Design the hybrid optic fiber-coax network (HFC) to provide IP-TV service in cable operator MULTICABLE from the city of Otavalo

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***Abstract*—This document indicates the main considerations for designing a network of great capacity, using optical fiber and coaxial cable as a transmission medium (networks hybrid fiber optic and coaxial cable, HFC) to transport audiovisual information through digital global communication protocols (IPTV) guaranteeing the operation of analogue television networks for cable, the case study is intended to keep part of the current infrastructure of the concessionary company of audio and video cable form MULTICABLE S.A. physicist from the city of Otavalo, in function to the determination of vulnerable points and technical improvements of your current system. Reducing also the viability of the project based on market research and finance. The study developed will serve as bibliographic support for future related investigation.**

***Keywords*—Cable Television networks, HFC, optic fiber , coax cable, Internet, television, IPTV.**

I. INTRODUCTION

A hybrid fiber optic and coaxial cable (HFC) network is the evolution of analog and traditional cable television networks(CATV) to broadband networks, mainly comprises of a combined wiring of fiber optic and coaxial cable, comprising the backbone and distribution network respectively. This type of adaptation allows to transport large amounts of data about existing CATV networks. Its development allows CATV operators, that in addition to providing television service cable integrate other services by the same means, as for example interactive TV (IPTV), video on demand, broadband Internet.

II. GENERAL STRUCTURE OF A CATV SYSTEM

Both a traditional CATV network and HFC network basically consists of a transmitter facility, backbone network, distribution network and Subscriber network.

The transmitter Center or headend of the network, are responsible for the reception, processing and issuance of signals to external networks. For the reception stage, the headend can have a broadcasting antenna to capture normal programming, several receivers of satellite channels, and a study of local television for the generation of own programming channels. In the next stage, these signals are modulated in different audio and video carriers of the NTSC (National Television System Committee) frequency range.

All of these signals are distributed to subscribers through the wired network, which may include many thousands of users in function within the reach of the laying of coaxial cable, that starting from the issuing Center expands through different individual lengths stem (amplifying each certain length), in an arrangement known as tree-branch topology.

The inclusion of optical fiber as means of transmission in CATV networks is due to the need to minimize the disadvantages of attenuation and distortion of the signal over long distances, currently comprises the backbone allowing evolve broadband networks using the coaxial network deployed in the distribution stage and rushed.

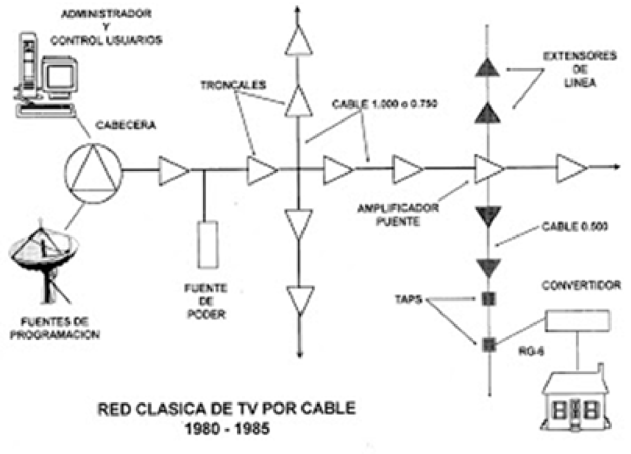

Fig. 1 Typical coaxial distribution network in CATV system.

III. TELEVISION OVER INTERNET PROTOCOL, IPTV.

IPTV (Internet Protocol Television), TELCO TV or broadband TV is a technological solution from content and information more and more capacious, as for example the digital high definition television, audiovisual content personalized, integrated services (3play) etc.

Onstage IPTV operator guarantees a quality of signal as well as minimum bandwidth to offer the service without problems from cuts, in addition to greater interaction with the return channel through which the operator can communicate with the customer in real time to offer different services (for example, VoD, video on demand). What can not be omitted, is that this type of solution, represents a large investment in network infrastructure.

A. Components in IPTV system.

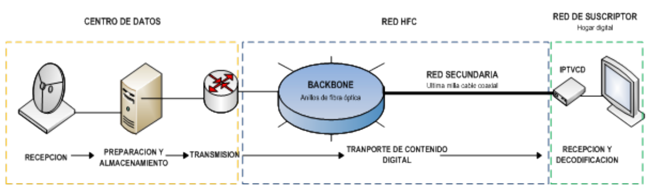

Fig. 2 Block diagram of an end to end IPTV System.

Also known as super Headend or IP headend, is a set of equipment designed to receive, reformat and prepare video content for distribution across the MAN or WAN; also in charge of the monitoring and supervision of the operation of the network fulfilling a basic requirement of cable networks that require a very high reliability network. Other functions relating to pricing and control of the services provided to the subscribers..

The architecture of HFC network consists of a backbone of fiber-optic coaxial network-attached through an optical node. Optical node acts as an interface that connects upstream and downstream signals that pass through the network of fiber optic and coaxial wiring. The portion of the coaxial HFC network uses tree-branch topology and using TAP to connect TV Subscribers to cable HFC.

IPTV (IPTV Costumer Divice, in English) user devices are components that connect to the broadband network and is responsible for decoding and processing of an IP-based video stream.

B. IPTV Communication Model (IPTVCM).

A communication IPTV model consists of a stack 7 layers, divided into a top and bottom layers; the upper layers describe applications and formats of the files involved in an IPTV system, while lower levels addressed the transport of content in real time.

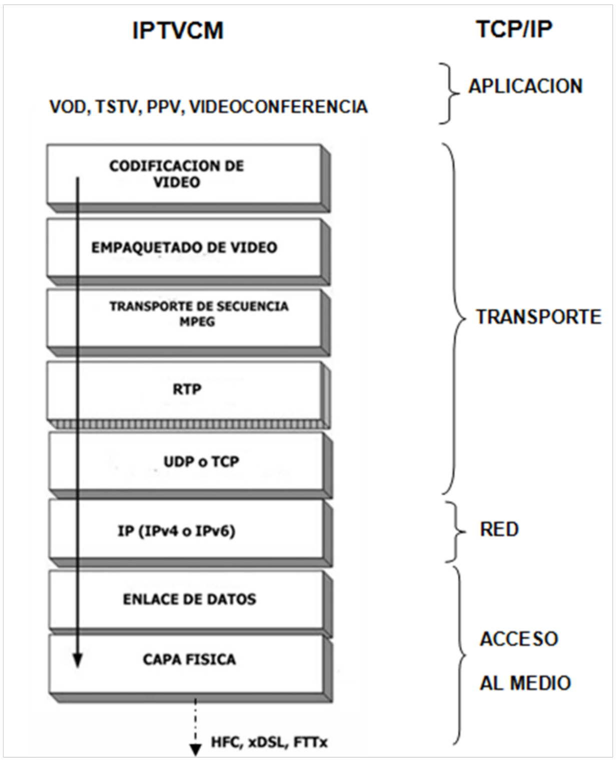

Fig. 3 IPTV Communication Model.

Video encoding layer: is the initial stage, where the original analog or digital signal is encoded with MPEG obtaining frames of audio and video in real time which in turn contain the elementary streams MPEG (ES). Each elementary stream has information on the type, rate, and the location of the frames on the screen.

Video packaging layer: elementary sequences of audio, data and video to be transmitted by digital network become an interleaved stream of packets known as packaged elementary streams (PES) whose size can reach up to 65 536 bytes each apack.

Transport Streams Construction Layer: these packages, commonly called TS packets, are formed from a continuous flow of PES packets. A TS package has a fixed size of 188 bytes of which 184 bytes are payload and 4 bytes of header. Transport packages do not support a mixture of media or content formats.

RTP layer: The RTP (Real Time Transport Protocol) Protocol represents the core of this layer and ensures transmission real-time multimedia content over an IP network.

Transport layer: IPTV transport layer has been designed to reduce the complexities of the upper in an IP network layer processes. The protocols at this layer are used for the reliability and integrity of the links end-to-end. If video data were not delivered to the IPTVCD correctly, the transport layer can start relay. Then, you can inform the upper layers that can take corrective measures. TCP and UDP are the two most important protocols used in this layer.

IP layer: This layer is used to send data on specific routes to their destination, the IP protocol is the best-known, whose function is to provide the delivery of packets to all IPTV services. The types of services provided by systems of unicast (systems where packets are sent from the source to a single destination IPTVCD) and multicast systems that send packets from a single encoder or a streaming to multiple IPTVCDs server.

Data Link layer: The link layer of collects data from the IP layer and provides the proper format for delivery on the physical network. Ethernet technology is one of the most popular mechanisms used by IPTV systems.

Physical layer: physical layer refers to aspects that coordinate the transmission of digital bits on the physical network (for example, DOCSIS, xDSL and wireless). It does define the structures of physical network (topology), the electrical and mechanical specifications to use the medium of transmission.

