TECHNICAL UNIVERSITY
OF CLUJ-NAPOCA
ROMANIA

Facultatea de Electronică, Telecomunicații și Tehnologia Informației

Radio Communications

Project name: Radio-Frequency Identification (RFID)

TECHNICAL UNIVERSITY
OF CLUJ-NAPOCA
ROMANIA

Coordinator teacher:
As.drd.ing. Cristian Codău

Student:
Onuț Elena-Sabina
Group 2331

Abstract

RFID (Radio Frequency Identification) is a well-known wireless application for tracking, logistics, and access control. It became common place in industry and our daily lives (ticketing, payment, passports, car keys, etc.). RFID is now a standardized technology; its inherent advantages, such as unitary identification, wireless communication, and low tag cost, provide it with significant practical benefits that drive new concepts and applications. This trend is largely confirmed by market forecasts, but it is also confirmed by its implementation in the areas of health (smart hospital), assistance to persons, anti-counterfeiting, and its outlook in terms of new paradigms for distributed ambient intelligence and the Internet of Things.

The first part of this paper briefly reviews the fundamental concepts of the RFID technology and shows the current interest for this technology. The history and evolution of RFID is also summarized. The second part illustrates the components of the technology. Finally, the last part highlights security and privacy aspects, the costs and some nowadays RFID applications dedicated to the service of humanity.

Table of Contents

1. Introduction

1.1. What is RFID?

RFID stands for radio frequency identification, which is based on a wireless communication technology between an object (tag) and an interrogating device (reader) to automatically identify and track the physical location of an object. The transmission range of a tag is restricted to a few meters away from the reader, and it is not necessarily required a clear line-of-sight between the tag and the reader. Generally, the RFID tag must be within the range of 0.9 to 90 m of the RFID reader antenna, depending on the tag, reader, and antenna being used.[1]

An RFID system consists of readers and tags. A typical system has a few readers, either stationary or mobile, and many tags which are attached to objects.

A reader communicates with the tags in its wireless range and collects information about the objects to which tags are attached. Essentially, the reader uses radio frequency waves to transmit signals that activates the tag and after that, the tag sends the waves back to the antenna, where they are converted into data.

The electronic signals between RFID readers and tags can operate in a variety of frequency bands, including 13.56 MHz (HF) for standard near field communication (NFC) and 860-960 MHz for standard EPC Gen 2 (UHF). The longer the operational distance between the RFID reader and the RFID tag, and the higher the data transfer rate, the higher the frequency.[2]

Almost anything can be attached with these tags, it has a wide range of applications, some present day examples includes: contactless payments, access control systems, asset and equipment tracking, analyze in-store traffic patterns, cargo and supply chain logistics, customer service and loss control, but they can also be attached to laundry, animals, humans, mobile phones and cars. The list of applications does not at all stop there. New RFID applications will emerge in the future years and large industries will take advantage of these applications in ways that no other technology has succeeded.

1.2. The current interest in RFID Technology

RFID is rapidly becoming a low-cost technology. "This is in large part due to the efforts of Wal-Mart and DoD to incorporate RFID technology into their supply chains."[2]

At the moment, according to a newsletter given by Emerald X, with the name "RFID Journal", the largest manufacturer of Gen 2-compliant ultrahigh-frequency (UHF) RFID readers is Motorola.[3]

A large number of RFID technologies are available nowadays on the market. Each technology is designed for a specific set of applications, and performance characteristics vary greatly between technologies. Some advanced readers accept multiple tag systems, despite the ones designed only for one system, which will not read tags developed for another.

As described by Techopedia, "In concept, RFID technology is similar to that of barcodes. However, unlike the barcode, the RFID tag does not need to be scanned directly and does not require line of sight to the RFID reader."[4]

In the near future, RFID technology is expected to substitute barcode technology. A single tag can serve multiple readers at a time, compared to only one for a barcode tag. Furthermore, barcodes only include details about the item's manufacturer and basic information about the object. Whereas, RFID is especially effective for applications where the item must be uniquely identified. Additional functionality, for example more bits of data can be stored in RFID tags. With all these differences, RFID technology has generated great interest in replacing barcode technology and developing numerous innovative applications.

Active, passive, and battery-assisted passive RFID tags are available on market. An active tag contains a battery and can transmit electronic signals periodically. A passive tag is one that does not have a battery and collects energy from the electronic signals of nearby RFID readers. A battery-assisted passive tag has a small battery, however it is only activated when signals from nearby RFID readers are received. The advantage of passive tags include: small size, light weight, affordability, long shelf life (up to 20+ years).[8]

According to Statista, "In 2020, the global market for RFID tags is projected to be sized at around 24.5 billion U.S. dollars. Retail applications are expected to account for the largest share of the market."[12] RFID has doubled its global market in just four years. As a result, it demonstrates the utility of RFID technology.

