CS2K707(P) Seminar Report

on

Radio Frequency Identification - RFID

Submitted In Partial Fulfilment Of The Degree Of

Bachelor Of Technology

by

Vineet Mohan
Y1.049,S7 CSE

Department of Computer Science & Engineering
National Institute of Technology, Calicut
2004 Monsoon

National Institute of Technology, Calicut
Department of Computer Science & Engineering

Certified that this Seminar Report entitled

Radio Frequency Identification - RFID

is a bonafide report of the Seminar presented by

Vineet Mohan
Y1.049,S7 CSE

in partial fulfilment of the degree of
Bachelor of Technology

Mr.Vinod P.
Seminar Coordinator
Lecturer
Dept.of Computer Science & Engineering

Dr.V.K.Govindan
Professor and
Head
Dept.of Computer Science & Engineering

Abstract

Radio Frequency Identification (RFID) is an upcoming technology which has application over a large domain of industries. It can be termed as the long term replacement for bar coding in the field of automatic data capturing. It has the potential to significantly change the way processes occur and companies operate. The last few years have seen several developments that have sped up the adoption of this technology.
1) The emergence of major consumer applications have brought RFID from an experimental technology into the mainstream.
2) The development of smart labels has also been a major thrust in its case against the existing bar codes. This paper discusses the technology involved in RFID as well as its real life application profiles. This is an attempt at understanding the technology better.

Contents

1 Introduction

Technological breakthroughs have a way of hanging around, sometimes for years, before finally exploding on to a ready and willing marketplace. Back in 1985, senior Philips executives were talking about new, super-thin TV sets that could be hung on a wall like a painting or a mirror. It was 12 years before the first plasma-screen TVs hit the shops and another six before they became even vaguely affordable. Today, they dominate many retailers showrooms and the manufacturers are adding extra capacity to meet demand.

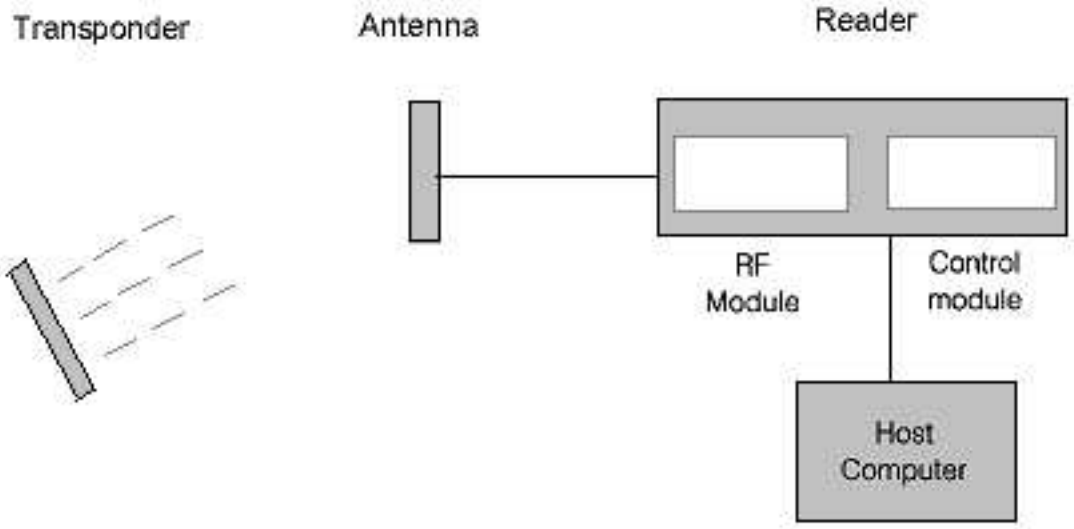
Much the same is true with radio frequency identification (RFID) technology, which has been around since World War II but is now poised to go mainstream on the back of three concurrent developments. First, semiconductor technology allows the chips that form the basis for RFID to be produced at viable prices; secondly, the Internet has evolved to the point where data can be shared easily around the world; and thirdly, mobile communication technology has evolved so that the huge amounts of data from mobile readers can be distributed.

Invented in 1969 and patented in 1973, but only now becoming commercially and technologically viable, RFID technology is growing by leaps and bounds. There are already many small-scale RFID solutions implemented around the world. Indeed, RFID has been described by industry commentators as one of the few truly disruptive technologies to emerge in recent years.

