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Mesoamerican information highway: channel for social development
Autopista mesoamericana de la información: vía para desarrollo social

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Abstract: The Mesoamerican Information Highway (MIH) is a dialogue and coordination mechanism that articulates cooperation, development and integration efforts among the Central American countries with the purpose of improving the quality of life of the inhabitants of the region. This research paper was made with the purpose of giving the reader a state of art about the Mesoamerican Project (MP) in order to review the past, present and future situation of these kinds of technological developments in the region and their impact on the Colombian case. It shows a map in order to lead the implementation of future projects of the Information and Communications Technology (ICT) and its implementation through those alternatives.

Keywords: Information Highway, Mesoamerican Project, Services Integration, Social ICT, Optical Fiber, Submarine Communication Cable.

Resumen: La Autopista Mesoamericana de la Información (AMI) es un mecanismo de diálogo y coordinación que articula esfuerzos de cooperación, desarrollo e integración entre los países de Mesoamérica, con el objetivo de mejorar la calidad de vida de los habitantes de la región. El presente artículo busca que el lector tenga un conocimiento más cercano sobre el Proyecto Mesoamérica (PM),

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de manera que revise el panorama pasado, presente y futuro de estos desarrollos tecnológicos en la región, y sus impactos en el caso colombiano. Se presenta un mapa de procesos para orientar la ejecución de futuros proyectos de las tecnologías de la información y las telecomunicaciones (TIC) y su implementación con este tipo de alternativas

Palabras clave: Autopista de la información, Proyecto Mesoamérica, Integración De servicios, TIC Sociales, Fibra Óptica, Cables Submarinos.

1. Introduction

The most obvious issues of the strategy of information society focus on the expansion of infrastructure and ICT services. In other words, the access and the universal use of the technology provide a basic minimum of access on the part of the population, especially in the marginalized groups where access is difficult. In order to ensure access to ICTs, it is necessary to promote policies, initiatives, and public projects to reduce individual access costs through shared access models, special funds, or associations between the public and private sector. Therefore, international cooperation can help to create and maintain such ICT infrastructure. In this context, transnational integration projects such as the MIH are important to maintain and improve the quality of Internet access.

On the other hand, this research paper describes the past, present, and future situation of the state of art of those integrations, as well as the social impact in regions where the projects are developed, and how this has contributed to the development of ICT in Colombia.

The research paper is organized as follows: 1, introduction. 2, a chronological state of art: from 2000 to 2015 with the main implemented submarine communication cables. 3, description of the MIH. 4, specification of the MIH infrastructure, Central American Electrical Interconnection System (SIEPAC, as per its acronym in Spanish), American Optical Fiber Network (REDCA, as per its acronym in Spanish). 5, social impact. 6, impact of MIH in Colombia. 7, design of a process map for an information highway. 8, project overview. 9, references.

2. State of the Art

The information highways are necessary for the growth and development of the entire world. For that reason, it is important to connect countries through media such as cables. It becomes the most effective tool, especially if those connections are made with Optical Fiber (O.F). Nowadays, there are many projects and the most important are those found at sea, such as submarine communications cables. There are currently more than 300 installed, [1].

Some of the major submarine communications cables are: SEA- ME -WE 3 (South-East Asia - Middle East - Western Europe 3), considered the longest in the world with a length of 39,000 km, which was finished in late 2000. Managed by Singtel and led by Telecom and China Telecom. It extends from northern Germany to Australia and Japan, [2].

On the other hand, the MAYA -1 cable is 4,323 km long, and was made by ASN (Alcatel Submarine Networks). It began its work in 2000. Its owners are AT&T, Telmex and Hondutel companies, who are also in charge of the administration part. It has anchor points in the United States, Mexico, Cayman Islands, Honduras, Costa Rica, Panama and Colombia. SAM -1 cable has 25,000 km long. It started in 2000. Its current owners are Telefonica and TE Connectivity companies. It connects to countries such as United States, Puerto Rico, Brazil, Argentina, Chile, Peru, and Guatemala. It was extended to Ecuador and Colombia in 2007, [4].

