DESIGN OF A WIFI NETWORK TO PROVIDE WIRELESS INTERNET SERVICE IN THE URBAN AREA NORTH OF THE CAYAMBE

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***Summary*— The project has as objective, to design a wireless network based on the 802.11n standard, to provide the Internet service to the population located in the urban areas to the north of the Cayambe in the province of Pichincha. There will be a review of the 802.11n standard, wireless networks, calculation of radio links and aspects related to wireless networks.**

The design takes into account a network model hierarchical structured in three layers: core, distribution and access. In addition is the design of subsystems that support the good performance of the wireless network: subsystems for electric continuous supply of electric energy, subsystem of electrical protection that ensures the safety of equipment and personnel to downloads atmospheric and irregularities in the power supply lines and the infrastructure subsystem needed to support wireless computers of the Access Network/backhaul of which depends on the coverage of the service. Will eventually submit financial analysis to determine the economic viability of the project for the investors.

***Related terms* — WIFI, WISP, Internet, Wireless.**

I. INTRODUCTION

As a policy of the Government in the National Plan for the good life, the access to information technologies including the Internet is considered as a basic service to the development of society, enabling with updated information, but becomes a problem when their subscribers are located in remote points inaccessible through media wired as copper lines, making wireless technologies the best alternative to provide this service, thus meeting the need of the user of connectivity to the internet. Projects such as that exposes, will contribute to the eradication of the digital illiteracy in this part of the country

II. THEORETICAL BASIS

A. Wireless Networks 802.11

In networks and telecommunications is called wireless communication that is not used as a means of spreading physical but electromagnetic waves that propagate through space and the transmission and reception of information is carried out through the use of antennas.

Communications by Radio Frequency (RF) begin with an oscillation transmitted from a device that will be received in one or multiple devices. This oscillation of the signal is based on a constant call frequency. The transmitter and receiver must be on the same frequency to transmit the same signal. In 802.11 is account with the same model or architecture of the family 802, that is to say that it is with a physical layer and the MAC sublayer of the data link. [1]

In the physical layer PHY distinguishes two sublayers: PMD (Physical Media Dependent-Dependent of the physical environment) that specifies to each to the drive systems at the physical level and the undercoat PLCP (Physical layer convergence procedure - Procedure for convergence of physical layer) responsible for harmonizing of face to the MAC layer the particularities of different specifications of the undercoat PMD. [2]

The MAC sublayer of the data link layer specifies protocols of access to media, wireless network properties such as sending acknowledgments (ACK), fragmentation of frames and mechanism of data encryption for its transmission [2]

B. 802.11n Standard

IEEE standard 802.11n corresponds to a modification to the IEEE standard 802.11-20017, significantly improves the performance of previous networks as 802.11b and 802.11g, significantly increasing the transmission speed theoretical maximum of 54 Mbps to 600 Mbps. Currently the physical layer supports speeds of 300 Mbps which may result in a performance of true 100Mbps. [3]

1) OFDM optimized

for environments fading (feathering of the signal) to interference; by modulating the data in a set of sub-carriers, being affected some that can be subsequently recovered through some method of error detection. [3]

2) MIMO

Describes a system in transmission and reception is composed of multiple antennas. Through this technique that leverages physical phenomena in the transmission as the spread multi-path of the signal to increase the rate of transmission achieving speeds of up to 600 Mbps. [3]

3) Channel Bandwidth

Uses a technique called bounding (Surround Channel) is achieved using two 20 MHz channels at the same time, getting a single channel of 40 MHz and transmission speeds of up to 108 Mbps. Using a 40-MHz channel takes advantage frequencies existing at the beginning and end of a 20 MHz channel to avoid interference between adjacent channels increasing the speed of transmission. [3]

C. *Radio links*

It is called radio link to any interconnection between telecommunications terminals made by electromagnetic waves. If terminals are fixed, the service will be called as such and if any terminal is mobile, it is called within the services of these characteristics. Used as the means of communication space using devices called antennas. Its planning requires the calculation of a power budget for a point to point link. [4] Is defined as the calculation of gains and losses from the radio transmitter, cables, connectors and free space until the receiver.

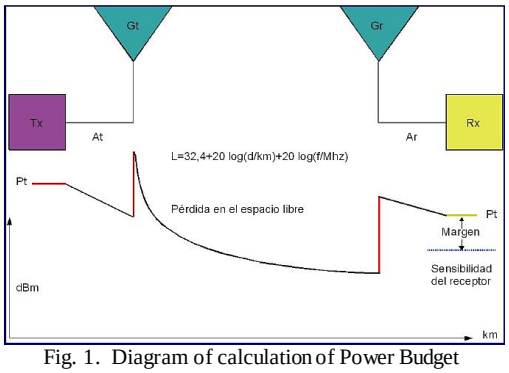

Fig. 1. Diagram of calculation of Power Budget

1) *Transmission Power*

Corresponds to the power emitted by the radio transmitter and its maximum value allowed depends on the regulations in force in each country. [4]

2) *Losses by Connectors*

Depending on the type of connector used it is advised to have a review of technical data. The loss will be given on the basis of the frequency of work. [4]

3) *Propagation loss*

The losses in spread occur during the journey of the signal from transmission to reception. [4]

4) *Antenna Gain*

The antenna gain expressed in dBi can mainly be affected by an incorrect installation of the antenna. [4]

5) *Losses in free space*

The loss in the free space (FSL) measures the power loss in the free space without any kind of obstacles. This loss occurs due to a wave loses energy to radiate in different directions in which the receiving antenna can´t capture. [4]

6) *Link Geometry*

The area of Fresnel defines the volume of space between the sender and receiver [5] shown in figure

