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FACULTAD DE INGENIERÍA EN CIENCIAS APLICADAS

**CARRERA DE INGENIERÍA EN ELECTRÓNICA Y REDES DE
COMUNICACIÓN**

**HOME AUTOMATED SYSTEM INCLUDING PLATFORMS OF
HARDWARE AND SOFTWARE FREE FOR UNA'S RESIDENCE IT
PRESENTS WITH PARAPLEGIA**

**PROJECT FORESAW TO THE OBTAINING OF THE ENGINEER'S TITLE
IN ELECTRONICS AND NETWORKS OF COMMUNICATION**

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“HOME AUTOMATED SYSTEM INCLUDING PLATFORMS OF HARDWARE AND SOFTWARE FREE FOR UNA'S RESIDENCE IT PRESENTS WITH PARAPLEGIA”

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Abstract.- The present implemented system allows the control of areas, doors, windows, curtains and an electrical blanket in the domicile of a person with paraplegia.

In order to obtain a system multiplatform orientates this application to the web, allowing to accede to the interface from any device across a mariner, both from the WLAN and from Internet.

The final obtained product is a system that reduces the time is inconvenience in the interaction with the controlled devices, improving the development of the person, in his home.

1. Introduction

In the present work like principal point there are studied the tools that are in use in the design and the construction of a home automated system, which allows the best development of a person with paraplegia in his housing.

The above mentioned system consists both of hardware and of software, which allows the control of actuadores in the residence by means of an interface orientated to the web. It works thanks to the union of different subsystems that expire with limited functions, which are controlled from a central device. For which there is necessary the study of the parts that they form to the system separately, for a better compression of the same one.

¹Document received in February, 2017. J. Michilena, Teacher of the Technical University of the North, D. Acosta Gone away from the Career of Engineering in Electronics and Networks of Communication.

2. Analysis of free tools and the standards ieee802.15.4 and 802.11b/g.

2.1. Free tools

The software is a "Set of programs, instructions, and IT rules to execute certain tasks in a computer" (RAE 2013).

Basically all these instructions are carried out by means of electronic circuits or hardware. According to the Organization (GNU 2013) when the source code of a software contemplates freedoms as: free study, modification, distribution and redistribution of the changes; and this one liberated with a license LPG considers it to be a free software.

On the other hand when one speaks about free hardware, it is notable to speak about it with a direct comparison with the free software regarding: study, modification, distribution and redistribution of the hardware.

But to share designs of a device is more complicated that to share software. Ultimately, it is necessary to emphasize that there is no an exact definition for " hardware free ", only there is present the ideology to develop something and to share the knowledge with the company to contribute with her.

2.2. Plates of development ARM.

Nowadays the free plates of development are in summit, with the advance of technologies like ARM it is possible to have absorbed systems traversing an operating system in areas not bigger than ten square centimeters. These tools allow to mount systems permanently connected without generating a great energetic consumption, without noises and with a degree of respectable processing.

2.3. Raspberry Pi

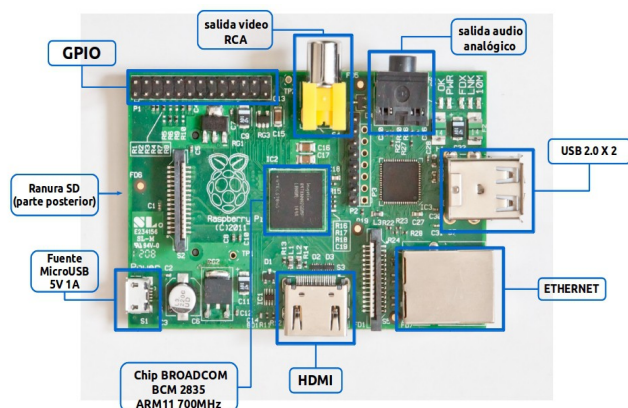


Figure 1. Plate Raspberry Pi.