In summary the encapsulation of data in a model IPTVCM shown below:

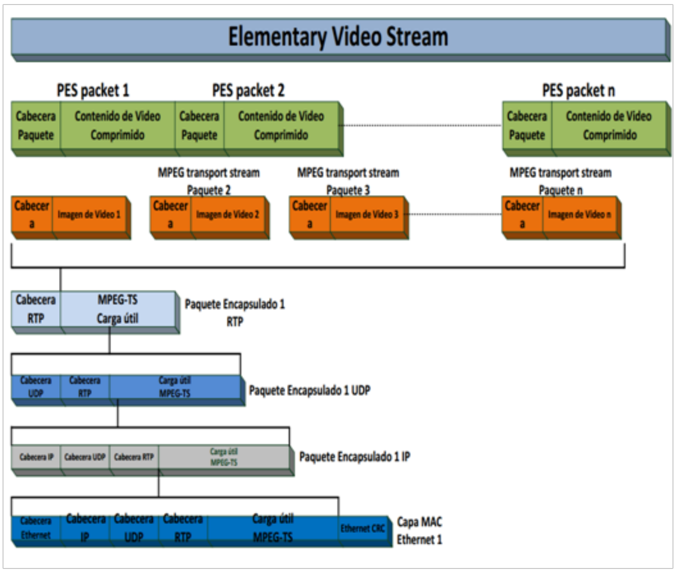

Fig. 4 Encapsulation of data in a model IPTVCM.

C. IPTV Services.

Time shift TV or TV-pause: allows the user to pause a live program and repeat (Replay) scenes you have chosen, allowing to return to playback in real time that originally was enjoying.

Video on Demand and video on demand (VoD): is the interactive feature that allows the user to request (rent) at your convenience programs such as movies, adult channels, series, channels of audio, etc., without the need for the user to subject to a schedule established by the supplier.

Pay per View or pay per view (PPV): PPV service consists of the feasibility of subscribers in hiring a programme in particular, usually is used to receive live sporting events or concerts, which implies that all users receive the same data flow to hire PPV. Both the service request as PPV VoD request is through the IPTVCD of customer.

Taking advantage of the available bandwidth, you can insert services of E-learning (e-learning), personal video recorder (personal videos, PVR recording), electronic program (GPE), audio channels.

D. Protocols used by IPTV.

Different protocols involved for proper video transmission through networks, IPTV, the following figure indicates the above protocols.

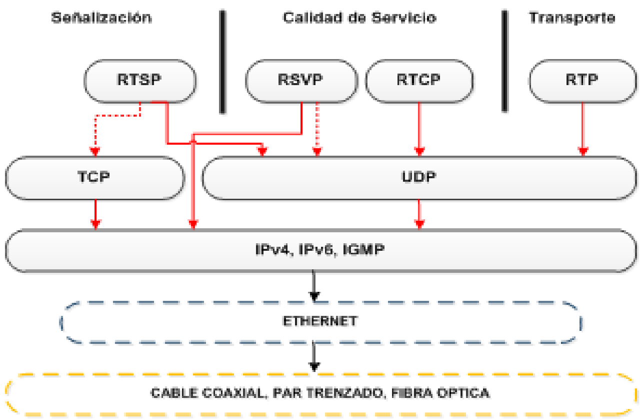

Fig. 5 Stack of protocols used by IPTV.

TCP protocol: TCP complements the capacity to manage and deal with errors that occur during the transfer of content through the IP network. Packets lost, messy and even duplicates are the three main types of errors that occur in an environment of IPTV. To deal with these situations, TCP uses a sequential numbering system to allow the sending device to relay video data that have been lost or damaged. The system of sequential numbering in the structure of packages through the use of two 32-bit fields is implemented. The first field contains the number of the initial sequence of the data and the second field contains the value of the sequence number that the video server is waiting to receive from the IPTVCD.

UDP protocol: User Datagram Protocol (UDP) is a protocol that is not oriented connection, which means that a connection between the IPTVCD and the video server does not need to establish the connection for video transfer over the network, making it a UDP network uses a best-effort approach to obtain data to its destination. One of the advantages of using UDP is the establishment and the disconnect between IPTVCDs and data center IPTV is carried out in a very short period and there is no pause in the delivery of IPTV content.

Supports one-way transmission since UDP does not require a return path allowing companies to provide multicast IPTV subscribers. The UDP technique is fairly easy to implement because it is not necessary to keep track of video packages once they are sent to the IP network.

RTP and RTCP protocols: RTP is on top of IP and UDP protocol layers, provides quality of service (QoS) mechanisms and is able to recover from problems that go unnoticed by UDP.

The RTP architecture includes two closely related parties, a data item and an element of control. The data part of maintaining the properties in real time as synchronisation, reconstruction, delivery, security, monitoring content identification and detection of loss.

Real-time Control Protocol (RTCP) is the part of the RTP control and monitors the quality of IPTV services in real time. Works in conjunction with UDP to provide information feedback (feedback) systems data center IPTV on the quality and delivery of data. Feedback information indicates how many packages IPTV were lost during the journey through the network, causing delays in the delivery of IPTV packages.

Network protocols: in a multicast broadcast packets travellers routes established by the following Internet Group Management Protocol (Internet Group Management Protocol IGMP, the current version is the third). IGMP is an integral part of the IP communication model, which is used by an IPTVCD to join or leave a multicast group, i.e., an IPTVCD sends a message indicating that you wish to join a group in particular. The message contains the address IP of the destination or group requested broadcasting channel, and the channel is transmitted to the applicant. The IP address of the multicast group is normally obtained from the electronic programming guide for the IPTVCD.

When receiving the broadcast channel, the IPTVCD is also configured to listen all traffic on this multicast group, with IGMPv3 instead of specifying the IP address of the group only, messages IGMPv3 contains the unicast of the content source IP address and the IP address of the multicast group.

Real-time Streaming Protocol (RTSP): is a protocol of application-level allowing the IPTVCDs to establish and control the flow of IPTV. The operation of RTSP is similar to HTTP, in the sense that operate in mode requestresponse (peticionrespuesta) when the communication between devices. However the protocol identifier is different. So instead of using the identifier http//: RTSP uses ″rtsp″ at the start of a URL to locate a specific channel IPTV or IP-VoD.

RTSP presents a model client/server by setting three separate connections to provide communications between an IPTVCD RTSP client and server IP-VoD.

E. IPTV via DOCSIS (Data Over Cable Service Interface Specification)

For data over cable service interface specification (DOCSIS) was originally designed to carry high-speed Internet traffic on wide area networks.

The specifications have evolved and the latest version of DOCSIS provides sufficient capacity to support the provision of IPTV services over HFC networks. The specification defines the protocols and formats of modulation (QAM) used to offer broadband IP over a television network cable.

DOCSIS defines the processes for the IPTVCD to communicate through an HFC network for a bidirectional link to a device located in the header called CMTS (Cable Modem Termination system). The current version of DOCSIS 3.0 is an important standard, which is broken down into four specifications.

CM-SP-PHYv3.0: This specification deals with the aspects of physical layer technology.

CM-SP-MULPIv3.0: This specification includes the implementation details to the media access Control (MAC) and upper layer protocols used in a DOCSIS 3.0 system.

CM-SP-OSSIv3.0: This specification defines the requirements for configuring and managing DOCSIS 3.0 features.

CM-SP-SECv3.0: This final specification provides the details necessaries to ensure end-to-end DOCSIS 3.0 systems.

One of the most important advantages in DOCSIS 3.0 is the channel bonding or bonding channels, this technique allows to increase performance data over an HFC network since it divides multiple smaller channels to create a logical channel with high-bandwidth capabilities. In addition to providing higher performance as compared to single-channel, this mechanism also reduces congestion delays associated with the sending of packages into a single channel. DOCSIS cable modems include multiple tuners, which are used to access the different channels available as part of the Group of channels allocated for use.

IV. DESCRIPTION OF CABLE OPERATOR MULTICABLE S.A. OTAVALO.

MULTICABLE S.A. Otavalo, is a private company that provides television service cable to the city of Otavalo, data from the first months of 1999. It is registered as a dealer of audio and video by subscription in the SUPERTEL from January 25, 1999, such concession granted permits to expand its network in the city of Otavalo and its surroundings.

A. Diagnostics of the MULTICABLE S.A. headend

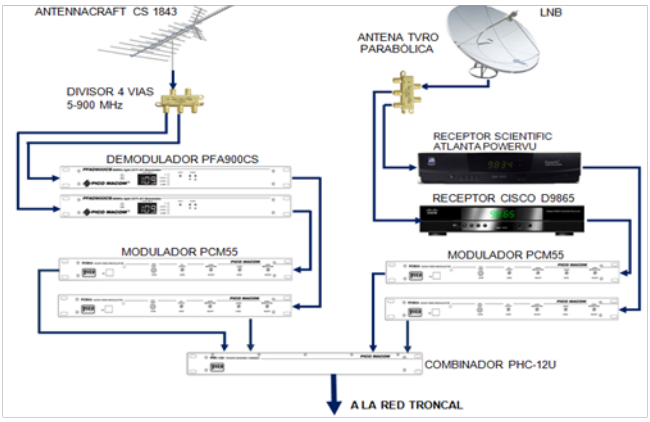

Fig. 6 Equipment for the reception, preparation, and combination of MULTICABLE S.A.

The part of terrestrial signal reception made basically capture channel national, regional I local VHF and UHF-band from the nearest broadcast repeaters, the location of reception antennas depends on as well as the geography of the terrain and intermediate obstacles, such as trees, fences, buildings, etc.

