RFID SMARTCART: RFID ENABLED TROLLEY FOR SHOPPING AND SHELVING

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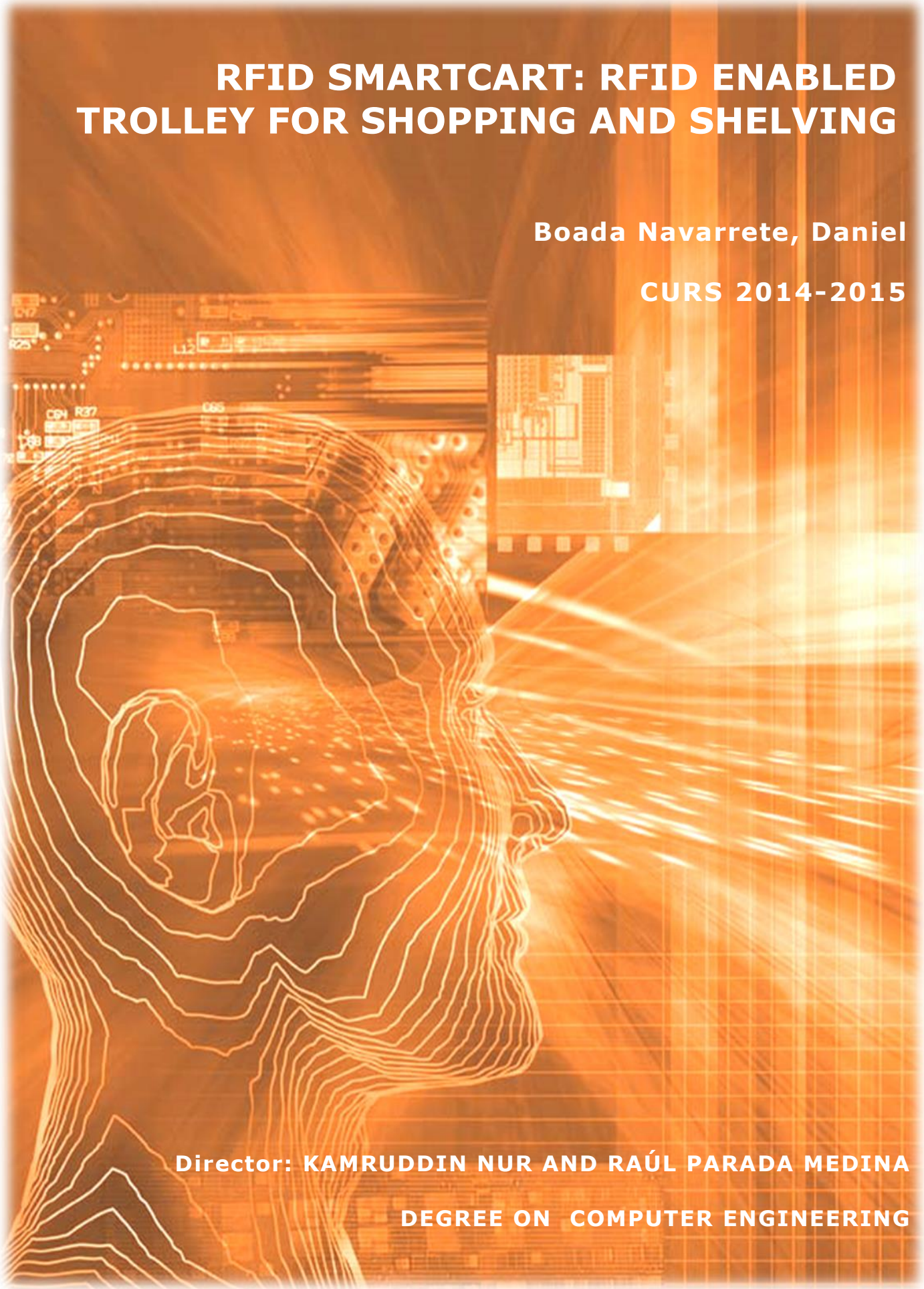

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Final Grade Project

RFID SMARTCART: RFID ENABLED TROLLEY FOR SHOPPING AND SHELVING

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FINAL GRADE PROJECT

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Thanks to

This project is a turning point in a very important stage in my academic life. Therefore, I take this section to write a few lines to those who have been significant for me and have helped me approach this moment in my life supporting me in my decisions.
First I dedicate it to my parents who have helped me during these four years of career will not have to worry about the issue of money and have to focus on learning everything possible and make the most of these years of study.
Another important part have been my friends, thanks to the good group that have formed since the beginning of the degree at UPF and how we have managed all the courses working hard and learning from each other.
And finally, write a few lines to several teachers who have made their subjects they were very nice and helped us to exploit the creative side no longer be simple machines to memorize.

Abstract

The aim of this project is to research and develop a smart trolley equipped with radio frequency identification (RFID) technology and the use of the latest advances in the field of 'Internet of Things' (IoT), called SmartCart. RFID is the next-generation wireless technology for item identification. The challenge of the project is to restrict the beam of RFID only within the shopping cart, to identify product items automatically within the shopping trolley, and to integrate the system with the shop inventory system efficiently. With this RFID SmartCart, shoppers are able to keep a record of the purchase at all times without using the scanner on each product with a system like barcode readers. This has a significant impact on saving time and money for shopper and customer. Moreover, the 'RFID SmartCart' can also be used by shopkeepers for shelving product items and save their valuable time.

(In Catalan)

L'objectiu principal del projecte és desenvolupar un carro intel·ligent equipat amb un sistema de tecnología per radiofreqüència (RFID) i els últims avenços sobre Internet de les Coses (IoT). La tecnología RFID és el futur en quant a tecnologies sense cables per la identificació d'objectes. El principal objectiu d'aquest projecte és limitar l'acció de les antenes RFID dintre del carro per identificar únicament els productes que es troben al seu interior i integrar aquesta informació amb un sistema d'emmagatzemament. Amb aquest carro equipat amb RFID, els usuaris poden saber de quins objectes disposa en tot moment sense haver d'emprar un escaner de codi de barres, com passa amb els sistemas de codis de barres actuals. Això té un impacte significatiu en temps i diners per al comprador i el client. Aquest carro també pot ser emprat en llocs amb prestatgeries que ajudaria a estalviar temps útils dels usuaris.

Prologue

Current technologies are advancing very fast. Current systems are about to be ousted from the market due to the great potential of the new technologies that are being discovered. This is the case of RFID.
This technology is based on radio frequency identification tags and has endless possibilities for creating simple but very useful applications. This paper will try to show that this technology has a bright future applicable to everyday objects such as a shopping trolley. We will try to show the great potential from current technologies and what possible future implementations may have with it. The RFID has just arrived and is here to stay in our lives trying to improve them.

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1. INTRODUCTION

1.1 Overview

The great inclusion of RFID technology in the field of new technologies has a very promising future, especially in the field of Internet of Things.
This new technology allows stop old technologies such as bar codes allowing real-time control of our applications. It is a technology that has a very simple operation and consists of 3 basic components: a RFID reader, an RFID passive tag and a computer that processes the data.
The mechanism is simple but this powerful technology can create very interesting and useful applications.

In my project I have used this technology to the shopping experience of users in a library. My product is to provide a control system purchase depositing the product in the shopping trolley. We can control the purchase in real time and show some information that is interesting for the user.

1.2 Motivation

My final thesis work was related with the field of RFID and everything that surrounds this technology. During my 3rd year in college, I studied a subject called the Internet of Things (IoT) and I found a concept extremely interesting with a very promising future, although we delve somewhat due to the limitations that are presented in a class with many students and a defined project involved.
It was not clear how I can apply this concept to something that was useful and was not more than a simple application. So I found the project purposed by Kamruddin Nur and Raúl Parada Medina related with the RFID. I think it's an ambitious project because it is a step beyond the currently established technologies and that's a great motivation to work hard.

Being able to keep track of the purchase at all times in a natural way, i.e without using the scanner on each product you want to the cart, allows the user to not feel any difference between this new technology and the actual way to make a current purchase.
Despite not undergo any drastic change in the development of the purchasing process, the user can access their current purchase in a simple interface using a portable computer or tablet and even receive purchase recommendations.

The purpose is clear: to improve the shopping experience for the user. Thanks to the great future with these new technologies on RFID, I decided to choose the project 'Shopping Trolley'. To work in a new technology and in a new product is always a great motivation.

1.3 Objective

On this section, the project will be divided in some parts explaining, for example, which is the description of the idea of the project, which is the main goal to achieve and how will be managed the calendar of the project.

1.3.1 Description of the project

The goal of the project is the configuration of a trolley with a RFID system that allows us to know in real-time which objects we have inside the trolley, applied to a library situation.
But is not only to show a code or a number, in our case, we apply this concept to improve the experience of the user in a library.
With our trolley the user is always keeping control about which products are on the trolley and the user can see some extra information like the author, the ISBN and some more data about the books.

The project is divided in two main phases: the hardware phase, which is to delimitate the fetch of the antenna within the trolley. The main problem of this part is to adjust the power of the antenna and create a good distribution because we just want to detect if a product is inside of the trolley. If a product is not inside the trolley the RFID system has no to detect it. The second phase is the software development, and is basically programming an interface to show the data that is on the trolley, synchronize it with a database and work in a localhost server.

1.3.2 Goal of the project

The main goal of the project is to develop a trolley using RFID technology that allows us to know in real time which products I have in my trolley. This Smart Trolley would improve the user shopping experiences and would help to be more efficient when they go to shopping in a library/shopping center.
So, the goal is try to join the powerful RFID technology and the daily user experiences and create a new product that make the life easier.

1.3.3 Project Scope

- Make a good study of the features of the antenna and try to use the lesser number of antennas to detect the products.
- Make an intuitive interface for the users that allow the user to make the booking process with any interference on the process.
- Make an efficient system that allows the user to know instantly which products it has on the trolley in real-time.

1.3.4 Sponsors

The project is sponsored by the Universitat Pompeu Fabra and Keonn Technologies, the company that provides us the RFID, readers and tags.

The project is directed by Kamruddin Nur and Raúl Parada, from the Research Group UbiCALab.

1.3.5 Schedule

The project starts in the last quarter of 2014 and it's planned to be completed during the second quarter of 2015.
The project has two main parts: the part related with the antenna distribution and testing about these part and, as second part, the software development.

	3th Quarter 2014	4th Quarter 2014	1st Quarter 2015	2nd Quarter 2015
Phases of the Project	PROJECT START	Installing RFID Software	Software Development	Testing the system
	Project Charter	Initial Hardware Testing	Web Interface development	Deadline TFG
		Adjust the antenna on the trolley	Testing interface	TFG Defense
				PROJECT ENDS

Figure 1. Schedule of the project

1.3.6. Project risks and cost

- Software development is critical because all the system is based on different parts with different programming languages (Java, HTML, CSS, PHP,…). Join all these parts could be a critical part.
- Design an interface adapted to the user requires different studies about user experience and some testing.
- The laboratory availability may be a problem because there are a lot of people that is working with the same material.
- Create an architecture that allows us to cover just the inside part of the trolley. Maybe we need to create a structure to cover the trolley and don't read anything outside.