In addition, there is the PanAm cable with a newer extension with a length of 14,490 km and a start up after its modification in February, 2010. It was built with the purpose of providing connection to South America and the Caribbean, through countries such as Chile, Peru, Ecuador, Colombia, Venezuela, Aruba, Panama and the United States. Alcatel, Submarine Networks and NEC companies were in charge of its construction, [5].

According to the Ministry of ICT, Colombia already has nine submarine communication cables. Four of them were obtained in the last four years, increasing internet traffic, data and voice. The nine cables are: Arcos-1 [6], Pan-Am, CFX-1 [7], Maya-1, SAM-1, Globenet [8], PCCS [9], SAC-LAN [10], and AMX-1.

The last cable has a length of 17,800 km, crossing the following countries: Colombia, Brazil, Dominican Republic, Puerto Rico, Guatemala, Mexico and the United States. This cable reaches 42,000 km of a submarine communication cable of O.F, about 24,000 Km of terrestrial O.F, and a hundred of internet stations, [11].

3. Mesoamerican Information Highway (MIH)

The MIH is comprised of a group of physical, logical and institutional infrastructures designed to provide a technological platform as part of the Mesoamerican Project and has the purpose of improving connectivity and access to broadband[1] Internet through optical fiber[2] [12]. The following countries are members of the project: Belize, Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama and the Dominican Republic.

The background of the project is the Puebla-Panama Plan (PPP) born in June, 2001, when a strategic alliance was suggested between the Central American countries as a result of the destruction caused by Hurricane Mitch in 1998, [13], which caused damage to the region. This is the beginning of the plan of cooperation among the regions, which is based on eight initiatives: transport, energy, telecommunications, sustainable development, tourism, trade facilitation, disaster prevention, and human development. Colombia joined in 2006 and the Dominican Republic in 2009, [14].

In 2008, new adjustments were made by the countries, as it was thought to generate more organized and oriented policies, in order to create a portfolio of projects focused

1 **Broadband:** According to its Recommendation l.113, the UIT considers the broadband as a service or system that requires transmission channels able to support speeds above the primary rate, which is at full speed. More than 1.5 Mbps or 2.0 Mbps.

2 **Optical Fiber:** Optical fiber is a transmission medium which is composed of filaments of glass or plastic. Optical fibers do not transmit electrical signals. The way of sending information through the optical fiber is through light beams by transducers.

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on emblematic and strategic works. At this time, PPP becomes PM, since the coverage of the project was extended to include Colombia and the the Dominican Republic. The working structure was changed. It produced closer links and economic complementation, as well as more physical, logistics, electrical and communications connectivity to generate cooperation activities between the regions, taking particular challenges such as health, childhood, education, among others.

4. Infrastructure of the MIH REDCA, SIEPAC

a. Central American Electrical Interconnection System (SIEPAC)

The Mesoamerican Project (MP), which is part of the MIH, also has other projects that want to contribute to the improvement of the region, finding a common interest between them. This is the case of the SIEPAC project that is used to install O.F, which has the same efficiency as submarine communication cables currently installed in the region.

The purpose of the SIEPAC is "*Turning the system on one of the axes of regional development through the integration of the electricity systems of Central America, in order to contribute to the reduction of energy costs, improve reliability of supply, provide economies of scale, generate higher levels of competition in domestic markets and attract foreign investment, as it will have a safer network and more capacity to consolidate the Regional Electricity Market (MER, as per its acronym in Spanish)*",[15]. This project is basically composed of a transmission line with a distance of approximately 1800 km of 230 KV and 28 access bays in 15 substations. This network goes through 6 countries in Central America, as is showed in illustration 1. It is a reliable and secure capacity network that can transport up to 300 MWatts.

The following table 1, [12], shows in detail how the distribution is in kilometers, sections, towers and substations of each country covered by the SIEPAC network.