2 What is RFID ?

RFID is an area of automatic identification that has quietly been gaining momentum in recent years and is now being seen as a radical means of enhancing data handling processes, complimentary in many ways to other data capture technologies such bar coding. Technically speaking, RFID is a system of small electronic tags (comprising a tiny chip plus an antenna) that transmit a radio signal, radio signal readers and related hardware and software infrastructure. These tags act as transponders (transmitters/responders), always listening for a radio signal sent by transceivers, or RFID readers. The basic objective of the RFID system is to carry information in these transponders or tags, and to retrieve the same information, as and when required for application purposes by the readers. The data retrieved from the tags can be used to identify the object on which it is placed. This is called Radio Frequency Identification. This object can be an item in manufacture, goods in transit, an individual or even an animal. In addition to the tags and readers, the system also needs methods to read and retrieve data from the tags and some means to communicate this information to a host computer or a central system. There should also be means to program the tags or enter data. These RFID tag microchips are so tiny that they can be embedded in almost anything to give it a unique ID code. Each tag generally contains its own unique 64-bit or 128-bit identifier. This yields about 18 thousand trillion possible values, each virtually impossible to erase without destroying the tag.

3 RFID - the technology



Fundamentally the technology is about identification of objects through wireless means. RFID is sometimes called dedicated short range communication or DSRC. The system communicates using radio signals that carry information. This can be either unidirectional or bi-directional depending on the application. The figure above depicts the basic working. When the transponder arrives in the vicinity of a reader, the information held by it is captured and sent through available communication interfaces to either a central system or a single host computer. This data is either stored or verified.

3.1 System Components

RFID systems have the following components that define them. These are:
1. A receiver - It includes an antenna. This is the device used to read data from the RFID tags.
2. A tag - The tag holds data. This is transmitted as and when required to the receiver
3. Protocol - RFID uses radio frequency and a specific protocol to transmit and receive data from tags.
4. Network Interface - A network interface such as RS 232 or IEEE 802.11 is needed to communicate with the central server.

3.2 Transponder

Figure 2. RFID tag

The device is basically a transmitter/responder. This essentially means that the tag responds with the data it carries when it receives the transmission requesting the same from the reader. The data communication within the system is through wireless means. The RFID tags consist of low power integrated circuits. These tags need to transfer data and also generate power for themselves. For this purpose they have to be either interfaced to external coils or must utilize 'coil-on-chip' technology. The antenna is an important part of the transponder. When the reader tries to retrieve information from the tag or tries to program the contents of the tag, it sends appropriate radio signals. The antenna detects these signals and they also come into play when the transponder responds to the request.

3.2.1 Memory requirements

The transponder generally consists of ROM, RAM and non-volatile programmable memory. The Read Only Memory deals with memory requirements regarding power supply, data flow and signal timings. The ROM stores the instructions and security information involved in these operations. The Random Access Memory is used for data storage for short intervals of time. Such cases arise when it responds to a request from a reader. The electrically erasable programmable read-only memory or EEPROM is used to store the data associated with the tag. The memory here is permanent since the data should be present under all conditions. Certain data buffers are also maintained by the transponder. This is used during modulation and demodulation of signals. This is required in the case of passive tags, which shall be discussed later, to accommodate the field energy which is used to power the tags. Also when the tag is to be programmed, the buffers provide the space required during demodulation of the incoming signal. The necessary circuit interface to the radio signals is present.

The characteristics of a transponder depends on the kind of application that it is a part of. The different features of a transponder are:

1. The way in which the transponder is powered.
2. The data carrying options depend on the application too. Certain data indentifiers and error

detection bits are associated with the stored data for recovery and protection.
3. The data transfer rates depends on the carrier frequency. The rates increase with higher frequencies. This is an important factor in situations where the tags move swiftly across a reader zone.
4. Depending on the type of memory the programming options vary. Read-only tags are programmed initally. The Write once read many (WORM) are also programmed by the user. In the case of read-write tags the user can reprogram the data stored in a tag in an online manner i.e while the tag is in motion or when it is associated with an object.
5. The physical form of the tag varies with the usage. The tags come in various shapes and sizes depending on the object that it is part of. The price of the tags also varies with the type of application and the number required. The costs increase in the case of highly sophisticated requirements. This is because the complexity of the circuit increas and so does the memory required for data storage.

3.2.2 Types of tags

Active tags These tags contain both a radio transceiver and a battery to power the transceiver. Because there is an onboard radio on the tag, active tags have substantially more range (300 feet) than passive or active/passive tags. Active tags are also considerably more expensive than passive tags and, as with any battery-powered products, the batteries have to be replaced periodically.