The cost of the project is related with the hours that are needed to develop and the material that we used to configure the system.
All the material that we need to create the system is:

- 4 Advantennas p11
- AdvanReader-100
- RFID passive tags[1]
- Material to make the structure to isolate the inner part of the trolley to the outside (Cardboard, paper-foil and PVC)

All the necessary equipment has been donated by the Universitat Pompeu Fabra in collaboration with the company Keonn.

[1] Passive tags: tag with no battery that only uses the radio energy transmitted by the reader.

2. STATE OF THE ART AND RELATED WORK

New technologies are constantly appearing and being more complete and interesting to create new applications. This project will work with a technology that is emerging on the field of The Internet of Things, because it is still under study and its price is high, but has great potential to simplify the daily lives of users in the future.

The great potential of this technology, apart from the physical concept, is the simplicity of the applications that we can create.

Currently, to solve the problem of keeping track and obtain information from a set of products, we use a bar code reader. This type of technology is the most widely used today because it is not overly expensive and efficient.

Figure 2.Barcode reader on a supermarket

The use is very simple and practical because it allows us to see information about the products we want to add to our shopping cart in a very simple way. Just bringing the code to the reader parses the system returns us information such as product name and price and other information interesting to the user.
It has an evident advantage, of course, but as it is improving the current technology and the tools that we have now in development, perhaps it is a bit limited because we cannot have control in real-time of our products.
It is obvious that the use of barcode or systems with similar technologies has been a big step to evolve to where we want to get in our project: the implementation of RFID technology in this type of scenario.

This technology is based on a RFID reader, an RFID antenna array and a set of passive tags.
These tags are engaged in the products we have in the library and when, is in the defined range of the antenna, the reader recognizes this and tells us that this tag is within range of current reading.

What is the main advantage over barcode reader? We can create a real-time reading system of all the products we have inside the trolley and show the data that is interesting for the users. What can we do with that? Countless applications.

This is an example from what we can expect to do with this type of technology: a system to control the renting of books automatically on a library.

Figure 3. RFID system for book checking in real-time[9]

We can apply this new technology in hospitals, libraries, supermarkets or stock control in warehouses. There are a lot of possibilities to take advantage of the many applications that offers us this technology to improve daily processes.

Currently, there are a lot of investigations and papers that shows the main applications that are being studied.
But we want to focus us on two simple concepts: **trolleys** and **product identification**.
There are several studies on different types of trolleys geolocation in shopping centers, for example on the paper "Supermarket Costumers Routes-and-Times Identifier"[6] of Jose Manuel Escobar Gomez, Andres Felipe Jaramillo Rodriguez Alvarez and Jan Bacca. It is based on the use of passive tags to map several local tours. It is a very useful and interesting concept.

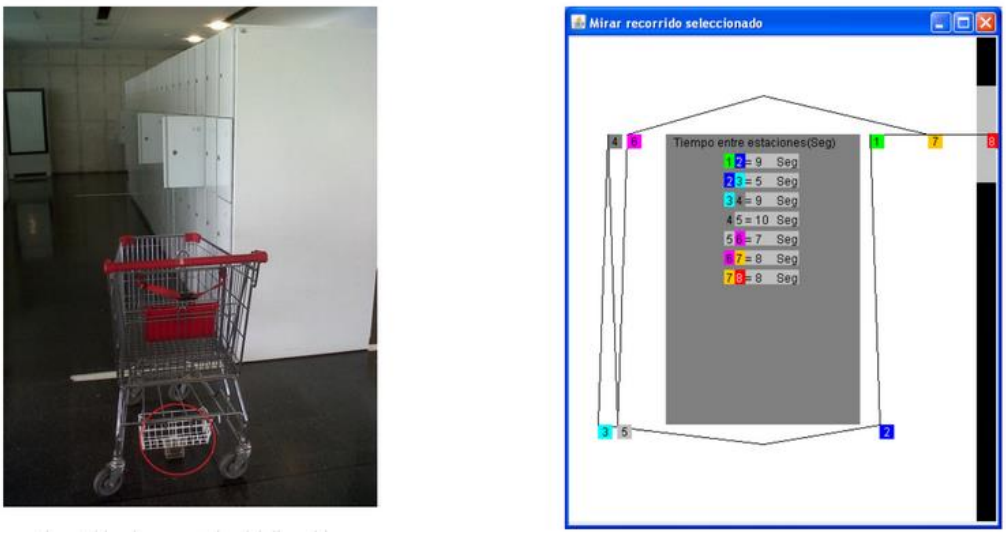


Figure 4.Design of the trolley that allows to mapping the navigation between corridors[6]

There are many studies on the RFID technology on the use of this library to shelves or appliance stores, in order to improve control of the products at all times and helps the users to find the products they want to buy. The paper "A smart assistant product-awareness Toward shopping"[3] Chia-Chen Chen, Tien-Chi Huang, James J. Park and Huang-Hua Tseng shows some of the most common uses of these technologies applied to shelves.

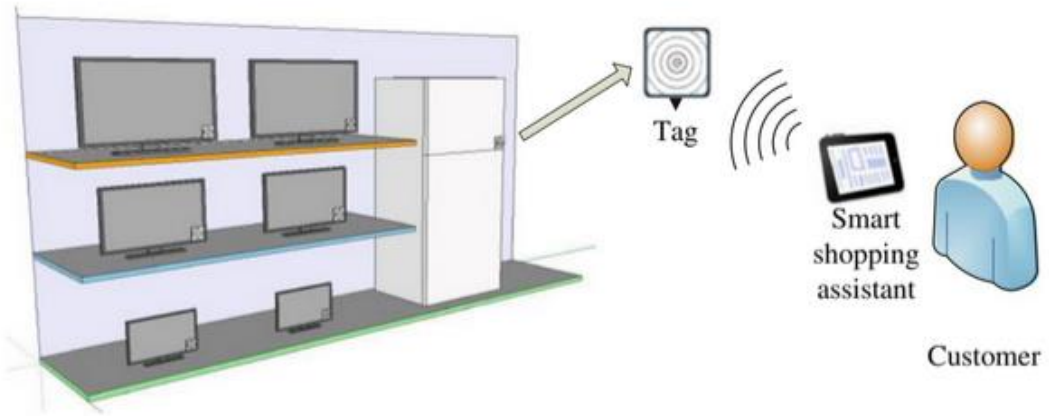


Figure 5.Smart Shelves with RFID system location[3]

One of the most influential papers for us has been "IRL SmartCart -A User-Context-aware adaptive Interface for Shopping Assistance"[2] of Gerrit Kahl, Lubomira Spassova, Johannes Schöning, Sven Gëhring, Antonio Krüger, which focuses on the creation of a trolley equipped with a geolocation system in a local by using multiple antennas and an optical mouse to reach the products of a shopping list.

Figure 6.Trolley with 2 antennas and an optical mouse to navigate on the supermarkets (IRL-SmartCart)[2]

Looking these types of systems, we want to create a new concept of trolley. Mix the two main ideas extracted from the papers (product identification and trolley equipped with a RFID system) and create a new product.
In our case, the idea is to create a trolley focusing in isolate the inner part of the trolley from the outside and create an interface applicable to a library to track in real time the books you have on the trolley. With this interface, the data about the books that are inside of the trolley is showed to the users, helping the users to know information about the books in an easy way.

In summary, with the use of RFID technology, in our case, we want to go a step forward and try to break with the current system information reading objects in this type of scenario and improve the user experience. RFID is the future of the Internet of Things and we want to start doing something interesting.

3. RFID SMART TROLLEY DESIGN

3.1 System overview

To analyze the idea and obtain some good results about this new technology we need the main actor: the RFID SmartCart.
The SmartCart system is formed by an RFID reader *AdvanReader-100*, a set of RFID passive tags, an Ethernet cable to connect to the board and a computer for data processing system. We will show the technical specifications later, on the hardware section.

The final product looks like this picture:

Figure 7. Final design of the trolley

But to know some interesting data about the products that we want to rent, a part of the RFID system, we need a shopping trolley where we add the RFID system and a laptop where the information for the client will appear.
To collect the data from the RFID system, the system make a query[2] from a database where we are connected. It is a very simple form to collect the data and show it on the screen.

The concept is simple: attach the RFID system to the shopping trolley to carry a real-time control products and exploit the features of this technology.

[2] Query: command in SQL programming language to extract information from a database

Just putting the products in the trolley, the system detects if the product is inside the trolley (detected with the RFID passive tag), and automatically the ISBN, publication author and extra information that may be useful to the customer is printed on the interface.
With the advancement of RFID technologies, we put aside outdated technologies as the barcode to keep track of the products that we put inside the cart because the barcode does not allow us to keep a real-time control systems, not allowing a total-control of the experience. Due to the overall architecture of shopping trolleys, we have the need to isolate the trolley from the outside with paper-foil. This will be explained on the Experiments section.
If the SmartCart is not covered with foil, is extremely hard to avoid to detect products only when they are inside the trolley and not outside. This is a picture of the different layers of the covering.

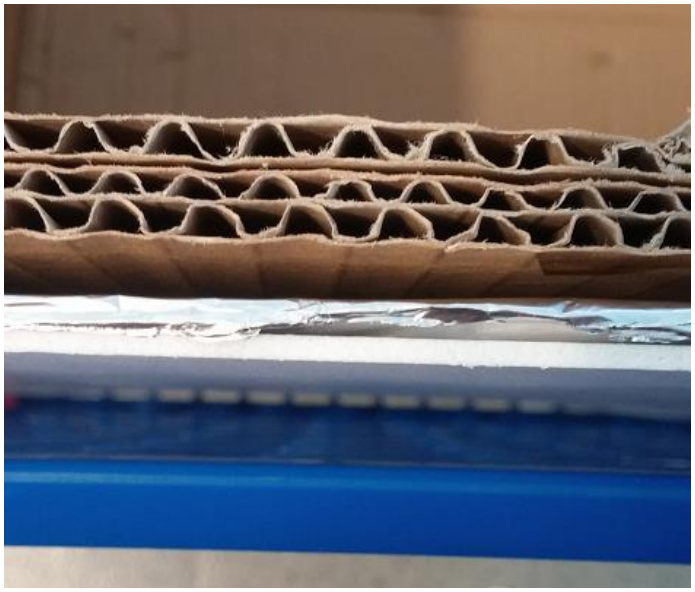


Figure 8. Different layers of the covering: card-board, paper-foil and PVC

3.2 Hardware

All the system that is configured on the trolley to use the RFID technology is given by Keonn. The technical specifications are the following:

– RFID readers: AdvanReader-100
This part of the hardware is a board connected to the computer using an Ethernet cable. Allows connecting 4 antennas at the same time and has a very flexible range of powers to configure the reader, from 5 dBm to 31.5 dBm.

– RFID antennas: Advantenna P11
The beamwidth[3]of the antenna is 100º/100º and the dimensions are 137 mm x 137 mm x 3.3 mm.

[3] Beamwidth: the angle between the half-power of an antenna pattern or beam over which the relative power is at or above 50% of the peak power.

This model is simple than others like P12, for example, and has a wider bandwidth.