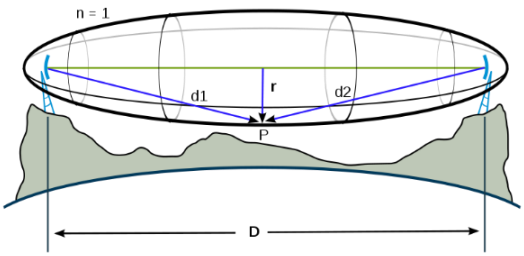

Fig. 2. Fresnel Zone

The height of clearance is a parameter that is related to the radius of the first zone of Fresnel to determine the margin of clearance. [5]

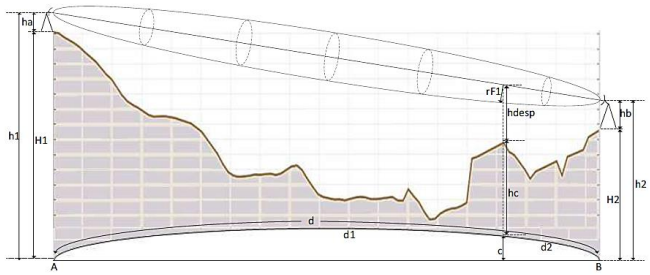

Fig. 3. Geometry of the Radio Link

D. Antennas

An antenna basically is considered as a device metal conductor designed for the transmission and reception of electromagnetic waves, transforming electrical energy in electromagnetic waves in antennas transmitters and conversely for receiving antennas. [6] Are classified by the shape of its radiation and address

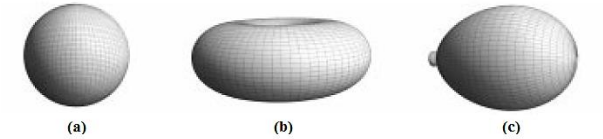

Fig. 4. Antenna types according to the type of radiation (a) isotropic, (b) omni-directional and (c) Directive

1) *Isotropic Antennas*

Consists of antennas whose radiating power is transmitted evenly in all directions and your diagram of radiation is seen as an area.

2) *Omnidirectional Antennas*

Antennas whose radiating power is transmitted in all directions of a plane of relatively uniform distribution, taking a low radiation in the shaft due to physical limitations of the antenna. [6]

3) *Directive Antennas*

This type of antennas radian or receive radiation at a specific address, limiting the largest amount of radiation in other directions. Are necessary to transmit a large amount of information, concentrating the largest amount of power in a small area. [6]

Parameters:

4) *Radiation Diagram*

Is the graphical representation of the properties of radiation of an antenna, in function of the addresses in the space normally through a spherical coordinate system, until a fixed distance. [6]

5) *Directivity*

The directivity of an antenna defines the relationship

between the density of radiated power in one direction at a certain distance, and the power density radiaría at the same distance an isotropic antenna that radiase the same power as the antenna. [6]

6) Polarization

An electromagnetic wave is composed of an electric field and magnetic that propagate together by the space, the polarization corresponds to the orientation of the vector of electric field depending on the position and time and $\vec{}(\vec{r}, t)$ at a fixed point in the course of time. [6]

7) Input Impedance

The radiating power of an antenna is the result of current flow from a transmitter with connection via a transmission line or wave guide until the antenna. [6]

8) Gain and efficiency

Corresponds to the ratio between the power input and the output power of the antenna. Is a comparison of how much energy radiates an antenna in question as compared with which he would go out of a isotropic. An antenna with low efficiency presents problems of absorption of power or its reflection due to bad links with the impedances. [6]

9) Bandwidth

Frequency range in which the antenna transmits or receives energy appropriately.

E. Normative Legal Regulatory

The transmission of wireless signals involves the use of the air as their means of transmission, i.e. it is making use of the electromagnetic spectrum. In Ecuador, its use and exploitation requires the prior grant of an authorization certificate issued by the Agency for the regulation and control of Telecommunications. [7]

The enabling titles authorize the installation of infrastructure and networks required for the provision of the service and will be granted to public enterprises legally constituted that comply with all the requirements established by the Agency for the regulation and control of Telecommunications and will have a limitation period of validity after which shall be renewed.

. According to what is established by the National Council of Telecommunications in its resolution 417-15 of 2005 and adopted by the current regulatory entity, the Agency for the regulation and control of telecommunications, are set frequency ranges controlled by the regulatory agency. [7]

TABLE I
MAPPING RANGES OF FREQUENCY ARCOTEL

BAND (MHz)	ASIGNATION
902 - 928	ICM
2400 - 2483.5	ICM
5150 – 5250	INI
5250 – 5350	INI
5470 – 5725	INI
5725 - 5850	ICM, INI

Likewise, are set power levels of operation

TABLE II
LIMITS OF POWER OF SYSTEMS BROADBAND

Configuration System	Operation Bands (MHz)	Máx. Power transmition (mW)
Point to point	902 – 928	250
point-multipoint		
Movil		
Point to point	2400 – 2483.5	1000
point-multipoint		
Movil		
point-multipoint		
Movil		
Point to point	5725 – 5850	1000
point-multipoint		
Movil		

III. ANALYSIS CURRENT MARKET SITUATION

The analysis consists in collecting, plan, analyze and communicate in a systematic way the data relevant to the situation of specific market facing an organization [8]

A. Background

Cayambe is formed by three urban parishes: San Jose de Ayora, Cayambe and Juan Montalvo. According to the limits established in the Development Plan Territorial 2015- 2025 for the Cayambe (Cayambe, 2001, p. 1). The sectors where will cover the service is located in the parish of San Jose de Ayora. According to data obtained from the National Institute of Statistics and Censuses (INEC) This parish has a population of 9028 inhabitants.

