UNIVERSITY TÉCNICA DEL NORTE

FACULTAD DE INGENIERÍA EN CIENCIAS APLICADAS

CARRERA DE INGENIERÍA EN ELECTRÓNICA Y REDES DE COMUNICACIÓN

DESIGN OF THE WIRELESS NETWORK OF METROPOLITAN AREA, TO PROVIDE INTERNET SERVICES, APPLYING THE STANDARD IEEE 802.11ac, IN THE URBAN ZONE OF THE CANTON CAYAMBE FOR THE COMPANY CAYAMBE VISION.

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

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Ibarra, Julio 2017

"DESIGN OF THE WIRELESS NETWORK OF METROPOLITAN AREA, TO PROVIDE INTERNET SERVICES, APPLYING THE STANDARD IEEE 802.11ac, IN THE URBAN ZONE OF THE CANTON CAYAMBE FOR THE COMPANY CAYAMBE VISION"

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Summary- The present project consists of the design of a wireless network to offer the Internet service to the population of the canton Cayambe, empelando the standard IEEE 802.11ac with the aim to improve the quality of life of the users of the canton, cooperating with the development of the TICs and reducing the digital gap.

I. Introduction

At present the wireless networks WiFi are a basic tool since he itself has turned in a need more than a luxury because it is used for the communication, education and entertainment, but the access to this service is limited or inefficiently in some sectors of the country, for lack of infrastructure. The devices that commonly use the wireless networks include portable computers, intelligent telephones and Tablets have turned partly essentially of the company as way to communicate.

Due to the easy access to Internet nowadays, it considers to work, by means of a new technology since it is the standard IEEE 802.11ac the same one offers efficiency, scalability and major speed of transmission with regard to standards and previous equipments

The design of the network to provide service of wireless Internet and to offer to the users of the canton Cayambe the Internet service to high speeds since it there provides the fifth generation of wireless standards, with a major available bandwidth, with this the users will enjoy access to services, updated information and the communications will be realized real time, as well as the safety of the information and policies of administration of the network

The contribution of this project for the company is identical to the Art. 11 of the General Regulation to the Special Law of Telecommunications Reformed, the Art. 4 of the Regulation for the provision of services of added value, which facilitates the process of socialization across the access to social networks, science, culture, accomplishment of school tasks and personal works, this across connections prolonged with a very limited cost taking advantage of the easy and rapid transmission of the information with the proportionate infrastructure of communications

II. IEEE 802.11ac

The standard 802.11ac there represents the fifth generation of standards IEEE 802.11 for networks wireless LAN, and a connection offers with speed of transfer of information of at least three times the speed of the standard 802.11n. (Cisco Solutions, 2014)

The fifth generation of wireless networks already has been standardized, this one is the first standard that provides speeds gigabit allowing to reach a major performance and capacity, that is to say that the users will enjoy a more rapid connection with his mobile devices 802.11ac.

A. Improve with regard to IEEE 802.11n

- Is employed at the band of 5Ghz, doing that the wireless networks are not subject to the interference and noise present in the band 2,4GHz.

- Is compatible with IEEE's previous versions 802.11.
- 802.11n offers speeds of 600Mbps whereas IEEE 802.11ac theoretical speed of 1,3Gbps.
- Bandwidth of channel of 20, 40, 80Mhz (mandatorios) and 160Mhz (optional).
- In 802.11n the modulation is 64QAM this one goes on to a modulation 256-QAM in IEEE 802.11ac this will serve to increase the efficiency in the transfer of information
- Transmission of up to 8 flows of information by means of a version improved of the technology I SPOIL (MU-CARESS) or SPOIL Multiuser who uses the mechanism SDMA (Multiple Access for Spatial Division) in that multiple transmitters send separated signs and multiple recipients receive signs separated simultaneously in the same band.
- Utilization of the technology "Beamforming" that allows the Points of Access to determine the location of the wireless devices and to direct a stronger sign to them.

B. *IEEE 802.11ac Need of more Rapid Networks*

Major density of codification: higher Modulations. Major density of bits for package.

Major number of flows of information: It allows to transmit more flows in the only channel.