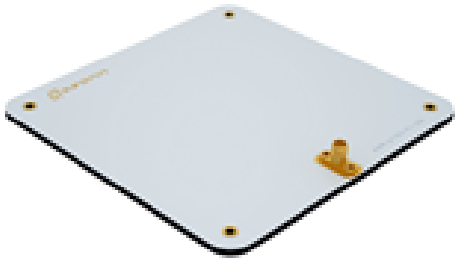
Advantenna-p11	***AdvanReader-150***
	

Figure 9. Antennas and the reader design

To process the data and show it on a screen we don't need any special equipment, just a computer with Ethernet connector.
The main element is the reader system. This system is the responsible to manage all the data that is on the trolley. If an element is inside, the system should detect it and insert it on the database. The system is based on the *RFID Reader:AdvanReader-100* and 4 antennas, that are located on the bottom of the trolley.
The antennas are 4 *Advantenna-p11* that give us a gain of 3.2 dBi and 100º of beamwidth.

3.3 Software Development

On this part all the software process will be shown. To show the results of the trolley system with the antennas we have developed an interface to show the data about the books of the library. With this software we want to improve the user experience keeping the natural way to take books but giving more information about the books to help the users.

The software includes a database with all the information needed about the books (name, number of the tag, description, author and more interesting information), some html and css file to create the interface and some scripts to became connected with the database and show the data on the screen.
All the project is running on WampServer[4], that allows to run the website on localhost and use the reader system.

[4] WampServer: WampServer is a Windows web development environment. It allows you to create web applications with Apache2, PHP and a MySQL database. Alongside, PhpMyAdmin allows you to manage easily your databases

3.3.1 Architecture of the System

The architecture of the System is based in 3 elements:

- Database on MySQL
- Web interface
- Reader System

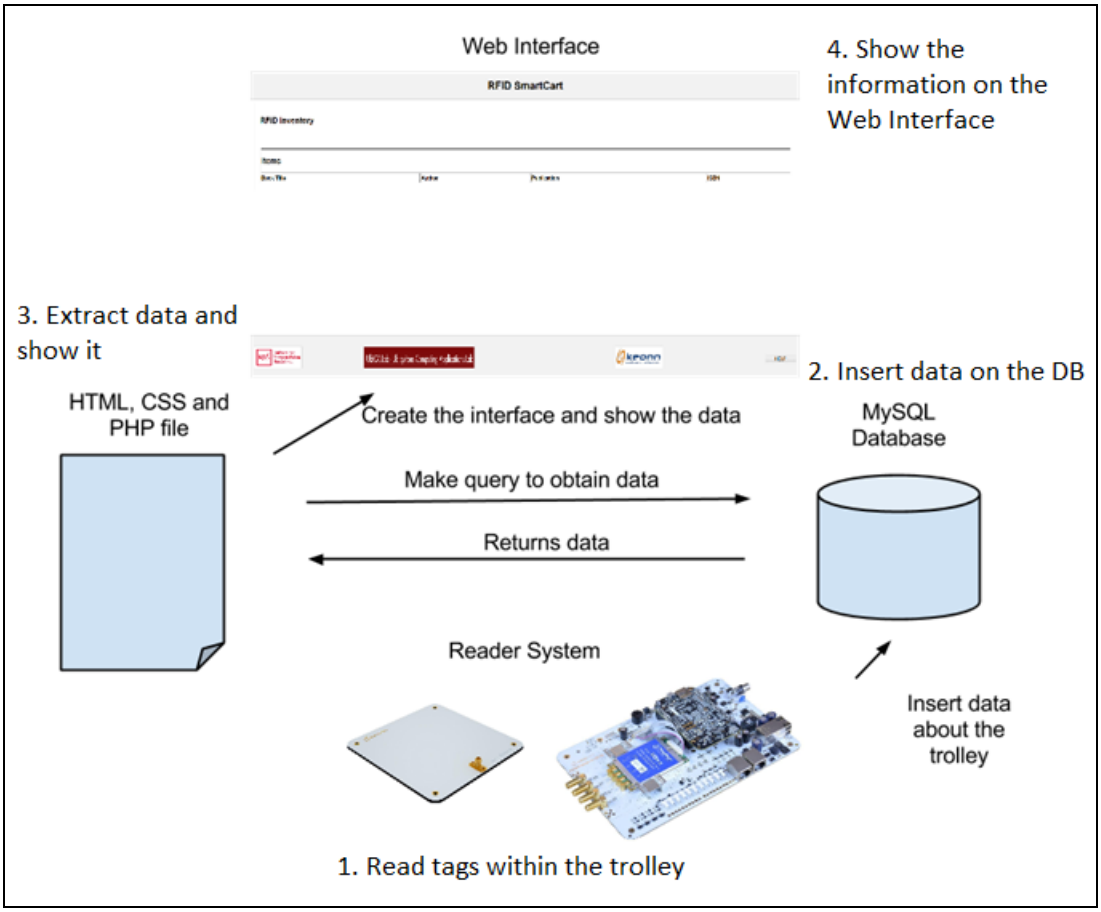


Figure 10. Logical schema of the system

Configuring some files, we can modify where we want to obtain the data and we can insert it directly to our database and work fast and simple. This configuration is very useful because the process to collect the data is automatic and very clear.
The databases of the project has been managed using PHPMyAdmin[5], a software that allows to create with a very simple way a database and synchronize it with the RFID system

[5] PHPMyAdmin: free and open source tool written in PHP intended to handle the administration of MySQL with the use of a web browser.

On the data base we have two main tables:

- **Inventory**: This table contains only the data that is on the trolley. On every iteration, the table is truncated and is empty, to avoid possible errors with the repeated data.
We use this table to make an EQUI JOIN with the LibraryBook2 table to obtain the information about the books (name, author and description, for example).

#	Nombre	Tipo	Cotejamiento	Atributos	Nulo	Predeterminado	Extra
1	id	bigint(20)			No	*Ninguna*	AUTO_INCREMENT
2	data_source	varchar(128)	latin1_swedish_ci		Sí	*NULL*	
3	cycle	int(11)			Sí	*NULL*	
4	epc_hex	varchar(128)	latin1_swedish_ci		Sí	*NULL*	
5	epc_decoded	varchar(128)	latin1_swedish_ci		Sí	*NULL*	
6	epc_serial	bigint(20)			Sí	0	
7	location	varchar(128)	latin1_swedish_ci		Sí	*NULL*	
8	time	timestamp		on update CURRENT_TIMESTAMP	No	CURRENT_TIMESTAMP	ON UPDATE CURRENT_TIMESTAMP
9	antenaX	bigint(20)			Sí	*NULL*	
10	antenaY	bigint(20)			Sí	*NULL*	
11	antenaZ	bigint(20)			Sí	*NULL*	
12	shelfNo	bigint(20)			Sí	*NULL*	

Figure 11. Content of 'Inventory' database

- **LibraryBooks2:** This table contains all the information about books that are on the 2nd floor on the UPF Library, from T to TK. We use this table to obtain the data that we will show on the web interface to the users and that will help to know the user which books are on the trolley.

#	Nombre	Tipo	Cotejamiento	Atributos	Nulo	Predeterminado	Extra
1	barcode	varchar(10)	utf8_general_ci		Sí	*NULL*	
2	epc_hex	varchar(24)	utf8_general_ci		Sí	*NULL*	
3	itemX	varchar(50)	utf8_general_ci		Sí	*NULL*	
4	COL 4	varchar(5)	utf8_general_ci		Sí	*NULL*	
5	COL 5	varchar(5)	utf8_general_ci		Sí	*NULL*	
6	COL 6	varchar(50)	utf8_general_ci		Sí	*NULL*	
7	title	varchar(255)	utf8_general_ci		Sí	*NULL*	
8	author	varchar(138)	utf8_general_ci		Sí	*NULL*	
9	publication	varchar(246)	utf8_general_ci		Sí	*NULL*	
10	description	varchar(91)	utf8_general_ci		Sí	*NULL*	
11	isbn	varchar(101)	utf8_general_ci		Sí	*NULL*	
12	volume	varchar(50)	utf8_general_ci		Sí	*NULL*	

Figure 12. Content of 'LibraryBooks2 database

3.3.2 Interface design

Maybe this is one of the more important parts to make easier the user experience, because if we don’t use an easy-learning interface we can create problems to the users and be a fail project. I have decided to create a very simple and clear interface to make easier the interaction and really improve their experience with the trolley.
The interface has been implemented using HTML, CSS and PHP to create the visual part and the connection with the database, which allows us to connect the interface with the database and show the data about the books that are on the trolley.

When the system detects a new book, just print the data that we want and when the system detects that the books is not on the trolley, this information is erased.

This is the final web interface to show the data about the books on the trolley:

Figure 13.Final interface design for the SmartCart

There is a footer that includes links to the websites of Universitat Pompeu Fabra, UbiCALab (the department that manage the project) and Keonn, the responsible to give us the hardware to complete the project.

On the right there is a button called ‘HELP that will make appear a pop-up window with some instructions if the system it doesn’t work well.

Figure 14.Pop-up window to help users

The most important part of the interface is the div[1] that contains the data about the database.
On this div the data is printed showing the information that we want to give to the users about the database.
In our case, the data that is shown is the book title, the author's name, the publication date and the ISBN of the book.
To create a system that works in real-time we need to refresh the div of the webpage every 2-3 seconds.
Using AJAX[6] we can update the information on the screen without any blinking or refreshing the page. We just refresh the part that we want to refresh sending the information in background.

[6] AJAX: is a group of interrelated Web development techniques used on the client-side to create asynchronous Web applications

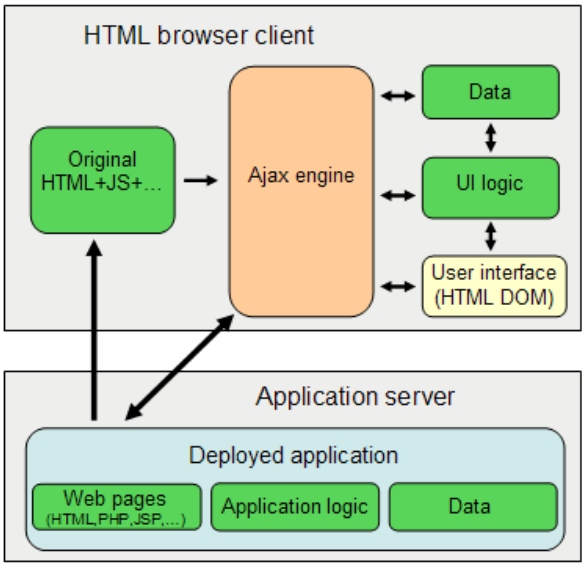


Figure 15.AJAX basic diagram

The interface includes extra information about how many books are on the trolley and when it has checked the last actualization.

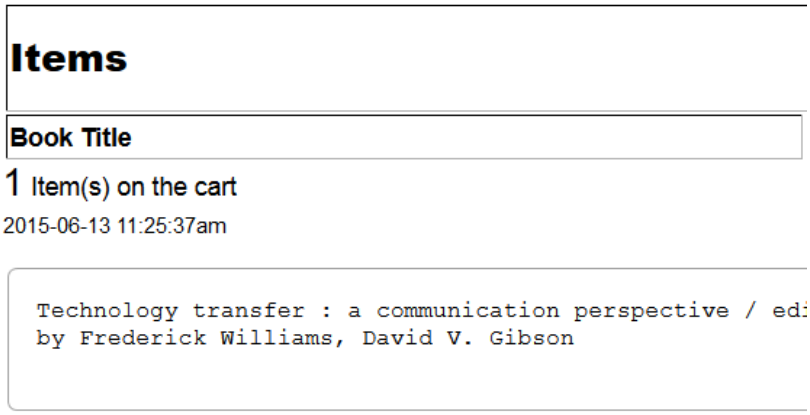


Figure 16. Counter of books and last refreshing of the system

4. METHODOLOGY OF WORK

One of the most important things to realize this project has been the workflow. During the entire project the development and testing has been always present and always we have been trying to improve the results.
The task, as shown in the calendar of the beginning of the project, has been divided into two main parts: the trolley configuration with the RFID system and the software and design of the interface and database.

