ANALYSIS OF CURRENT AND FUTURE DEMAND FOR BROADBAND ACCESS IN CANTÓN ANTONIO ANTE AND PROPOSAL FOR THE DESIGN OF A PASSIVE OPTICAL NETWORK (PON) FOR THE COMPANY CNT E.P. AS A SOLUTION TO FUTURE DEMANDS

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Abstract - The present work aims to analyze the current and future demand for broadband access in the canton of Antonio Ante and to design a passive optical network capable of satisfying the requirements and requirements of future users in the sector.

An analysis of the current and future demand for broadband access is carried out in all urban and rural parishes of the canton Antonio Ante, the analysis of the current situation is performed using the process determined as sampling by surveys in all parishes Of the canton Antonio Ante. To estimate the future demand for broadband access, parameters such as population growth with respect to telecommunications services and the estimation of the population unsatisfied with the service that each subscriber own are used.

Subsequently a GPON network design is realized considering the results and requirements established by the surveys and the analysis of the current and future demand, finally, a financial analysis is carried out to determine the economic viability of the work using the profitability indicators as the VAN, the TIR and the PRI

***Terms of use — FTTx,* GPON, ITU-T G984, FEEDER, ODN, OLT, ONT, SPLITTER, FDH, NAP.**

I. THEORETICAL FOUNDATION

A. *General Concepts About Optical Fiber*

Optical fiber refers to the technology associated with transmitting information with pulses of light along a fiberglass or plastic wire. Technology developed in the 1960s that is rapidly replacing copper cables in telecommunications.

Optical fiber is the most powerful wired transmission medium today. Its appearance and use has given rise to the emergence of new communication systems that interconnect the entire world.

a. *Structure of the Optical Fiber.*

They are rigid or flexible ducts, with the approximate dimensions of a human hair, constructed from plastic or glass, capable of conducting light between their ends. They can be considered as waveguides that work at optical frequencies. The basic structure of an optical fiber consists of three parts; The core, the coating, and the coating. The basic structure of an optical fiber is shown in Figure 1.

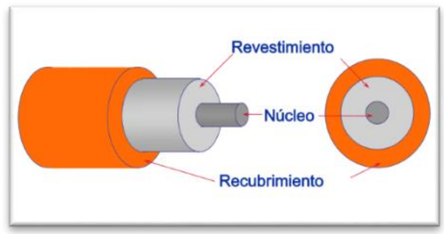

Fig. 1. Structure of the Optical Fiber

b. *Advantages and Disadvantages of the F.O.*

The main advantages of the optical fiber with respect to the coaxial cable are:

- ✓ It has a much longer shelf life than copper.
- ✓ Fiber-optic communications can reach very high transmission speeds over long distances.
- ✓ The attenuation does not depend on the transmission speed, but only on the distance.
- ✓ Information transmission is safer than using coaxial cable because it is very difficult to place a listening device on the transmission line, providing better physical network security.
- ✓ Allows to offer a greater bandwidth and therefore a greater capacity to each individual user.
- ✓ They are lighter than copper.
- ✓ In the long term the cost of optical fiber will be much lower than today.
- ✓ Low signal loss, typically less than 0.3 dB / km, so transmission using a repeater over long distances is possible.
- ✓ Immunity to electromagnetic interference, including nuclear electromagnetic pulses.
- ✓ There is no electromagnetic radiation in fiber optic communication systems.
- ✓ High electrical resistance, so it is safe to work near high voltage equipment.
- ✓ Signals contain very little energy
- ✓ There is no crosstalk between fiber optic cables.

The disadvantages of the Fiber Optic are the following:

- ✓ Greater difficulty in maintaining the system.
- ✓ Optical fibers are very fragile; any violent movement can cause fiber breakage and this would involve high costs in repair.
- ✓ High cost of investment in optical equipment and systems.

- ✓ The need for more expensive optical transmitters and receivers.
- ✓ The cable connection is complicated.
- ✓ At high optical powers, it is susceptible to "fiber fusion" in which a little too much light encounter with an imperfection can destroy up to 1.5 kilometers of wire at several meters per second.

c. *Types of Fiber Optics*

According to the number of modes or light beams that can be transported, optical fiber is classified into two types:

Fiber Optic Monomode: The single-mode fiber allows a greater capacity to transmit information because it can retain the fidelity of each light pulse over long distances without the dispersion caused by the multiple modes. In addition, the single-mode fiber has less fiber attenuation than the multimode, so more information can be transmitted in less time

Fiber Optic Multimode Phased Index: They are optical fibers in which the index of refraction of the nucleus is constant, therefore, the speed of propagation is the same for all the modes, reason why when covering different trajectories, the modes will arrive at different times, Producing a delay that widens the pulse of light.