Top performance: The granted throughput, for this first phase, is average 2 or 3 times top with regard to 802.11n

Clients' major quantity: they can use the resources granted by an Access Point, due to the fact that more efficient

Use of the way is possible to transmit identical information to different users: the information is transferred to a top speed, allowing that the devices should liberate more rapidly the way, offering a more robust connectivity and with fewer dead points

Minor energetic consumption: For the devices that use it which is translated in major duration of the battery, and consequent prolongation of his useful life.

C. *Basic Concepts*

Antennas

They are passive elements that issue energy of radio frequency (RF), since they take charge transforming the energy of alternating current, generated in the wireless equipments, in an electromagnetic field and the receptora realizes the inverse function. (Cabezas & Gonzàles, Redes Inalámbricas, 2010)

An antenna is a device done to transmit (to (remove) and to receive (electromagnetic) waves of radio. There exist several important characteristics of an antenna that must be considered to the moment to choose specific one for his application:

- Pattern of Radiation
- Polarization
- Range of frequencies of operation

Pattern of Radiation:

The pattern of radiation of an antenna can be represented as a three-dimensional graph of the removed energy dress from out of this one. The patterns of radiation usually are represented of two forms, the pattern of elevation and the pattern of azimuth.

The pattern of elevation is a graph of the energy removed by the antenna dress of profile. The pattern of azimuth is a graph of the removed energy dress directly from above. On having combined both graphs a three-dimensional representation is had of how the energy is really removed from the antenna.

Polarization:

It is the orientation of the electromagnetic waves on having gone out of the antenna. There are two basic types of polarization that they apply to the antennas, since they are: Linear (vertical, horizontal and oblique) and to circulate (right, circular left, elliptical right, and elliptical left circular letter). Bear in mind the polarity of the antenna is very important if the maximum performance wants to be obtained of this one. The antenna transmisora must have the same polarity of the receiving aerial for maximum performance.

Range of frequencies of operation

It is necessary to to bear in mind the standard that is in use for the design, since the same one specifies the frequency in which it operates, being in the band of 5 GHz, because there is less interference with other networks Wi-Fi, but especially because the range of frequencies is more wide and therefore, we can use bigger width of channel to transmit to the maximum speed.

III. Design of the Wireless Network

There appears the design of the wireless network of the WISP for the zone of urban of the canton Cayambe and this way determines the location of the nodes and his respective links point to point to offer access to Internet to the users, the speed of transmission, comparison of the equipments and the respective tests of functioning, the forms that must fill to be able to implement the links of a legal way, the safety and administration of the network.

A. Area of Coverage

In the Fig. 1 shows himself the area of coverage, same that is shaped by the urban zone of the canton Cayambe, where one tries to implement the service of the WISP.

Fig. 1 Area of Coverage of the WISP

B. Design of the network of the WISP

For the design of the WISP there exist model of connection which are links point to point for the wireless backbone and point multipoint for the connection of the subscribers used for WISP's implementation, to the physical network it will divide in the following modules: access, distribution, core or core.

Access module

The network of access is the one that connects the final user directly with the distribution network, where the only devices that intervene are the sectorial antennas and the antenna of the client, since it appears in the Fig. 2, in addition point is in use links of radio multipoint for connecting the distribution node and the clients.

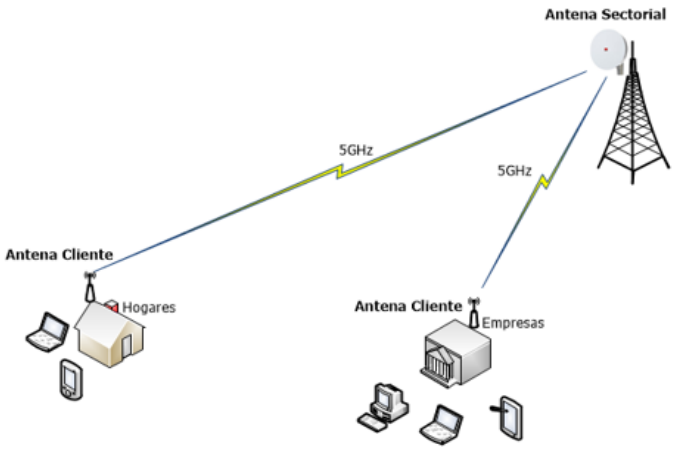

Fig. 2 Access module

Distribution module

The distribution module like shows in the Fig. 3, type is formed by links of radio point to point and establishes the delimiting between the module of access and module of core. In addition it consists of a redundant link to offer major availability of the network of the WISP. The function of the distribution module can be summarized as the cap that provides the bases of the policies of connectivity.