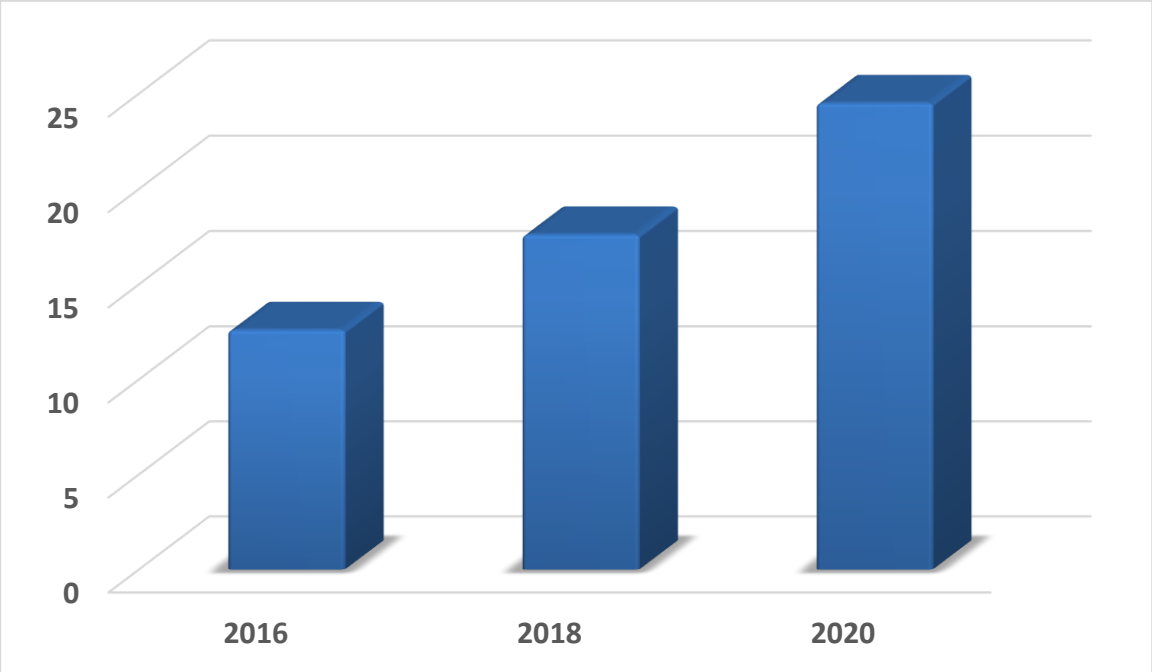

Figure 1. Projected size of global market for RFID tags from 2016 to 2020 (in billion U.S. dollars) [12]

2. The history and evolution of RFID technology

Radio Frequency Identification (RFID) is not a new technology despite rapidly developing automatic wireless data-collection technology in recent years.

Historically speaking, on 4 August 1945, the Soviet Union offered to the U.S. ambassador a magnificent gift, in which it has embedded a spying device called “The Thing” developed by L. Theremin [5]. This device, which was not discovered until years later, operated the backscattering technique to spy the conversations of the ambassador. In this way, the first tag was born.

The concept of the technology was used also in the development of radar during World War II. Britain invented the “identification friend or foe (IFF)” transponder in 1939, a device that the allied side installed on their planes to differentiate them from the enemy’s. During the years 1960-1970 academic institutions, government laboratories companies and independent researchers are all working to develop RFID technology, following that in 1980 RFID technology is fully implemented.[6] By the early 2000s it had turn out to be clear that $0.05 tags could be feasible and that RFID generation should sooner or later replace bar code systems.[2]

3. An overview of RFID technology

3.1. Components of RFID Systems

RFID solutions combine a few key components that work together to meet a variety of needs. These components are:

- RFID tags
- RFID readers
- Antennas
- RFID software

Radio waves are used to convey information between the tag and the interrogator. When a tagged object enters an interrogator's read zone, the interrogator instructs the tag to send its stored data. Serial numbers, date and time, configuration instructions, and other data can be stored on tags for the objects to which they are connected. The data from the tag is communicated back to the controller through a regular network interface, such as an ethernet LAN or even the internet, once the interrogator has received it. The information can then be used by the controller for a variety of purposes. The controller may, for example, utilize the information to simply inventory the object in a database.