The most commonly used antenna is the Yagi-Uda and consists of a dipole and a series of metal rods called liabilities; the longer Rod functions as reflector which radiated electrical on directors field, to get to the dipole as much as possible from signal you.

At the same time, held the reception of satellite signals through satellite type TVRO (Television Receive Only) receivers only television, which is attached an LNB (low noise amplifier) located in the focus of the *dish* to reflect signals from satellites, it is very useful since the satellite downlink transmission frequencies are impossible to distribute by coaxial cables. By what an LNB converts the signals of high frequency either C or Ku band frequencies of work that supports the digital receiver usually 950 to 2150 MHz. In MULTICABLE operates the LNB Pansat PC-9500W LNB.

An IRD or Integrated Receptor-Decodificador equip complies with the function of receiving a digital signal in any of the standards (cable, satellite, terrestrial, IPTV), and verify that you have permission to view this video signal. MULTICABLE S.A. brands CISCO D9865 decoders and set-top boxes from SCIENTIFIC ATLANTA POWERVU D9835 model.

Once recepted signals, directs them towards the section of preparation and treatment, where suits and combines the programming plan to bid.

*Demodulators:*it is responsible for the reception of the broadcast signal and their passage to baseband (41-47 MHz in NTSC signals). It allows mixing and equalization of input and output channels. In the header of MULTICABLE S.A. operates a agile PICOMacom PFAD-900cs demodulator for each captured national channel.

Modulators: the next phase consists in the transfer of signals in baseband to the process of adaptation of the carriers of audio and video and convert them to radio frequencies (RF) to be assigned on a channel that is adding to the other channels of the programming of the company plan. A channel is all the audiovisual information contained in a specific size spectrum, serves to place and send multiple channels on a single line of transmission, and can then retrieve them separately unless they are mixed. One format of 2 carriers, information and different modulation in each one, all is handled in a standard television channel this content in a bandwidth of 6 MHz according to the international system NTSC.

Combiners: Modulated RF signals are coupled in combiners to be transmitted by a single cable, in the case of MULTICABLE are used combiners passive PICO MACOM PHC-12U.

B. Diagnostics of MULTICABLE S.A. backbone

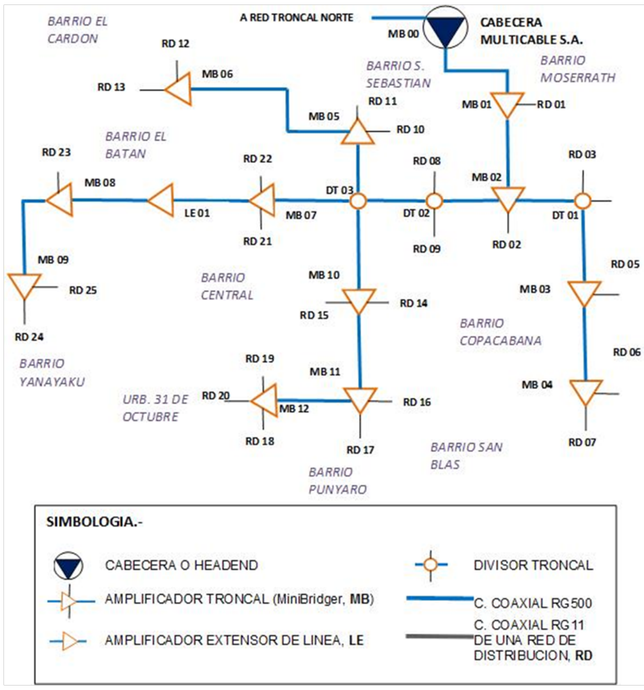

Fig. 7 Diagram of the backbone network deployed for the southern sector of the Otavalo city.

The backbone network is wiring coaxial cable of greater diameter, usually inch (RG500), whose function is to transport the RF signal with minimal losses to distribution networks. Typically are 300 to 500 meters air routes, if required extend the backbone routing is necessary to use amplification equipment.

For the backbone of MULTICABLE S.A., from located in the San Sebastian neighborhood network header, leave two lines of trunk cables RG500, one of them to cover the southern sector of the city of Otavalo and the other in the northern sector.

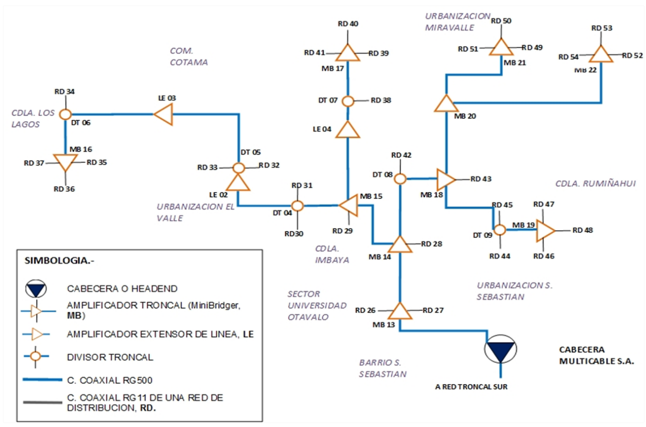

Fig. 8 Diagram of the backbone network deployed to the northern part of the Otavalo city.

The constituent parts of a CATV backbone consist of passive elements (coaxial cable, couplers, splitters) and assets (amplifiers and voltage sources).

Coax cable: Is defined as coaxial cable that consists of two concentric conductors; the Center conductor is a solid cable known as core or live, the outer conductor is called mesh or shield (shield), outer conductor form a cylinder separated from the inner conductor through a dielectric material, and this whole protected by a cover.

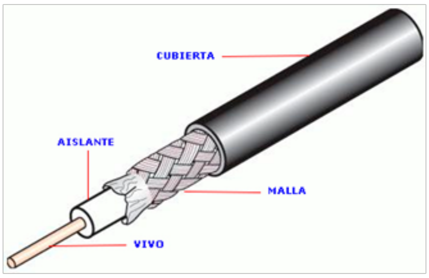

Fig. 9 Parts of the coaxial cable.

Directional Couplers: is a passive device that separates the RF signal into a derived direct-out output. Consists of three terminals, one for the signal input, other transports it to the trunk line and gives continuity to the network, and the third derives the signal to the distribution network, and, depending on the number of users the attenuation of the output vary from 7, 9, 12 and 16 dB, being of higher values those who are closest to clients referrals.

Splitters: The backbone of MULTICABLE there are splitters that have 2 and 3 outputs, to consider outstanding characteristics are the capacity of bandwidth (5-1000 MHz), 3 dB per each output impedance of 75 ohms, typical attenuation.

CATV amplifiers: are waterproof structures, aluminium casting and come equipped with mounting hardware, both for clamping in post or to be suspended on a steel bearing rein. Availability cascade of trunk amplifiers can be made up of 20 to 30 teams in high-capacity networks and up to 60 in broadband networks. MULTICABLE, all amplifiers minibridger are of type MB-750 d-H of General Instrument (now this brand was acquired by Motorola) with output levels among the 37-47 dBmV and gain between 22 and 27 dBmV.

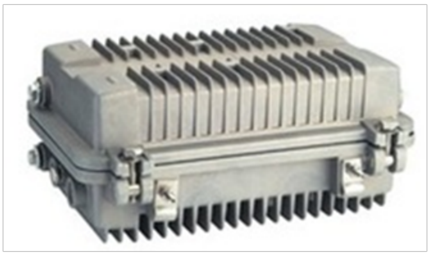

Fig. 10 Outdoor CATV Amplifiers.

Power supplies: are those that supply voltage sufficient to active network devices such as amplifiers. The power supplies are placed at intervals of long-distance, subsequent to the sixth amplifier from the network header.

C. Diagnostics of MULTICABLE S.A. distribution network

The distribution network is in charge, as its name implies, distribute the RF signals to the network of the Subscriber connection. Distribution of MULTICABLE comprises sections of different lengths of coaxial cable RG11, most give coverage to 3 blocks, but in addition there are sectors of greater extension, in that case are applied every 300 meters of line or LINE EXTENDER amplifiers Extenders.

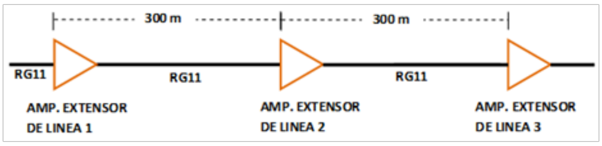

Fig. 11 Extension of network distribution based on cascade of line Extenders amplifiers.

Distribution line starts at elements deliverers of the backbone network, that is, from the outputs of the amplifiers minibridger or from the main deliverers (splitters) located at a point of division of the backbone stretch. MULTICABLE company presents two distribution settings: network of secondary with a single line of distribution, and distribution network with multiple lines of secondary, up to 3 branches.

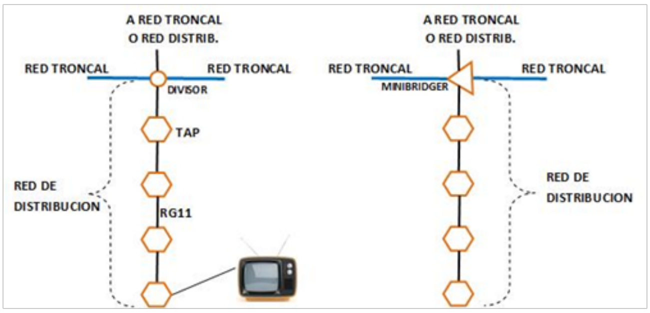

Fig. 12 Starting points of a distribution network.