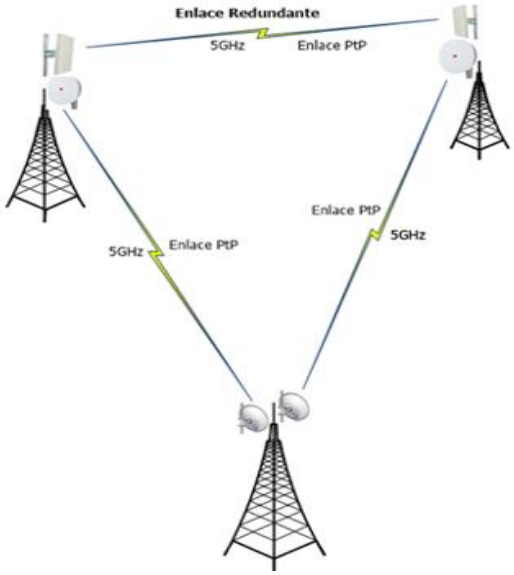

Fig. 3 Módulo de Distribución

Core's module or Core

The module of core or core appears in the Fig 4, constitutes the central or principal system of the network of the WISP, this module is designed by equipments of high presentations and policies are established of routing that favor the distribution of load between all the links, to establish a high quality of access to Internet, additional this module is capable of administering and managing the internal network of the WISP.

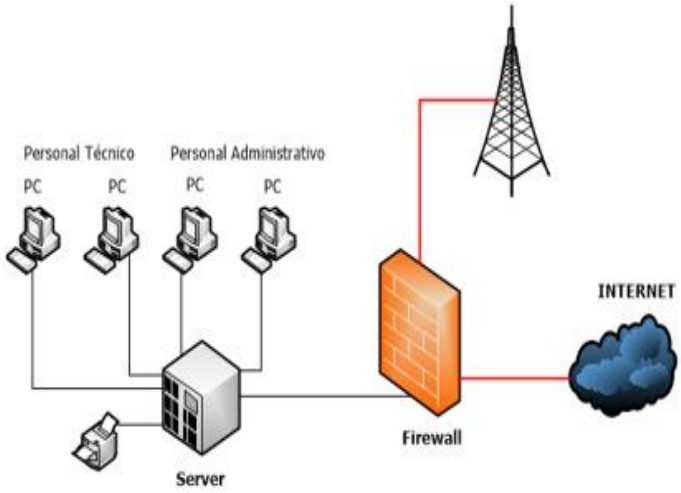

Fig. 4 Core's module or Core

C. Estimation of the Internet speed of the WISP

The calculation of the size of the sample is one of the aspects to making concrete in the previous phases of the commercial investigation and determines the degree of credibility that we will grant to the obtained results.

The very widespread equation 1 that it orientates on the calculation of the size of the sample for global information is the following one:

$$n = \frac{k^2 * p * q * N}{\left(e^2 * (\mathrm{N} - 1)\right) + k^2 * p * q} \quad (1)$$

$$n = 120 \text{ usuarios}$$

To calculate the bandwidth that is going to be contracted for the WISP, the equation 2 will be in use.

$$AB = G * CN \quad (1)$$
$$AB = 0.75Mbps * 120$$
$$AB = 90\ Mbps$$

D. Typical General of the Equipments

On the basis of the studied technology and the development of the project to present a complete design of a Supplier of Service of Wireless INTERNET for the selection of the equipments that would be the most advisable. The equipments for the links Point to Point and of the same way for the links Point Multipoint in addition the equipments recipients used in the final user, must be employed at the frequency of 5,8GHz it is necessary to to apply to the maximum values that ARCOTEL establishes for the choice of the equipments.