In this type of optical fiber, the core is made up of several concentric layers of optical material with different refractive indexes, causing the ray of light to refract gradually as it travels through the nucleus, Ray curve

d. *Losses in the Optical Fiber.*

There are several types of losses in the optical fiber, the most important are losses by:

- ✓ Absorption by ultraviolet and infrared rays
- ✓ Absorption due to impurities.
- ✓ Ray Rayleigh scattering
- ✓ Macro curvatures
- ✓ Micro curvatures

e. *Transmission windows of the F.O.*

Optical communications take place in certain areas of the optical spectrum, where favorable conditions exist for them to be carried out, such as less attenuation. These zones are called windows and there are five, which are presented below:

- ✓ First window: wavelength = 850 nm
- ✓ Second window: wavelength = 1310 nm
- ✓ Third window: wavelength = 1550 nm
- ✓ Fourth window: wavelength = 1625 nm
- ✓ Fifth window: wavelength = 1470 nm

In Figure 2 the windows of the optical spectrum can be seen.

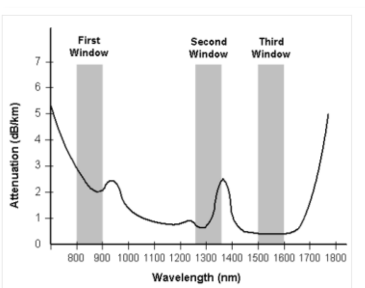

Fig. 2. Optical Spectrum Windows

B. *Access Networks and Technologies*

Access networks connect end users to the service provider. At present, given the need for bandwidth that customers have, the vast majority of access networks use fiber optics as a transmission medium.

It has the main components of an access network:

- ✓ Physical transmission medium: Which can be: twisted pair, coaxial cable, optical fiber, or air.
- ✓ Telecommunication elements: Such as antennas, optical access equipment, DSL access equipment (digital subscriber line), MSAN (multiservice access node) equipment.
- ✓ Interconnection devices: Twisted pair connectors, fiber optic splices, distribution boxes, etc.

C. *Networks XPON*

PON networks replace all active computers that may exist between the server and the end user, with passive components that guide the traffic throughout the network. A PON network is a fiber network that uses only passive components as dividers instead of active components as amplifiers.

These networks cost much less than those using active components. The main disadvantage is a shorter range of coverage limited by signal strength. While an AON can cover a range of about 100 kilometers, a PON network is typically limited to fiber cable lines up to 20 km.

a. *APON*

APON (Asynchronous Transfer Mode Passive Optical Network), Is defined by the ITU-T G.983 standard. Uses ATM for signaling on the data link layer. For the downstream channel ATM cells with a size of 53 bytes are used, at a speed of 622 Mbps, which is distributed among all connected ONTs. On the other hand, in the ascending channel, maximum 54 ATM cells are used at a speed of 155.5 Mbps.

b. *BPON*

BPON (Broadband Passive Optical Network), It is specified in the ITU-T G.983 standard revisions. It emerged as an improvement over APON, using WDM which allows it to have a greater bandwidth and to be able to access to more services like for example Ethernet.

c. *GPON*

GPON (Gigabit Capable Passive Optic Network), is standardized in several of ITU-T G.984 recommendations. It was the first PON network that allowed to have speeds superior to 1 Gbps. In the upstream channel it is transmitted to 1,244 Gbps while for the descending channel the transmission is realized to 2,488 Gbps.

d. *EPON*

EPON (Ethernet Passive Optical Network), is defined in the IEEE 802.3ah recommendations. It basically encapsulates traffic in Ethernet frames. EPON 802.3ah specifies a similar passive network with a range of up to 20 km. Uses WDM with the same optical frequencies as

GPON and TDMA. The transmission speed is symmetrical and is 1.25 Gbps.

D. GPON Networks

Defined as an innovation of the PON standard set, the Passive Optical Network with Gigabit capability, GPON, has been a member of this family since 2004 with the creation of ITU-T G.984 recommendations. X

a. UIT-T Recommendations G.984.X

Due to the need to provide the user with better costs, competitiveness and brand diversity, a set of recommendations have been proposed that regulate the different characteristics of the equipment developed to support the GPON standard, following are the five recommendations approved in The International Telecommunication Union ITU in the G series: (Transmission Systems and Media, Systems and Digital Networks):

- ✓ ITU-T G.984.1: Caracter I General sticas
- ✓ ITU-T G.984.2: specification or n - dependent Layer Media
- ✓ UIT-T G.984.3: specification or n - layer or n Transmission Convergence
- ✓ ITU-T G.984.4: specification or n Interface Control And Gesti or n or n From the completionor network ptica
- ✓ ITU-T G.984.5: Band enlargement or n

b. Architecture GPON Network

Starting from the central office is connected by means of a single-mode fiber to a Splitter close to the end users. It is at this point that the division of the fiber into N routes to the subscribers takes place. Figure 3 shows the GPON network architecture.

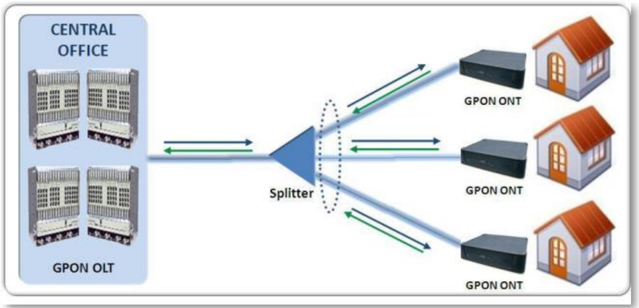

Fig. 3. Architecture GPON Network

The wavelengths are related to Upstream and Downstream 1310 nm and 1490 nm respectively, for video RF 1550 nm. The number of routes or routes can vary from 2 to 64 from the single mode Splitter to each user, where the transmission of fiber from the central office to each user can be up to 20 km.