In the first case the distribution network through a single ride (bus topology) RG11 coaxial cable of a maximum of 300 meters from a crossover point of the backbone, which may be an output of the amplifier minibridger or an exit from a trunk divider. In such length are placed (each 40 meters, pole to pole) referral to the utility network elements known as TAP, wiring type bus it can be seen in the graph above. The second case, the distribution network part from a computer splitter, this type of wiring has several branches forming a topology tree.

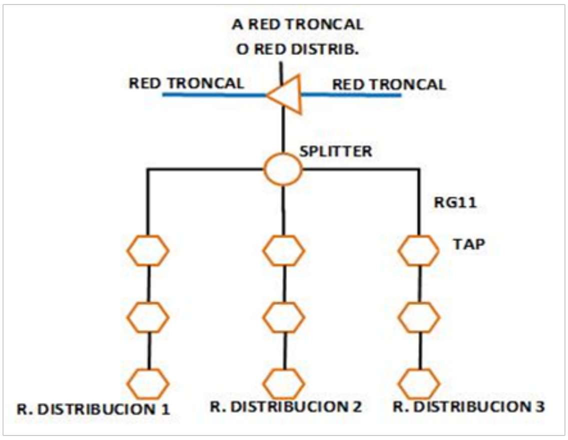

Fig. 13 A branch of a distribution network through a splitter.

D. Diagnostics of the customers network of MULTICABLE S.A.

The network connection for subscriber starts from a TAP to the coaxial input of the TV of the customer, usually suscriber network complies with RG6 coax cable that launches into one of the ports F of the nearest diverter until the Subscriber TV wiring. The maximum distance that runs in Multicable RG6 cable is 50 meters, longer is not recommended, due to the attenuation which at that distance is 6 DB.

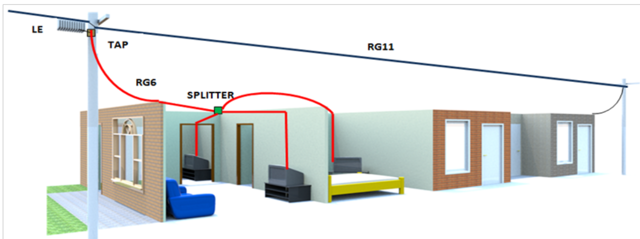

Fig. 14 Home installation of CATV in MULTICABLE S.A.

The RG 6 cables are 6.9 mm in diameter, while RG-59 cables are thinner, with a diameter of 6,15 mm. The RG 6 cables consist of bare copper, of copper with Tin and aluminum polyester tape. The RG-59 cables consist of silver covered copper and bare copper. Rush the customer may not necessarily end on a TV, but the same output of the tap can be subdivided it for 2, 3, 4, 5 TVs within a same housing. This function is responsible for the splitters.

V. CALCULATION OF THE COAX LINKS OF THE NETWORK MULTICABLE S.A.

Attenuation: CATV network attenuation is the amount of loss of power of the signal because of the distance, the attenuation also grows with increasing frequency. It also varies depending on the temperature (20 C, nominal) and the amount of intermediate components that are used to distribute I join a coaxial section. The total attenuation is equivalent to a stretch of RG500 coaxial cable is:

$A_{RG500} = TotalLength_{RG500} * dB/m$
$A_{RG500} = 350m * 4.77dB/100m$
$A_{RG500} = 16.695dB$; attenuation at 330 MHz

$A_{RG500} = 350m * 1.83dB/100m = 6.405dB$; attenuation at 55 MHz

As you can see in the above calculations, about one cable attenuation varies depending on the frequency, and can have multiple levels of attenuation being the higher value in high-frequency, very important point to consider as the IPTV System occupies the entire range of frequencies available in NTSC networks (5 MHz to 860 MHz, up to 1000 MHz with DOCSIS 3.0).

With respect to the backbone stretch with biggest drawback of attenuation is the one who connects him 03 and 16 MB, amplifiers with a 27.3 dB of attenuation to 510 metres in length. This section is located in the Northwest of the backbone network and feeds the distribution networks of the Citadel Los Lagos despite the fact that there are more extensive RG500 sections, this section presents problems of signal, due to the extensive distance, intermediate splitter which attenuates 3.5 dB Additionally and little gain (LE 03 amplifier (, gain 25.5 dB) from where it flows out the signal.

By the distribution network presents some disadvantages of high attenuation, thus, the stretch of distribution which runs almost 4 blocks (350 meters) in the Central District by street rock presents greater attenuation 32.55 dB, because of the distance and 5 intermediate shunts. If you want to install more quantity of shunts or extend the network, it is recommended to install an Extender amplifier at a distance of 300 meters from the LE05.

Another RG11 coaxial section that presents problems of attenuation is that distributes the signal to the northern sector of the Citadel Rumiahui presents 30.76 dB of attenuation, since the distance of 340 meters from the source on the amplifier minibridger 18 MB to point of termination exceeds the values recommended (max. 300 m), also used a splitter on the way which in turn adds the attenuation. In this case the amount of HP (past homes, subscribers) is 1 family and they are connected to the TAP of minimum loss (11 dB of output) and the distance of the Tap customer must not exceed 20 metres.

Carrier relation to noise (C/N): is the relationship or ratio between carrier signal and noise in a given bandwidth. It is a measure that allows us to know what is located so close to the noise about the signal that you want to transmit. The C/N is manifested in the screen of the tv such as snow or rain.

The CNRs at the end of the involved amplifiers is the following formula for a trunk section made with a cascade of amplifiers.

$$CNR_S = -10log_{10}(10^{-CNR_1/10} + ... + 10^{-CNR_n/10}$$

For the CNR of an amplifier is used only the following formula.

$$CNR = OutputLevel - (-59.2 + NF + gain)$$

Where;

Output Levela: for exampleo 44.01 dBmV in amplifier MB00 of Multicable S.A.

NF: amplifier Image noise (NF=11.5 dB by the manufacture MB 750D-H).

- 59.2: Constant (termical noise).

gain: amplifier gain specified by the manufacturer (36 dB).

The result of the relationship of the level of the video regarding the system noise carrier must not be less than 43 dB according to the FCC. Then the following table summarizes the CNR of all the sections that make up the backbone.

TABLE I
LEVELS OF QUALITY FOR EACH COAX SECTION OF THE BACKBONE MULTICABLE S.A.

No	Amplifiers	CNR(dB)	CSO(dB)	CTB(dB)
1	MB00, MB01,MB02, MB03 y MB04	48.18	51.03	52.92
2	MB00, MB01, MB02,MB05 y MB06	48.48	50.47	51.26
3	MB00, MB01, MB02, MB07, LE01,MB08 y MB09	44.23	51.58	52.44
4	MB00, MB01, MB02, MB10,MB11 y MB12	45.05	51.19	52.13
5	MB00, MB13, MB14, MB15, LE02, LE03 y MB16	45.86	50.58	51.06
6	MB00, MB13, MB14, MB15, LE04 y MB 17	45.48	52.97	52.89
7	MB00, MB13, MB14, MB18 y MB19	45.60	54.13	54.56
8	MB00, MB13, MB14, MB18, MB20 y MB21	45.63	51.01	51.78
9	MB00, MB13, MB14, MB18, MB20 y MB22	45.49	51.23	52.63

Distortion of the components of the second order (CSO): composite distortions are produced alterations when all frequencies pass through the amplifier; more frequencies present in an amplifier, produces more combinations of distortion. They may become a limiting factor in systems carrying 60 or more channels as the CSO affects images causing annoying diagonal lines.

To calculate the CSO at the end of the cascade of amplifiers, it is essential to know the CSO at the exit of each one of the amplifiers that make it up. To know the CSO of a single amplifier results from the following formula:

$$CSO = CSOref - (OutputLevel - ReferenceLevel)$$

Where:

CSOref: second order beats (CSOref=59 dB According by manufacturer).

OutputLevel: measured on each amplifier for output level

ReferenceLevel: dBmV at output specified by manufacturer (47 dBmV).

Then at the end of a waterfall (trunk stretch), the total CSOs is equivalent to develop the following formula:

$$CSO_S = -15log_{10}(10^{-CSO_1/15} + ... + 10^{-CSO_n/15})$$

Where:

CSOn: econd order beats at each amplifier.

Table 1 summarizes each CSO value for each core section, which shows that all CSO values are higher than 51 dB, thus complying with optimal performance specifications established by the FCC.

Distortion of the components of third-order (CTB): Triple blending compound (CTB) is called a type of distortion caused by the unwanted mixing of carriers in the system. In contrast to the CSO, the CTB falls directly on the position of the channel video carrier. The effects of the CTB will be visible diagonal lines moving through the image or as a spurious Rainbow-shaped. The formula to calculate the CTB from a single amplifier is:

$$CTB = CTBref - 2(OutputLevel - ReferenceLevel)$$

The CTBs at the end of the cascade of amplifiers, results from applying the following formula:

$$CTB_S = -20log_{10}(10^{-CTB_1/20} + ... + 10^{-CTB_n/20})$$

Where:
CTBn: Triple compound beat to each amplifier output.

