avoidance algorithms execution, encryption and decryption of data at both ends, authentication between transponder and reader.

The high frequency interface is responsible for high frequency transmission power generation so that transponder can be activated, signal modulation to send data to transponder and receiving and demodulating of signals transmitted by transponder. A microprocessor is used to hold control unit to perform such complex functions. In order to relieve the processor from intensive calculation processes, cryptologic procedures like signal coding, stream ciphering between transponder and reader are normally performed in an extra ASIC module.

3 Applications of RFID technology

The functions of RFID technology can be divided into three categories: monitoring, tracking and supervising. Monitoring is concerned with the latest situation of the system. It means special conditions must be observed and detecting any abnormal behaviour, warnings should be initiated. Tracking means observing an object while on the move and providing respective location data in a sequence for modeling. Supervising is concerned with observing and monitoring activities or behaviour of applications, humans, or any type of objects. Most, supervising is done without the knowledge of the object [7].

RFID is vastly used in various applications. Most, it is used in supply chain management systems, object tracking mechanisms and production processes control. These days, the use of RFID is also growing into manufacturing, agricultural management, healthcare management and tele-medicines, marine operations, payment transactions management etc.

4 Challenges in RFID technology

RFID is definitely a promising technology but it has many technological challenges associated with it.

4.1 Collision Problems.

The electromagnetic interference can cause malfunctioning of both tags and readers leading to incorrect decisions. Multiple transmissions among readers and tags can produce collision problems because tags and readers use the same wireless frequency channel. That’s why reliable and efficient collision avoidance protocols are required for identification of multi-tags communication. In this way, it will be much easier developing large scale RFID systems. Query tree protocol, binary tree protocol frame slotted aloha protocol etc have been proposed for RFID systems but all of such protocols do not produce required efficiency as their identification efficiency is below 50% which is unacceptable at commercial level. Designing new and better protocols demand finding out good features of identification protocols.

4.2 Privacy and security concerns

Privacy and security issues of RFID tags can bring great impact on any individual and organization. Tags not protected appropriately are always easy target to eavesdropping, DoS attacks, traffic analysis and many more. Furthermore, unauthorized readers can breach privacy by having access to various tags without privileged access control. Even the most secure tag can be tracked on the basis of predictable tag responses. Traffic analysis attack can cause location privacy. RFID systems still need appropriate privacy and security mechanisms keeping in mind the total cost associated with them. Large scale research is going on to find out and implement low cost privacy and security protocols to heighten reliability and applicability of RFID systems. Many lightweight protocols have been suggested but they possess high cost and low security, therefore they do not ensure security issues will be resolved fully. A good research scope for designing an efficient ultra-lightweight cryptographic protocol for low-cost RFID system is available.

4.3 Interference Issue

RFID is among few technologies which can be implemented in installed systems and solutions of an organization. But installed system can create interference problems for RFID components which can bring required operations of RFID systems to an end.

Readers and tags rely upon bidirectional wireless transmissions. In passive RFID tags, the reader spews a signal which induces current in tag to power up transmitter of a tag. On the other hand, the active RFID systems do not need induced current to broadcast their existence in the system.

Due to wireless transmission, there is always possibility of interference between RFID and other wireless technologies deployed in workplace or data center. This is outstandingly true in an environment which contains certain classes of RFID technologies and where interference sparks serious consequences. Two particular classes of interference must be taken into account. First, interference that hinders transmission of correct data and causes performance decline in one or more than one systems. Second, the risk of interpretation of one incorrect signal from one system as valid data by other systems. The interference mostly results from environment aspects in deployment. In the past, problems were reported when RFID tags were mounted on metal or on containers of liquids. In both scenarios, tags were not activated and failed badly to respond to the readers. Due to recent developments, such issues can be overcome at planning stage with correct antenna design and tunneling. UHF systems can also cause interference owing to re-radiation or reflection of power signals. On the other hand, passive systems have less chances of interference than active ones where tags transmit continuously. One more scenario of interference is cross interference which occurs between RFID and WLAN or WPAN such as Bluetooth where various devices share common or adjacent frequency bands. In medical field, some incidents of interference between a wireless microphone and wireless endoscope have been reported.

The following table shows areas of risks of interference between various network devices and RFID frequencies.

Frequency	BandwidthRFID Usage	WLAN & WPAN Usage
58KHz - 1KHz	EAS Electro magnetic Tags	
125 - 135KHz	LF Passive Tags	
7.4KHz - 8.8MHz	EAS Swept-rf Tags	
13.56MHz	HF Passive Tags	
868MHz - 928MHz	UHF Passive Tags	IEEE802.15 WPAN (Zigbee @ 868 & 915MHz)
902MHz / 111.5KHz2.4GHz / 111.5KHz	EAS Re-radiating Tags	
2.4GHz	Some WiFI based active Tags	IEEE802.11b & g WLAN IEEE802.15 WPAN (Bluetooth & Zigbee)
5GHz		IEEE802.11a WLAN
60GHz		IEEE802.11ad WiFi

Table 1

4.4 Miscellaneous Challenges

Some other issues are also hindering large scale deployment of RFID systems. The prime issue is the cost as RFD labels possess high cost as compared to printed labels [8]. The design of RFID systems is another issue. High reliability ensuring readers and tags are still unavailable in the market so reliable identification is not guaranteed. Integration of RFID systems into existing infrastructure is also a big issue which needs resolution for large scale adoption of RFID systems [9] [10]. The development of effective middle is mandatory to

find out solution to integrate newly developed RFID systems into existing infrastructure.

5 Conclusion

In order to extract correct information and intelligence, IoT applied various information sensing devices and technologies like RFID, GPRS, WSN, WLAN, WPAN only few to name. These technologies are joined with the Internet to make up a protracted network for information collection and information processing about unique objects. This paper has analyzed RFID applications and major challenges in their large scale adoption.

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