Throughout the process the feedback from teachers has been constant, which has helped to bring everything up to date and have a constant control of any doubt, unforeseen technical issues. The configuration part of the cart with the RFID system has been the most complicated, because RFID work requires a lot of trial and error to identify weaknesses and work on them to improve it. It was a staged process, we've gone increasing the requirements. We started testing some basic configurations and seen the problems. Analyzing the results obtained on every experiment, we have been changing the location of the antennas trying to improve the results. Gradually, we have been shaping the system to get the final product that we had to finish the project.

The software development has been a lighter process. The programming part has been a faster process but not less important, because it is necessary to have a good interface and receive good feedback to really improve the user experience with the cart.

With teachers have been added to improve the interface details but keeping clear a philosophy: easy to use and clear. Create an excessively overloaded interface in this case it did not have much sense as a general rule users will not interact too much with it. Simply fulfill its function: to show the necessary information to help the user to know what is inside the cart.

Now the experiments that have been performed on the laboratory and the library with the SmartCart system will be explained and the results will be analyzed too.

5. EXPERIMENTAL RESULTS

To check if the system is working properly, is essential to make some tests to extract results and define if the project is going well or not.
The main structure of the tests is basically directed by the following restrictions:

Experiment restrictions

- **Goal**: Figure out minimum Read Time and Read Power to read a specific amount of items inside the trolley without reading the items surrounding.
- **Items**: Books
- **Description**: Attach the antenna to the trolley and check if the systems detects the products only when are in the inner part.
- **Parameter & Values**:
    - Read Time: From 50 to 1500 ms
    - Read Power: From 10 to 31.5 dBm
    - Session: 1
    - Target: A
    - Enable Low Level Filter

Results: Minimum Read Time and Read Power (constant) where the system reads ONLY the specific tags.

To say that the system is working as we expect, is need to check if all the experiments that we do on the lab and the library (final experiment in a real situation for the user) is validating the following milestones:

Milestones:

1. Read nothing 0.3 meter outside of the card (Primary Importance)
2. Read all inside the card (Secondary Importance)
3. Web user interface showing read items and some extra information (title, author and more extra information)

The configuration of the antenna, specified on every test, is basically the value that are selected to make the experiments trying to adapt as best as I can the system to the trolley.

- **Antenna type**: It is the model of antenna that is used on the test

- **Power**: Fix the power to read closer or farther and the range is 31.5 dBm to 5 dBm

- **Read-time**: This values determines how frequently the antenna is reading tags

- **Filter**: It is a Boolean value that is to apply a filter when the antenna is reading or not. If we apply a filter we can read only the tags that we want to read.
- **Filter tag**: Specifying a filter we can define which tags we want to read only

- **Sensitivity**: A parameter that fix which intensity you want use as maximum to read tags.

5.1 Tests on the Lab and Library

The process of creating the cart with the RFID system has been progressive. It is divided into several cases or different tests to show step by step how has gone the process and why every test has been done.

- CASE 1. First test with the antenna
- CASE 2. First test with covered box
- CASE 3. Testing covered box by the outside and inner part with antenna on the bottom.
- CASE 4. Testing covered box by the outside part and antenna on the bottom
- CASE 5. First test on the real trolley covered with foil and antenna on the back
- CASE 6. Second test on the real trolley covered with foil and antenna on the front.
- CASE 7. Third test on the real trolley covered and antennas on the sides
- CASE 8. Final tests on the real trolley (I) One antenna on the bottom
- CASE 9. Final tests on the real trolley (II) Two antennas on the bottom
- CASE 10. Final tests on the real trolley (III) Three antennas on the bottom
- CASE 11. Final tests on the real trolley(IV) Four antennas on the bottom

Now, the different cases will show the evolution of the location and of the antennas and the isolation on the trolley.

CASE 1. First test with the antenna

The first test that I realized is basically to know where I have to locate the antennas. I started using only one antenna, try to go step by step.
I started using the antenna P12 because due to the shape of the cart the beamwidth could work better than the beamwidth given by the P11.

Location: UbicaLAB
Antenna configuration:

- Antenna type: P12
- Power: 31.5 dBm to 18 dBm
- Read-time: 500 ms
- Filter: true
- Filter tag: ‘abcd’
- Sensitivity: 82 dBm

Test case 1:

The first test is locating the antenna P12 in the back of the trolley, trying to take the best profit of the beam width of the antenna that the Keonn’s website shows us.
Some different powers has been tested from 31.5 dB to 19.5 dB, which seems to be the minimum required power to cover all the trolley structure that we want to measure, at least to cover to the front of the trolley.
Adjusting the antenna to below 19.5 dB we can check that it works but not always.
The test it consists in put the tag around the whole trolley, mostly inside but testing how it works when the tag is outside too.

Results case 1:

This has been the position to check how it works the p12 antenna on the trolley. The antenna is at 2-3 cm from the trolley floor.

Figure 17. First test of antenna p11

These are the results of the test, where you can see where the tags are detected by the reader and where aren't detected. The red dots represent where the tag is not read and blacks represent where they are captured by the reader.

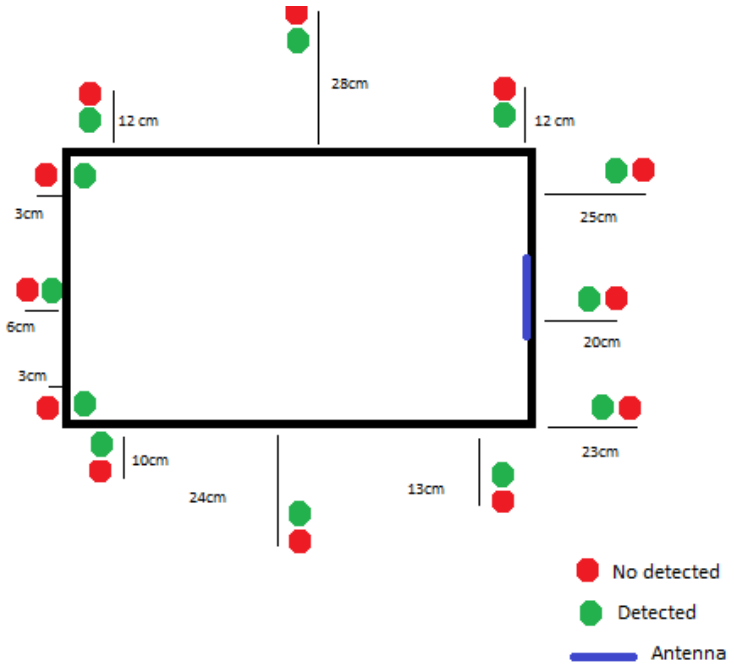


Figure 18. Graphic of results from case 1 test

Summary case 1:

From all the powers that I tested during the test on the laboratory, the minimum to cover the trolley is 19.5 dB. In some areas, because of the antenna beam, the tags are read at a greater distance, which still have to improve it.
Before this test analyzed, the next test will be using P11 antennas to be located in different parts of the trolley, trying to avoid the problem with the tags that are not well detected.
Another option would be to use the P12 with different orientation but due to beam having much more complicated would cover the entire trolley as cover to start the trolley, the sides would be greatly affected.
Another change that will be added is to make a test with a box (keeping the scale of the trolley) covered with foil, trying to isolate the inner part from the outside.
If the trolley is not covered, the project would fail because is not possible to read only the inner part.

There are 3 different ways:

- Cover only the inner part
- Cover the outside
- Cover inside and outside

Trying to improve the problem with the height, we have done a top-cover for the trolley, covered with paper-foil too that will check on the next test.

CASE 2. First test with covered box

Location: UbiCALab
Antenna configuration:

- Antenna type: P11
- Power: 19.5 dB
- Read-time: 500 ms
- Filter: true
- Filter tag: ‘abcd’
- Sensitivity: 82
- Location of the trolley: In the middle of the department

Test case 2:
On the second test has been used the antenna P11 putting it in the back of the trolley but putting inside of a box made with card-board and covered with foil.
This test is realized with the P11 antenna because if I had used the P12 antenna probably would have been too big. We used a scale example of the trolley just to know how the paper-foil helps us to isolate the tags when are outside of trolley.
We have done the same tests as the previous experiment, like testing where the antenna stops capturing tags and checking that within the trolley, the tags are captured always.
For this experiment, we made a top cover just to check if it's necessary or not for isolate by the top part of the trolley.

Results case 2:

The box that has been used to realize this test is the following:

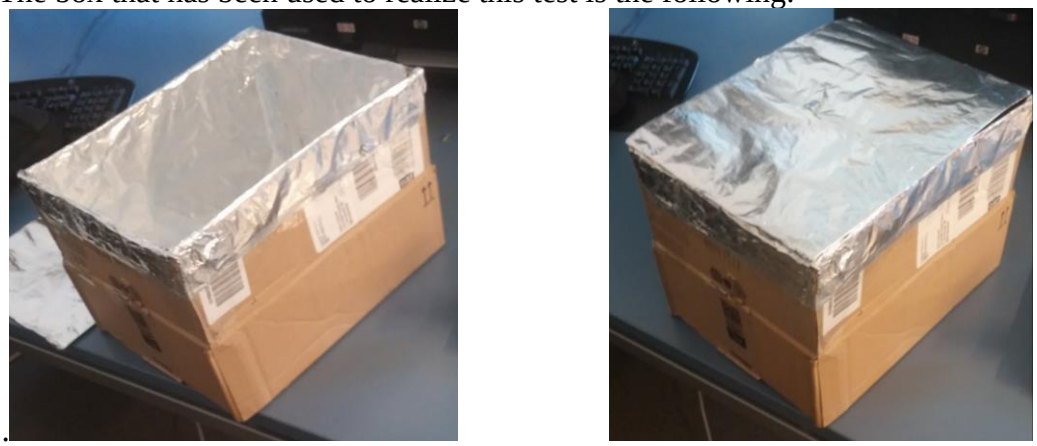


Figure 19. Scale-box to check paper-foil isolation

The box is made with card-board and covered with two levels of paper-foil to ensure the well isolated from the outside.

- The dimensions of the box are 35 cm x 20 cm x 20 cm.

This graphic shows the results of the test that has been done with the box covered with foil on the inner part

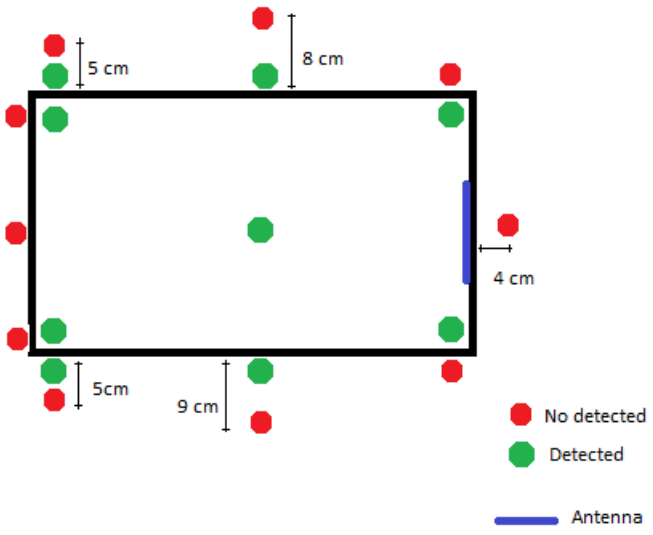


Figure 20. Graphic about results from case 2

The following image shows where the tag, when is put below from the box, is not detected.