In table 1 are organized the results of calculation of CTB for each core section, these values comply with the performance specifications determined by the FCC (CTBs>=51dB).

In conclusion, backbone aims to supply to the distribution network input not less than 40 dBmv. This requirement forces on the part of distribution amplifiers so it is recommended only one or two amplifiers line Extenders cascade. These amplifiers are separate 300 m depending on the number of taps required by the density of homes (home passed or HP).

At the same time, the distribution network aims to provide at least 0 dBmv but not more than 10 dBmv to the terminal on the TV receiver, one lower value produces rainy images and values older overload the tuner of the TV receiver, resulting in cross modulation of the channel (a hum in audio, for few channels less zoom).

A signal level of 10 to 15 dBmv bypass, is necessary to compensate for losses in the feeding cable. According to the information provided by Mr. Abel Simbaa, technical of Multicable S.A. the maximum distance that a customer is 38 m, longer feel greater reception in TV sets of customer problems.

There are additional reasons that decrease the quality of the signal and can cause poor images for the Subscriber, a leak caused by a faulty connector signal, a piece of damaged or defect in the television receiver. This can cause when installing splitters of signal in the House, not authorized, to feed multiple receivers.

VI. MARKETING STUDY.

An important part of the design is the sizing in capacity and coverage of the network, so that the projection of the real values-based network sustains the viability of a project. As first step is to obtain opinion and level of interest of consumers towards a product to create, to this end, the survey was used as a method of collection of views of interactive television that the company intends to provide, where the customer can choose and enjoy the programming you want, at any time and in the comfort of your home. In addition to content services Premium, video on demand (VoD), or pay per view (PPV) with which the customer can enjoy channels to see the best videos, world cinema, premieres, series and programming for adults. Interruptions without commercial breaks.

In addition, the questionnaire allows information about the level of interest of the respondents about additional services where customer can put together his plan, selected the number of channels that you want to hire (TV on demand) last but not least, lets know interest about services of telephony, broadband internet and audio (radio, music) on a same connection channels.

A. Implementation of the survey.

Depending on the scope of the network of Multicable S.A., respondents were inhabitants of the districts that comprise the urban sector of the city. The estimated time was 10 working days to run all of 171 surveys, this amount was obtained from the calculation of the size of the sample knowing the size of the population using the following formula:

$$n = \frac{N * Z_a^2 * p * (1-p)}{d^2 * (N-1) + Z_a^2 * p * (1-p)}$$

Where,
n: The sample size
N: Population size (N= 46 372 otavaleos of the urban sector at 2014)
Za: Trust level (Za=1.645 level of uncertainty to tolerate at least of 90
p: Probability of success, or expected proportion (p= 0.1982 Since for each 100 otavaleos is 19.82 televisions)
d: Precisin (d=0,05 for error maximum allowable in terms of proportion of 5%).

Then,

$$n = \frac{46372 * 1.645^2 * 0.1982(1-0.1982)}{0.05^2 * (46372-1) + 1.645^2 * 0.1982(1-0.1982)}$$

$$n = 171,3738$$

So to get information of an adequate amount of samples is necessary to conduct surveys to 171 otavaleos.

B. Tabulation of results of the survey.

Respondents interested for IPTV=82%
Respondents interested for VoD =66%
Respondents interested for PPV =65%
Respondents interested for Internet=67%
Respondents interested for=42%
People with cable TV service=32%
Sectors to cover: San Luis, El Jordan, San Pablo, Gonzales Surez, Eugenio Espejo, Ilumn and Miguel Egas (Peguche)

VII. PROJECTION OF DEMAND.

In this way, the method of projection of the demand with more approximate reality results is model or Gompertz function (also known as ″S-shaped curve adjustment″) representing the trend to grow to mature product, i.e. they start low, increases as the product is given to know and finally acquired a fixed level when it reaches saturation. The formula considers the future demand of P subscribers in T years.

$$P = e^{a-b*c^T}$$

Where:
P: Projection to year T,
T: time in years,
e: Euler Constant (2,7182...),
a, b y c: Function parameters, a=9.2103 (if Pα=10000 at Tα=undefined and c = 0 whereas the saturation of the sistema), b=2.1064 (if P0= 800 to T0=0 years whereas current subscribers of Multicable S.A.) and c=0.9454 (if P1=1365 to T1=1 whereas the level of interested according to population warmy projected for 2015).

TABLE II
PROJECTION OF THE DEMAND FOR SERVICES IN THE FIRST 7 YEARS.

Year	IPTV	PPV)	VoD	Internet	Telephony
T1	1365	220	216	278	102
T2	2080	406	400	510	191
T3	2900	681	671	846	330
T4	3768	1049	1035	1286	528
T5	4632	1508	1490	1822	791
T6	5451	2045	2022	2432	1122

VIII. DESIGN OF THE HYBRID SYSTEM FIBER OPTIC-COAXIAL (HFC) OF CABLE OPERATOR MULTICABLE OTAVALO.

A. Calculation of capacity for IPTV service.

In a digital scheme, the required transfer rate depends on the current compression techniques (MPEG or H.264) video and the quality of the image, thus: to transmit videos in standard definition (SD resolution of 750 x 480 pixels, is of similar quality to the analogue TV or a DVD disc videos) is necessary to a transfer rate of 3 to 6 Mbps for images coded with MPEG-2; While in the case of the standard-definition MPEG-4 or H.264 video compression requires a transfer rate of 1.5 to 3 Mbps. For an IPTV service the transfer rate is defined to 4 Mbps (MPEG-2) and 1.5 Mbps for MPEG-4.

The videos in high definition (HD resolution of 1280 x 720 pixels) need to transfer no less than 15 Mbps MPEG-2 and 6 to 9 Mbps with MPEG-4H.264. IPTV defines a transfer rate of 15 Mbps and 8 Mbps with MPEG-4 compression to MPEG-2. For stereo audio with MPEG-1 layer 2: 128 Kbps.

A CATV network to transmit data reserves a television for the downstream station; the bandwidth of the channel is 6 MHz. Which, using 256-QAM modulation gives a maximum fixed amount transfer flows from 42.88 Mbps and a nominal maximum rate of approximately 38 Mbps for downlink traffic, and 30.72 Mbps for upstream traffic with 64 QAM modulation.

Initially the bandwidth must be able to transport flows downstream (descending) of 42 television channels offering the company MULTICABLE S.A. today but considering its digitization, then:

$$Capacity_{video} = quantity\ streams * transference\ rate$$
$$Capacity_{video} = 42 * 1.5Mbps$$
$$Capacity_{video} = 63Mbps$$

For audio is required:

$$Capacity_{audio} = 42 * 128Kbps = 5.376Mbps$$

So:

$$Total\ capacity_{AV} = capacity\ video + capacity\ audio$$
$$Total\ capacity_{AV} = 63Mbps + 5.376Mbps = 68.376Mbps$$

As already mentioned, part of the HFC network maintains the coaxial infrastructure, therefore, and based on the DOCSIS standard, it is necessary to calculate the capacity of traffic considering the bandwidth in which operate the coaxial systems, therefore the number of channels to be used are:

$$QuantityChannels_{dowstream} = \frac{TotalCapacityRequired}{CapacityMaxDOCSIS}$$
$$QuantityChannels_{dowstream} = \frac{68.376Mbps}{42.88Mbps} = 1.5946,$$ for SD streams

Therefore, to transmit 42 videos in standard definition is required 2-Channel 6 MHz with DOCSIS technology, using MPEG-4 compression.

In short, 8 digital channels for downstream of 42 flows of audiovideo HD with MPEG-4 compression is required. The following summarizes the capacity required for downstream of television programming that currently the company MULTICABLE S.A. offers:

TABLE III
BANDWIDTH REQUIREMENTS FOR IPTV WITH DOCSIS 3.0.

IPTV Service	Capacity (Mbps)	Channel DOCSIS)	Compression
42 SDTV channels	173.376 63	5 2	MPEG-2 MPEG-4/H.264
42 HDTV Channels	635.376 341.376	15 8	MPEG-2 MPEG-4/H.264

B. Calculation of the Pay Per View service.

According to IBOPETIME Ecuador franchise that made the television audience measurement on the national market, recorded a peak of viewers (66,98%) in 7 to 9 PM regardless of the content you are viewing. Applying that ratio, for example, for the case study is a maximum of 148 (66.98% of 220 clients estimated for 2015) independent connections and simultaneous.

TABLE IV
CAPACITY PROJECTION FOR PPV VIDEOS IN STANDARD DEFINITION.

Year	Customer	SD stream)	Required Capacity (Mbps)	DOCSIS ch.
T0	106	71	116	3
T1	220	148	240	6
T2	406	272	443	11
T3	681	456	743	18
T4	1049	703	1144	27
T5	1508	1010	1644	39
T6	2045	1370	2230	53

C. Calculation of capacity for upstream traffic of requests for PPV or VoD.

Upstream bandwidth is a finite resource, it should be shared by all users, this bandwidth is usually divided into multiple RF channels ascending, from 1 to 6 MHz each, with capacity from 1.6 to 10 Mbps. With technology DOCSIS could get transfer rate greater than 120 Mbps, on a combination of 4 channels of 6.4 MHz. Each channel supports up to 30.72 Mbps transfer.