The following map shows the table information in a graphical way. (Figure 1)

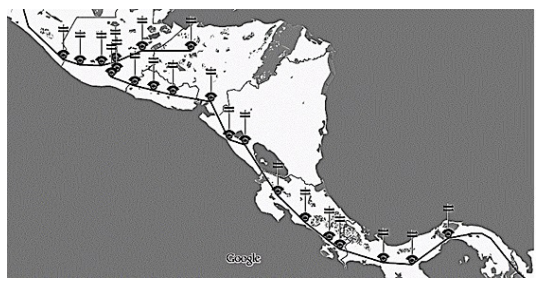

Figure 1. Infrastructure map of SIEPAC. Source: own

Country	Approximate length in kilometers	Total sections	Total towers	Total substations	Substations
Guatemala	282.8	3	662	3	Aguacapa, North Guatemala, Panaluya
El Salvador	286	4	736	3	Ahuachapan, Nejapa, September 15
Honduras	275	4	727	2	Aguacaliente, Buenaventura
Nicaragua	307.5	3	756	2	Sandino, Ticuantepe
Costa Rica	499	5	1,343	4	Cañas, Parrita, Palmar Norte, Río Claro
Panama	150	1	398	1	Veladero
Total	1800	20	4622	15	

Table. 1. Sections by countries of the SIEPAC. Source: own

According to the information provided by the MP, the project implementation has produced the union of the respective electrical systems of the beneficiary countries in a single energy market. In addition, air pollution has decreased due to the reduction of greenhouse gases emissions, [15].

They have invested a total of $ 505 million in its financing, covered by the participating countries. Funding and investment sources for the SIEPAC project are: Inter-American Development Bank (IDB) (50%), loans with the Central American Bank for Economic Integration (CABEI) (21.6%), BANCOMEXT (8.8%), CAF– Development Bank of Latin America (3%), Davivienda (2.2%), and shareholders contribution (11.6%), among others.

The last section of the SIEPAC network (Palmar Norte - Parrita) opened on October 16, 2014, concluding the project of the new electrical transmission line and the successful accomplishment of the project. It became the backbone that joins Mexico and Colombia [17].

According to the MP, ISA[3] is involved with a shareholding of 11.11 % in the company that owns the ERP network. REDCA has also its shareholding with 11.11 %. As for FO, ISA has extended about 21,217 km connecting Colombia, Venezuela, Peru, and Chile. According to its official website, Argentina, Brazil, and Central America will soon be joined, [18]. This coverage is consolidated as the largest integrated terrestrial network throughout Latin America. ISA is seen as a strategic company for the expansion of the SIEPAC. As a result, its completion and official opening on December 10, 2014 was obtained. The meeting of energy ministers was held in Panama City in the "SIEPAC Celebration: Driving the Mesoamerican Energy Integration", [17]. We have a different vision of growth in the region with this implementation. These countries understand that this network can keep growing and expanding its benefits across the continent, reaching previously inaccessible places such as rural areas, indigenous communities, among others. It shows that just like all places, this areas are entitled to enjoy and take advantage of the tools that come with the implementation of new technologies, either for the intellectual, economic or cultural development, which generate an improvement in the quality of life of the population.

b. Central American Optical Fiber Network (REDCA, as per its acronym in Spanish)

The MP decided to invest in the construction and operation of the Optical Fiber network to transmit data, voice, and video. For this reason, the company Central Optical Fiber Network (REDCA) was created. It is a public-private company that has a main objective to develop, design, finance, build, support, operate, and use the Optical Fiber networks and interconnect the telecommunication systems of the region. The organization is considered a carrier of carriers, that is to say a company whose clients are operators of telecommunications including fixed-lines and mobile users, among others. It also includes all kind of

3 The Company "Interconexión Eléctrica S.A. ESP (ISA)" is the company with the highest international transport of electricity in Latin America. This company is dedicated to the transmission of electricity through its 33 affiliated and subsidiary companies. It is involved in business such as highway concessions, telecommunications transport and intelligent management of real-time systems. It has a high voltage circuit of 41,650 km and 77,710 MVA of transformation and interconnection capacity.