Passive tags Passive tags can be either battery or non-battery operated, as determined by the intended application. Passive tags reflect the RF signal transmitted to them from a reader or transceiver and add information by modulating the reflected signal. A passive tag does not use a battery to boost the energy of the reflected signal. A passive tag may use a battery to maintain memory in the tag or power the electronics that enable the tag to modulate the reflected signal.

Battery-less (pure passive or beam powered) Pure passive tags do not contain an internal power source such as a battery, and are thus easier, and less expensive to manufacture. These purely passive or reflective tags rely upon the lectromagnetic energy radiated by the reader to power the RF integrated circuit that makes up the tag itself.

With a battery (active/passive) There is a version of a passive tag that does contain a battery. This type of passive tag has some of the enhanced, and speed attributes of a true active tag, but still communicates in the same method, as do other passive tags. These active / passive tags that do contain an internal power source, usually are much more complex integrated circuits with multiple components. Consequently, they are more expensive to make and purchase.

3.3 Receiver

Figure 3. Handheld and Stationary Readers

They are also called readers or interrogators. The receivers retrieve data from the transponders. The functions of a reader depends on the tags being used and the requirements of the application. The receiver-transponder interaction is based on communication and data transfer. The reader uses two tag polling techniques:

Hands Down Polling- Here it uses the Command Response Protocol. This is to make sure the signals received from the transponder are not repeat signals and to take the appropriate action. This situation arises when a number of tags have to be read in a short span.

Hands Up Polling- Here the tags are interrogated one by one based on their specific identities. This method is more efficient but also very time consuming.

There are also other methods, such as multiplexing of multiple readers into one interrogator, to improve the reading process.

3.4 Programming the transponder

Programming is done initially at the beginning of a batch-production run. This is called offline programming. User programming is necessary in the case of write once read many (WORM) tags and read-write tags. For some systems online programming is required for example in places where interactive portable files are carried. Data held in the tag will have to be changed such cases. If we have to remove the transponder each time reprogramming is required, the application becomes difficult to manage. Hence we include programming facility within the reader so that the data can be recorded as and when recorded. In most systems , near contact positioning is required for programming since the range is not as much as the read range. There are also restrictions regarding the number of tags that can be programmed at a time. Generally systems are designed such that one tag can be programmed at a time.

3.5 Types of communication

Tags and a reader communicate by wireless signal in a process known as coupling. Two methods of wireless signal in RFID systems:

1.Close proximity electromagnetic, or inductive coupling

2.Propagating electromagnetic waves.

Coupling is via antenna structures forming an integral feature in both tags and readers.

Transmitted data is influenced by the channels through which it must pass, including the air interface. Noise, interference and distortion are the chief sources of data corruption. The data communication process may be asynchronous or synchronous in nature. Structuring the bit stream to ensure error-free, asynchronous data transfer through this channel is often referred to as channel encoding. Although transparent to the user of an RFID system this coding scheme is important to engineers as often appears in system specifications. Various encoding schemes can be distinguished for this purpose, each exhibiting different performance features. Transferring data efficiently via the air interface requires the data to be superimposed upon a rhythmically varying (sinusoidal) field or carrier wave. This process of superimposition is referred to as modulation, and various schemes are available for this purpose. They are essentially based upon changing the value of one of the primary features of an alternating sinusoidal source, its amplitude, frequency or phase in accordance with the data carrying bit stream. In this way it is similar to the way AM or FM radio works. On this basis one can distinguish amplitude shift keying (ASK), frequency shift keying (FSK) and phase shift keying (PSK). In such wireless systems non line of sight communication can also be enabled. This can be done with appropriately designed antennas in high frequency systems.

3.6 Radio frequency and range

Frequency Band	Characteristics
Low 100-500 kHz	Short to medium read range Inexpensive low reading speed
Intermediate 10-15 MHz	Short to medium read range Potentially inexpensive medium reading speed
High 850-950 MHz 2.4-5.8 GHz	Long read range High reading speed Line of sight required Expensive

RFID uses electromagnetic radio signals to operate, so its effective operation is subject to the same physical laws any RF operating device is. The RF field distance or space between an RFID interrogator antenna and the corresponding RFID tag, and the frequency of operation

are directly interrelated. Thus, different RFID frequencies have different RF effective ranges. Two terms used often are near field, and far field.

Early in the technologys development, three carrier frequencies were identified. They were used to refer to different ranges: Low (125kHz), Intermediate (13.56 MHz) and High (2.45 GHz). Today there are eight frequency bands in use around the world for RFID applications, identified by number and not name. Despite this, many companies still organize their products by low, intermediate, and high range. The rate of data transfer is influenced primarily by the frequency of carrier wave used to carry the data between the tag and its reader. The higher the frequency the higher the data transfer or throughput rates that can achieved. The channel bandwidth needs to be at least twice the bit rate required for the application in mind.