Raspberry pi It is a platform considered an icon in the development of the hardware and free software; created with the aim to stimulate the creativity of the students in areas as the electronics, programming and computer science. Raspberry pi is a SBC of limited size with own characteristics of a computer and has the aptitude to execute an operating system GNU/Linux. Between his more important characteristics they emphasize a processor of 700Mhz with architecture ARM, a memory RAM of 512MB, Ethernet communication and USB; besides ports of general intention (GPIO) that allow the interconnection with different plates electronics of expansion (Upton 2013).

2.4. Raspbian

The operating system that is in use in the Raspberry Pi is Raspbian, which is based on Debian and for ende inherits his robust and stable qualities. According to the Raspbian ORG (Raspbian, 2013), the S.O was created specifically by the community for the hardware of the Raspberry and account by about 35 thousand packages pre compiled ready to be secondhand. In addition, it possesses an updated repository and a manager of packages who takes charge of the installation and configuration of the same ones.

2.5. Tools for the development of web applications.

For the development of web pages it is necessary to to have different tools that work together to create web content, to this he is known as a frame of work that in turn allows to develop web interfaces with a predefined style (Fernandez, 2013).

2.6. Web servant Apache.

According to the Apache ORG, the project APACHE is a software of opened code, of free disposition and supported by a developers' community dispersed all over the world. The principal aim of this web servant is to be insurance, efficiently and extensible; providing services on the Protocol of Transfer of (HTTP) Hypertext and respecting his standards (Apache, 2013).

2.7. Framework JQuery Mobile

In the graph of the figure 2 it is possible to observe the environment of work of a contained way that is in use for the development of the web application, the most prominent of this graph is the equivalence between the languages HTML, Javascript, CSS y AJAX with JQuery Mobile.

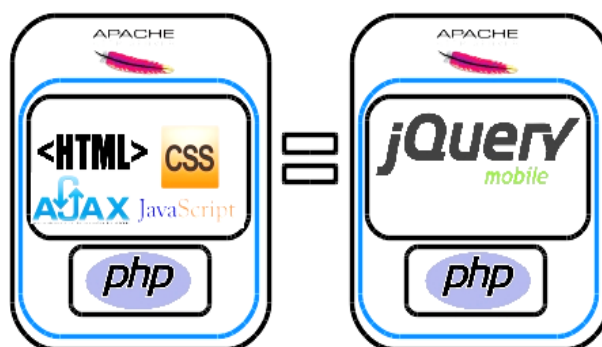


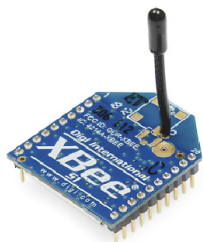
Figure 2. Environment of tools of web work.

2.8. Arduino

Arduino is a plate of electronic development directed all kinds of persons who are interested in

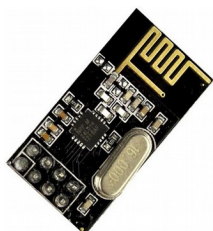
the development of electronic applications composed by software and hardware. (Banzi, 2010).

2.9. Modules of radio frequency XBEE.



The modules XBEE are devices developed by the company Digi, 802.15.4 are based on the standard IEEE and work in 2,4GHz. In his manufacture there is recorded a set of functions described by the standard besides the only direction of 64 bits. These modules were designed principally for the sending and receipt of information in networks of low traffic, specifically for networks of sensors. The utilization of these modules they present several advantages in the project development that they involve a network of sensors with low traffic, the wide experience of the company that is behind these modules allows to have the guarantee of a mature, robust and stable product.

2.10. Modules of radio frequency NRF24L01.



Since one could have demonstrated the modules XBEE they are a solution for the implementation of networks of sensors with low traffic, with the development of the IEEE and the company Digi there can be obtained products of great quality to disposition. The weak point of these devices, is maybe his high cost and the consequence that this has in networks with several devices, an excellent solution is had but simultaneously very costly; in addition it is necessary to bear in mind that not all the applications can allow him this. For this motive one resorts to the modules NRF24L01 that complement the system and makes it more accessible economically. These modules possess very similar characteristics in functioning to the XBEE but they are not based on the standard, rather they work by means of bookshops as a whole with the plates arduino.