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value-added services, including data services or corporate networks and ISP´s[4].

REDCA business focuses on the marketing of telecommunications transmission capacity on Optical Fiber lines between the six major cities of the region. These fibers extend from the nearest substation of each capital city to the city center where it is connected to a point of presence in each country. The point of presence is operated as a point of interconnection between clients and its capacity. It will also allow the interconnection between its customers, and not necessarily customers, in a neutral environment. Nowadays, the interconnection between operators in the region is generally limited to controlled places by the dominant operators in each country, that is, subject to restrictions and obstacles that otherwise would be called unfair competition.

The optical fiber network of the MIH will be used in a similar way to the private submarine communication cables. In these schemes, the transmission capacity is marketed either via leasing or buying long-term capacity. The model of the cable groups, as the Maya - 1, although it has worked in the past, is no longer working in competitive and complex markets. It works where there are few players with aligned interests, which is not the case the region faces, due to the liberalization of telecommunication markets. From here on out, group cable types could tend to disappear.

c. MIH Infrastructure

In the first stage, the MIH joined telecommunication networks in Central America, and in the second phase, in Mexico and Colombia by complementing the existing interconnection through submarine communication cables in order to reach a high broadband connectivity at a Mesoamerican level, particularly with converged services and optical fibers able to transport all kind of information (data, voice, video), [12].

There are several Optical Fibers installed in this system. The cable has 36 O.F, and 12 of them are used in telemetry and control of the same electricity exchange network, and the rest are used in the services offered by REDCA. It was thought mainly, to place the fiber for the control and telemetry of the SIEPAC network. But by adding extra fibers, the price would be lower with a great benefit to the development of the MIH project, taking advantage of the coverage of the major cities and rural areas of the region where the SIEPAC crosses.

The installed cable is an OPGW[4] cable that does the work of the UIT recommendation to the DWDM[5] transmission.

The functional diagram of the MIH is based on Multi terminals Switching Provisioning Platform (MSPP), which is an industry response to the needs of high-capacity networks to take advantage of the DWDM.

4 Internet Service Provider (ISP): an organization or company that provides internet access to its customers as a service.

5 Optical Ground Wired (OPGW): it is a cable designed to replace the traditional cable guard and extend over 10 km which has, in this case, 12 fibers G.652 and 24 fibers G.655. The optical fiber core is housed inside a tube covered by aluminum that provides both mechanical protection to the core and protection against humidity or water penetration.

6 Dense Wavelength Division Multiplexing (DWDM): it is the technique which multiplexes the light wavelength signals in a dense form. These systems are able of transporting terabits in a pair of fibers, depending on the combination of the number of wavelengths transported simultaneously and the speed of each of them, [40].

Through a direct connection to the optical signal DWDM, the MSPP (figure 2) allows a reconfigurable connection of the circuits TDM type (Time Division Multiplexing) and Ethernet - IP in every city of the MIH network.

New Generation solution SDH (Synchronous Digital Hierarchy) allows the integration within the capacity of a single wavelength 2.5 Gbps, initially.

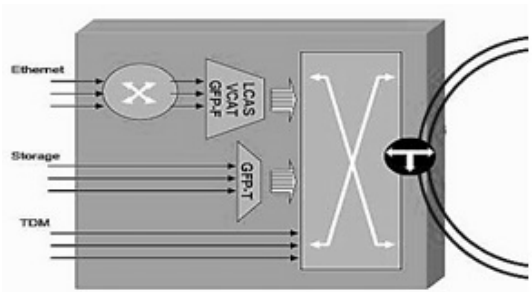

Figure 2: FUNCTIONAL DIAGRAM OF A MSPP TERMINAL. Source [20]

The MSPP terminals, figure 3, are based on the new optical fiber network of the MIH and replace the set of all equipment that were formerly part of a network of this kind. It is a next-generation network, flexible and low-cost type. The demand that the Optical Fiber Network of the MIH would attend is focused on four sources: Voice (international telephone calls), TV and broadcasting, data (fixed corporate networks) and Internet.