Equipments For the Wireless Network

The equipments that are going to be in use on the station transmisora, on the station receptora and equipments clients with his respective technical specifications are the following ones:

Antennas for links Point to Point

Antenna for transmission: RB911G-5HPacD-NB PtP Generalmente is used for the distribution links in the base station for the link point to point by the following specifications:

- **Characteristics:** RB911G-5HPacD-NB
- **Bands of Frequency:** 5,15 - 5,85 Ghz
- **Power of the Transmitter (Dbm):** 30dbm
- **Sensibility of the Recipient (dbm):-**96dbm
- **Loss of the cables and connectors:** 0.52dB
- **Type of integrated antenna:** Board 120 °
- **Width of the Channel (mhz):** 4920-6100 MHz
- **Profit of the Antenna (dbi):** 30dbi
- **Polarization:** Double polarity
- **Update of software**: If

Antenna for links Point Multipoint

Antenna for transmission: Sxt Sa5 Ac PtMP Generally is used for the distribution links in the base station for the link point multipoint by the following specifications:

- **Characteristics:** Sxt Sa5 Ac
- **Bands of Frequency:** 5,15 - 5,85 Ghz
- **Power of the Transmitter (Dbm):** 36dbm
- **Sensibility of the Recipient (dbm):**-96dbm
- **Loss of the cables and connectors:** 0.52dB
- **Width of the Channel (mhz):** 5470 - 5875 MHz
- **Type of integrated antenna:** Omnidireccional 360 °
- **Profit of the Antenna (dbi):** 19dbi
- **Channel (mhz):** 20/40/80
- **Polarization:** Double polarity
- **Update of software:** If

Client Antenna

Antenna of receipt: NBE-5ac-16
Generally it is used for the links of access located in every park by the following specifications:

- **Shape:** SXT lawsuit 5 ac
- **Frequency (GHz):** 5,150 - 5,850 GHz
- **Profit Antenna (dBi):** 16
- **Promotes (dBm):** 26
- **Sensibility (dbm):**-81
- **Type of antenna:** Board
- **Channel (mhz):** 5/10/20/40/80
- **Polarization:** Double polarity
- **Speed of Transmission (dbm):** 22dbm

E. Determination and Location of the Nodes

The principal node with the quarter of equipments is going to be I am located in the streets Terán and May 24, where there work the offices of Tv's System for Cable Cayambe Visión.

For the location of the nodes it is necessary to consider to be the following parameters, a great height to install the antenna of the base station, in such a way that all the antennas of the clients could see the central antenna without any obstacle of for way, for it must bear in mind the following considerations:

- The highest part of a building in the city
- The highest part of a hill, near to the area of coverage
- A high tower (tower of communication)

Additional it will have bear in mind other important factors for the moment of the implementation, since this might raise the costs of implementation of the WISP.

- The Service of Electric power
- The local Rental where the tower is going to be located for the antennas.
- Type of Exit ramp to the site where the tower will be located.

With these precedents the distribution nodes were located in two strategic sectors of the canton Cayambe, hereby to cover most of the same one.

Node Porotog

This node will be located in Cangahua's parish, community Porotog, because it expires with the described parameters previously, the location of the node appears in the Fig. 5.

Fig. 5 Node Porotog

Node Cruz Loma

This node San Carlos will be located in Cayambe's parish neighborhood, of equal way it expires with the described parameters previously, the location of the node appears in the Fig. 6.

Fig. 6 Node Cruz Loma

OFFICE

- Address: Terán y 24 de Mayo
- Coordinated: 00°02’39,1’’ N; 78°08’29,2’’ W

POROTOG's COMMUNITY

- Address: Parroquia Cangahua
- Coordinated: 00°00’11,7’’ S; 78°08’05,4’’ W

CRUZ LOMA

- Address: Barrio San Carlos calle Pichincha y Don Bosco
- Coordinated: 00°02’28,1’’ N; 78°07’50,0’’ W

F. Simulación de los Radioenlaces

The simulation by means of the tool Radio Mobile of systems of radioenlace is in use for checking if it is ideal or not to implement a wireless system with equipments and conditions that the place of work establishes, according to the results that it offers the simulations it is possible to pass or not the installation of the wireless system of communication.