3. Current situation and parameters of the design

It is necessary to establish a general panorama relating to the situation of the person benefited with the system across a study, to determine which is the best way of helping to that it could have a better development and for ende a better quality of life.

The principal aim of the system is to facilitate the interaction with the common things inside the home, without managing to have an intruder system; it is to say the devices to controlling they must not alter mainly his functioning or cause inconveniences for other persons.

3.1. Characteristics and situation of the person with paraplegia.

Mr Jaime Cadena has 46 years of age and suffers from paraplegia for an accident at the age of 19, I motivate as which it has neither sensibility nor movement in his low extremities. His brother Mr Luis Cadena who has an own family, shares his housing with his brother and hereby he and his family they help him in what they can, allowing that it could take a comfortable life, in the possible thing.

The housing constructed with concrete and steel possesses the basic services, water, electric power, telephone and Internet. The facilities of the housing consist of room, quarters, dining room, kitchen, garage, two normal baths and one adapted specially to satisfy the needs of the person with paraplegia; in addition one possesses accesses and ramps in order that the mobility should not be a problem.

The verbal opinion of Mr Jaime Cadena has been that feels comfortable in his home and that the difficulties or needs that appear him are tried by it to he itself solve, when his physical limitations do not allow it comes to some member of the family.

Mr Jaime Cadena is a young person who has a profession and a stable work, his desire of overcoming has done that could achieve great

independence and his autoesteem is very healthy and contagiante.

3.2. Characteristics of the housing and more frequent areas.

The housing has a total area of 260m² which divide in two business premises, a garage, a small court, room, kitchen, three baths and three bedrooms.

It possesses diverse spaces of common use for all the members of the family; but the system centres on the spaces most used by the person to whom one dedicates the system. This way it manages to determine that the areas more frequently used by the person with paraplegia, and they are these areas on where the efforts are focused to eliminate the possible inconveniences and difficulties that could appear him.

In the figure 3 a plane appears with the areas is necessary to bear in mind in including the garage with his court, the room, kitchen, the bedroom number two and the bath number two.