5. Social impact on the countries benefiting from the MIH project.

Broadband as a form of internet connection has improved in order to favor the users, giving them the possibility of expanding its boundaries.

The benefits were observed immediately, is a better experience on the internet connection regarding the shorter waiting time and higher broadband, allowing the development of internet content such as applications and interactive sites. The contents provide a development in the society that has access to this service at a low cost, generating a flow of accelerated information along with a cost reduction in the commercial and business transactions as an increased dissemination of information, which can generate a better efficiency in the market and can produce a better competition and benefits for the economy in the long term.

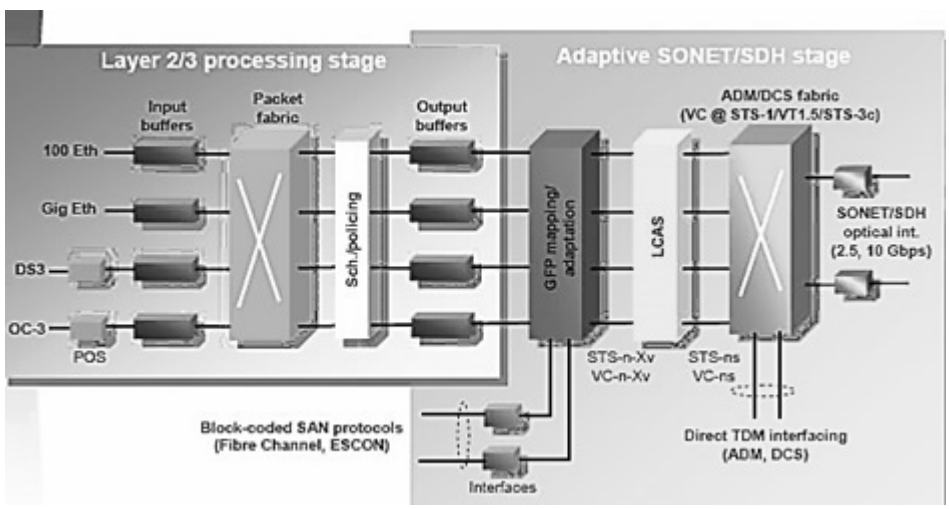

Figure 3: functional diagram of a MSPP terminal. Source [21]

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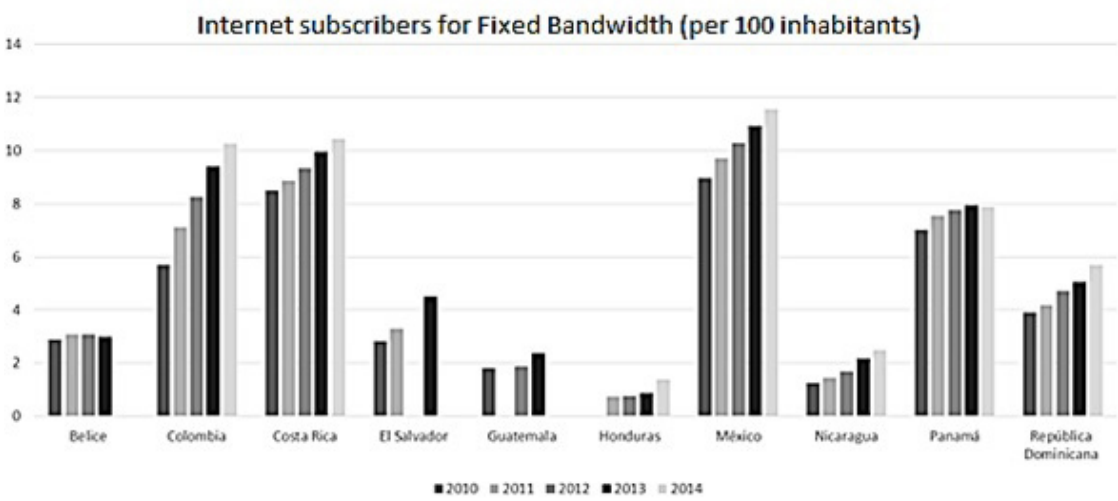