TABLE V
CAPACITY PROJECTION FOR UPSTREAM CHANNEL.

Year	Customers PPV	Upstream)	Required Cap. (Mbps)	DOCSIS ch.
T0	106	11	0,704	1
T1	220	22	1,41	1
T2	406	41	2,6	1
T3	681	68	4,36	1
T4	1049	105	6,71	1
T5	1508	151	9,65	1
T6	2045	205	13,09	1

D. Calculation of capacity for data traffic (Internet).

A 67% of respondents would like to see internet at home, which, the digitalization of the company's systems will facilitate the integration of additional services.

TABLE VI
CAPACITY PROJECTION FOR INTERNET.

Year	Customs	Oferted Plans	Required Cap. (Mbps)	DOCSIS ch.
T0	133	2	10.64	1
T1	278	2.5	28.69	1
T2	510	3.3	67.90	2
T3	846	4.3	145.29	4
T4	1286	5.5	284.90	7
T5	1822	7.1	520.70	13
T6	2432	9.2	896.59	21

E. Calculation of capacity of telephone traffic.

The total amount of telephone traffic in a network that is the formula:

$$A = n * Erl/Subscriber$$

Where;

A is the total traffic generated by n suscribers.

n is the number of Subscribers.

Erl/Subscriber is the traffic generated by each Subscriber (0.1).

$$A = 49 * 0.1Erl/Subscriber \quad A = 4.9Erl$$

is equivalent to that 49 users occupy a total traffic of 4.9 Erlangs.

Subsequently, the calculation addresses in obtaining the number of telephone lines used for 4.9 erls. So using the Erlang B web setting allocated in web page http://www.erlang.com/calculator/erlb/,see below:

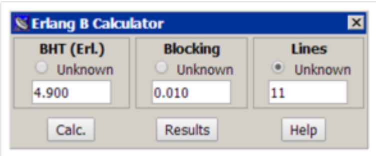

Fig. 15 Calculation of quantity of circuits required to transmit voice traffic for subscribers projected to the year T0.

Where:

Pbis the probability of blocking (Pb=0.01 that is to say 1 call blocked by 100 attempted calls).

m is the number of circuits

A is the total quantity of traffic offered in erlangs.

According to the International Telecommunications Union (ITU), an E1 (2048 Kbps) is composed of 30 voice channels of 64 Kbps each one, the number of E1s needed are: quantity of E1= (voice channels)/30=(11)/30=0.4

TABLE VII
PROJECTION OF TOTAL TRAFFIC OF VOICE (DOWNSTREAM AND UPSTREAM) FOR NEXT 7 YEARS.

Year	Customs	Total traf-fic(Erl.)	voice channel	Quantity E1s	Dws/Ups ch.
T0	49	4,9	11	0,4	1/1
T1	102	10,2	18	0,6	1/1
T2	191	19,1	29	1,0	1/1
T3	330	33	45	1,5	1/1
T4	528	52,8	67	2,2	1/1
T5	791	79,1	95	3,2	1/1
T6	112	2 112,2	130	4,3	1/1

F. Distribution services in the frequency spectrum.

Normally the cable TV channel occupies 54-550 MHz region in which there is an 88-108 MHz FM radio band. Each channel is 6 MHz of bandwidth.

The inclusion of digital technologies allows to operate over 550 MHz, often at 860 MHz for data downstream DOCSIS 3.0 technology can operate in bands until 1002 MHz. The upstream channels are introduced in the band 5-88 MHz.

For the design of the network, it is necessary to find channels projected to 2020, because obviously, for that period is estimated increasing demand thus greater network capacity.

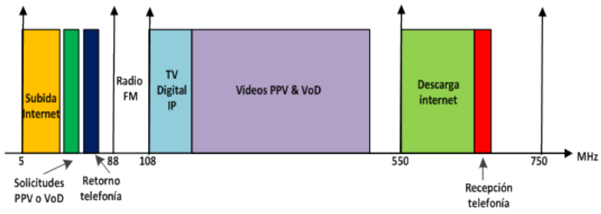

Fig. 16 Distribution of IPTV services in NTSC spectrum projected for MULTICABLE S.A. for the year 2020.

The figure above provides a summary view of the traffic generated by new services offered by the company towards the year 2020, can certainly be contained and supported by an HFC network, because as indicated in the results of the calculations, digital channels can take advantage of the range of frequencies NTSC that currently support distribution amplifiers and other devices deployed in the analogical of MULTICABLE S.A.

G. Choice of the topology.

As first point of HFC network design is the choice of the topology by deploying at MULTICABLE S.A., for the present study is defined a ring topology, which corresponds to the broadband backbone understood by fiber optic links which will replace the stem sections of coaxial cable which does not yield to IPTV solutions the optical backbone links lead to optical nodes which in turn to be fed each of coaxial distribution which, at the time, has desplagada in the city of Otavalo.

The scheme with links for loop or trunk rings is favorable from the rest (Star, bus, mesh topology) in a ring topology is more viable to use two independent optical cables, routed along different routes, ensuring the transportation service to damage all the fibers in one of the wires (networks of support or backup).

Of course consider redundant lines by a single sets with different pairs of fiber optic cable. In the event that some fibre damage, is switching to other reserve fibres available on the cable.

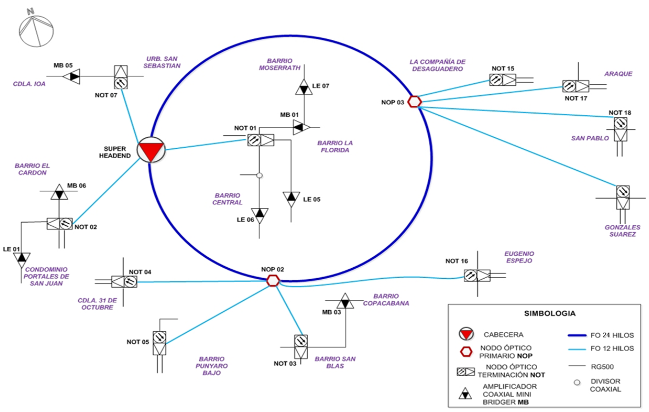

Fig. 17 HFC Primary network with coverage of the southern sector and East of Otavalo

With all these considerations, the network hybrid fibre - coaxial cable of Multicable s.a. is designed in two main rings (of access) or net primary optical fiber made by sectors: East and West of the city of Otavalo.

The eastern ring covers the neighborhoods: Central, Copacabana, La Florida, San Blas, sector of the bus terminal and Monserrath;

these places correspond sectors covering MULTICABLE coaxial networks at the time.

As a result of the analysis of the demand, a market to consider are the inhabitants of the parishes of San Pablo, Gonzlez Surez and Eugenio Espejo, the same that are connected to the access of Eastern optical ring network as shown in the figure17.

In this topology, the objective of the design HFC is will hold the majority of deployed coaxial distribution at present by the company, whereupon, the coaxial part will not be major changes in routing or location of the passive equipment that comprises the signal to customers, in addition, the main advantage of a HFC network is to eliminate amplifiers waterfalls , which are used mostly in the backbone, so, with the deployment of optical networks, few sectors of the secondary network used amplifiers to reach customers with which ensures that the changes do not affect largely secondary networks to which clients are currently connected.

Similarly, another ring of fiber-optic considered in the design covers the northern and western part of the city of Otavalo with extensions of the network to the parish of Ilumn according to study of demand.

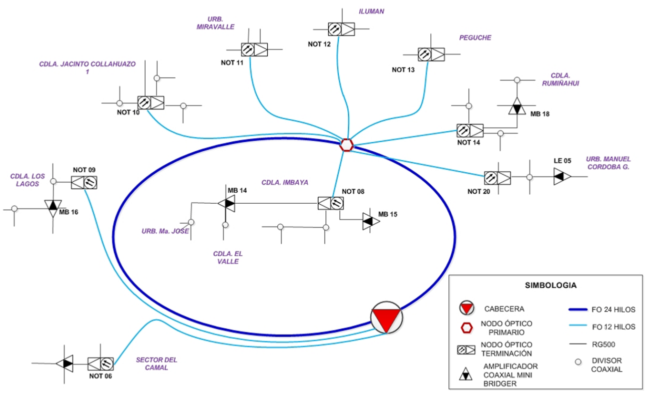

Fig. 18 HFC Primary network with coverage to the West and North sector of Otavalo.

H. *Calculation of the optical links.*

The cable optical chosen for the case study is Singlemode ADSS, the attenuation of the optical fiber is 0.35 dB for each Km and is considered a factor of dispersion of 1 DB. These lengths are carried out in the finish with the placement of connectors SC-APC type whose loss will be maximum 0.5 dB for each one.

In addition, are considered losses by optical splices (loss of 0.1 dB using fusion technique) required in cases of marriages on optical links in greater lengths 4 km (maximum length of each reel of ADSS fiber) specified in the previous tables.

For example, the total attenuation of the links that make up fiber optic ring connecting the transmitter located in the header and the primary node NOP01 located in the cdla. Rumiahui (northern part of the city) it is considered that the length is 1.31 Km which corresponds to the main link CRC-NOP01a, and your backup CRC-NOP01b link is 3.5 Km. With these values, attenuation results from the following formula.

$$AT = A_F L + A_e N_e + A_c N_c + Mr$$

Where,

AT: Total attenuation in dB

AF: Coefficient of attenuation according to the cable technical sheet (0. 35dBKm according to standard EIA/TIA 568 B3).