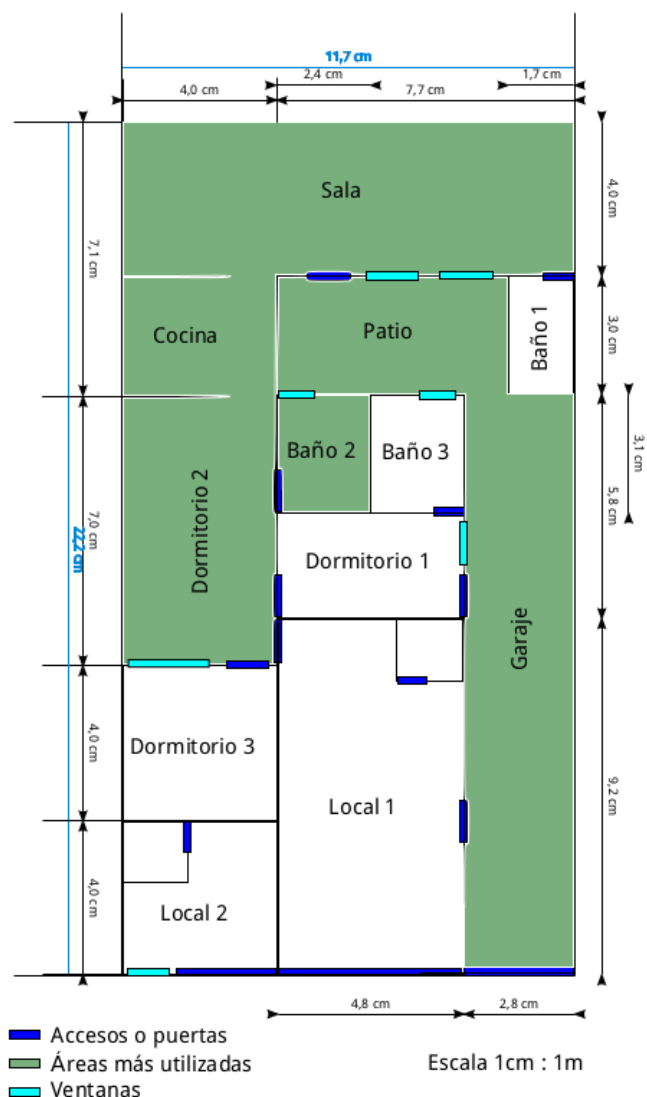


Figure 3. Plane of areas mas used.

These areas are the seizures in account for the study, design and installation of the system.

4. Design of the home automated system.

The design of the system is based on the installation of two types of networks on the housing, the first one containing to all the devices that are going to be controlled and the second one that allows the communication from a final device towards a central node based on IEEE 802.11b/n; in order that these technologies could be related, there is in use a device that one can communicate with both, being the door of link between both types of communications. The devices are formed in

frequencies and channels that are not interfered between yes in such a way that there are no conflicts in the traffic of information.

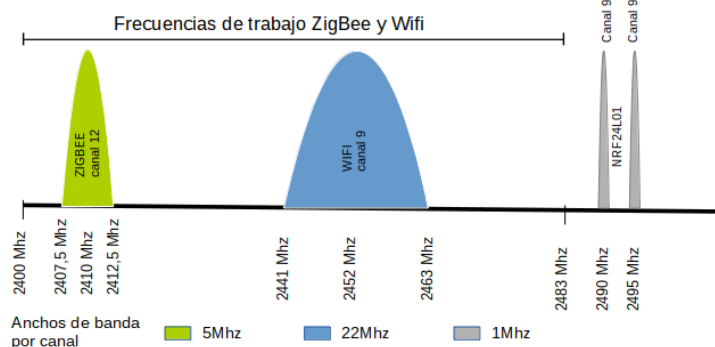


Figure 4. Separation of frequencies.

In the following figure 5 observe the general characteristics of the proposed system, each of them include aspects and functions that are important and necessary; the union of these characteristics they appear towards the only aim to obtain a functional system.

In accessibility there is included the possibility of acceding to the system from any final device, so much in a local as remote way across Internet, this eliminates the dependence of an alone device for his use, obtaining a system multiplatform.

The organization of the elements of the system allows an interaction and communication adapted between the user and the system; this way also between the different elements that shape it. The interface is divided in sub-menus that are related to the areas to controlling and to allow that the user could accede without problems to each of them.

In a similar way the installed devices are organized in such a way that the information could flow in a suitable way and the results of the interactions could be reflected rapidly in the interface.

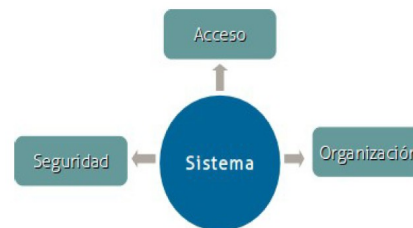


Figure 5. Design of the home automated system

4.1. Topología of devices.

For the construction of the devices first it is necessary to to establish a royal topología to establishing itself, and since every topología of network there consists of a graph of communication logician and physicist, the logical topología of the network appears later to be implementing