The following Radio Connects, it is of the Principal Node located in the Office with Porotog's Node, being a link Point to Point and later they will be located of the sectorial antennas for the distribution of the service to the final users, since the

Fig appears. 7, where the following parameters are observed:

- Azimut
- Angle of Elevation of the Antennas
- Distance between Links
- Loss in the Free Space
- Level of Receipt
- Fresnel's Worse Zone

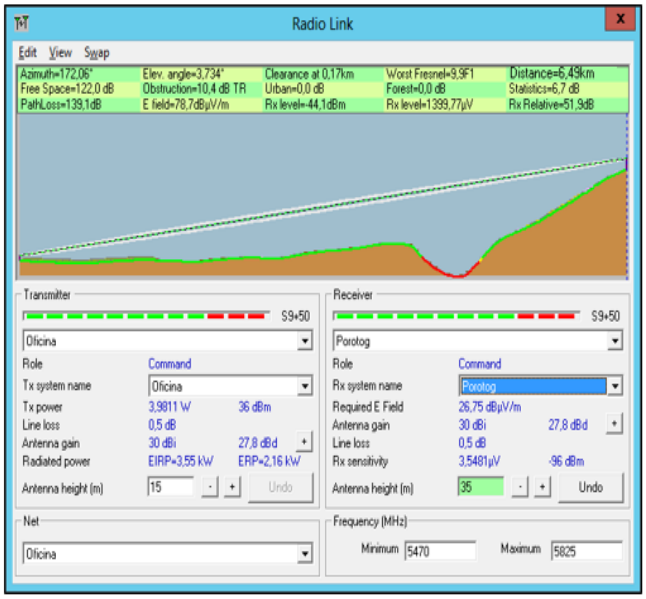

Fig. 7 Information I Remove Link Office-Porotog

Calculation of the Losses in the Free Space (FSL)

For the case of the link the following information is had:

F= 5.8 GHz
D= 6.5 Km

The Losses in the Free Space of the link are calculated by means of the equation 3.

(2)

$$FSL(dB) = 92.4 + 20\log f + 20\,log\ d\ (dB)$$

$$FSL(dB) = 92.4 + 20\log 5.8 + 20\,log\ 6.5\ (dB)$$

$$FSL(dB) = 123.92(dB)$$

Calculation of the level of sign in the recipient

Calculation of the level of sign received in the recipient is calculated by means of the equation 4.

$$P_{RX} = P_{TX} - A_{LTX} - A_b - A_f + G_{TX} - A_P - A_0 - A_V + G_{RX} - A_f - A_b - A_{LRX}\ dBm \quad (4)$$

$$P_{RX} = 16dBm - 1dB - 0.4dB - 0.4dB + 17dBi - 0.5dB - 123.92dB - 0.5dB + 8dBi - 0.4dB - 1dB - 0.4dB$$

$$P_{RX} = -59.92\ dBm$$

In the table 1 are observed the results obtained of the Losses in the Free Space, the sign in Receipt, distance between links, which are obtained of the software Radio Mobile.

TABLE 1.
I calculate of the links

	Oficce – Cruz Loma	**Oficce - Porotog**
Azimut	106.1º	172.06°
Angle of Elevation of the Antennas	6.191º	3.73°
Distance between Links	1.26 Km	5.32 Km
Loss in the Free Space	110.46 dB	122 dB
Level of Receipt	40.78 dBm	44,1dBm
Fresnel's Worse Zone	4.03 m	5.66 m