B. Sample Size

C. To determine the number of surveys to be carried out and by the limited number of users in the areas of study is used the equation of random sample for a finite population [8]

$$n = \frac{N\ x\ Z^2 x\ p\ x\ q}{d^2\ x\ (N\ -\ 1)\ +\ Z^2 x\ p\ x\ q}$$

Where:

n= Sample size (number of surveys to be carried out, 69.95 per cent of this population is considered as economically active, counting with a stable job and remuneration in accordance to the law)

Z= Degree of reliability

N= Sample Size

p= Probability of occurrence (degree of validity of answers)

q= Probability of not occurrence

E= Degree of error (error estimated maximum allowed in the survey)

$$n = \frac{2^2(6353)(0.5)(0.5)}{(0.1)^2\ (6353\ -\ 1)\ +\ 2^2(0.5)(0.5)} = 98\ (surveys)$$

D. Estimating the demand

Of a total of 98 respondents has a 42.86% corresponding to 42 respondents did not have the service currently, therefore, has.

$$D_0 = \frac{\varepsilon_{meta}}{\varepsilon_{total}} N = 163.14 \approx 163 = Initial\ Demand$$

According to the obtained in the survey, for the type of service, a 13.26% corresponding to 21 the estimate as commercial users and an 86.74% corresponding to 142 as residential users.

- Users Residential Service: 163(0.8674) = 142
- Users Commercial Service: 163(0.1326) = 21

E. Projection of the Demand

The rate of growth in the level of Internet penetration in Ecuador in recent years has been very variable with a tendency to increase from year to year. It takes into account the last period from June 2014 to May 2015 (τ=14%) in annual rate accumulated. The projection of 5 years will be.

$$Projection\ U.\ Residential\ D_p = 142(1+0.14)^5 = 273$$
$$Projection\ U.\ Commercial\ D_p = 21(1+0.14)^5 = 40$$

IV. NETWORK DESIGN

A. Network Backbone

The backbone network is considered as the main point of connection to the Internet for the provider network, using one or more WAN links through a particular access technology, protruding the use of the optical fiber that provides a bandwidth significantly highe.

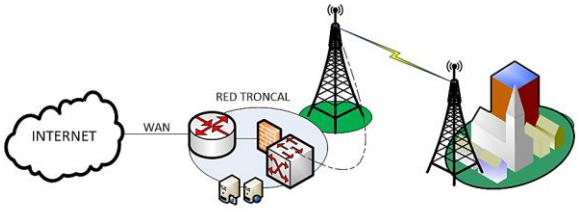

Fig. 5. Backbone Network

1) Calculation of bandwidth to the network backbone

Corresponds to the necessary which will service the access network. Discusses two necessary factors at the time of performing this calculation.

Overbooking: is a term which can be understood as the multiplexing of dedicated link with that account. Applies considering that the user while browsing does not fully used the channel constantly, because after having loaded the web page, the channel is released and can be used by another user.

Simultaneity Factor: index that allows to estimate the number of users that are connected to trying to use your bandwidth at a given time. Even if you have an 80% of users simultaneously connected, it is estimated that only a percentage of these would be accessing web content at exactly the same time. For rural environments applies a factor of 20%.

To determine the bandwidth on the network backbone will be taken into account users type residential and commercial established the following equation.

$$ABw = \frac{[Nº\ Clientes * Factor\ Simultaneidad * Velocidad\ (Mbps)]}{Factor\ Overbooking}$$

Thus, for a period of 5 years, assuming that all the users will perform the contract in a plan of 5 Mbps and based on the projection of the demand for residential users and commercial, bandwidth to hire will be.

$$ABw = \frac{[273 * 0.2 * 5(Mbps)]}{8} + \frac{[40 * 0.2 * 5(Mbps)]}{3}$$

$$ABw = 47{,}47 \approx 48\ [Mbps]$$

The administration of the network also held a consumption of a width of band additional, same that not must affect to them 48 [Mbps] destined to the network of access. Services such as access to web pages, email, video IP call will require an average bandwidth of 7 Mbps., i.e., a channel of 55 Mbps for the backbone is required. To avoid possible encolamientos, and saturation during switching in the ports of the equipment, is recommended as minimum ports with twice the capacity of calculated switching, i.e., 110 [Mbps]. In the absence of a standard that defines this speed, ports with immediate capacity is chosen, being necessary equipment capable Gigabit Ethernet with other capabilities of a router switches and Edge Core.

B. Backhaul Network

A network of backhaul is an ideal choice for the transport of information in an economical and sustainable without the use of wires and covering long distances. Its role will be to interconnect the distribution nodes of service through point-to-point links. The frequency used will be the 5 GHz considering is of free use, that there are antennas higher gain and you have a lesser degree of interference that to 2.4 GHz.

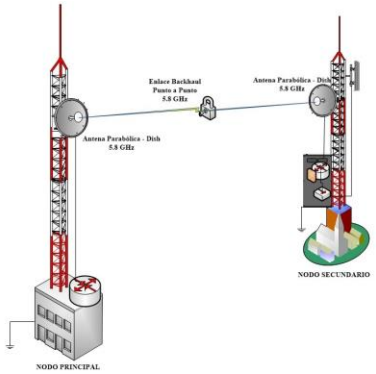

Fig. 6. Backhaul Network

1) Topographic Analysis of the coverage area and location of the transmission nodes.

The coverage shall be related to the points of presence of the supplier. The location of these points requires analysis of some factors such as topography the place, line of sight from

any point of the area of interest, projection toward the future. For the design takes into account the points that protrude topographically in the area coverage by the conditions of the sector (trees, irregularity of the ground) there is a need for a secondary node in the sector of Ayora.

TABLE III
UBICATION SITES

Node	Latitude	Length
Main	0°2'57.85" N	78°8'18.28" O
Secundary	0°4'07.41"N	78°7'56.71" O

2) Calculation link

To be regarded as an extension of the network backbone, the network backhaul will have a channel capacity for 48 [Mbps]. To achieve this value in the secondary node is made analysis of the table.