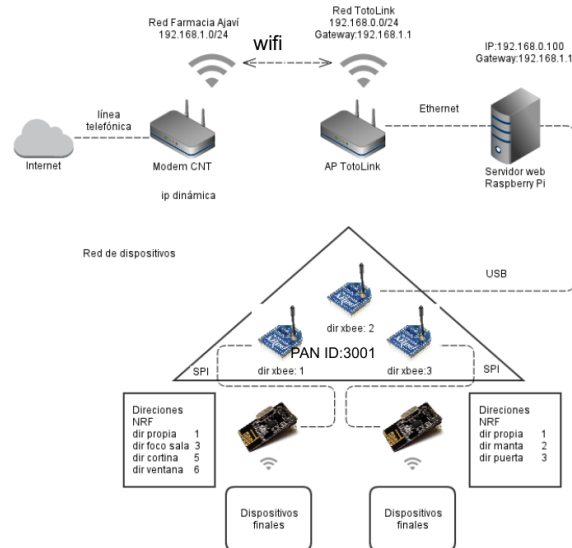


Figure 6. Logical Topología of the network.

The figure shows the logical relation that the devices have and the directions are detailed of each one of them. Since it is possible to estimate every device it is interconnected using his own technology of communication, for which three types of addressing exist.

4.2. Royal Topología to be implementing.

The topología to be implementing is the showed one in the figure, as one made clear previously the

requests and changes of condition always originate in the Raspberry, then to realize the pertinent tests of communication the information always initiates and ends in the Raspberry, that is to say it will think that the test is a success when the information could come to his destination and the response of the node returns to the Raspberry.

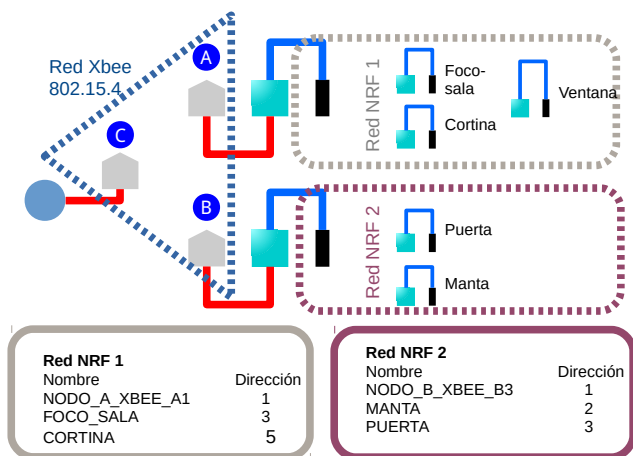


Figure 7. Implemented Topología.

4.3. Node lamp

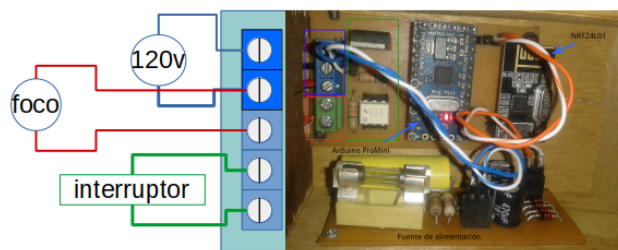


Figure 8. Connection node lamp.

The connection of the node area shows itself in figure 8, this connection does it to him together with the cajetin of a lamp that possesses a voltage of supply of 120V, two drivers for the switch (in the figure of green color) and the contacts where it connects the lamp itself represented in the figure of red color.

4.4. Nodes curtain and window

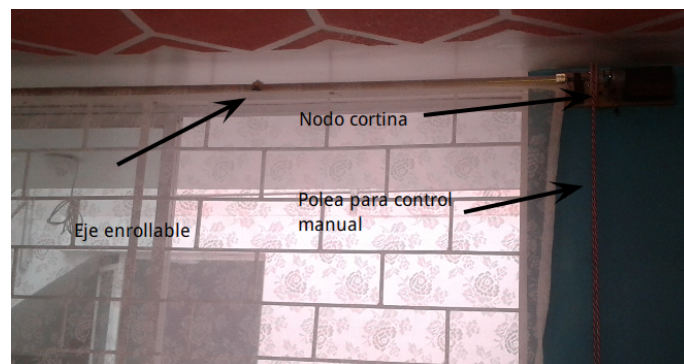


Figure 9. Node curtain.