Figure 21. No detection from a tag that is under the box covered with foil

The box was checked using the top-cover but as I commented before it didn't work too well because the tags detected at a considerable distance. The problem is because covering the inner part, the signal is amplified and the height where is detected the tags are extremely high.

Figure 22.Checking the top-cover isolation

Summary case 2:

The power used for the test is the same power as the previous experiment because we checked that this is a good power for the experiment.
Actually works quite well, except for the top part, that is not working as we expect.
On all sides of the box, the material insulates quite well, since the distance that stops capturing is much better than without using aluminum foil.
The main problem is that without top-cover the readers detect the tags at a very high distance. It's because paper foil amplified signal up.

Using a top-cover covered with paper-foil the problem with the height is not solved totally. The problem is that if the top-cover is used on the final SmartCart design, the user experience will be affected, so the top cover will not be used.

As a final conclusion of the test, is possible to say that seems pretty well the isolation system with paper-foil. The problem is the top-part of the trolley because is not possible to cover it and the problem with the height is a real problem. The most important parts of the structure, as the sides and bottom, are well isolated with the foil and will keep covered on the final design.

CASE 3. Testing covered box with antenna on the bottom

Location: UbiCALab
Antenna configuration:

- Antenna type: P11
- Power: 16 dB
- Read-time: 500 ms
- Filter: true
- Filter tag: 'abcd'
- Sensitivity: 82
- Location of the trolley: In the middle of the department

Test case 3:

I tested the antenna P11 putting it in the bottom of the trolley. I used the same box, which is covered with foil by the inner part and the outside
I did the same tests as the previous experiment but only changing the position of the antenna and the power.

Results case 3:
The results are very encouraging because is the first time that I finally get to make the system does not detect labels out of the box and it seems that works better.

I tested the tag putting in different position around the box and moving it, as if I were walking through a supermarket and I had products around me. To prove which is the best form to cover the trolley with foil I will make a models just covered by the outside. With this experiment I want to compare which is the best form to isolate the products that are outside of the trolley.
I saw that covering only the inner part, it works but not so good as we expected, as I commented on the last test.

As it happens with the last test, in the top part, the signal is amplified because I can detect tags when are very high. Using the top-cover that we made, it happens the same, so I think I cannot avoid that with this antenna configuration.

Figure 23. Checking the inside and outside isolation

Summary case 3:
I did the same test but reducing the power of the antenna. I changed the power because with the power that I used in the last test, some tags were detected when are outside of the box and changing the power this problem is not so evident.
With 16 dB, I can detect the tag when is inside of the box and when is outside the system doesn't detect it.
Only in the corners, when is a little bit high from the bottom level of the box, sometimes the system detects the tags when are outside but in general it doesn't.
The problem with the height it keeps.

CASE 4. Testing covered box by the outside part and antenna on the bottom

Location: UbiCALab
Antenna configuration:

- Antenna type: P11
- Power: 16 dB
- Read-time: 500 ms
- Filter: true
- Filter tag: ‘abcd’
- Sensitivity: -82dB

Test case 4:

On this experiment I have tested the antenna P11 putting it inside of a box made with card-board and covered with foil. I used two levels of foil to be sure that the box were well isolated.
I made the same experiment but just changing the side where the box is covered with foil and the antenna location.
In the last experiments, I tested two different boxes: a box covered only inside and other box covered inside and outside. Now I will test covering only the outside part.

Results case 4:

The experiment shows that the best form is to cover the box only outside because we avoid problems of reflection with the paper-foil and the sides are well isolated. After the test, I made this graphic that represents the situation of the box covered with foil and how the material isolate the box from the tags

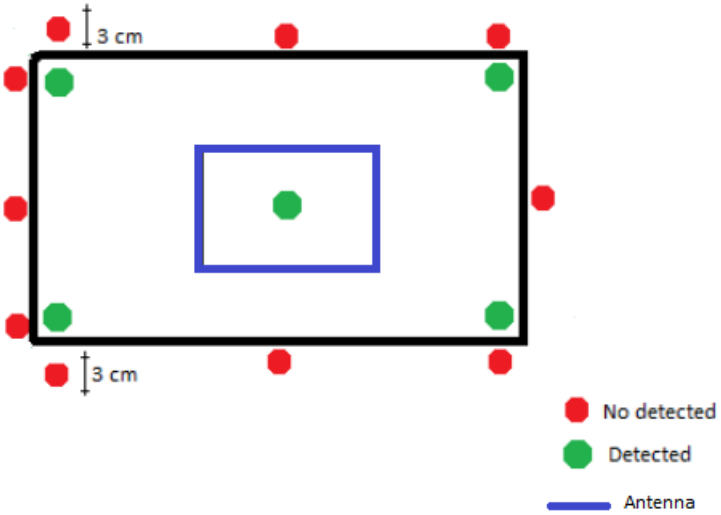


Figure 24. Graphic about results from case 4

Figure 25. Box isolated by the outside

Using a top-cover for the box has the same result than the last test because the problem is related with the power.

Figure 26. Testing the top-cover isolation

Summary case 4:

The results are better comparing with the other two forms to cover the trolley. The isolation is well and the problem with the height is not so evident.
The problem still exists but with much less intensity. Probably this kind of coverage and adjusting power, we can control the height problem.

So, the final conclusion about the three tests with different forms to cover the trolley is that the best way is cover only by the outside.
If we try to cover the inner part, if the antenna is touching the foil and the inner sides are reflecting the signals of the antenna, the problem with the height will be always present and the system will not work well.
Only covering the outside we can avoid the problems reading tags that are near from the trolley and stop problems reading tags that are very high only adjusting the power

Now, being tested the problem of paper-foil and analyzed with good results, the next step is to cover the real trolley and test it to see how it works.

CASE 5. First test on the real trolley covered with foil and antenna on the back

Location: UbiCALab
Antenna configuration:

- Antenna type: P12
- Power: 19 dBm
- Read-time: 500 ms
- Filter: true
- Filter tag: 'abcd'
- Sensitivity: -82 dBm

Test case 5:

On the first test using paper foil on the real trolley, the intention it was try to cover all the trolley without read nothing outside taking advantage of the antenna beamwidth and the cover with foil on the outside part.

Results case 5:

On this image is shown the first test trying to use the less height possible (thinking about the tags that are above the trolley). We achieved to configure a power for this but problem is that I can't cover all the trolley, so this antenna location is not very useful. With the trolley covered with foil, the main problem is the height because on the sides the tag is never detected.
Trying to adjust the power to control the height but then the problem is that I can't read in all the trolley.

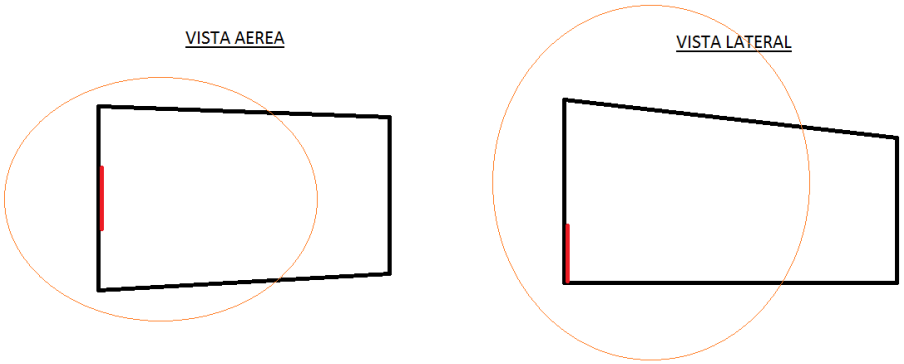


Figure 27. Graphic about results of case 5 avoiding height problem

After that, we tried to increase the power trying to cover all the trolley but the problem it was that I could read tags too excessive height.

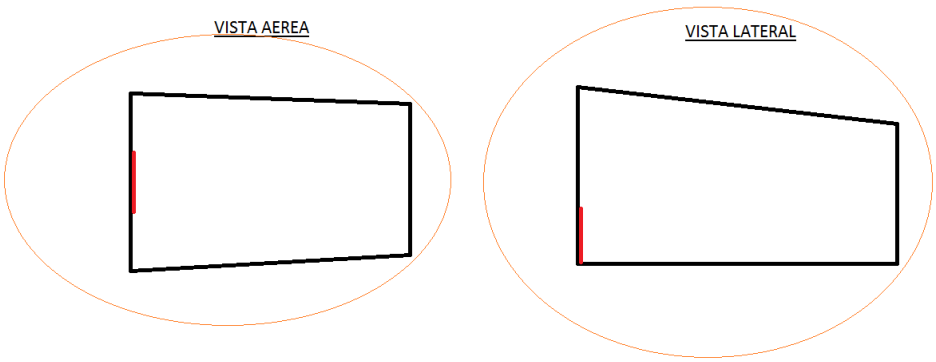


Figure 28.Graphic about results of case 5 increasing power

Summary case 5:
Seeing these problems we decided to try another location of the antenna and change the type of antenna. We decided to change the type of antenna because P11 is little than P12 and maybe is better to locate more than 1 on the trolley because may be necessary.

CASE 6. Second test on the real trolley covered with foil and antenna on the front.

Location: UbiCALab
Antenna configuration:

- Antenna type: P11
- Power: 22 dBm - 24 dBm
- Read-time: 500 ms
- Filter: true
- Filter tag: 'abcd'
- Sensitivity: -82 dBm

Test case 6:

As was commented, we decided to change the type of antenna because the new location was smaller and the P12 didn't work well.
The main purpose of the test is basically test how is working the antenna p11 with the trolley covered with paper-foil.

Results case 6:

As the previous test, we had problems with the height trying to adjust the power of the antenna.

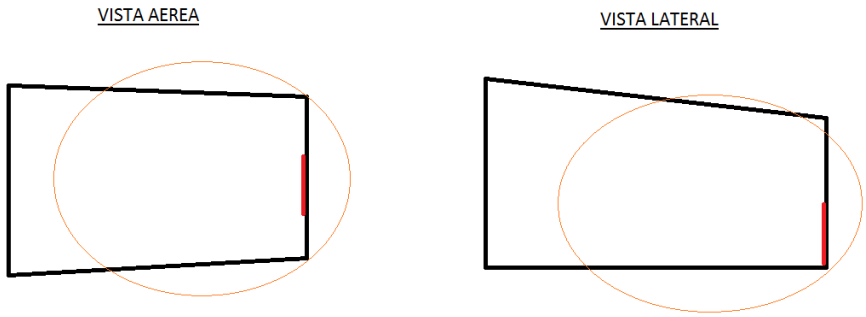


Figure 29. Graphic about results of case 6 avoiding height problem

Increase the power it wasn't the solution because the problem with the height it was the same.