Downstream: The operation consists of the OLT sending the traffic using Broadcast where each ONT verifies the address in the frame header, because the ONTs receive all the traffic, it is necessary to make use of encryption. The OLT determines and notifies the ONTs of the Time Slots for sending the data.

Upstream Frame: The operation of the GPON Upstream Network takes traffic from the user port and maps it to GEM frames. The way to carry out the transmission of the data is using TDMA by means of Time Slots assigned by the OLT.

c. GPON Network Elements

The GPON access network is divided mainly into three parts, the OLT, which is interconnected by an ODN to a node or an ONT. A GPON passive optical access network consists basically of:

Optical Line Terminal Equipment (OLT): The OLT is an active element from which fiber optic networks to users, OLTs have the capacity to serve thousands of consumers connected to the service they wish to provide. This element of the GPON network is located in the dependencies of the operator, and consists of several GPON line ports, each supporting up to 64 ONT. Although it depends on the supplier, there are systems that can accommodate up to 7,168 ONTs in the same space as a DSLAM.

Optical distribution network (OND): The optical distribution network in the FTTx architectures corresponds to the optical infrastructure that goes from the OLT to the subscriber ONT. The ODN is passive, has no active or energized elements like the OLT and the ONTs. Figure 38 describes what has been described above. The transmission in the ODN is bidirectional being able to use the same fiber for the upstream and downstream traffic or a separate fiber for each one of them. In the first case a band of different wavelengths should be used, the 1530-1570 nm band being used for downlink traffic and the 1280-1340nm band for the upstream. The ODN is composed of the following elements in general:

- ✓ Patchcord of fiber between OLT and ODF.
- ✓ The ODF.
- ✓ Fiber optic cables OR FEEDER that is to n associated with the GPON network.
- ✓ Primary splitters.
- ✓ DISTRIBUTION cables or N.
- ✓ Side Splitters if the level of attenuation or n permitting.
- ✓ DROP cables or cables.
- ✓ Terminal boxes.
- ✓ Roseta or optical.
- ✓ Fiber patch cord between the rosette or optical and ONT.

Optical network terminal equipment (ONT): The ONT is the element that is located in the user's home where the fiber optic ends and offers the user interfaces. ONTs must be manufactured in such a way as to withstand the worst environmental conditions and are usually equipped with batteries.

E. FTTx Architectures

a. FTTH

The optical fiber reaches the home of the subscriber. It uses a star configuration which allows to provide greater bandwidth to each user. Splitters can be used; the important thing is to comply with the fundamental principle of having a fiber in the telecommunications center and several fibers on the user side.

b. FTTB

The fiber network reaches the entrance of the commercial or residential building. Access to the network by internal users is done through a copper network with structured cabling.

c. FTTC

It is commonly used to interconnect buildings, where a closet serves several users. The fiber will reach this closet, and from it, copper will be used.

d. FTTN

The fiber goes from the central office to the node closest to the user. However, this distance may be relatively long. From the node and up to the end user, the transmission medium will be copper.

II. CURRENT AND FUTURE DEMAND ANALYSIS

A market is defined by the characteristics of the demand of the users for a certain service. Market demand is the total amount of purchases of a service that can be made by a particular demographic group or a specific geographic area.

In other words, a market is the place where the forces of supply and demand relate to the transaction of goods and services at a certain price. A fundamental part of the analysis of demand is to determine the size of the market, which will make it possible to determine if the company needs to stimulate the interest of the consumer of a particular demographic group to generate business or promote different markets.

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A. Coverage Area

The canton Antonio Ante is located in the north of the country specifically in the province of Imbabura. The canton Antonio Ante is in the center of the province of Imbabura, and its cantonal head is Atuntaqui. According to the official website of the canton, it has an area of 79 Km2 and a population of 43,518 inhabitants based on the last census in 2010. Antonio Canton Ante is composed of 6 parishes, of which 2 are urban (Atuntaqui and Andrade Marin) And 4 are rural (San Roque, Natabuela, Chaltura and Imbaya). The population of the canton is detailed below in Table I:

TABLE I
POPULATION CANTÓN ANTONIO ANTE

Territorial Unit	**Population (Urban)**	**Population (Rural)**	**Total**
Atuntaqui-Andrade Marín	21.286	2.013	23.299
Imbaya	-	1.279	1.279
Chaltura	-	3.147	3.147
Natabuela	-	5.651	5.651
San Roque	-	10.142	10.142
TOTAL	**21.286**	**22.232**	**43.518**

B. Current Situation or Subscribers

To determine the current situation of the broadband access subscribers in the canton Antonio Ante, the number of users that each telecommunications service provider has in the sector was taken as a reference. To have real and reliable data, the values that are detailed below were referenced by each ISP.