The node curtain is clear of an engine of steps with his axis joined a support that it is allowed that the curtain should jabber on. This node feeds for two voltages 5V for the logical part and 12V for the engine of steps, motive for which there has been in use a source of PC ATX.

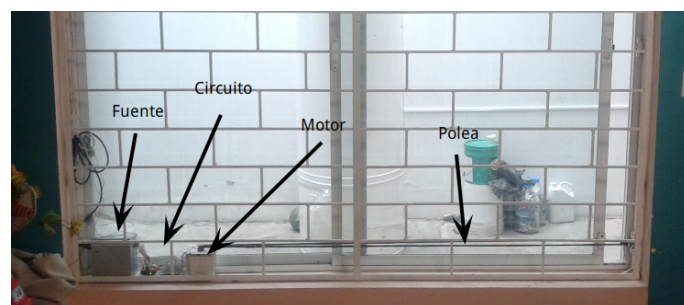


Figure 9. Node Window

4.5. Node door.

This device fixes in the door itself, at the time the components they are moving contante mind, but this condition does not prevent from having a very good communication with the node, the part most complicated in the installation of this node was the location and subordination of the engine of steps.

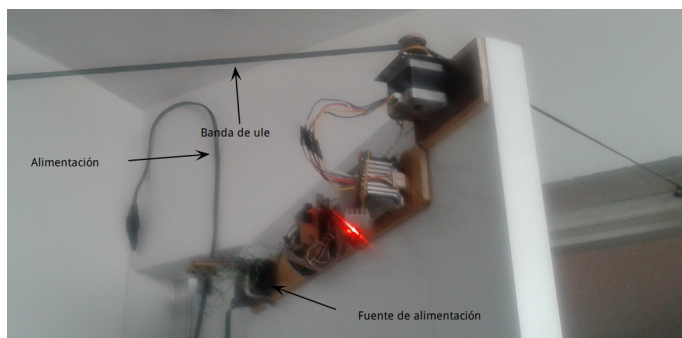


Figure 10. Node door.

4.6. Node blanket.

The node blanket is a small device, relies on a plug to connect it to the electrical network and it is possible to move it to the whim of the user. If the figure is observed 11 in the frontal part exist two buttons that allow the manual use of the node, whereas a led works as indicator.

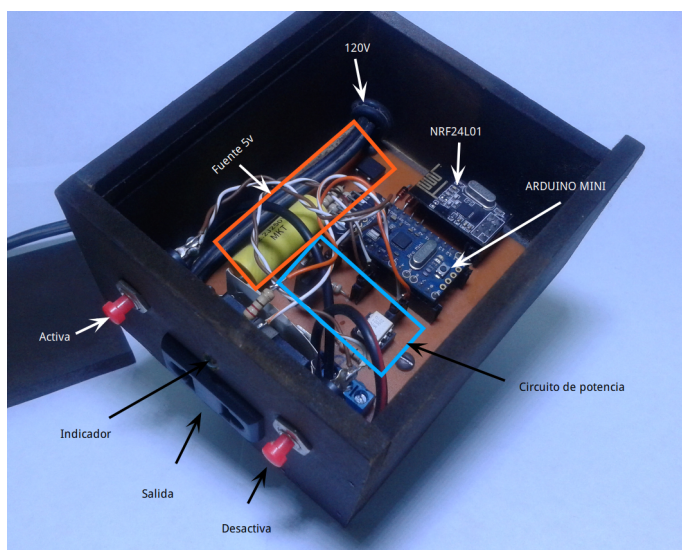


Figure 11. Node Blanket.

Finally in the implementation of all the devices the pertinent adequacies had to be realized in order that all the devices are in the range of coverage. Also they had to increase the electrical points of connection. In the figure 12 it is possible to observe in that positions according to the plane remained located all the nodes.