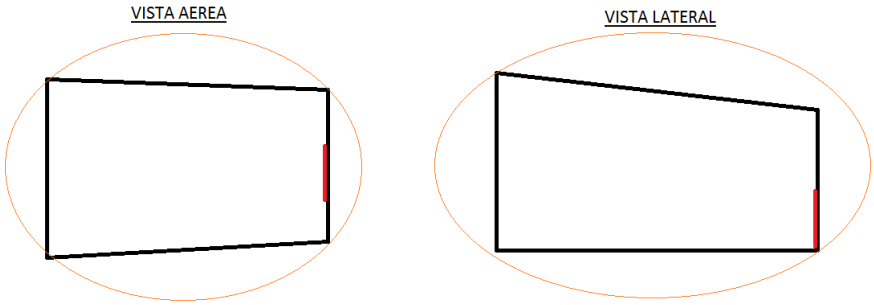


Figure 30.Graphic about results of case 6 increasing power

Summary case 6:

The main result that we obtained with this test is the necessity to add more than 1 antenna P11 because we can't control all the trolley with just one.
Another conclusion is that the location is not very useful for our project, so the location would be changed too.

CASE 7. Third test on the real trolley covered and antennas on the sides

Location: UbiCALab
Antenna configuration:

- Antenna type: P11
- Power: 17 dBm
- Read-time: 500 ms
- Filter: true
- Filter tag: 'abcd'
- Sensitivity: -82 dBm

Test case 7:

To change the locations, the decision to situate the antenna on the sides of the trolley was a good idea, waiting interesting results but that never happens.
We decided to change the location and the number of antennas that will be use.

Results case 7:

This new location for the antennas is not very useful because the mainly beamwidth is not well spent and a lot of power is not used.

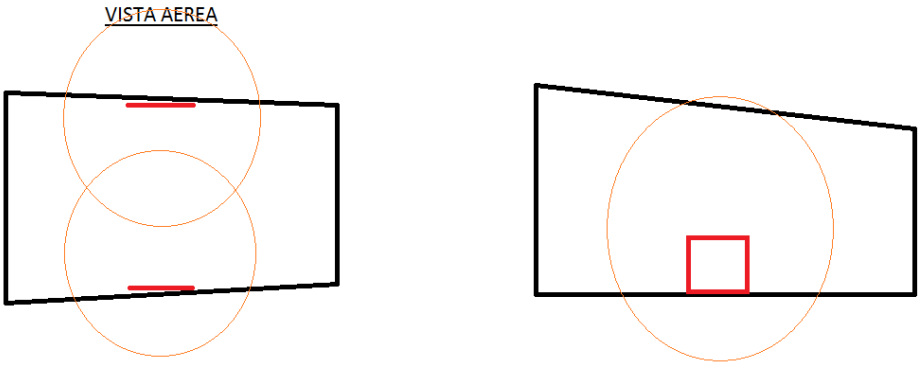


Figure 31. Graphic about results of case 7 avoiding height problem

As we commented before, if we try to increase the power of the antenna, the graphic shows the result of the experiment. We can cover the 70% of the trolley but if we want to cover all the trolley the height problem remains.

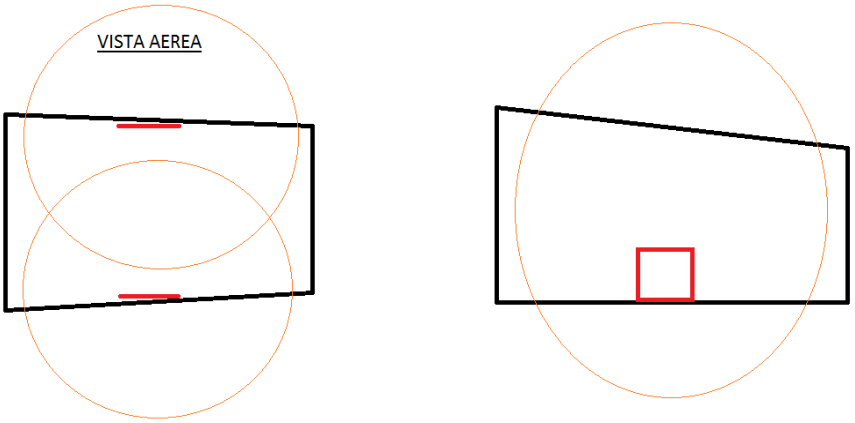


Figure 32.Graphic about results of case 7 increasing power

Conclusions case 7:

The height problem it was the same and it was impossible to cover all the trolley with only two antennas with this location. So, we decided that on the next test the number of antennas would be bigger on the trolley and different locations would be tested too, because with this distribution we cannot all the trolley without have height problems.

Final distribution of antennas for the final design

When the last test is finished, the decision to change the location is approved. The working team decided to locate the antennas on the "floor" of the trolley trying to control to cover all the trolley and have controlled the problem of adjusting the power level of each antenna.
We will start putting just one antenna but the number of antennas would be increased if it's needed to ensure the proper functioning of the system.

CASE 8. Final tests on the real trolley (I) One antenna on the bottom

Location: UbiCALab
Antenna configuration:

- Antenna type: P11
- Power: 19 dBm
- Read-time: 500 ms
- Filter: true
- Filter tag: 'abcd'
- Sensitivity: -82 dBm

Test case 8:
As I commented before, I decided to make a change about the location of the antenna on the trolley, hoping to find a solution for the height problem.

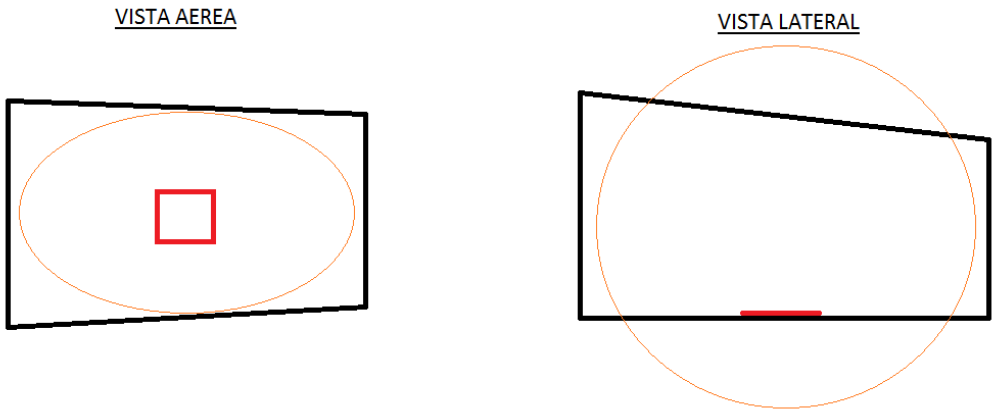


Figure 33. Graphic checking distribution p11 in case 8

Results case 8:

I put the P11 on the middle of the trolley, with the intention to cover all the trolley but the height problem still existed, I began to try more than one antenna. I tried to increase the power to see what happens and I decided to use two antennas, with less power each one, trying to solve the height power.

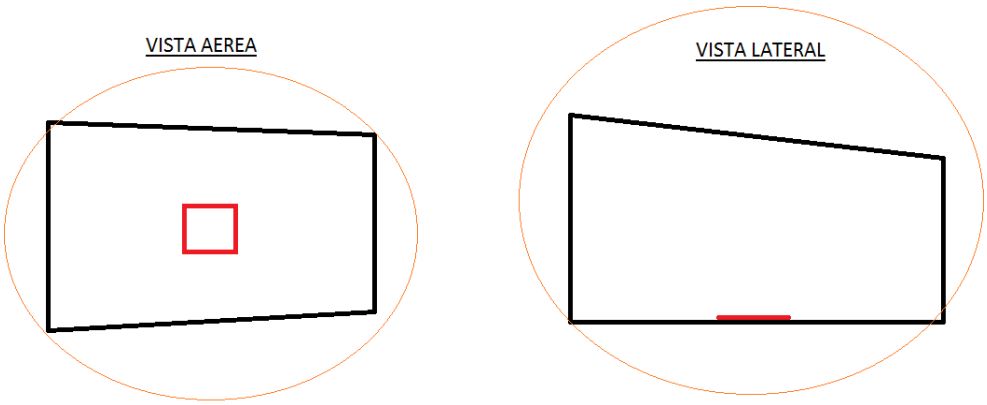


Figure 34.Graphic about results of case 8 distribution increasing power

Summary case 8:

Obviously, when we analyze the results we can extract that if we want to cover all the trolley without problems with the height problem we need to increase the number of antennas on the trolley.
If we just want to increase the power we have seen that this is not a way to make a good system because in our case we need not to read anything outside of the trolley including this isolation the top-part of the trolley.

CASE 9. Final tests on the real trolley (II) Two antennas on the bottom

Location: UbiCALab
Antenna configuration:

- Antenna type: P11
- Power: 16-17 dBm
- Read-time: 500 ms
- Filter: true
- Filter tag: 'abcd'
- Sensitivity: -82 dBm

Test case 9:

Following the idea that I had with the last test, I decided to start using two antennas to see how it works the idea. I locate the antennas on the middle of the trolley trying to cover all the extension.
That's the new location that I proposed.

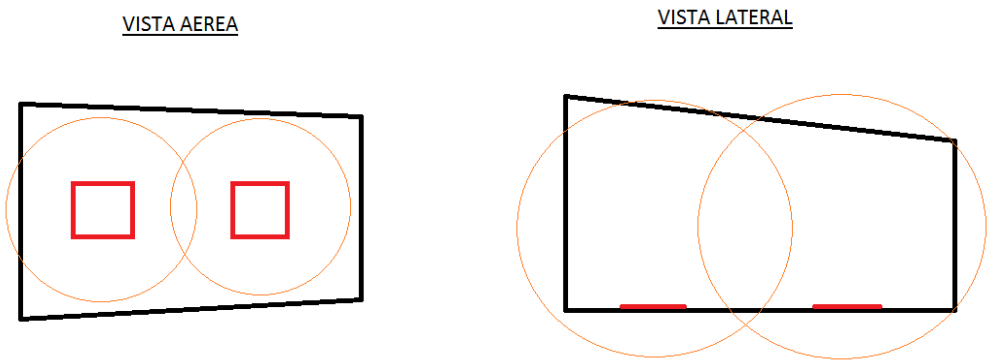


Figure 35. Graphic checking distribution of 2 p11 antennas in case 9

Results case 9:

With a power that is not very heavy I could complete the 85% of the trolley and the height it was not very high but is a problem yet. So, it seems that this idea it works better than the previous ideas.
Increasing a little bit the power I could read in all the trolley, but the height it was too high yet.

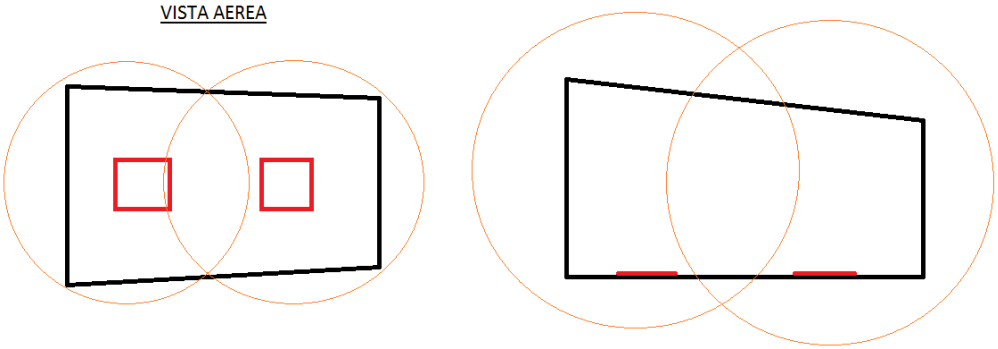


Figure 36.Graphic about results of case 9 distribution increasing power

Summary case 9:

The next test I will try to use three antennas, decreasing the power of each and seeing how it works the problem with the height.