TABLA IV
DATA RATE VS. MODULATION

	MSC	Streams	Modulation	Codif.	Data Rate [Mbps]	Req. SNR [dB]	Signal Rx [dBm]
Simple Polarity (1 x 1)	0	1	BPSK	1/2	15	9.3	-88
	1	1	QPSK	1/2	30	11.3	-82
	2	1	QPSK	3/4	45	13.3	-79
	3	1	16-QAM	1/2	60	17.3	-76
	4	1	16-QAM	3/4	90	21.3	-73
	5	1	64-QAM	2/3	120	24.3	-68
	6	1	64-QAM	3/4	135	26.3	-65
	7	1	64-QAM	5/6	150	27.3	-63
Dual Polarity (2 x 2)	8	2	BPSK	1/2	30	12.3	-85
	9	2	QPSK	1/2	60	14.3	-79
	10	2	QPSK	3/4	90	16.3	-76
	11	2	16-QAM	1/2	120	20.3	-73
	12	2	10-QAM	3/4	180	24.3	-70
	13	2	64-QAM	2/3	240	27.3	-65
	14	2	64-QAM	3/4	270	29.3	-62
	15	2	64-QAM	5/6	300	30.3	-60

Considering that the actual capacity of the channel or throughput will be 50% of the data rate, you choose a scheme of coding and modulation MSC11, modulation 16-QAM, data rate of 120 [Mbps], at a frequency of 40 MHz (802.11n), reaching a throughput of 60 [Mbps]. In addition, reception will require a minimum sensitivity of -73 [dBm].

Calculation of loss in free space (d = 2.237 Km, f = 5.805)

$$PEA\,(dB)=20\log 10\,(2.237)+20\log 10\,(5.805)+92.4$$

$$PEA = 114.66\ [dB]$$

Calculation of the minimum power in transmission (sensitivity at Reception - 73 [dBm], gain antennas 23 [dBi])

$$P_{TX} = -73 + 33.12 + 0 - 25 + 114.66 - 25 + 0 = 24{,}78\ [\text{dBm}]$$

Calculation of power in Reception

$$Pr = 24.78 - 0 + 25 - 114.66 + 25 - 0$$

$$Pr = -39.88\ [dBm]$$

By subjecting these values to the simulator, you get the following result

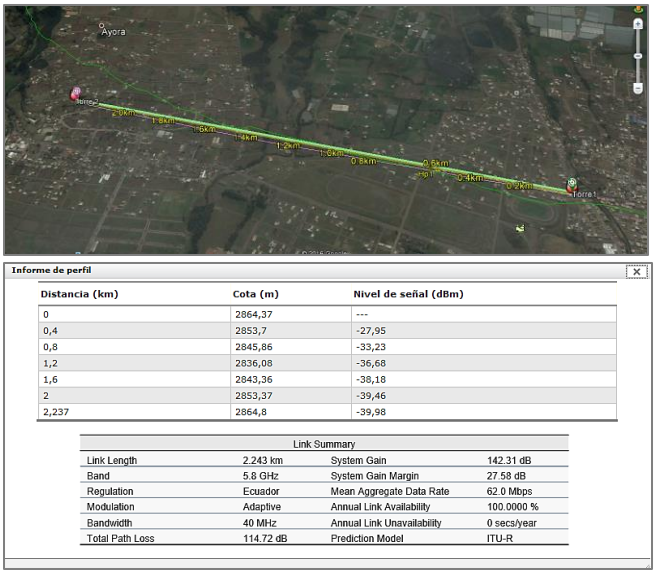

Fig. 7. Study of Profile Radio Network Backhaul

C. Concentration Network

The network of concentration is in charge of the control of the connections of the subscribers in the points of presence of the supplier, by assigning the bandwidth contracted by the client. It is an intermediate point of the network provider that interconnects the core network and access, routing all traffic from one network to another network.

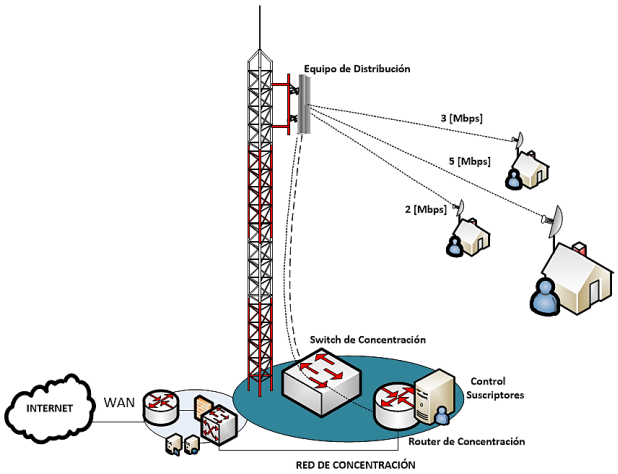

Fig. 8. Concentration Network

D. Access Network

This network allows you to provide coverage of wireless Internet service to end users from the distribution nodes, using a network topology point multi-point.

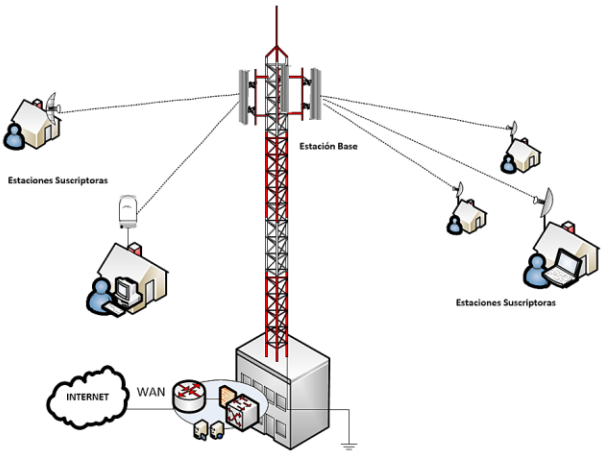

Fig. 9. Access Network

Base station: wireless device for issuance of the signal of Internet service. It is possible to use omnidirectional antennas or sectoral depending on the needs for coverage. For the design choose sector antennas with an opening angle of 120º, frequency of 5GHz making 360º coverage with 3 devices of this type.

Station Subscriber: Are directive antennas type outdoor receivers of the transmitted signal from the base station. Operate at the frequency set by the aerials transmitters. This type of device can vary in shape and size depending on the characteristics of the radio link.