TABLE II
NUMBER OF CURRENT MEMBERS AT CANTÓN ANTONIO ANTE

PARISHES	**CNT**	**REDECOM**	**TELECOM**	**TOTAL**
Atuntaqui	1.494	99	15	1.608
Andrade Marín	609	41	5	655
San Roque	311	21	3	335
Natabuela	317	19	12	348
Chaltura	309	20	2	331
Imbaya	132	9	5	146
Total	**3.172**	**209**	**42**	**3.423**

C. Universe sampling and research

The analysis of the demand begins with the determination of the market size to be used to carry out the respective study, for this reason the sampling is used, which is the procedure by which a representative sample of the population to be used is selected analyze, for this case is considered to canton Antonio Ante as the universe in the investigation.

It is very important to determine the size of the sample, and the following question is answered: What sample size do you need to use for a given universe? The size of the universe depends on the level of error you are willing to accept, the more precision you require, the more sample you will need. As larger universes are studied, the sample size required each time represents a smaller percentage of that universe. The universe proposed to perform the sampling will be the current number of Internet subscribers.

D. Sample Size and Calculation

The calculation of the sample size is one of the aspects that determine the degree of credibility that will be granted to the results obtained. Equation 1 is used to determine the size of the sample.

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$$n = \frac{Z^2 * \sigma^2 * N}{e^2 * (N-1) + Z^2 * \sigma^2} \qquad [1]$$

Where:

n = The size of the sample.
N = The size of the universe
σ = Standard deviation of the population 0.5.
Z = Value obtained by confidence levels.
e = Acceptable sample error limit of 5% (0.05)

The level of confidence most used in various investigations is 95% (1.96).

Analyzing the number of subscribers in each parish, the manner in which the surveys were to be determined was determined. For the cantonal headwaters Atuntaqui and Andrade Marín the surveys will be conducted through an online survey, this way times and resources are reduced, in this case the survey will be distributed through emails and social networks. For this sector, a 99% confidence level will be used to obtain enough specific data and a much smaller margin of error.

For the rural parishes of San Roque, Natabuela, Chaltura and Imbaya, the surveys will be conducted personally by visiting the domicile of the people to whom the research is directed, the confidence level to be used will be 95% because a personal survey decreases in The margin of error. After performing the calculations the sample sizes in the different parishes are as follows:

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- ✓ Parroquia Atuntaqui/Andrade: 2.263 Subscribers
  Level of confidence: 99%
  n=514
- ✓ Parroquia San Roque: 335 Subscribers
  Level of confidence: 95%
  n=178
- ✓ Parroquia Natabuela: 348 Subscribers
  Level of confidence: 95%
  n=182
- ✓ Parroquia Chaltura: 331 Subscribers
  Level of confidence: 95%
  n=177
- ✓ Parroquia Imbaya: 146 Subscribers
  Level of confidence: 95%
  n=106

E. *Current Demand Analysis*

All the questions used in the survey allow us to have a very close knowledge of details that will be very helpful in the analysis presented. However, for a better appreciation of the results obtained, a detailed summary has been presented in Table III with all the values obtained in each of the parishes surveyed.

TABLE III
SUMMARY SURVEY

SURVEY QUESTIONS		Imbaya	Chaltura	Natabuela	San Roque	Atuntaqui / Andrade M.
Nivel de satisfacción	Muy Satisfecho	17%	10%	5%	16%	22%
	Satisfecho	65%	76%	77%	56%	38%
	Poco Satisfecho	16%	12%	13%	24%	26%
	Nada Satisfecho	2%	2%	5%	4%	14%
Planes Internet	1-3 Mbps	84%	87%	77%	86%	46%
	3-5 Mbps	14%	12%	23%	14%	47%
Aumentar navegación	SI	75%	82%	86%	67%	84,5%
	NO	25%	18%	14%	33%	15,5%
Contratar Internet	SI	59%	87%	75%	72%	90%
	NO	41%	13%	25%	28%	10%

F. *Projection and Estimation of Future Demand*

Projecting involves quantitative and qualitative studies, which seek to describe how economic growth will be in a given time frame into the future. The projection of the demand allows to have an estimate of the requirements of the network of access to future; An estimated time of projection of 5 years has been considered because an adequate time is considered in which will be implemented new technologies and therefore the current demand will change proportionally.

The analysis of population growth is based on the general increase or reduction of individuals that a sector has over a period of time. Population growth is the change in population over a given time period, and can be quantified as the change in the number of individuals in a population per unit time for measurement. The Population Growth Rate (TCP) is the increase in the population of a country in a given period, expressed as a percentage of the population at the beginning of the period.This rate reflects the number of births and deaths during the period and the number of immigrants and migrants in the country.

The percentage can be positive or negative. The growth rate is a factor that determines the magnitude of the demands that a country must satisfy due to changing needs. In the case of this research the analysis is done in the matter of telecommunications services.

During the analysis of the market demand, we proceeded to determine the population growth that will have the sectors analyzed in the canton in a period of 5 years, taking into account the growth rates of each parish and in this way to be able to correctly dimension the network for That it can cover current demand, projected demand and population growth.

According to the INEC, the annual inter-census growth rate in the country is 1.52%, however, to study this research will be used growth rates by parishes, these data were obtained from the official website of the INEC and are detailed In Table IV.