4 Applications of RFID technology

4.1 Current Applications

While the potential for RFID applications appears virtually limitless there are only a few applications that have been implemented and are continually being used. In the year 2000 the most common uses for radio frequency identification technologies included transportation, materials management, and security and access control. Currently, there are a variety of other applications for RFID in agriculture, construction, and athletics.

4.1.1 Transportation

The transportation industry is one of the leading users of RFID technology because they have identified numerous applications. RFID applications in transportation include railroad car management, traffic management, tolls and fees, fare collection, equipment identification, fleet management, solid waste hauling, and fuel dispensing (CII, 2001). When a hometown commuter passes through an express toll lane an RFID tag alerts the tag reader that someone has passed through the toll and the reader then identifies the commuter and communicates the charge to an account setup in a networked computer system. Tractor-trailer traffic is also managed in much the same way through weigh stations. Once a semi tagged with RFID technologies enters an interstate highway it stops at the first weigh station along its journey on the interstate to be identified and approved, then throughout the rest of its passage along that same stretch of highway it is not required to stop at any other weigh stations. The truck is simply tracked by RFID technology along the highway.

4.1.2 Security

Many businesses use RFID to control access to hotels and business facilities by attaching a tag to an employees room card or ID badge. Such technology ensures that only authorized persons are allowed access to particular rooms or entrances. This application is also becoming more common in nursing homes and hospitals where the management and tracking of individuals is very important, and alarms are more discrete. Other security features include RFID chips embedded into automobile keys that enable the car only to start if the key has the proper chip embedded into it. Video stores and libraries are also applying radio frequency devices to checkout rentals and detect stolen or misplaced items. Law enforcement officers are now able to track credit cards, jewelry, vehicles and artwork by radio frequency tags embedded in these objects.

4.1.3 Manufacturing

Radio frequency identification systems allow the tracking of work-in-progress in automobile manufacturing and computer hardware manufacturing. Such technology allows managers to track goods through the manufacturing process and then the tags can either be reused on other products coming down the assembly line or they may stay permanently fixed to the product to provide a secure serial number. The tags also may contain important information about a particular assembly method or piece of equipment necessary to complete the product.

4.1.4 Agriculture

The agriculture and livestock industries have shown an increase of interest in food processing and distribution and animal tracking. In July 2001 the Canadian Cattle Identification Program (CCIP) mandated a mandatory cattle identification plan that has allocated more than 18.5 million RFID tags to trace back an outbreak of disease back to its origin. CCIP claims that tagging the cattle is more than cost-effective when trace backs can be made quickly and efficiently, and fines of up to $500 are used to enforce the cattle identification mandate.

4.1.5 Athletics

Golf ball identification and tracking devices have been implemented for accurate identification purposes; however, there may be a better market for the tracking of baseballs in todays homerun hitting bonanza. Another use for RFID tags in athletics is implemented in almost all major track and field events. Road races, running races or marathons in the streets, use shoelace RFID tags to get race results of runners as they cross the start and finish lines where there time is officially kept regardless of when the runner begins the race. These technologies are also being used to track athletes to verify that the path traveled is the same as the course defined by the race officials.

4.1.6 Global Positioning System (GPS)

Global Positioning Systems (GPS) have revolutionized the means to accurately locate and identify objects on the earths surface using a system of satellites in space and transmitters and receivers on earth. The combination of GPS and RFID identification tags has made real-time tracking a reality. Materials and assets can be identified and tracked as they are installed or transported.

4.2 New Applications

4.2.1 Airports : Security and Baggage Handling

RFID tags could be used to track and identify airline luggage and passengers increasing national security, speeding up luggage sorting and transfer, and decreasing expenditures resulting from heightened security measures. The International Air Transport Association (IATA) believes this technology has countless potential benefits for simplifying passenger travel for airports and airlines. The major advantages of RF technology in baggage handling are an increased journey speed of luggage as a result of faster read rates and elimination of human intervention in misdirected bags and security procedures. Airline travel consists of 100 million customers each year making the cost of the tags and the read range of baggage a great concern. However, if the tags cost can be reduced from its current price around 50 cents down to 15 cents and the IATA makes the 2.45 GHz frequency standard (doubling the read range of 13.56 MHz frequencies), this tagging application in the airline industry would takeoff.