1) Study of Coverage

It is desirable to organize the operation of equipment, particularly the working frequencies in such a way as to take advantage of the efficient use of radio spectrum, avoiding interferences between computers, for this reason they are done a frequency planning taking into account the use of 3 sector antennas of 120º.

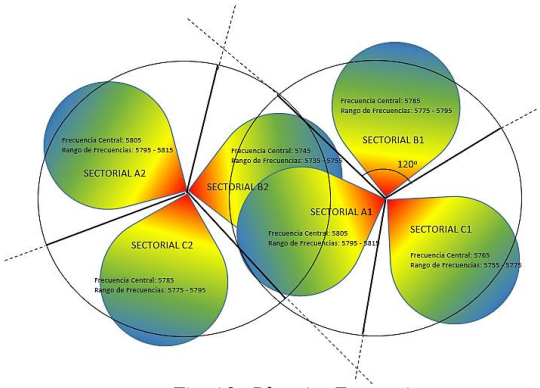

Fig. 10. Planning Frequecies

TABLE V
PLANNING OF FREQUENCIES

Frequency	Base Station	Area of Coverage	Distance (Km)
5805	SECTOR A1	La Remonta	1.38
5785	SECTOR B1	La Florida – 23 de Julio	1.24 - 1.22
5765	SECTOR C1	Nápoles	1.12
5805	SECTOR A2	Ayora Noreste	1.206
5745	SECTOR B2	Ayora Noroeste	1.128
5785	SECTOR C2	Ayora Centro y Sur	1.054

With a similar analysis for the network backhaul, you get the results described in the table.

TABLE VI
STUDY OF COVERAGE OUT

Parameter	Sector A1	Sector B1	Sector C1	Sector A2	Sector B2	Sector C2
Frequency [MHz]	5805	5785	5765	5805	5745	5785
Coverage	La Remonta	Florida, 23 de julio	Nápoles	Ayora E.	Ayora O.	Ayora C.y S.
Distance	1.38 Km	1.24 Km	1.12 Km	1.206 Km	1.128 Km	1.054 Km
Polarization Antenna	2x2	2x2	2x2	2x2	2x2	2x2
Modulation	BPSK	BPSK	BPSK	BPSK	BPSK	BPSK
Data Rate	30 Mbps	30 Mbps	30 Mbps	30 Mbps	30 Mbps	30 Mbps
Channel	40 MHz	40 MHz	40 MHz	40 MHz	40 MHz	40 MHz
Throughput	15 Mbps	15 Mbps	15 Mbps	15 Mbps	15 Mbps	15 Mbps
Sensibility Rx. [dBm]	-85	-85	-85	-85	-85	-85
Free Space Loss[dB]	110.53	115.55	108.05	110.13	110.64	108.17
Power Tx [dBm]	22.86	16.99	24.12]	23.07	22.74	24.01
Power Rx [dBm]	-47.61	-58.56	-43.93	-47.06	-47.92	-44.16

Subjecting the calculations to the simulator is obtained the following result of coverage electrical radio.

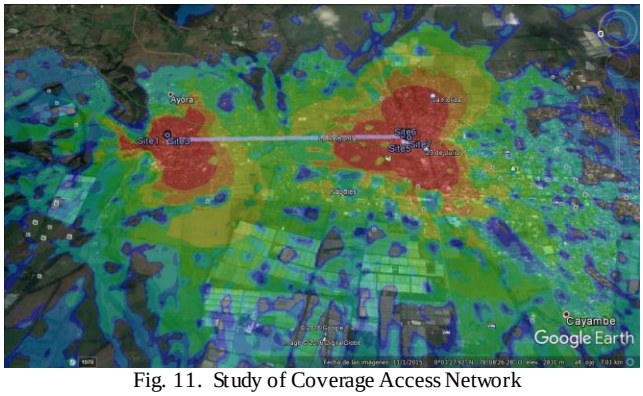

Fig. 11. Study of Coverage Access Network

E. Management Network

A fourth of equipment is considered to space where you will find all the telecommunications equipment. For your design will take into account recommendations that conform to the schema of the design of the proposed the following standards.

ANSI/TEI/EIA 569 spaces and pipes for telecommunications: the standard identifies six components of the infrastructure for the fourth of equipment, all these are welcomes those that are adapted to the design of the project. Entrance facilities, equipment room, distance to the electrical wires, internal channels, pipelines horizontal. Its design is defined via the figure.

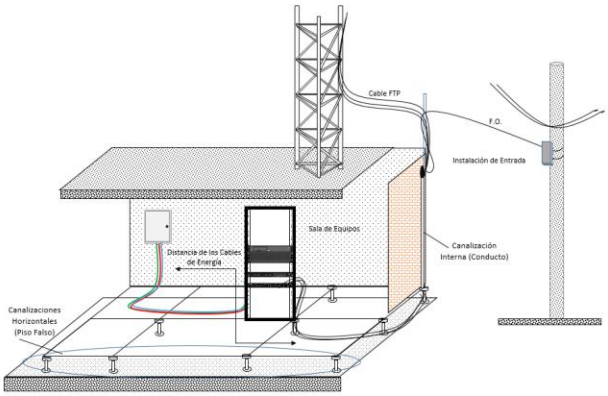

Fig. 12. Standard ANSI/TEI/EIA 569

ANSI/J-STD-607 Lands for telecommunications systems of commercial buildings: constitutes an essential part in the life of the equipment and protection of personnel. With the main purpose of creating a suitable path to direct currents and voltages static and fleeting toward earth welcomes some recommendations. TMGB (main bar of land for telecommunications), TGB (bars of land for telecommunications), TBB (backbone of land). The figure describes the application of this rule.