TABLE IV
POPULATION GROWTH RATES

Parroquia	**Man**	**Woman**	**Total**
Antonio Ante/Andrade M.	2,13%	2,15%	2,14%
San Roque	1,85%	1,82%	1,83%
Natabuela	3,00%	3,13%	3,07%
Chaltura	0,94%	1,33%	1,14%
Imbaya	2,11%	1,04%	1,57%

According to the guide of the Latin American Institute of Economic and Social Planning (ILPES), "Guide for the presentation of projects", Equation 2 is used to determine population growth.

$$D(t) = Do\,(1+i)^t \qquad [2]$$

Dónde:

D(t)= Projected demand with respect to time (t)
Do= Initial demand
i= Population growth rate
t= Time in years.

The analysis and estimation of the projected demand with respect to the population growth is done based on the data collected in the ISP with respect to only the current demand of the Internet.Using equation 2 the following results are obtained with respect to an estimated demand of Internet users in 5 years. Table V details the results.

TABLE V
ESTIMATED DEMAND IN 5 YEARS

Parroquias	**Current Demand Subscribers**	**Estimated demand in 5 years**	
Imbaya	146	158	**1.280**
Chaltura	331	350	
Natabuela	348	405	
San Roque	335	367	
Andrade Marín	655	728	**2.516**
Atuntaqui	1.608	1.788	

III. DESIGN OF THE PASSIVE OPTICAL NETWORK

A. Preliminary Conditions

Following the respective analysis of the current and future demand for broadband access in the canton Antonio Ante, and based on the results obtained, it was determined that the network design will be done only for the urban sector of the canton, specifically For the parishes of Atuntaqui and Andrade Marín, since in these areas there is a great penetration of the current economic, technological and industrial market in the long term.

Taking into account that Atuntaqui is the cantonal head of Antonio Ante and also considered as "The Industrial Center of Fashion" it becomes very important to have as a priority the network design in this sector, due to the remarkable economic and technological progress Which is evident in this industrial city. Rural parishes do not have a technological and economic growth of a high magnitude as evidenced in the urban sector, therefore, it is considered that designing a passive optical network is not a priority in this research and that process Can do in a few years without having a negative impact during the current project titling.

In order to realize an optimum network design, two regulations will be used: the International Telecommunication Union ITU-T G.984, which is responsible for the passive optical network that supports bandwidths up to 2.4 Gbps, and By the CNT EP the current regulations of design of the ODN and the Technical Standard for Drawing of External Plant Networks.

Determining the data transfer capacity that will support the network becomes essential at the time of designing the network. At this point, having analyzed the current and future demand for broadband access in the canton in the Demand Analysis Chapter, provides a great help in determining the necessary bandwidth that the network must resist to provide excellent service in a long run.

B. Criteria for Design

Considerations for network design involve choosing appropriate and accurate technical criteria with respect to the selected network architecture and designing an efficient optical distribution network (ODN) that optimizes resources, reduces initial investment, Capital to achieve the highest levels of flexibility possible and thus achieve the objectives set out in this project. The technical criteria to consider are detailed below:

a) Type of Network to be used

There is no doubt that any investment of an Operator other than a pure FTTH network will be a CAPEX wasted at the end of the cycle of 2 to 3 years more where commercially the desperate survival of an operator who wants to deliver value-added content for their Customers, will inevitably end up in a pure fiber optic network. There is no doubt that the only robust network to withstand the clashes of the Zettabytes that come from the growth of video, is an FTTH network.

FTTH is evidently considered the only suitable network to guarantee the future requirements of customers and companies, in this way FTTH technology will serve as a platform for business applications and business infrastructure, Smart Grid, Video Monitoring Urban, FTTH in Health Applications, FTTH in Health Applications, etc.

b) Topology of Network

The topology of the GPON network considered for the present design is of the tree type of four nodes or levels, it has as central node the OLT located in the central office of the CNT in Atuntaqui, which feeds to the nodes of distribution (second level) Represented by the optical distribution cabinets, the number of optical cabinets required will be defined later; Similarly, the optical distribution cabinets connect several third level nodes, such as optical distribution boxes, and finally as the fourth level are the ONTs located in each sector or neighborhoods to be covered with the GPON network. Figure 4 specifies the 4 levels considered in the network topology

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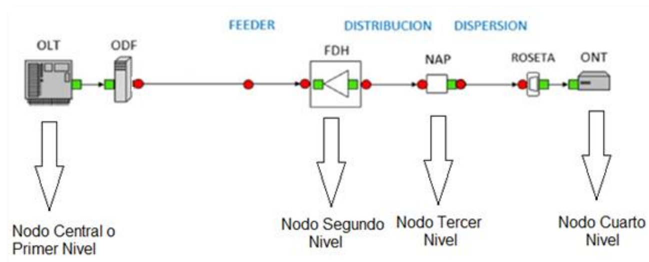

Fig. 4. GPON Network Topology

c) Division of Selected Sector

In order to make a more efficient network design it has been considered convenient to divide the entire urban sector into two zones, Zone 1 will be the Atuntaqui parish, and Zone 2 will be the Andrade Marín parish. In this way a suitable distribution of the FDH and NAPs is made in each of the established zones.

d) OLT Ubication

In order to determine the appropriate place where the OLT is considered, the existing infrastructure is analyzed, in the case of the Canton Antonio Ante, the CNT EP has installed the telephone switchboard in the center of the cantonal Atuntaqui, specifically in Bolivar streets 1331 And Olmedo

e) Optical Splitters Ubication

As can be seen in Figure 5, the optical dividers are located in the FDH, taking into account that the maximum storage capacity in a cabinet is 9 optical dividers. The following sections detail the exact locations where the optical distribution cabinets (FDH) will be placed and thus the location of the Splitters.