Figure 4. Internet subscribers per 100 inhabitants. Source [22]

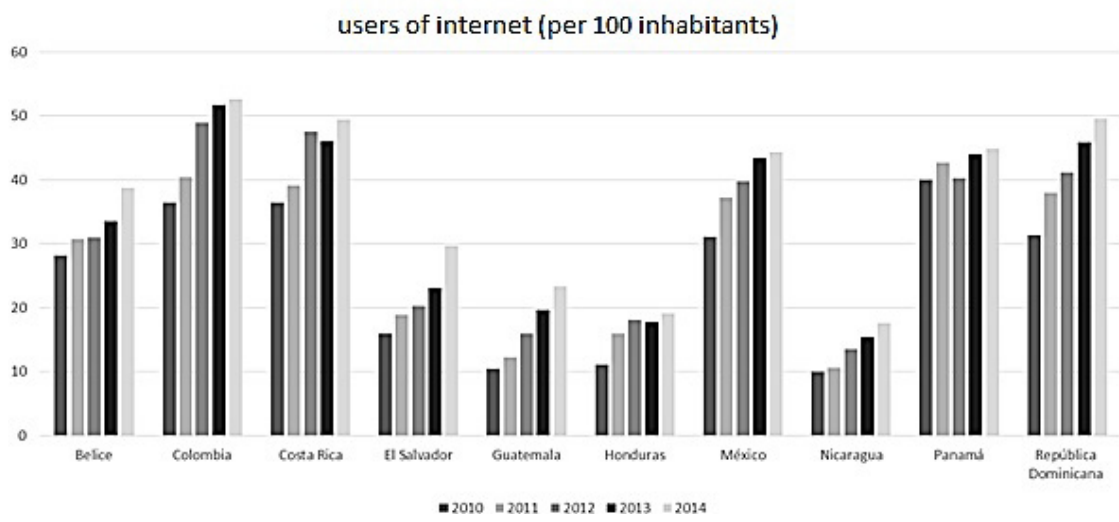

Figure 5. Internet users per 100 inhabitants. Source [23]

Since its beginning, the MIH project was designed as a way for the integration of regions through the internet. Since the deployment of its infrastructure began, it is possible to observe the increasing access to internet and subscribers without the intervention of the MIH. It is expected that as the project develops to its full potential, these measurements show a substantial increase in capacity connections, demonstrating the social contribution of this project. See Figures 4 and 5.

6. MIH: the impact on Colombia

According to the report of the first quarter of 2015 of the ICT Ministry (MinTic), Colombia has 10.1 million broadband connections. These connections provide support to Co-

lombian people in matters of health, education, justice, tourism, peace, and coexistence, [24]. 1, 2 and 3 social stratifications have as a result a high penetration degree in recent months, compared to the last year (2014). We can see the result in Figure 6, which is taken from the report.

The government wants to reach rural places that have poor broadband coverage. Those places could take advantage of this tool.

Colombia has a program called "*Compartel*" (sharing telecommunications), led by the MinTic, which is composed and funded by its contracting entities. Among the main entities are the Communications Fund and the Financial Fund For Development Projects FONADE. The program intends to expand the network coverage in rural and urban low-income areas all around the country [26]. This program seeks to expand internet access to low-income Colombians. There are three main elements to which "*Compartel*" is committed: Community rural telephony, social internet and telecentres, and broadband connectivity. Reaching areas of low population such as small towns, Police Inspections, villages, indigenous reservations, border-crossing points, and natural parks. They have installed more than 9,500 points of community rural telephony, 1,490 telecentres in all the main municipalities. The objectives of "*Compartel*" include giving internet access to 3,775 public institutions.