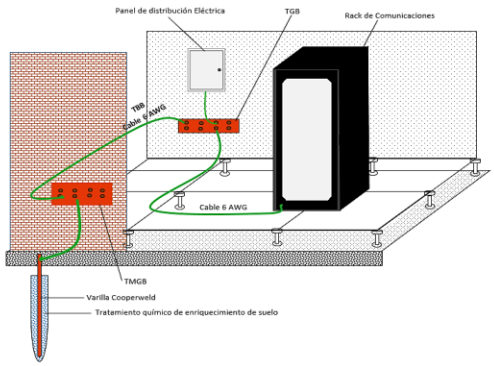

Fig. 13. Standard ANSI/J-STD-607

ANSI/TIA/EIA 568 telecommunications wiring for commercial buildings: Applies two recommendations. ANSI/TIA/EIA 568-C.1 (MDF, work areas, Input Installation) and ANSI/TIA/EIA 568-C.2 (cable FTP Category 6A). Its design is defined in the figure.

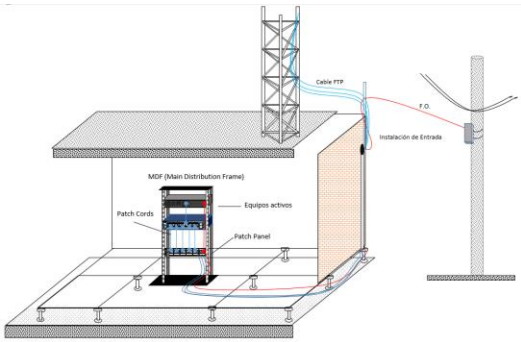

Fig. 13. Standard ANSI/TIA/EIA 568

F. Energy Subsystem

Provides supply uninterrupted power to the network and protects computers of irregularities as: POWER OUTAGE, surges, Fall of tensions, voltage peaks, Electrical Noise or electromagnetic, instability in the frequency, harmonic distortion. For sizing of an uninterruptible power supply (UPS) takes into account the critical equipment to protect (routers, switches, etc.), it is estimated the total power consumed by the equipment to be protected and finally choose the ups appropriate to support the load of the equipment.

1) Power Factor

Defined as the ratio between the active power (P), and the apparent power (S), being voltages and currents sinusoidal signals. If the power factor is less than 0.9, means that you have a high energy consumption reactive with respect to the active, giving an excessive circulation of the electric current in the facilities of the user and hence in the distribution network. There will be no payment if it is superior to 0.9, while if cosϕ < 0.7, you can force the user to make the correction.$\cos\varphi = \frac{P}{S}$.

Where:

S: Aparente Power [VA]

P: Active Power

Cos φ: Power factor (0.7 assuming an unfavorable scenario, not all energy is aprovehada)

2) Dimensioning of the system of protection

The teams that will be protected will be the main node and child node. Its consumption is shown in the tables.

TABLE VII
POWER CONSUMED EQUIPMENT MAIN NODE

Description	Power [watts]	Elements	Total [watts]
Mikrotik SAR2	12	1	12
Radio Mikrotik RB912UAG-5HPnD-OUT Basebox 5	11.5	3	34.5
AntenNa Sector AM-5G19-120 Ubiquiti	6.5	3	19.5
CCR Router Mikrorik	14	2	28
CCS Switch Mikrotik	14	2	14
PC de Monitoreo de Red (CPU+ Monitor LED)	(150+30)	1	180
TOTAL			288W/h

$$S require = \frac{P}{\cos\varphi} = \frac{288}{0.7} = 411.43\ [VA]$$

TABLE VIII
POWER CONSUMED EQUIPMENT SECONDARY NODE

Description	Power [watts]	Elements	Total [watts]
Antena Mikrotik SAR2	12	1	12
Radio Mikrotik RB912UAG-5HPnD-OUT Basebox 5	11.5	3	34.5
Antena Sectorial AM-5G19-120 grados Ubiquiti	6.5	3	19.5
CCS Switch Mikrotik	14	2	14
TOTAL			80W/h

$$S require = \frac{P}{\cos \varphi} = \frac{80}{0.7} = 114.29\ [VA]$$

The UPS systems are designed to deliver its maximum load in estimated times ranging from 5 to 15 minutes. If you want to reach higher times of supply of energy will be necessary battery banks or over sizing the load that will protect the UPS.

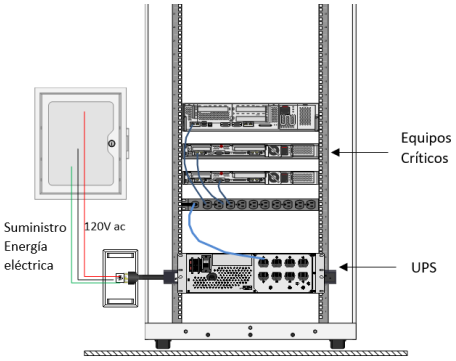

Fig. 14. System of protection

G. Electrical protection subsystem

Neutralizes the energy produced by atmospheric phenomena and ensures the security of persons and equipment. Is an entire system that on the whole provides security to the installations, applying international standards: NFPA 780 for America and the IEC-62305 for Europe.

1) Capture atmospheric discharge.

For lightning rod type Franklin, NFPA 780 and IEC 62306 defines a degree of risk, depending on which to select the tips of the lightning rod, accessories and caliber of driver (minimum cross-section 0AWG) for connection to the earthing system. Will be at a minimum height of 2 m on the elements within its angle of protection.

2) Conduction the energy produced to ground

By capturing lightning generates a current of download you must be driven to ground through a conductor (0 AWG). Will have direct path and vertical following the shortest path in the largest of the possibilities.

3) Dissipating energy in the system to ground

The atmospheric discharges transitory with rapid training times and flows of great magnitude imply the need for an effective system for placing panics. The methods and techniques used in systems of earthing vary from one another, the most common in the form of a set of rod embedded in the ground. To have an effective system are handled the following criteria.

Impedance of the ground: a low impedance is the key to the protection of atmospheric discharges. In soils considered poor by having a high resistivity (sandy soils, humidity variable and rocky), it is recommended the use of materials enriching, guaranteeing a conductivity over and thus improving the efficiency of the ground.