G. *Topología of the Wireless Network of the WSIP*

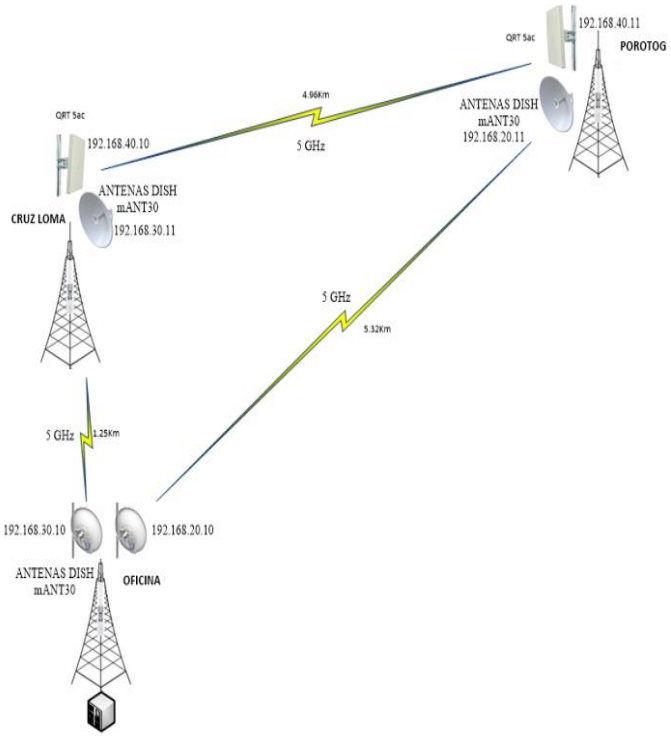

Fig. 8 Topología of the network Point on the verge of the WISP

H. *Norm for the implementation and system operation of digital modulation of broad band*

To be able to obtain a title habilitante and support the legal operation of the System of Digital Modulation of Broad Band inside the canton Cayambe, it is necessary to carry out a legal in force procedure in the Ecuador and is organized of the following form as there mentions the ARCOTEL (Agency of Regulation and Control of the Telecommunications):

- Form ST-1A-DGGST (Form of General Information)
- Form ST-2A-DGGST (Form for Information characteristic technologies and control of documentation)
- Form RC-1B (Form for Information
- Legal Digital Modulation of Broad Band)
- Form RC-2A, (Form for Information of the Structure of the System of Radio communications)
- Form RC-3A (Form for Information of Antennas)
- Form RC-3B (Form for bosses of radiation of antennas)
- Form RC-4A (Form for Information of Equipment)
- Form RC-9B (Form for Systems of Digital Modulation of Broad Band Links Punto-Multipunto)
- Form RC-14A (Form for Scheme of the System of Radio communications)
- Form RC-15A (RNI-T1) (Form for Technical Study of RNI's Emission)

IV. Economic analysis of the Project

In the table 2 indicate themselves the referential costs of the equipments and tools necessary for the future implementation the wireless network of the WISP, links point to point and point - multipunto of the canton Cayambe.

TABLE 2
Referential budget of the total cost

Detail	Cost
Cost of Equipments	34.372,53
Cost of Engineering	24.920,00
Costs of Operation	1.097,76
Cost Salary to the personnel	382,24
TOTAL COSTS OF IMPLEMENTATION	**60.772,53**

A. *Analysis Cost-benefit*

The relation cost I am of benefit, it is one of the indicators most important to analyze in the development of a project due to the fact that with this calculation the monetary benefits are going to be obtained in relation to the costs of the initial investment, if the benefits exceed the above mentioned investment the project is viablemente profitably and it should implement it, opposite case must discard.

This method is applied to benefit societies, projects, private companies, between others, paying attention to the importance of his social or economic consequences.

V. Conclusions and Recommendations

V.I. Conclusions

The offer of the design of the network of the Supplier of Service of Wireless Internet applying the standard IEEE 802,11ac presented for the urban zone of the canton Cayambe it will allow the universal access to the technologies of access to the information, though it is not a new standard, it is a very proven and stable version, with significant improvements with regard to previous versions, operating in the band of 5Ghz, doing a flexible, scalable network of rapid deployment and of low cost in comparison with wired up technologies

For the design of the network of the WISP there was analyzed the standard IEEE 802.11ac, emphasizing the quality of a radius there connects which depends the correct choice of the antennas according to the needs in power, profit and directivity, additional it is necessary to to bear the devices in mind for the quarter of equipments. His process of planning initiates knowing which will be the rate of transfer that it will have to support. There has been in use the band of 5 GHz for he was considering less inclined to interferences and especially it is a band of free operation. The radius connects, sign depends besides other important factors as the level of sensibility of the antennas, relation to noise, power of transmission and the installation of the device, supporting a perfect alignment of antennas and checking that do not exist obstructions inside Fresnel's zone. This emission will have to be realized under the limits imposed by the ARCOTEL.