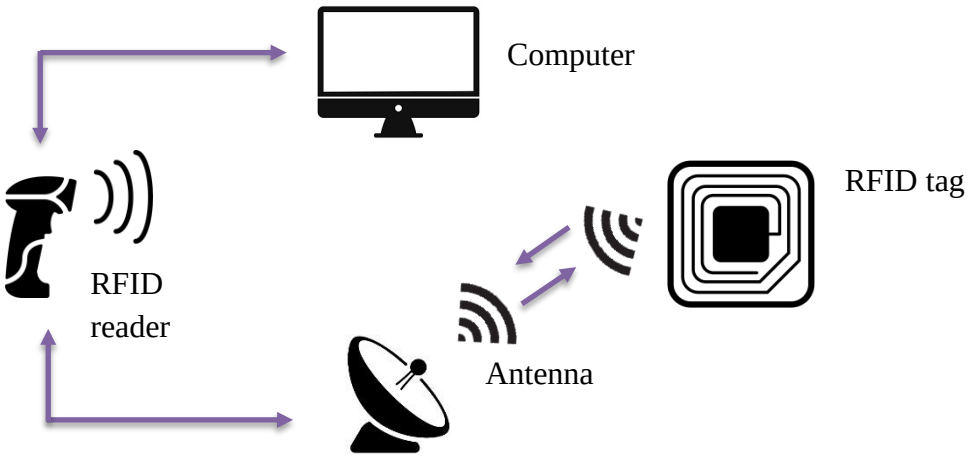

Figure 2. A basic RFID system

3.2. RFID tags

The basic function of an RFID tag is to store data and transmit data to the interrogator. Typically the RFID tags include at least two major components. One is a radio frequency (RF) antenna, which receives RF waves. Another component is an integrated circuit (IC), which processes and stores data as well as modulates and demodulates radio waves received and sent by the antenna. RFID tags are also referred to as RFID chips.[2]

There are two kinds of RFID systems that exist: passive and active. Passive RFID systems use tags with no internal power source and instead are powered by the electromagnetic energy transmitted from an RFID reader. Passive RFID tags are used for applications such as access control, file tracking, race timing, supply chain management, smart labels, and more. Compared to passive tags, active RFID tags possess their own power source – an internal battery that enables them to have extremely long read ranges as well as large memory banks.

3.3. RFID readers

RFID readers collect data from tags. The type of reader needed will be determined by what you trying to track, where you are trying to track it, the materials in the area, and what you want to know about it. RFID readers do not need to see a tag in order to read it. Even if tags are hidden by wood, plastic, or other materials, they can collect data from them. Readers might be stationary or mobile. Fixed readers are installed in specified areas and track items as they move from one point to the next. Hand-held readers make up the majority of mobile readers. You may scan individual items or a pallet of items on the go with handheld readers.[2]

3.4. Antennas

Antennas on tags and readers allow them to communicate with one another. The read range refers to how far away they can be and still communicate. The size of the tag antenna and the design of the reader antenna define the read range. Antennas for RFID systems are divided into two types: linear and circular. Antennas for tags are available in a number of sizes. In comparison to a smaller antenna, a larger antenna can absorb and return more energy from a greater distance.[8]

3.5. Software

It is not enough to be able to read RFID tags just for reading RFID tags. Without the ability to access and use the data collected, an RFID solution is incomplete. This link is provided by software, which assists in making the data meaningful and actionable.

When it comes to RFID solutions, there are three basic types of software to consider. Then there's firmware, which is the software that runs on the RFID hardware. Firmware is primarily responsible for running the device and that is all it does. There's also application software, which uses the data collected by RFID to meet a specific purpose. Middleware sits between the firmware and the application, gathering raw RFID data and serves as a vehicle for sharing this data with the application software.[9]

4. Security and Privacy

RFID tags are watching us. Not surprising for a technology whose origins can be traced back to Cold War era in Soviet Russia. These technologies are now being used in everything from clothing to passports.

As RFID technology becomes more sophisticated and item level tagging promises more control and large savings in the supply chain management, companies are tagging items within their production process. To maximize the benefits companies start to require their suppliers to label all items delivered to the company.

The following fundamental security elements are included on all RFID tags:

• Tags can be "locked" to prevent them from being reprogrammed. Once locked, the tag will reject any programming attempts until the tag is unlocked by an application sending an unlock command with the correct access password.[1]

• Tags have the ability to be "killed." A tag that has been terminated will no longer respond to read requests.[1]

• The tag identification memory bank contains a factory-programmed tag serial number that cannot be changed using any documented method. An application can pr ovide a minimal level of protection against tag cloning by validating this serial number.[1]

In an industrial or retail environment, these elements are intended to provide minimal security.

5. RFID Costs

The cost of RFID tags is a major consideration in RFID applications, especially in large-scale deployments. Costs have been reduced even further with the use of carbon nanotubes to produce chips.[7] Passive tags are cheap, costing a few cents each, whereas battery-assisted tags and active tags are more expensive, usually a few dollars or more. The cost of RFID tags is rapidly decreasing using Moore's Law.