Electrodes or rods to ground: the electrode or rod provides the connection with the ground to dissipate the currents. A conventional method to obtain a good ground system is the combination of electrodes vertical and horizontal, being the typical star configurations, ring or mesh. Under these considerations the protection system is designed as a basis in the figure.

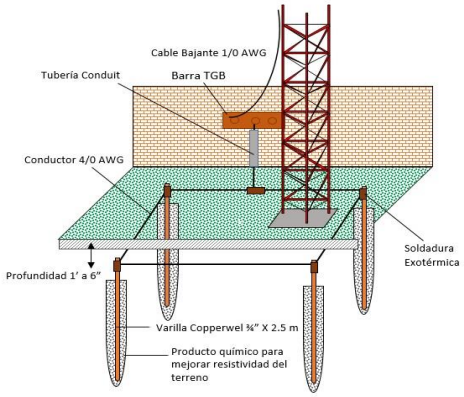

Fig. 15. Electrical Protection subsystem

H. Infrastructure subsystem

There are different types of communications towers, whose structure varies according to the needs and conditions of the site where they will be implemented, but all will be designed and implemented under the standard ANSI/EIA/TIA-222-G of "structural standards for towers of steel aerial and supporting structure of antennas".

In the design takes into account arriostradas towers, require a reduced area, but, above all, the cost of implementation is the scope of the project. Its geometrical arrangement at the time of its installation is shown in the figure.

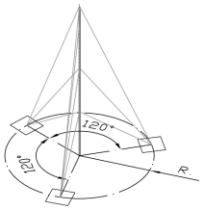

Fig. 16. Geometry of Installation

Its implementation phase requires to attention of the aspects shown in the figure.

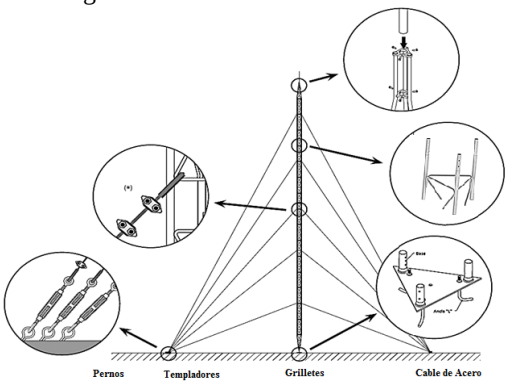

Fig. 17. Tower Structure

V. FINANCIAL ECONOMIC ANALYSIS

Allows get information about the State of income and expenditures economic for who are involved in the project as investors, determining costs, rates of production, justifying its viability, sustainability and profitability in the course of its development.

1) Budget

The budget reference guide for project takes into account all the necessary costs invested in the network to put operation. These values are listed in the table.

TABLE IX
COST OF INITIAL INVESTMENT

Main node equipment	$5809,30
Elements and materials network, equipment room	$935,66
Computers and network elements, secondary node	$1950,41
Infrastructure communication towers	$720,70
Electrical protection system	$1041,12
Utilities Office	$2447,20
Permission for the provision of value added service	$500,00
Homologation radio base station and cpes	$513,00
Internet link instalation	$300,00
Total USD without IVA	$14.217,39
IVA 12%	$1.706,09
Total USD with IVA	$15.923,48

2) Financing

The financing of the investment will be through the social capital of the stakeholders in the implementation of the project.

TABLE X
FINANCIAMIENTO

Initial Investment	$ 15.923,48
Number of partners	3
Individual Contribution	$ 5.307,83

3) Pricing

Imposing attractive values, the user and authorities within the market.

TABLE XI
PRICING OF SERVICES

Type of Service	Channel Compartition	Monthly cost
Residential 1	2Mbps 1:8 (Download/Upload)	$20
Residential 2	3 Mbps 1:8 (Download/Upload)	$25
Residential 3	4 Mbps 1:8 (Download/Upload)	$30
Residential 4	5 Mbps 1:8 (Download/Upload)	$35
Commercial 1	3 Mbps 1:3 (Download/Upload)	$75
Commercial 2	4 Mbps 1:3 (Download/Upload)	$125
Commercial 3	5 Mbps 1:3 (Download/Upload)	$175

4) Income

Valor cancelado mensualmente por los usuarios, considerando contratos de servicio en el plan más bajo en residencial y comercial.

TABLE XII
INCOME FOR PAYMENT OF SERVICES

Year 1	Year 2	Year 3	Year 4	Year 5
$52.980,00	$68.460,00	$84.060,00	$87.660,00	$101.520,00

5) Maintenance costs

With a semi-annual maintenance are generated the following expenses.

TABLE XIII
MAINTENANCE COST

Maintenance Cost	Half-yearly cost	Annual cost
Network Infrastructure	$177,00	$354,00
Equipment Maintenance	$354,00	$708,00
Total USD		$1062,00

6) Salary of Staff

On the basis of an initial salary scheduled for the first year is calculated to be an annual increase of 10%, according to historical data of salaries in Ecuador.

TABLE XIV
SALARY OF STAFF

Description	Manager	Secretary	Installer	TOTAL
Monthly salary	$ 858,85	$ 656,05	$ 393,49	
Personal	1	1	2	4
Year 1 Salary	$10306,20	$7872,60	$$9443,76	$27.622,56
Year 2 Salary	$11336,82	$8659,86	$10388,14	$30.384,82
Year 3 Salary	$12470,50	$9525,85	$11426,95	$33$33.423
Year 4 Salary	$13717,55	$10478,43	$12569,64	$36.765,63
Year 5 Salary	$15089,31	$11526,27	$13826,61	$40.442,19

7) Administrative Costs

The administrative costs will be those necessary for the operation of the company, these include: basic services, office supplies, cleaning, mobilization.