There was realized the raising of information about the current and topographic situation of the areas of coverage of the canton Cayambe for the location of the nodes and this way to cover in its entirety the urban zone of the city, across the incorporation in the use of the technologies of access to the information

The investigation and the analysis realized of the legal in force regulation in The Agency of Regulation and Control of the Telecommunications (ARCOTEL) like regulatory entity and supervisor of the spectrum radioeléctrico in the Ecuador, imposes limits to the parameters of functioning of the systems of wireless communication like frequencies, powers of emission, etc. In addition, the operation in the sale of the service of added value (SVA) of Internet needs of titles habilitantes given by the same regulatory entity before the presentation of requests, forms and reports related to the project

The network of the WISP that contemplates this project has the capacity of expansion since it is a scalable network, which contains the active equipments of the network, which it is possible to increase it in agreement to the growth and users' demand, applied a compartición 4:1 considered very well for residential service, and 2:1 for the corporate service for treating itself about semi-dedicated links. This way, it is necessary to contract a bandwidth of 90 [Mbps], capacity that the design of the network will have to be in conditions to support without the quality of the service sees the final user affected.

For the simulation of the network the software was in use Radius Mobile which presents a great advantage on other malingerers because it is of free distribution, unlike others that possess licenses, showing the behavior of the transmitted signs and using as support to the planning of wireless systems of communication, before his installation.

The economic analysis I it realize to check that the implementation of the project is viable and represents profitability for the company, with a period of recovery of the initial investment later to 21 months of putting in operation on the project.

V.II. Recommendations

To design networks of a reliable way it is necessary to bear in mind that every network has

certain basic requirements that must be fulfilled and to there not exist a standard design that it could realize, therefore every implemented network must be done to the measure, stopping laid the foundations for future extensions that it is what appeared in a beginning for the implementation of the WISP, and if this implementation is realized in a geographical locality, it is necessary to to realize the studies and analyses corresponding to the spectrum of frequency, noise and other factors that influence the space, therefore on having be implemented it is necessary to to know this information to form the parameters corresponding to the antennas and be able like that to effect the wireless link without present disadvantages.

Before the installation of a wireless network, it is necessary to to realize field trials in the place to be implementing, since there can exist factors that force to effect corrections in the design or in turn in the wireless network it is necessary to realize tests of traffic that allow to saturate the channel to know the maximum capacity of the latter and to determine the clients' quantity that could be connected simultaneously to an Access Point

There is recommended that the selection of the equipments should be realized first identifying the requirements of the network, to choose the antenna the most important thing is his profit in relation to the distance, likewise to choose the acces point the necessary power was born in mind first to come to the point most removed from the zone of coverage.

The inhabitants' quantity increases in a percentage of 1,419 % in the Ecuador (INEC 2010), this does that the market in the province of Bargain is partially profitable for the WISP. For what recommends to itself that the implementation of this project should consider future extensions of points of service in other cantons of the Province.

One recommends to extend policies of detection of faults to the wireless network, to determine that disadvantages originate in the performance of the network. At present they exist workgroups like the IEEE that devotes itself to improve the wireless and like that networks are appearing new functionalities specially in the field of the safety, then one recommends to update from time to time the firmware of the equipments

One recommends to use a software for the management and administration of the network, one of them serious SYSLAND since it is a solution of software completes and efficient, easy to install and administer, to control and to optimize the Internet service in the whole network, other one might be WHATSUP GOLD for the monitoring unified of infrastructure and applications.

The investigation and the analysis realized of the legal in force regulation of the ARCOTEL must be exact, since it is an extensive process and the documentation must be clear and is necessary for the approval of the permission of concession

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