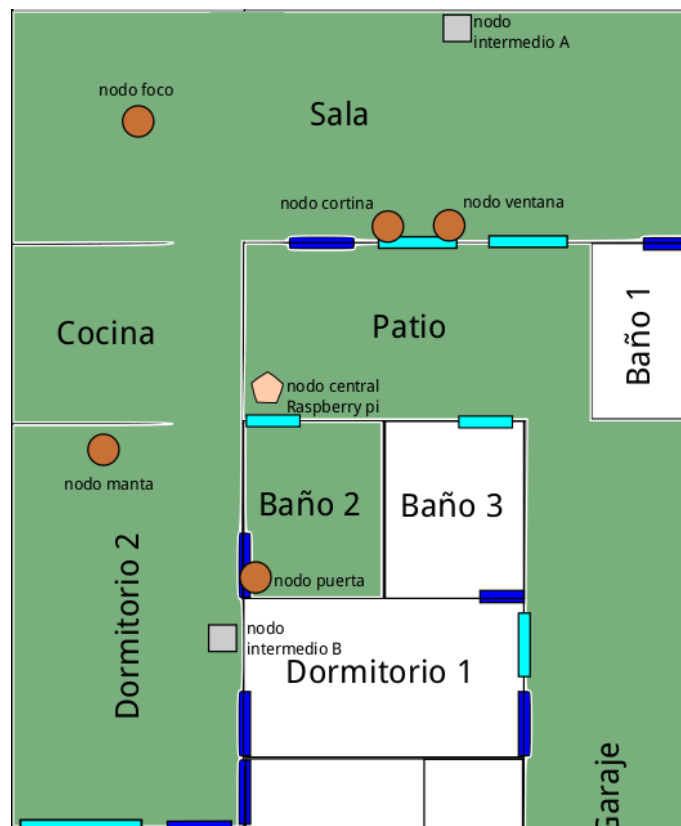


Figure 11. Node Blanket.

5. Analysis cost I am of benefit

This project of qualifications has as principal aim improve the quality of a person with paraplegia, for what it is a social project if an economic cup of return, that is to say exists an economic investment but the benefit is not economic. The benefit that is obtained can focus in the independent activities, which the user can realize after the installation of the home automated system.

It is the basic benefits of the home automation that it offers a more favorable and ideal environment for an as autonomous as possible life. The fact that the systems of the housing can be programmed already be in order that they realize certain functions in spite of only touching a button or that they carry out them depending on other conditions of the environment, it produces an increase of the comfort and a saving of time.

Nobody better that the user directly benefited to give an opinion of the real benefit, are here some questions that fulfilled him like interview:

-¿Which is his opinion about the project as a whole?

“It offers many comfort, imagine that the things can be controlled without having to get up and also from Internet”

-¿What expectations it has on the project and which were fulfilled?

“The ridge-tile or the blanket was looking like to myself an excellent idea, had thought before if there existed some way of automating it. The case of other devices I think that each one has a substantial contribution for the comfort in the home, I personally am very satisfied.”

-¿What thinks about the interface?

“One sees as Android's native application, does not look like a web page. It looks like to me a very good idea that the devices have divided by areas, to avoid confusions. Another thing that seems to me to be excellent is that when the areas corresponding to the devices are opened it could reflect in that been they are, then also I can use the manual controls”

-¿What thinks about the device that it controls the blanket?

“This device seems to me to be excellent, for my work I go out to the neighborhood of the two of the morning and when I come to my house have to connect the blanket manually, the process until the blanket warms the bed and I can sleep it is of to the neighborhood of 45 minutes, this time I might use it to rest. Thanks to this device now already I can activate it from the work before going out and when I come I can sleep directly. It takes care of my health and allows me to have a better performance to the following day of work”

-¿Which is his opinion about the doors and the windows?

“There is brilliant the benefit that drinks to me, since for my it is a bit complicated to move windows, depending wherefrom I am situated sometimes I ask for help. In him case of the doors I think that what reaches is the possibility of seeing and limiting the areas for example in order that they do not enter the pets or to prevent my small nephews from going out”

-¿You think that the system saves him time in his activities?