CASE 10. Final tests on the real trolley (III) Three antennas on the bottom

Location: UbiCALab
Antenna configuration:

- Antenna type: P11
- Power: 15 dBm
- Read-time: 500 ms
- Filter: true
- Filter tag: ‘abcd’
- Sensitivity: 82 dBm

Test case 10:

The main purpose of this test is to check if we can improve the results of the last test increasing the number of antennas and modifying a little bit the locations of the antennas.

Results case 10:

Keeping the idea to decrease the height, I decided to use more antennas with less power, to cover all the trolley. The new distribution purposed for the trolley is the following:

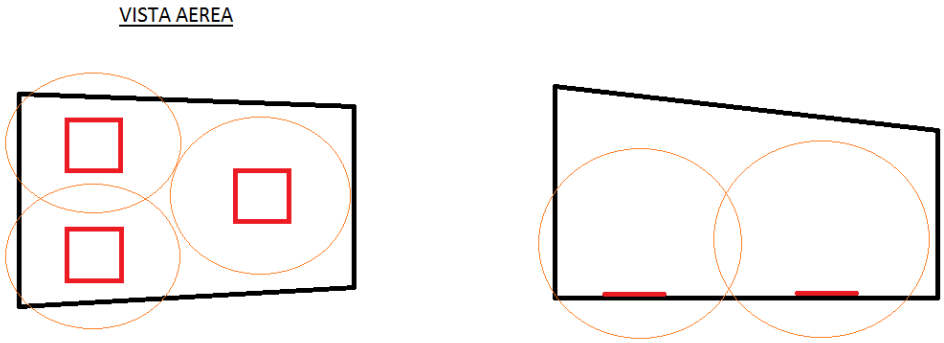


Figure 37. Graphic checking distribution of 3 p11 antennas in case 10

I decreased the problem height but still if I try to not have the problem with the height, I can't cover all the trolley.
As you can see, if I try to increase the power to cover the trolley the height problem is the same, a little bit less, but it exists yet.

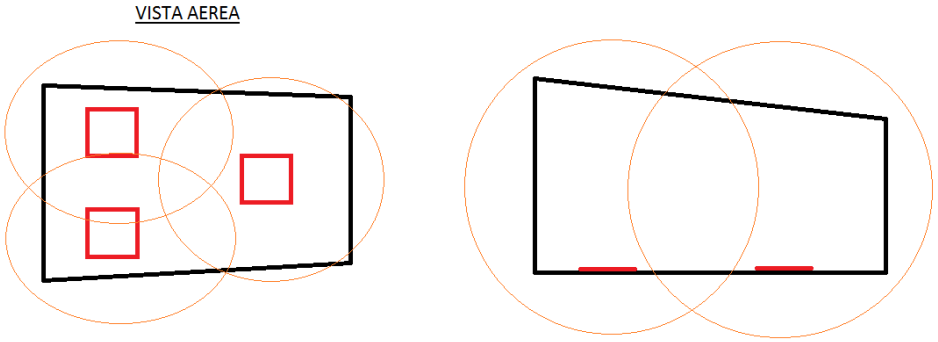


Figure 38.Graphic about results of case 10 distribution increasing power

Summary case 10:

When this test was finished I decided to try with a fourth antenna on the trolley, waiting to find the real solution for this problem.

CASE 11. Final tests on the real trolley (IV) Four antennas on the bottom

Location: UbiCALab
Antenna configuration:

- Antenna type: P11
- Power: 14 dBm
- Read-time: 500 ms
- Filter: true
- Filter tag: 'abcd'
- Sensitivity: -82 dBm

Test case 11:

Before doing a lot of tests, I hope to find a real solution for this trolley.
I put 4 antennas on the trolley using a low power on each, trying to cover all the trolley and solve the height problem. If I use low power, as I have been doing on the last test, I hope to decrease the height and isolate really well the trolley from the outside.

These are the new locations:

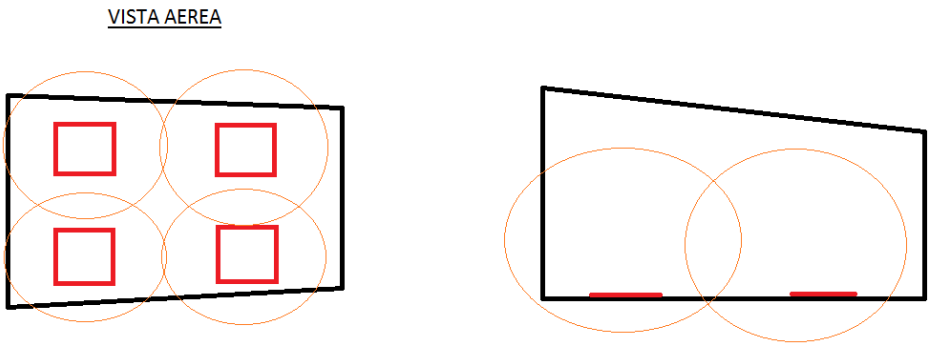


Figure 39. Graphic checking distribution of 3 p11 antennas in case 11

Results case 11:

As I planned: **less power of each antenna → less height**
Adjusting the power of each antenna I, finally, covered all the trolley without height problems.

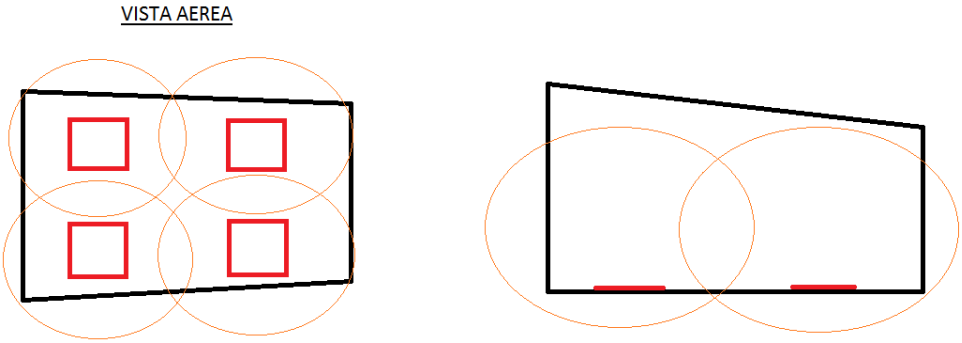


Figure 40.Graphic about results of case 11 distribution increasing power

Summary case 11:

Despite there are zones with some problems (maybe on the middle of the trolley the tag is not always detected, but it is not the usual) the trolley it works fine.
So, once this last test, design and distribution of the antennas are finalized.

Last modification on the structure of the trolley before final tests

During all the tests, the readings of the tags on some specific locations have given some problems, so we decided to create a kind of surface height to 4 cm to improve the process of reading the tags.
The problem is when the tag is at the same height than the antenna the readings are not working well but with this new platform this problem is avoided.

Figure 41. Schema about structure to avoid problems from reading

The red lines are the antennas of the system and the brown line is the structure to avoid the problems with the readings.

The last tests on the library shows us that in some specific cases, some books are being detected when are not on the trolley. We had the idea to make a test of threshold and try to adjust the sensitivity trying to avoid this problem as much as possible.

Test Sensitivity to fix the last problems on the UPFLibrary

In this test we want to "fix" a threshold between books inside and outside the trolley. Generally, books inside the trolley will receive better RSSI than those outside. We cannot avoid antennas to read certain books or control their beams totally.

So, the test to adjust the sensitivity is based on the following steps:

1. Pick three books with different width (number of pages).
2. Register their EPCs (don't filter by EPC during the experiment)
3. Locate each book along the trolley in 6 or 8 different locations. Read each book with different read power from 10 to 20 dBm in steps of 1 dBm. Read each book 10 times.
4. Create a summary table like this one.
    1. Book: Name each book like A, B and C
    2. Divide the trolley in 4 to 6 areas 1,2,3…
    3. Find a correct power to read only on the inner part

The trolley is divided in:

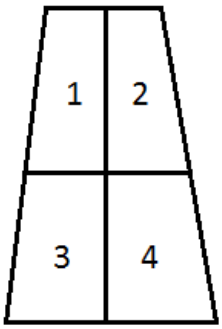


Figure 42. Trolley zone division

This table contains the information about the values of the RSSI that is detected by the antennas when read some books. This values are used to adjust the sensitivity value of the reader's configuration trying to avoid some problems when the system is detecting some books when are not inside the trolley.

This table is made with 3 books with different number of pages, trying to know how it works every type of book that is on the real library at UPF Library.

# Test	Book	Location	Read Power	Mean RSSI
1	Historia de la Tecnología. Desde 1750 hasta 1900 (I)	Front left antenna (1)/ Front Right Antenna (2)/ Back left antenna (3)/Back right antenna (4)	14 dBm	-60 dB/-59 dB/-43 dB/-47 dB Total Mean= -52.25 dB
2	Fondement Didactique de la Traduction Technique	Front left antenna (1)/ Front Right Antenna (2)/ Back left antenna (3)/Back right antenna (4)	14 dBm	-59 dB/ -60 dB/ -48 dB/ -50 dB Total Mean= -54.25 dB
3	Computer graphics : C version / Donald Hearn, M. Pauline Baker	Front left antenna (1)/ Front Right Antenna (2)/ Back left antenna (3)/Back right antenna (4)	14 dBm	-55 dB/ -53 dB/ -58 dB/ - 59 dB Total Mean= -56.25 dB

Table 1.Experiment Sensitivity mesures

The following graphic shows the values that has been checked on the test to know which values are corresponding to the books that are detected by the antennas when are inside of the trolley.

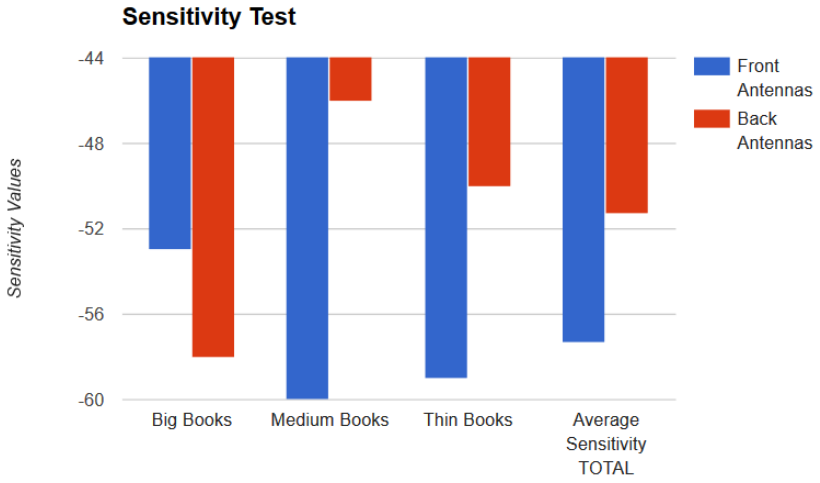


Figure 43. Graphic to show the mean of sensitivity

The mean of the RSSI in all the books are around -60 dBm, so the parameter of the sensitivity can be adjusted to -65 dBm without any effect in the books that are inside the trolley. Maybe in some cases this change it helps us make a more accurate reading of the contents of the trolley and be more realistic.