4.2.2 Transportation and Access/Security

At the American Association of Airport Executives (AAAE) Conference in May 2002, TransCore and Gatekeeper systems, INC. partnered up to create a Ground Transportation Management System (GTMS) that would deal with travel and security around airports. The technology allows authorized vehicles (airport busses, taxis, cargo vans, etc.) to enter the grounds. This enables airports to have manless security checkpoints that monitor, track, control, record, and report vehicle operations. Nearby traffic congestion and air pollution from vehicle emissions would be reduced, and airport revenues from commercial vehicle access charges would increase because vehicles would be charged on a per use basis.

4.2.3 Medical Applications

Medical applications include allowing restricted access and tracking patients and guests with authorized wristbands through hospitals. Hugs with Kisses, produced by Xmark, is an electronic tagging and monitoring system for controlling the movement of newborn babies in a hospital environment. The system comprises active transponders attached to the baby, monitoring receivers at doorways and a computer networking system to reduce the risk of abduction and to ensure mother and child identification.

4.2.4 Supply-Chain Management

Retailers are very interested in turning the supply chain management industry into an RFID dependent business as long as it is cost efficient. Recently, Gillette ordered 500 million RFID tags from Alien Technologies for about 10 cents a piece. They plan to tag every pallet and carton coming out of its distribution centers to reduce losses from out-of-stock, stolen or lost products, and the company believes that with increased tracking ability it will increase revenues by leveraging inventory information into smarter marketing to retailers. Gillettes smart tags will also be used to track inventory through direct communication with smart shelve technology developed by the Auto-ID Center at Massachusetts Institute of Technology, Cambridge. According to IBM, the smart tag smart shelf combination would shrink inventories by 5-25

5 RFID Challenges

5.1 Effective read/write ranges of readers

Reading large objects whose tag may be positioned on opposite side. Proximity distinguish specific object from other objects on either side. Reading mixed-case pallets fast enough and accurate. Materials of the object or around the object (metal, liquid) can affect readability. Currently 20-30% error rate in reading tags.

5.2 Standards- EPC, ISO, proprietary

There are actually hundreds of standards related to RFID being developed or modified by scores of national and international standards bodies. Examples include the format and content of the codes placed on the tags, the protocols and frequencies that will be used by the tags and readers to transmit the data, the security and tamper-resistance of tags on packaging and freight containers, and applications use standards. Until these standards are finalized, there will be a risk of non-compliance associated with any solution implemented. Currently: Wal-Mart supports EPC Department Of Defense (USA) wants to support EPC but using ISO standard for air interface

5.3 Costs

Although the costs for tags and readers continue to come down, implementing an RFID solution is still a very expensive venture. AMR Research estimates that a typical consumer goods company shipping 50 million cases per year will spend $13 million to $23 million to deploy RFID to meet Wal-Marts requirements. Besides the cost of the tags for every pallet, case or item to be tracked, there are the costs of the readers at every identification point, the software development and implementation costs for use of the information, and the supporting infrastructure costs. The biggest risk at this time, however, is that a company will incur these substantial costs only to find out that the solution deployed does not meet future standards or that the technology or vendor used for the deployment has not survived the inevitable shakeout of early contenders in this emerging field. To protect against this possibility, companies should select technologies and vendors that are adaptable to emerging standards and protocols.

5.4 Privacy

There has already been significant backlash from consumers over announcements by Wal-Mart, Gillette and Bennetton that they would use item-level RFID tagging. All three companies have had to pull back from these initiatives as a result. Privacy has always been a strong value and concerns over the perceived invasion of privacy these announcements incited, whether justified or not, is a factor that must be considered in any RFID rollout.

6 Conclusion

Lack of standardization, high costs of implementation, slow technology development and deployment risks, and the elimination of unskilled labor are all contributors currently preventing the adoption of new RFID technologies. As RFID technologies develop, the cost of RFID equipment and software will continue to become more affordable. Just in the last four years the price of RFID tags has shrunk by 75%. Besides, RFID systems require no maintenance and can be used repeatedly. The benefits that can be obtained are very far reaching and hence RFID technology is certainly the step forward.

References

[1] Nadeem Raza,Viv Bradshaw,Matthew Hague,Microlise Systems Integrations Limited, Applications of RFID technology, IEE 1999

[2] AIM Inc. White Paper, RFID - a basic primer, 1.2, 23-08-2001

[3] Susy d'Hont, The Cutting Edge of RFID Technology and Applications for Manufacturing and Distribution, Texas Instrument TIRIS