TABLE XV
ADMINISTRATIVE COSTS

Description	Monthly	Yearly
Office supplies	$30,00	$360,00
Cleaning Supplies	$40,00	$480,00
Office rental	$180,00	$2.160,00
Rental Space Communication Towers	$160,00	$1.920,00
Movilization	$80,00	$960,00
TOTAL	$540,00	$6.480,00

8) Service Charges Carrier

The costs for internet access correspond to the value to pay for the number of megas hired.

TABLE XVI
EXPENSES FOR CONTRACT SERVICE CARRIER

Period	Mbps Contracted	Telconet Cost	TOTAL
Year 1	10	(670 + costo de instalación)	$820
Year 2	13	820	$820
Year 3	15	920	$920
Year 4	17	1020	$1020
Year 5	19	1120	$1120

9) Financial analysis of the company

To perform the financial analysis, it is necessary to perform a flow of funds. For a company that evaluates your project

needs to identify what your cash flow generated by the project from year to year. This is done by determining the amount of income and expenditures for each year.

TABLE XVII
FLOW OF FUNDS

Año 0	-$15923,48
Año 1	$10.445,98
Año 2	$18.485,36
Año 3	$26.371,15
Año 4	$26.409,94
Año 5	$32.772,79

To evaluate the project should take into account the following indicators of profitability.

10) Net Present Value (VPN)

VPN = $62679,14 USD, > 0, The project is acceptable and represents profits.

11) Cost - benefit

$$\text{RC-B} = \frac{\text{VPN Incomes}}{\text{VPN Expenses}} = \frac{78602,62}{15923,48} = 4,93$$

12) Internal Rate of Return (TIR)

TIR = 0,99 %. The rate of studied interest is major than the opportunity valuation, that is to say that the TIR is major than the interest rate and as investors of the project it is convenient to realize the investment because there would be obtained a major yield of the investment than the one that would be obtained in another investment alternative.

13) Recovery Period (PRI)

PRI = 2 periods, the investment recovers to the second year of operation of the project.

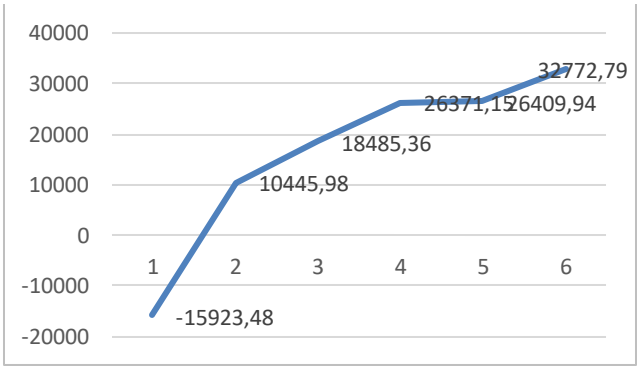

Fig. 18. Periodo de Recuperación de la Inversión

VI. CONCLUSIONS

Apply the Wireless standard 802.11n in the design of the project allows you to deploy flexible networks, scalable, fast deployment and cheap in comparison with technologies wired, although it is not a new standard, a version is very stable and tested the 802.11 standard, with significant improvements over previous versions both at the level of the PHY layer and MAC achieving higher rates of transfer at frequencies of 2.4 and 5 GHz.

The project is outlined as an ideal solution that conforms to the current situation and topographic coverage areas, providing a solution to the demand for Internet service at a reasonable cost to the user and yield economic for the supplier, also improving the quality of life of the inhabitants through their inclusion in the use of the technologies of access to information.

The Agency for the regulation and control of the Telecommunications (ARCOTEL) as regulator and supervisor of the radio spectrum in the Ecuador, imposes limits on the operating parameters of the wireless communication systems as frequencies, powers of issuance, etc., that must be complied with in a strict manner. In addition, the operation in the sale of Internet service requires authorization certificates given by the same regulatory entity prior to the submission of requests and reports related to the project.

The channel capacity measured in [bps] for international access to the Internet backbone network is directly related to the number of subscribers of the access network. For its calculation is implemented methods that relate indexes of concurrency and sharing the service. According to the number of projected users in the market study and assuming that not always the user will be making use of the service and that there is a probability that not all users will use their service simultaneously, is applied a sharing 8:1 considered very good for residential service, and 3:1 for commercial service or corporate as links semi-dedicated with an index of concurrency in 20%, value applied to environments semi-urban. Thus, it is necessary to hire a bandwidth of 48 [Mbps] in the fifth year of operation, capacity that the design of the network must be able to withstand without that the quality of the service to the end user is affected.

The quality of a radio linkage depends the correct election of the device or antenna as the needs in potency, profit, directividad, etc. Its planning process initiates knowing which it will be the valuation of transference that he will have to support. The band of 5 GHz has been used for consider less inclined to interferences and especially it is a band of free operation. At level of physical layer, the standard 802.11n defines schemes of modulation and codification which determine the broadcast speed, this way, mints major be the transference valuation, the suitable type of modulation will be applied. I remove linkage, it depends in addition to other factors like the level of sensibility of the antennas, relation sign to noise, potency of transmission and the installation of the device, maintaining a perfect antennas alignment and verifying that obstructions do not exist inside the Fresnel area. This emission will have to be realized under the limits imposed by the Arcotel.

Using the simulation tool Xirio, verified the feasibility of the links of backhaul and access network with diagrams of propagation and reports the results, showing the behavior of transmitted signals and providing support to the planning of communication systems wireless, prior to its installation.

The design of the subsystems of power backup, electrical

protection and infrastructure are important part stop The performance of the wireless network supplying the service, applying standards ensures the continued availability of the service for users and protection of the equipment and staff, to possible changes in the electrical power supply or unsettled weather.

The financial analysis of the project made it possible to check that the implementation of the project is viable and represents profitability for investors, with a period of recovery of the initial investment already in the second year. While there may be indicators not scanned, the success or failure of the project will depend on the takes appropriate decisions without affecting the service to the user, who are economically dependent operation of the project.

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