L: Total length of the optic cable including the 5% of reserve margin (CRC-NOP01a1.38 Km).

AE: Attenuation by joint (0.1 dB with fusion according to standard technique).

Ne: Amount of used joints (CRC-NOP01a=0 joints).

Ac: Attenuation by connectors (0.5dB in SC connectors).

Nc: Number of connectors (2, one on each end of the link).

Mr: Repair margin of 1 or 2 dB, contemplating some extra repair, cuts, changes in trajectories of wiring, etc.

$$AT_{CRC-NOP01a} = 0.35[db/Km] * 1.38[Km] + 0 * 0.1[dB] + 0.5[dB] * 2 + 1[dB] \;\; AT_{CRC-NOP01a} = 2.481[dB]$$

Similarly, for the link scraping CRC-NOP01b is:

$$AT_{CRC-NOP01b} = 0.35[db/Km] * 3.68[Km] + 0 * 0.1[dB] + 0.5[dB] * 2 + 1[dB] \;\; AT_{CRC-NOP01b} = 3.286[dB]$$

The total attenuation in optical link values allow at the same time estimate the total power of arrival in the remote optical receptors (receptors in NOP01), so the following formula is used:

$$P_{IN(RX)} = P_{OUT(TX)} - AT$$

Where,

PIN: Power input at receiver of parent node.

POUT: output power of the transmitter in the network header (min. 2 dBm according to specifications of the equipment).

AT: Total attenuation of the optical link.

Para el presente ejemplo, el enlace primario CRC-NOP01a se tiene un nivel de seal de:

$$P_{IN(NOP01)} = 2[dBm] - 2.481[dB] = -0.481[dBm]$$

To the backup CRC-NOP01b link, it is estimated that:

$$P_{IN(NOP01)} = 2[dBm] - 3.286[dB] = -1.286[dBm]$$

If we consider that a receiver presents a level of - 4-2 dBm sensitivity (see more specifications in annex) input power in NOP01 calculated previously, both on the main link and the backrest are in that range, so the link is optimally according to the recommendations of the International Telecommunications Union ITU-T.

TABLE VIII
VALUES OF ATTENUATION AND SIGNAL LEVELS OF THE MAIN AND SECONDARY OPTICAL LINKS OF MULTICABLE S.A. HFC NETWORK

No.	Link	Att.Total (dB)	Pot. Input (dBm)
1	CRC-NOP01a	2.481	-0.481
2	CRC-NOP01b	3.286	-1.286
3	CRC-NOP02	2.452	-0.452
4	NOP2-NOP03	4.492	-2.492
5	CRC-NOP03	4.217	-2.217
6	CRC-NOT01	2.213	-0.213
7	CRC-NOT02	2.291	-0.291
8	CRC-NOT06	2.486	-0.486
9	CRC-NOT07	2.154	-0.154
10	CRC-NOT09	2.717	-0.717
11	NOP02-NOT03	2.151	-0.151
12	NOP02-NOT04	2.143	-0.143
13	NOP02-NOT05	2.228	-0.228
14	NOP02-NOT16	3.533	-1.533
15	NOP03-NOT15	2.309	-0.309
16	NOP03-NOT17	3.680	-1.680
17	NOP03-NOT18	4.360	-2.360
18	NOP03-NOT20	5.518	-3.518
19	NOP01-NOT08	2.276	-0.276
20	NOP01-NOT10	2.247	-0.247
21	NOP01-NOT11	2.559	-0.559
22	NOP01-NOT12	3.911	-1.911
23	NOP01-NOT13	3.056	-1.056
24	NOP01-NOT14	2.125	-0.125
25	NOP01-NOT20	2.232	-0.232

I. Choice of headend equipment for design MULTICABLE S.A.

Deploying an IPTV System MULTICABLE S.A. enterprise requires the acquisition of additional equipment, the required quantity and functionality are listed below:

TABLE IX
EQUIPMENT REQUIRED TO IMPLEMENT HEADEND OF MULTICABLE S.A. HFC NETWORK

Equipment	Qty.	Function
encoder mpeg2/h.264/sd-hd/4 in/mark picodigital pd1000	11	It is responsible for the digitalization of signals in MPEG or H.264 compression
multiplexer-scrambler/mpeg/4 in/mark picodigital pmx41	3	Is responsible for multiplexing the signals coming from encoder, it delivers IP flows to its output
switch gigabit cisco sge 2010 p	1	switching of traffic IP
modulator qam/mark pico digital	4	It modulates the signal in format suitable for RF transmission
middleware server netup	1	Manages the content network distribution
vod server cisco 9300	1	It stores the contents
Server pricing netup billing	1	Generates registers of events for service billing
cmts cisco ubr10012 ios 12.2/docsis 3.0	1	It combines video, voice and data signals and transported as RF signals to and from the Subscriber
softswitch cisco bts10200 rtu-p50	1	Generates and manages telephone traffic
router gigabit ehernet mikrotik 1100 ah	1	Internet Server (edge router)
optic transmiter pico digital dwdm/1550nm	1	Transmitter and receiver of optical signals in the network
bi-direccional combiner/mark pico digital	1	Add the analog signals of CATV and multimedia data delivered by CMTS

Integration of multimedia services, data and voice in the current network of MULTICABLE S.A. headend requires scanning of systems, then shown the architecture that must be implemented.

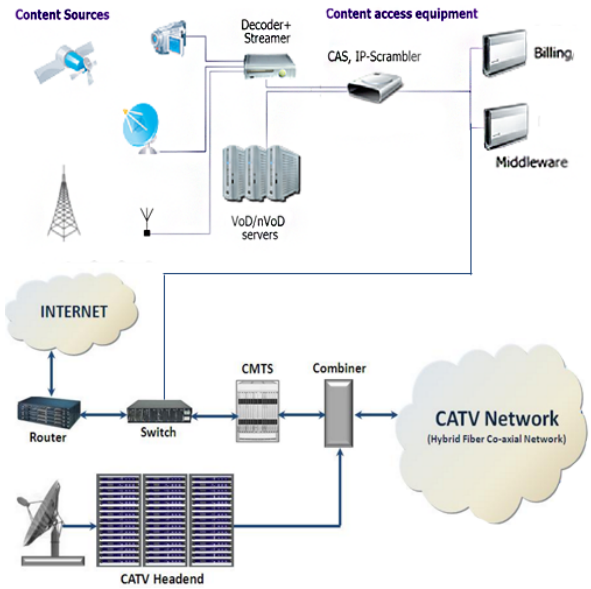

Fig. 19 Equipment required in a head-end IPTV System.

J. Choice of equipment for outside plant for MULTICABLE S.A.

Choice of optical cable: the distances of the links that unite the different nodes ranging from 800 meters to 9 Km and transmission speeds required in the HFC system, suggest use of monomode fibers for the design of this project, which must be contained in cables type ADSS (All-Dielectric Self-Supporting Aerial Cable, Cable dielectric self-bearing. Air force of high-tension cable, Extra long spans up to 1800 m). This set represent transmission line lying air of MULTICABLE S.A. system HFC access network

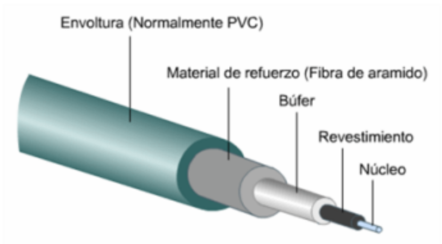

Fig. 20 Composition of an optical cable.

Selects the third window of operation (1550 nm) since it has low attenuation compared to other optical windows and scattering is close to zero compliance with recommendation ITU-T G.655, which is paramount in the links over long distances and high speeds.

Optical nodes: optical nodes are responsible for performing the conversion between optical and electrical signal for downlink and vice versa for the return link, so you need an optical transmitter. Different nodes returns reach the headend by different methods or multiplexed at different wavelengths. Optical nodes considered to design have four main outputs 34 dBmV of gain and with a range of optical power of - 32 dBm, that support bi-directional traffic on frequencies specified by the DOCSIS 3.0 (Forward: 88-750 MHz;) Reverse: 5-88 MHz) and operation in bands NTSC, four ports coaxial 75 ohm output, bi-directional and independent and functioning with the wavelength specified for the type of fibre used (1550 nm).

Fig. 21 Optical node in an HFC network.

All devices of external plant for the HFC network of MULTI-CABLE S.A. According to design presented in this case study is summarized below.

TABLE X
EQUIPMENT REQUIRED TO IMPLEMENT MULTICABLE S.A. HFC NETWORK

Equipment	Quantity
Terminal optical node/ 1 optic input/4 output RF/mark LINKTEL	20 units
Power supply 110VAC-60VAC/mark ALPHA	20 units
Singlemode fiber optic ADSS Cable G.655/24 fibers/mark DRAKA	34470 m
Singlemode fiber optic ADSS Cable G.655/12 fibers/mark DRAKA	6410 m
aerial Sleeve type linear	11 units
retention hardware	506 units
b hardware (conical)	746 units
Preformed helical	506 units
outdoor tag for cable	300 units

K. Suggestions on the current coaxial network of MULTICABLE S.A

Replace broken, old or corroded wires. Avoid the reuse of coaxial cable broken, old or warped.