As described by RFID Journal, Emerald X Newsletter, nowadays „active tags are $25 and up. Active tags with special protective housing, extra-long battery life or sensors can run $100 or more. A passive 96-bit EPC inlay (chip and antenna mounted on a substrate) costs from 7 to 15 U.S. cents. If the tag is embedded in a thermal transfer label on which companies can print a bar code, the price rises to 15 cents and up. Low and high-frequency tags tend to cost a little more.”[10]

6. Current applications of RFID

1. Casinos: Robbery-proof chips

Loss prevention is one of the most popular uses for RFID technology, as demonstrated recently by a $1.5 million robbery prevented by RFID embedded poker chips. However, casinos can utilize RFID tags for more than just loss prevention. Casinos may utilize the tags to track how much you spend and where you spend it, and then exploit that data to keep you in 'the game' longer by adapting drinks and services to your preferences.[11]

2. Car rental: No-waiting vehicle returns

The company *Avis Rent a Car* implemented RFID to track vehicle returns and got a big customer service win by enabling customers to park in any available spot and drive away. While the two technologies compete at times, RFID and GPS work effectively together in many management applications. For limited, on-the-lot tracking, inexpensive, passively powered RFID tags are ideal, while more expensive, actively powered GPS systems provide a long-distance vehicle monitoring alternative.[11]

3. Amusement parks: No-swipe ticket passes

In an attempt to improve their customers theme-park experiences, Disney recently put RFID technology into their tickets, which eliminated the need for scanning and swiping in ride lines, resulting in shorter queues and lower staffing costs.[11]

Besides the 3 applications presented, according to Asset Infinity company at the moment there are 5 Big Brands that uses RFID Technology in Business Smartly: **Amazon** (has a RFID system linked to our Amazon account and sensors in the store that show exactly what we are looking at and what items we put in our bag, or even put down. Our entire shopping experience is monitored, and Amazon will know exactly what products we buy and how), **Zara**, **H&M** and **Decathlon** (uses this technology for inventory tracking), and **BJC HealthCare** (it is one of the largest nonprofit healthcare organizations in the United States and they are using radio frequency identification technology for several years to track and deal with a huge number of surgery tools, medicinal stock supplies, and track their validity dates. They also use RFID on the patient to keep track of them and their health records).[12]

7. Conclusions

RFID is now widely used to track items in almost every sector, from biomedical labs to aerospace, engineering, and logistics. It has many advantages over conventional barcodes, including storing far more information and reading multiple tags simultaneously without having to remove items from storage. It is also a critical tool for logistical applications, and it is being utilized to improve supply chains and manufacturing processes in a variety of industries. As RFID technology continues to evolve, it will eventually become cheaper and more user-friendly, keeping inventories and workflows up to date and well-managed. However, that also creates concerns, most common privacy concern, but also other security related issues.

Finally, while RFID technology is now a well-known technology and is already present in many applications of our everyday life, it continues to develop and renew itself.

8. Bibliography

[1] Laurel C Sadler and Jesse Kovach, Radio-Frequency Identification (RFID) MultiReader/Integrated Sensor Architecture (ISA), 2020

[2] V. DANIEL HUNT, ALBERT PUGLIA, MIKE PUGLIA, "RFID-A guide to radio frequency identification", 2007

[3] ***, RFID Journal, https://www.rfidjournal.com/question/what-are-the-leading-rfid-companies [accessed 07 April 2022]

[4] Radio frequency identification reader (RFID reader). Technopedia; 2020 https://www.techopedia.com/definition/26992/radiofrequency-identification-reader-rfid-reader [accessed 28 March 2022]

[5] P.V. Nikitin, L. Theremin, L. Termen, EEE Antennas and Propagation Magazine, Volume 54, Issue 5, (2012), pp. 252-257

[6] OECD (2008-04-18), "RFID Applications, Impacts and Country Initiatives", OECD Digital Economy Papers, No. 144, OECD Publishing, Paris. http://dx.doi.org/10.1787/230464075484

[7] Crepaldi P, Pimenta T. Introductory Chapter: RFID: A Successful History. In: Radio Frequency Identification. doi:10.5772/intechopen.69602

[8] Li Yang;Amin Rida;Manos Tentzeris, „Design and Development of RFID and RFID-Enabled Sensors on Flexible Low Cost Substrates", 2009

[9] ***, https://www.sstid.com/blog/the-4-most-important-components-of-your-rfid-solution/ [accessed 20 April 2022]

[10] ***, https://www.rfidjournal.com/faq/how-much-does-an-rfid-tag-cost-today [accessed 20 April 2022]

[11] ***, https://www.paragon-id.com/en/inspiration/7-magnificient-uses-rfid [accessed 20 April 2022]

[12] ***, 5 Big Brands that Uses RFID Technology in Business Smartly, https://www.assetinfinity.com/blog/big-brands-uses-rfid-technology [accessed 20 April 2022].