“Exactly, the case of the blanket is a very clear example of it, imagine the great advantage of saving myself 45 minutes and to take advantage of them resting instead of being waiting, speaking about other devices inconvenient movements save inside me my house, and in addition already I do not have to bother anybody in order that I help myself”

-¿It has some final comment?

“For his position, I imagine the things that might be done by this technology, today in a beginning these devices seem to be slightly rustic, but with the experiences and the tests that are done, it is like a feedback that goes is necessary to allow that these devices should get improved, I imagine that in a few years already marvels will exist with regard to this topic. Of my part a letter of congratulation to you and to the university for resting and to extract forward this type of projects. Thank you very much.”

5.1. Total cost of the installed system.

To finish with the analysis cost I am of benefit of the system, there is born in mind the total price of the installed system which promotes to the 687,99\$ dollars, opposite to all the described advantages more the comfort, the comfort and the time that the user saves himself with the installation of the system in his house.

home automated system mas finds of benefiting the person with paraplegia also he is of benefit to his family.

As it is observed, the number indicated to the one that promotes the system, rises a bit more than that of two basic monthly ones in the Ecuador that might be amortized to help more persons in the same condition, for such a motive it is considered to be a good investment for a person by this type of disability. Investment that does not return any capital but that if it helps in an important way this type of persons.

The most important thing on having finished the installation of the system is that there was improved notably the autoestima of the benefited user.

6. Conclusions and recommendations

6.1. Conclusions

The installed system improves notably the quality of life of the user, reducing the level of dependence, the time and the inconvenience in the accomplishment of daily activities in his home.

The tools of hardware studied together with the work in the bands ISM, allowed to obtain a basic network of low traffic for the control and compilation of information, which can expand to other fields similar to the domótica.

By means of some modifications in the controlled devices, a transparent functioning was achieved for the benefited user and other members of the family, demonstrating that they are not necessary specialized devices for the implementation of the system.

The project benefits favorably from the modules NRF24L01 that there is to weigh of not being based on a standard and thanks to the efforts of the

community of free software, they have come it is necessary to be a fundamental part of the project doing to the most accessible system economically.

A free and feasible way of publishing content to Internet is to use VPNs, hereby point is added encriptación to point and there is restricted the access to only a user group.

By means of the activation of the devices across Internet, the user saves up to forty five minutes on having activated the electrical blanket of remote form. Allowing that it could use this time to rest when it comes to his home.

6.2. Recommendations.

For a better development of projects with the plate Raspberry pi and Raspbian, the system one recommends to support updated to correct mistakes and if it is necessary to update the whole operating system for a version mas new, hereby a better performance is obtained by the same hardware.

When one works with arduino it is recommended to investigate exhaustively on bookshops that could improve the development of the final application, this saves a lot of time and allows to focus the efforts in the final application.

The design and implementation of the system can get improved notably with the incorporation of new protocols orientated to home automation as MQTT, which would allow the reduction of the hardware and the orientation there is Internet from another approach, opening the possibility of adding other technologies as BDD ó some LOGS's system for the follow-up of events and safety, allowing to construct a more robust system. One recommends to study these topics to have a vision mas wide and current of the so called Internet of the things.

Having worked with wireless communications is necessary to possess the major number of possible

tools, since the bands ISM are of free use in Ecuador, in many places one presents saturation in the electromagnetic spectrum, being in some cases indispensably of the help of someone of these instruments of measure and detection to avoid disadvantages.

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It was born in Quito - Ecuador on October 8, 1987. Son of Fabián Acosta and Belgium Iron-works. It realized his primary studies in the Fiscal "General Rafael Arellano" School. In the year 2005 Technical Manufacturer obtained his Graduate's title in the specialization in the Technical Industrial College " Ibarra's City ". Nowadays, gone away from the Career of Electronic Engineering and Networks of Communication of the Tecnica del Norte University of Ibarra's city.