Final case to adjust sensitivity

The last test realized on the UPF Library it was to check if adjusting the threshold we can avoid some problems with the books that are outside of the trolley. The results of the test are the following:

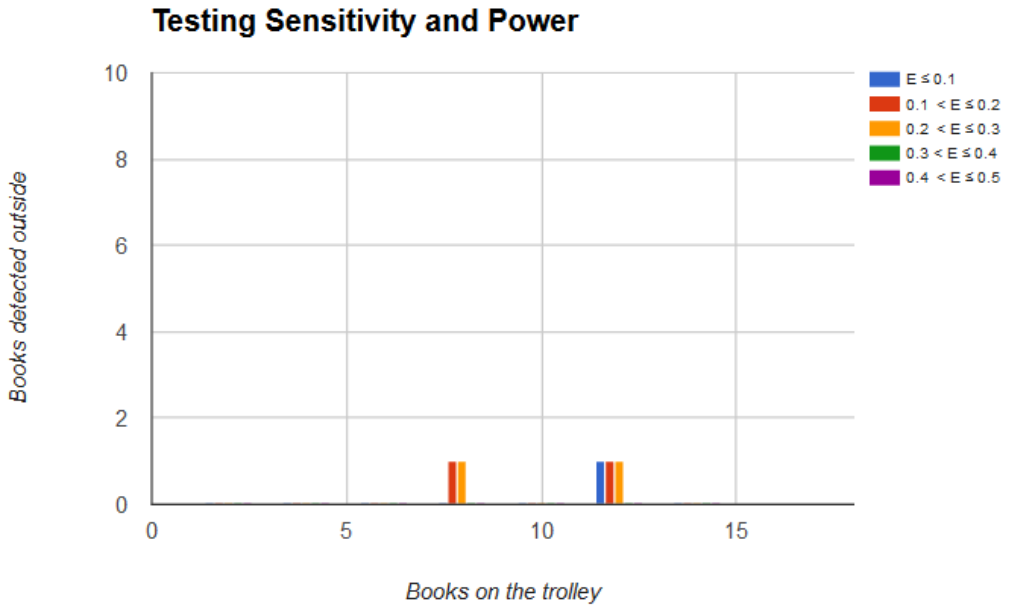


Figure 44. Graphic to show the error on the system reading outside

Here we can observe that the maximum numbers of books tested on the trolley are 15 and the system it works really well. With more than 15 books sometimes the system doesn't recognize some books and some troubles appears.

The result of the test shows that the system it works quite well and the sensitivity is not very relevant but helps us to avoid some wrong detection of books that are outside of the trolley.
We can see that the books that are detected wrong are minimal and adjusting a little bit the power we can read perfectly the books that are inside of the trolley and avoid the books that are outside.

5.2 Conclusions about the tests

Checking all the tests that have been done during the project, we can extract some interesting conclusions:

- The structure of the trolley is not the best to add just an antenna and cover all the volume, so is necessary add more than one to cover all the volume to have no problems with the height. In our trolley we need 4 antennas to configure a real-time system to detects the books when are inside of the trolley.

- The structure is very hard to cover just using antennas and is necessary to cover the structure with cardboard and paper foil to isolate the system from the outside. If we do this, we can configure a system that allows reading only inside of the trolley.
  This is our main goal on the project and it was very successful. The process to cover the structure it shows us that the best way to isolate the inside part from the outside part is covering just the outside part. If we cover the inside part too we will have problems of reflection and the problem with the height will come back again.

- Increase the number of antennas, at least in our case, it was necessary because we cannot cover all the trolley just increasing the power. If we just increase the power, we have problems with the height because the system reads books that are not on the trolley and this is a very hard problem.

- The antenna does not works well when is at the same height that the tags, so in our case the creation of a structure to 4 cm from the floor of the cart to have a correct reading is necessary. If this step is avoid, try to read tags inside will be a strong problem.

- Adjusting the sensitivity is not very relevant, at least in our case, but is an interesting point to study.

6. FUTURE WORK

Once the project is completed, we can look beyond and try to bring improvements to make the system more features and better performance.

Possible improvements to the project

The main improvements would apply to the coverage of the cart to isolate it from the outside, using a unique material that is strong but insulation as the foil without having to use cardboard to create the structure. Thus, the structure would have the same strength and probably would be simpler and lighter.

Include improvements to the software level would apply depending on what we wanted to do. In our case, the idea was to make a simple interface to give basic information about the books.
If we wanted something more elaborate we could make changes such as:
- Inclusion of a registration system to keep track of which users are using the trolleys in real time. Very useful if the library wants to know which books are more popular.
- Creating book rental system simply introducing them in the cart and confirming the order.
- Using a login system the library could know who has rented.

With this system we could improve even further the user experience during their walk through the library.

Product variations for future uses

The concept of SmartCart using RFID technology is not only applicable to the library, of course. This product has a lot of possible scenarios to be useful, for example a hospital or a supermarket. Including this SmartCart on different scenarios we can improve the user experience and make it easier.

The use of this type of SmartCart on a supermarket is very similar to the library but including other functionalities or data displayed on the screen.
In addition to displaying information of products we have in the trolley, you might create a kind of geolocation system using passive RFID tags.
We can add a passive tag to each corridor and show in which corridor is each product.
It is a very simple geolocation system but thus it would give the user additional information and that he could be of great help when moving around the supermarket.

Using this product,the SmartCart, that includes a pay-system too, companies can save a lot of money.

The actual system process to buy is:

- Put the products on the conveyor belt
- Pass them by the barcode
- Pay cash / card

So, using a login and pay system with RFID we can reduce the time per customer and earn more money. If we reduce the time per customer, we will win more money in the same time. That's what the companies want to do

With our trolley and including a login-system and a pay-system we can have a product very interesting.

In a hospital this kind of trolley can be a very interesting to track the stock of medicines use too.
The idea is very similar but slightly changing the concept because in this case it would not be important when we put the material but when we took him out.
This cart would help us take control about the stock of the products we carry and replace them if the product is running out. Being health issues, it would be an interesting concept because these issues require a very thorough control.
Furthermore, given that the cart carrying the antenna to track the stock, we could associate each bed a passive RFID tag as the medical approach to the patient's bed to consult medical information.

As you can see, introducing the RFID in some different scenarios like supermarkets or hospital, we can reduce the timing of simple actions and improve the user experience and improve the economy of our company too if we use the RFID wisely.

7. CONCLUSIONS OF THE PROJECT

Once the project is completed it is time to evaluate the results and what has been learned about this project.

I have learned that the field of RFID technology is a field that requires a lot of lab work and, above all, product testing in real situations. Not just in the laboratory testing in an idyllic environment to get reliable conclusions.
Being a wireless technology, it is subject to many environmental factors, and it is necessary to know very well what will surround your product when it's released and how it behaves at that stage.

Another thing I learned from the RFID technology is the large amount of possibilities with a very simple system to use. In this area, the imagination plays an essential role since 3 elements such as passive RFID tags, readers and a computer can make improvements objects that everyone uses on a daily basis and can improve the everyday life of quite significantly.

As for software, the knowledge acquired has been less because I had some previous knowledge about this type of programming.

The hardest part of software has been the set-up of the whole:
- Interface
- Database
- Real-time synchronization software antenna.

The hardest part has been the real-time synchronization because we need to create a function specifically to make a smooth refreshing of the data and avoid any blinking on the webpage.

Despite the difficulties, the valuation of work is positive. I have learned to work with researchers in the field of RFID collaborating with a leading company like Keonn and helped me get the project quite satisfactorily.

As for the staff, I have been very comfortable working with such a comprehensive project that has united several areas such as software and research of RFID technologies.

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[9] http://www.rfid-library.com/

APPENDIX

Here I add some code lines that shows the basic elements of the software develop process

Code to connect the interface with the data base

```
$connection = mysql_connect('localhost','root','root');
mysql_select_db('advannet');
```

Query to extract the information from the data base

```
$query=mysql_query("SELECT librarybooks2.author, librarybooks2.title, librarybooks2.publication, librarybooks2.isbn, inventory.cycle FROM inventory, librarybooks2 WHERE inventory.epc_hex=librarybooks2.epc_hex");
```

Code to print data on the interface

```
while($d = mysql_fetch_array($query))
{


$data .='<table style="width:100%" frame="void">'.
            '<div>'.
              '<tr>'.
                  '<td>'.'<textarea readonly style="width: 462px;">'.$d['title'].'</textarea>'.'</td>'.
                  '<td>'.'<textarea readonly style="width: 315px;">'.$d['author'].'</textarea>'.'</td>'.
                  '<td>'.'<textareareadonly style="width: 515px;">'.$d['publication'].'</textarea>'.'</td>'.
                  '<td>'.'<textarea readonly style="width: 230px;">'.$d['isbn'].'</textarea>'.'</td>'.
              '</tr>'.
            '</div>'.
            '</table>';

            $contador ++;
}
echo '<font size=5>'.$contador.'</font>'. ' Item(s) on the cart';
echo '<br>';
echo  '<font size=2>'.date("Y-m-d h:i:sa").'</font>';
echo $data;
```

Refreshing function with AJAX

```
function refreshDivs(divid,secs,url) {
	var divid,secs,url,fetch_unix_timestamp;

	if(divid == ""){ alert('Error: escribe el id del div que quieres refrescar'); return; }
	else if(!document.getElementById(divid)){ alert('Error: el Div ID selectionado no esta definido: '+divid); return; }
	else if(secs == ""){ alert('Error: indica la cantidad de segundos que quieres que el div se refresque'); return; }
	else if(url == ""){ alert('Error: la URL del documento que quieres cargar en el div no puede estar vacia.');
	  return;
 }

	// The XMLHttpRequest object
	var xmlHttp;
	try{
		xmlHttp=new XMLHttpRequest(); // Firefox, Opera 8.0+, Safari
	}
	catch (e) {
		try {
			xmlHttp=new ActiveXObject("Msxml2.XMLHTTP"); // Internet Explorer
		}
		catch (e) {
			try {
				xmlHttp=new ActiveXObject("Microsoft.XMLHTTP");
			}
			catch (e) {
				alert("Tu explorador no soporta AJAX.");
				return false;
			}
		}
	}
	fetch_unix_timestamp = function() {
		return parseInt(new Date().getTime().toString().substring(0, 10));
	}

	var timestamp = fetch_unix_timestamp();
	var nocacheurl = url+"&t="+timestamp;
	// the ajax call
	xmlHttp.onreadystatechange=function() {
		if(xmlHttp.readyState == 4 && xmlHttp.status == 200){
			document.getElementById(divid).innerHTML=xmlHttp.responseText;
			setTimeout(function(){refreshDivs(divid,secs,url);},secs*1000);
		}
	}
	xmlHttp.open("GET",url,true);
	xmlHttp.send(null);
}
```