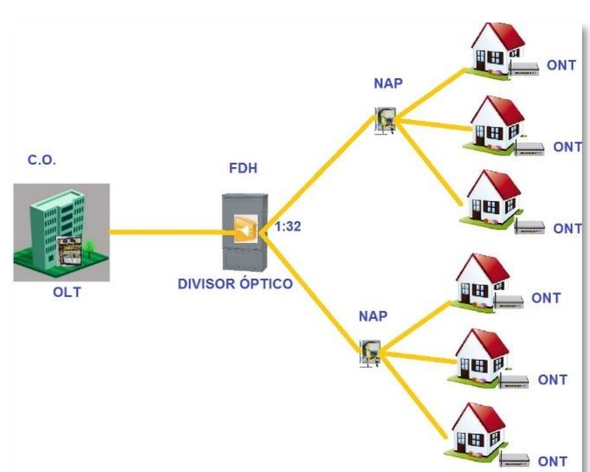

Fig. 5. GPON Network Logic Diagram

f) Type of Fiber to be used

The type of fiber considered to be used will be the single-mode fiber, since this type of fiber is suitable for medium and long distance networks and with high data transmission rate. Also important factors are considered as the price, attenuation values, distances between OLT and FDH, etc.

C. Optical Budgeting and Calculation of Losses

Calculating the optical budget of an FTTH network is one of the most basic activities that must be clear. The optical budget determines how far you can have customers without the transmitted signal loses power and information is not lost.

To calculate the established optical budget, the relationship described above is used:

Optical Budget Established = (Tx Power) - (Receiver Sensitivity)
Opposed Budget Established = (5 dBm) - (-27 dBm)
Estimated Optical Budget = 32 dB

Now you must calculate the loss budget, in this case should take into account losses that are introduced by all network elements, additionally, you should consider a range of support, covering losses that may arise from various causes and that they are not predictable. The optical loss budget must not exceed the established optical budget of 32 dB. Losses to consider are Attenuation: For distance in the optical fiber, caused by connectors, optical splitters, splices and margin for backup.

The total attenuation is calculated by adding the distance attenuation in optical fiber, produced by optical splitters, splices and connectors.

Attenuation Total = (Ad) + (Ac) + (As) + (e) + (Ar)

Where:

- ✓ Ad = Damping or n by distance fiber or optical.
- ✓ Ac = Damping or n by connectors.
- ✓ As = Damping or n by dividers or optical.
- ✓ Ae = Damping or n for joints.
- ✓ Ar = Damping or n reserve.

Nearest Client:

Attenuation T (1310 nm) = (0,02) + (3,5) + (18,6) + (1,05) + (3) = 26,17 dB

Attenuation T (1550 nm) = (0,015) + (3,5) + (18,6) + (1,05) + (3) = 26,165 dB

Further Customer:

Attenuation T (1310 nm) = (1,2) + (3,5) + (18,6) + (1,05) + (3) = 27,35 dB

Attenuation T (1550 nm) = (0,9) + (3,5) + (18,6) + (1,05) + (3) = 27,05 dB

As mentioned above, the total losses should not exceed the optical budget established, in this case the established budget is 32 dB, therefore, the budget is highest loss of 27.35 dB and, therefore, does not exceed 32 dB and is considered an adequate budget losses for the network design.

D. GPON Network Design

a) Red Feeder

The section that interconnects the OLT with Optical Distribution cabinets (FDH) is called or commonly referred to as primary feeder network. The location of the optical cabinets becomes very important, this part of the detailed in section optical distribution network (ODN), as noted above, the estimated number of current subscribers in the parishes of Atuntaqui and Andrade Marin is 2.263 however, making the design of a network that technological changes and increased demand is very important, with the analysis in Chapter demand analysis, it was determined that the estimated number of users for the 2020 suits will of 2516, therefore leaving ports reserves optical splitters is paramount.

It is recommended that communication between the OLT and the Optical Distribution cabinets through a pipeline. In this case the existing pipeline for the passage of the fiber cable will be reused from the OLT to the optical distribution cabinets (FDH) in sectors where no pipeline be built the projection of the same will be done.

b) Optical Distribution Network

The section interconnecting the Feeder network to the dispersion is called optical distribution network (ODN), this network comprises the location of the optical cabinets, distribution of optical splitters and the connection to the NAP distribution network is the stretch connecting optical distribution cabinets (FDH) to optical distribution boxes (NAP). Within the optical cabinets they are located optical splitters. Optical cabinets have the ability to support up to 9 splitters with 1:32 split ratio.

The distribution architecture dividers will be centralized, this means that only primary optical splitters are used, ie one level splitteo. An optical cabinet stores up to 9 splitters ratio 1:32, so a number of 288 subscribers per cabinet is obtained. However, it is very important to make reservations optical splitters and the NAP, this procedure is done with the intention of having space for future subscribers without and that the network design is flexible to future demands, this way is to use 8 and leave the remaining divisors for future prospects, likewise each divider 32 can supply subscribers, therefore, is essential to leave two empty threads and only use the remaining 30.