Adjust and ensure the connectors, remove connectors poorly installed and place the respective Thermo contractile sleeves on coaxial cable connections.

Properly seal the amplifiers and eliminate noisy amplifiers, of low quality, damaged or corroded.

Land Rush and correct land incorrectly installed.

Replace cables of low isolation (RG59) connection.

Avoid the Subscriber to install additional splitters installed low quality and bad or connectors.

Install 75? terminators in taps, splitters and directional couplers to avoid the capturre or inclusion of noise in the network .

IX. FINANCIAL VIABILITY.

A. Initial investment.

The design proposed in this paper is, in most cases, keep the great investment that pitting the displacement of the CATV network analog on the beginnings of the company, as well as in the network header, the equipment for reception of television signals is terrestrial or satellite are kept; scanning and processing of these signals involves the acquisition of new equipment. Another part of the IPTV system is the network will travel where the signals and according to design, requiring several devices that comprise the network primary and secondary HFC. At the level of Subscriber is also necessary to install the necessary equipment, that ensures the reception of video and data, therefore will need an initial investment of:

TABLE XI
TOTAL INITIAL INVESTMENT FOR IMPLEMENTATION OF IPTV SYSTEM.

Description	Total (USD)
Costs for IPTV headend	75 362.60
Costs for HFC network	153 841.45
Cost for subscriber equipment	40 646.25
Costs for contract services	5 020
TOTAL INITIAL INVESTMENT=	274 870.30

B. Operating expenses.

Expenses annually for the running of the business as a multiservice carrier, as it is posing in this work, requires a periodic outlay of capital, such as payment of contracted services (electricity, internet, TV), wages, etc. Below are expenses that should be considered to keep operating system start-up time.

TABLE XII
OPERATING EXPENSES FOR THE OPERATION OF THE IPTV SYSTEM.

Concept	T0	T1	T2	T3	T4	T5	T6
Depreciat.	0	13721	13721	13721	13721	13721	13721
e. electric HFC	480	480	480	480	480	480	480
e. electric headend	360	360	360	360	360	360	360
Subscriber equip	40650	31837	43261	53897	62217	67934	70639
Centralizer salary	9600	9995	10405	10833	11278	11742	12224
Techs salary	8160	8495	8845	9208	9586	9981	10391
TV Provider	24000	24000	24000	24000	24000	24000	24000
Internet Prov	14963	40343	95479	204311	400640	732234	1260821
telephony Prov	2700	2700	2700	5400	8100	10800	13500

C. Calculation of income.

Revenues come entirely from sale of IPTV, Internet and telephone services, and it will allow it to make a comparison with the investment to determine the profitability of the project, in that sense today MULTICABLE S.A. provides a unique plan of CATV and other companies of telecommunication in the village (both Internet and CATV) also follow this guideline so it is difficult to consider a price for service packs since in the local environment, there is no any reference of a fee to charge subscribers for integrated services. Then, plans that could offer MULTICABLE S.A. as multiservice operator MSO and income are:

TABLE XIII
REFERENTIAL RESIDENTIAL PLANS FOR 3 PLAY SERVICES OF MULTICABLE MSO.

Plan	Description	PVP (USD)	Suscription (USD)
Basic Plan	42 Ch SDTV, 600 min of telephony e internet 2/0.5 Mbps	40	75
Special Plan	42 Canales HDTV, audio ch, 1000 min of telephony e internet 5/1 Mbps	100	75

With these considerations, the income estimated for the first 7 years after putting into operation the system is.

TABLE XIV
INCOME AS REFERENTIAL RESIDENTIAL PLANS FOR 3 PLAY OF MULTICABLE MSO ENTERPRISE SERVICES.

Plan	T0	T1	T2	T3	T4	T5	T6
basic	63840	133440	244800	406080	617280	874560	1167360
Special	15600	33360	61200	101520	154320	218640	291840
VoD	12480	25920	48000	80520	124200	178800	242640
PPV	12720	26400	48720	81720	125880	180960	245400
Suscrip.	9975	10875	17400	25200	33000	40200	45750

D. Net cash flow.

Net cash flow is a term of accounting that describes the movements of cash (income and expenses) in a given period, i.e., refers to the statement which reflects the amount of cash that remains after expenses.

TABLE XV
CASH FLOW ESTIMATED FOR A PERIOD OF 7 YEARS.

Year	Expenditures	Incomes)	Cash Flow
T0	100912,75	114615	13702,25
T1	131930,53	229995	98064,47
T2	199249,96	420120	220870,04
T3	322209,78	695040	372830,22
T4	530383,08	1054680	524296,92
T5	871251,85	1493160	621908,15
T6	1406135,66	1992990	586854,34

E. The Net Present Value (NPV)

The NVP is a financial indicator that measures the flow of future inflows and outflows which will take a project, to determine, after discounting the initial investment, and you get some gain; If the result is positive, the project is viable.

The NVP is based on the fact that the value of money changes with the passage of time to do this uses a discount rate (i), which is often considered the inflation or the cost of a loan, in Ecuador is set for 2013 a reference rate of 11.1 for the productive segment of small and medium sized enterprises, SMEs.

Applying the Excel NPV function, the result is a positive value for US. 1 144 025.38 for the net present value, then for a period of 7 years the investment in this project is profitable.

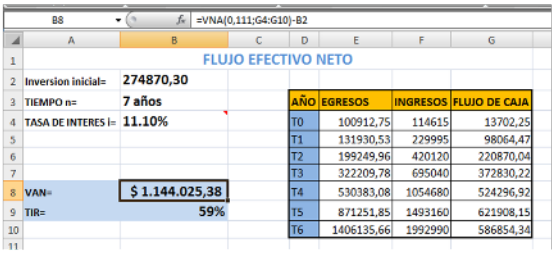

Fig. 22 Calculation of NVP and IRR in a Microsoft Excel worksheet.

F. Internal Rate Of Return (IRR).

The second indicator that helps determine whether a project is viable or not is the internal rate of return, this determines which is the discount rate that makes that the go project is equal to zero. The IRR is expressed as a percentage (for example, TIR=30%).

Case study of the calculated IRR is 59%, and the discount rate is 11.5%, therefore the internal rate of return is much higher than the discount rate which determines that the project is financially viable.

X. REGULATORY REFERENCES.

In terms of regulations in the field of telecommunications, the regulatory body of the Ecuador is the Agency for the regulation and Control of telecommunications (ARCOTEL), this being a newly created institution, operates from 18 February 2015 the effective law of telecommunications, adopted in February by the National Assembly. Thereafter, it proceeded to fusion of the Superintendence of telecommunications (Supertel), the National Secretariat for telecommunications (Senatel) and the National Council of telecommunications (Conatel), with the aim of forming the new agency of regulation of telecommunications, institution that will integrate the functions of administration, regulation and control of telecommunications and radio spectrum.

On the subject of study, the existing telecommunications law places the cable operators within public telecommunications networks and defines ”television paid subscription which transmit and eventually receive signals of image, sound, multimedia and data, which are used exclusively to a particular audience of subscribers as the service provided through audio and video systems”.

In that sense, it is clearly described in one of the goals of the organic law on telecommunications to”promote and encourage the convergence of networks, services and equipment”. The law also suggests that ”operators of public telecommunications networks shall comply with fundamental technical plans, technical standards, and specific regulations related to the implementation of the network and its operation, in order to ensure its interoperability with other public telecommunications networks”.

On the technical side, the recommendation of the hotel for the digitization of systems of cable television as part of the digital revolution promoted by the national Government; one finds its considerations in the resolution RTV - CONATEL-2013 effective since March 19, 2013 in which is detailed ”LA NORMA TCNICA PARA EL SERVICIO DIGITAL DE AUDIO Y VIDEO POR SUSCRIPCIN BAJO LA MODALIDAD DE CABLE FSICO” whose purpose is to establish the basic technical regulations for the exploitation of Digital Audio and Video in the cable subscription service operators.

XI. CONCLUSION

The development of the DOCSIS standard gives a great opportunity to CATV networks to transported large amount of both ascending and descending traffic about television systems operating in bands NTSC which operate both active and passive in a coaxial network. The increase of traffic on these networks leads to the need to plan broadband backbone networks using optical fiber as a transmission medium, which, at the same time eliminates the problems of attenuation and distortion of signals affecting coaxial networks in greater distances. HFC schema original signals that leave the network headend reaching subscribers homes with high quality, because already they should not travel by long coaxial amplifiers Cascades. These features facilitate the development of new services, as it is the case of IPTV, Internet, telephony through a same connection (service 3play) influencing the evolution of CATV systems true multiservicos operators, MSO.

Regarding the goal of the grade work, the study showed the feasibility of the project on the basis of a comprehensive study of the market, demand and financial study, which estimated profitability from the third year after operation the new system. On the other hand, the design indicates the exact points where will be laying optical links, the location of the optical nodes, which resulted from a comprehensive collection of information, measurements on the network, signal calculation, dimensioning of the network capacity and coverage, detection of vulnerabilities, approach to recommendations for improvements in the wiring of Multicable S.A. which is directed this study.

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