Then, each cabinet would be providing service to 240 subscribers (30 * 8 dividers), so you have 48 ports are available for use in the future. the location of the optical closets over existing infrastructure, in this case, the connection between the OLT and DHF are performed by channeling was determined, therefore, lockers stood at strategic points to leverage existing pipeline. Each cabinet stores 240 subscribers, will then be necessary to Atuntaqui 7 and 3 FDH FDH for Andrade Marin sector, and are distributed as follows:

Zone 1: FDH 1 FDH 2 FDH 3 FDH 4 FDH 5, FDH 6, FDH7
Zone 2: 8 and FDH FDH FDH 9 and 10

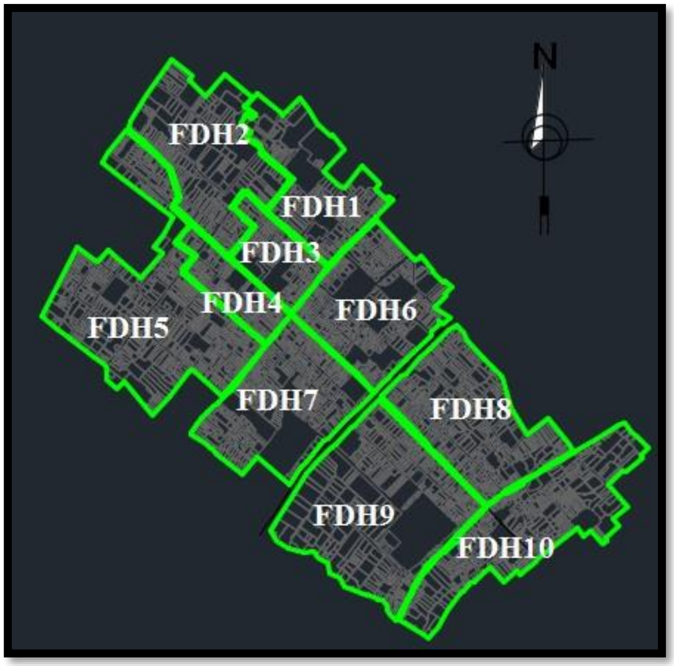

Fig. 6. Location FDH Zones

c) Red Dispersión

Dispersion network is running from the box to the ONT optical distribution, ie, it is the network connection to each subscriber. This type of network is installed in accordance with the requirements of the subscriber and the network portion not covered in the proposed design specifications for this project due to the excessive number of ONTs in the sector exceeds 2,000 subscribers. A NAP is the point of connection between the distribution network and individual connections for each subscriber having a maximum capacity of 12 ports per team, ie, each NAP can supply up to 12 subscribers also are cutoffs for operation and maintenance work.

As explained in the previous section, it is advisable to leave reservations optical cupboards and the NAP, in this way, in the proposed design is set to leave 2 empty ports on each NAP for future customers, ie, only 10 port will be used for each NAP. Each optical cabinet 24 can supply NAP (24 * 12 = 288 subscribers), however, leaving two free ports for each box, there are 48 ports available that can be used in the future demands.

Moreover, as it determined in the previous section will be used only 8 of the 9 optical splitters available in each cabinet, and 8 ports splitters are used 30 and the remaining two will be left free. Then, the distribution of the NAP is: each optical splitter with 30 usable supply ports 3 NAP, NAP ie each have 10 ports. By thus 240 air NAPs, 24 per FDH optical boxes, of which 168 belong to Zone 1 (Atuntaqui) and the remaining 72 to Zone 2 (Andrade Marin) will be used

IV. COST BENEFIT ANALYSIS

A. Expenditure Project

Table VI is the total cost of network implementation. The prices are estimated to establish the budget for the implementation of the network are referenced in the volume of work of the CNT EP updated in April 2016.

TABLE VI
TOTAL BUDGET IMPLEMENTATION

Detail	Expenses (USD)
Red Feeder	183.878,61
Red Distribución	442.272,99
Red Dispersión	587.610,58
Canalización	147.753,84
Total, Gasto Implementación	**1.361.516,02**

This section describes the current total costs are calculated, ie, the cost of network maintenance, staff salaries, mobilization of personnel and equipment assets. expenses for implementation of the network are taken into account. In Table VII details are observed.

TABLE VII
CURRENT TOTAL COSTS

Detail	Expenses (USD)
Mantenimiento De Red	68.075,80
Gastos Personal Administrativo	62.880,00
Movilización Personal	9.600,00
Equipos Activos	219.725,00
Total, Costos Actuales (USD)	**360.280,80**

B. Project Income

Table VIII annual income from the provision of Internet services is displayed, and the installation of equipment to new subscribers.

TABLE VIII
TOTAL REVENUE

Años	Tarifa Anual Telefonía Fija (USD)	Tarifa Anual Internet (USD)	Instalación (USD)	Ingresos Anuales (USD)
Año 0	315.689,64	0	0	315.689,64
Año 1	315.689,64	156.116,16	19.020,00	490.825,80
Año 2	315.689,64	289.578,24	35.280,00	640.547,88
Año 3	315.689,64	423.532,80	51.600,00	790.822,44
Año 4	315.689,64	245.255,04	29.880,00	590.824,68
Año 5	315.689,64	124.597,44	15.180,00	455.467,08
Total	**1.894.137.84**	**1.239.079,68**	**150.960,00**	**3.284.177,52**

C. Performance Indicators

It was determined that the estimated total implementation cost is $ 1,361,516.02, along with data from the project department of the CNT EP current total expenditure was determined, ie annual expenses including maintenance network, administrative staff salaries, expenses for mobilization and active equipment, giving a total of 360.280,80 estimated USD expenses.

Likewise, revenues from services and installation of equipment was determined, with the income of $ 3,284,177.52 during the first 5 years. Thus a table of cash flow was performed to establish the net flows and to determine the feasibility of the project through profitability indicators. Thus concludes the following:

- ✓ The VAN value is $ 439,305.60, it is determined that the project is feasible, in addition to s can be concluded that the implementaci or n of this network be to feasible.
- ✓ The TOR of 17.72% was obtained, and considering that the rate of inter é s discount lending rate used was the Central Bank 8.02%, TIR is higher, therefore, it is considered a project with a feasibility huge.
- ✓ The exact time in which to recover to the investment or initial n is 3 to ñ years, 5 months and 26 d í ace. The per í odo of recovery or n is within the first 5 to ñ os, therefore, it is considered adequate time

to recover the investment or initial n and the project is obviously very feasible.

- ✓ With regard to the relationship or n cost / benefit, determin or that for every d or lar that the CNT EP invest in the project will be obtained to a gain of one day or lar and 91 cents, that is considered a gain almost double, therefore the relationship or n cost / benefit ratio is very positive and favorable, then the project is considered feasible.

V. CONCLUSIONS AND RECOMMENDATIONS

A. *Conclusions*

The population in the Canton Antonio Ante increases at a rate of 2.5% per year, a high rate of growth compared to the national that is 2.1%, additionally this canton is considered a sector with a high industrial, textile growth and be an axis economic development of the north, the current copper network will not provide future requirements of subscribers, the future demand for future customers requires a GPON network that supports average transfer rate of 15 Mbps per subscriber.

In Ecuador only 28.3% of households now have Internet access. It clearly shows that Ecuador has a low percentage compared to 56% that the ITU estimates for 2020. In addition, the country has a density of fixed broadband connections of 4.19%, which is below 8% the Latin American average. In conducting the study of the current and future demand in the sector Atuntaqui and then carry out the design, the canton increase broadband penetration and turn Internet service will increase.

FTTH is considered as the most appropriate technology to use in the sector, since this type of network is adapted to the demands of the urban sector Atuntaqui. Because the demand for current users and estimated the current network that is purely copper, can not cater for future requirements where transfer rates greater than 5 Mbps, it is at this point FTTH networks reach a great advantage over a copper or hybrid networks.

As we begin the analysis of the current demand, had planned the design of the network for the entire canton, ie urban and rural parishes, however, after analyzing the rates of population growth in each parish, it is concluded that priority to make the design of the GPON network in the cantonal head Atuntaqui, since it has a growth rate of 2.14%, well above the rural parishes, as well as these are, areas where the penetration of the Internet service is low, it is considered to use technologies such as FTTC or FTTN, and leverage existing infrastructure.

The number of current subscribers in the urban sector of Antonio Ante is 2,263, however, a design of flexible network was carried out in line with technological changes and increased demand, the estimated number of users for the 2020 number will be 2,516, therefore, it was considered appropriate to leave reserves ports optical splitters. Thus a design suitable network was established to accommodate future prospects.

The project is financially feasible, this was determined by profitability indicators, a NPV of $ 439,305.60, an Internal Rate of Return (IRR) of 17.72%, this analysis showed values appropriate to consider the project viable was obtained, and thus the company which is intended to serve for very profitable gains also payback period of the initial investment (PRI) is 3 years, 5 months and 26 days, the period is within 5 early years and is considered an appropriate time to recover capital, also invested for every dollar that the company invests, 1 dollar and 91 cents will be obtained, that is considered a gain of nearly three for every dollar invested, obtaining a relationship cost / benefit ratio (C / B) very profitable.

B. *Recomendations*

The surveys of the urban sector of the city of Atuntaqui was not done personally, but through emails and social networks. It is recommended that this type of online surveys way since this time and resources is optimized, this type of survey is considered carried out in urban areas where many inhabitants there.

It is very important to know the characteristics of the active equipment of the GPON network, such as OLT and ONT, because in this way is achieved calculations of optical links and missed by very reliable attenuation, in addition to determining if a team of a given manufacturer will satisfy the needs and requirements that the network design requires compliance with standards and national and international standards.

Advised a georeferenced up the sector to cover, so it facilitates the design of the network, as it has exact geographic faults, and do not need a specific place to go for any particular measurement. It is also essential to arrange a mapping of the sector, where street names, Posteria, land registry is located, etc.

Have a basic knowledge of AUTOCAD is fundamental and paramount when making network design. It is advisable to handle the software quickly and efficiently, have become familiar with the commands, thus avoiding going through risky situations like losing information, while simplifying time and resources to the designer.

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