Another way by which the government reaches rural areas is the national optical fiber project. It operates in more than 1,000 Colombian municipalities. Passing from 29% of interconnected municipalities with optical fiber networks to 96% of interconnected municipalities. They provide free internet for a period of five years by about 2,000 public institutions [27]. There are municipalities that are not included in the coverage of this project, but they are benefited with another great contribution of the Colombian government: the High-speed Project. [28].

The High-speed Project of the ICT Ministry intends to connect the regions of Amazonas, Guainia, Vaupes, Meta, Antioquia, Guaviare, Putumayo, Vichada, Arauca, and Casanare, which represent 62% of the country, benefiting about 445,000 inhabitants. These regions were not included in the national optical fiber project. This project connects 27 municipal seats and 20 departmental small towns [29]. The project is shared with the people directly

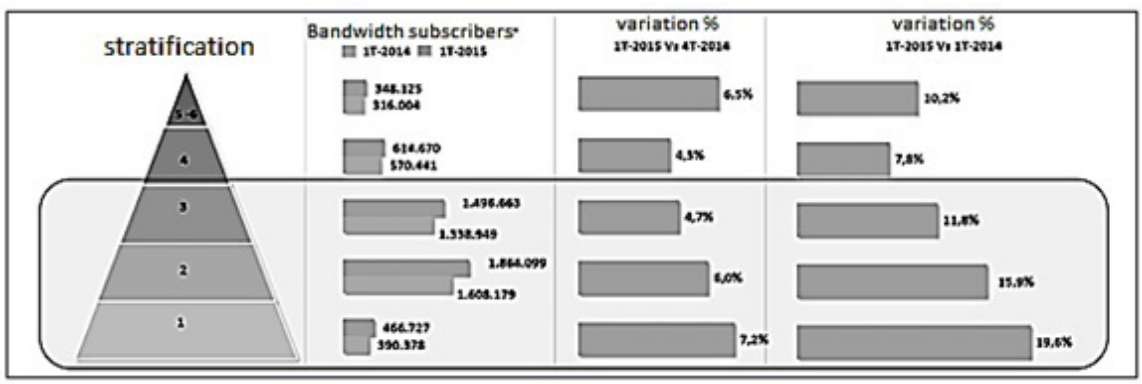

Figure 6. Fixed Broadband Internet subscribers. Source [25]

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involved, such as local authorities and regional leaders along with the participation of the media, which are aware of the network benefits.

On the other hand, with the same intention of reaching rural areas, there are the "*Kioscos Vive Digital*" (KVD), places that allow internet connection from different communities between children, youth, and adults in 5,300 population centers (villages and small towns), [30]. So far, it has more than 7,600 kiosks. In addition, it has 200 kiosks in guard posts, indigenous communities, military bases, national natural parks and border places. Kiosks are categorized by three types: A, B, and C, [31].

On the other hand, the municipal centers and regions of 1, 2 and 3 social stratifications were benefited through "*Vive Digital*" points consisted of some phases: Phase 0 placed 71 points in 67 municipalities. Phase 1 placed 341 points in 245 municipalities during the first half of 2014. In total, there were 800 "*Vive Digital*" points. Among the objectives of this program are Internet access and the use and development of ICTs, including creation workshops of applications, animation, and software development [32]. This program turned students into entrepreneurs. They have also ventured into new knowledge.

The geographical location of the projects is presented below (Figure 7):

The government has sought to have places where the community has a friendlier relationship with the use of ICT. Access to the Internet has become essential to the development of human beings in matters of economy, culture, entertainment, education, among others. Colombians have begun to take great interest in the information, and this is where the participation of the MIH in Colombia can generate a network access of a perfect 100% of all Colombians in broadband connections. We know that this network is important to go into the information highway. The benefit that the MIH brings is important to the age in which humanity is going through, as it is shown that there is no development without information quality.

Today, industries such as farmers business need to be known by everyone. There is no doubt that the information should and must be transmitted from generation to genera-

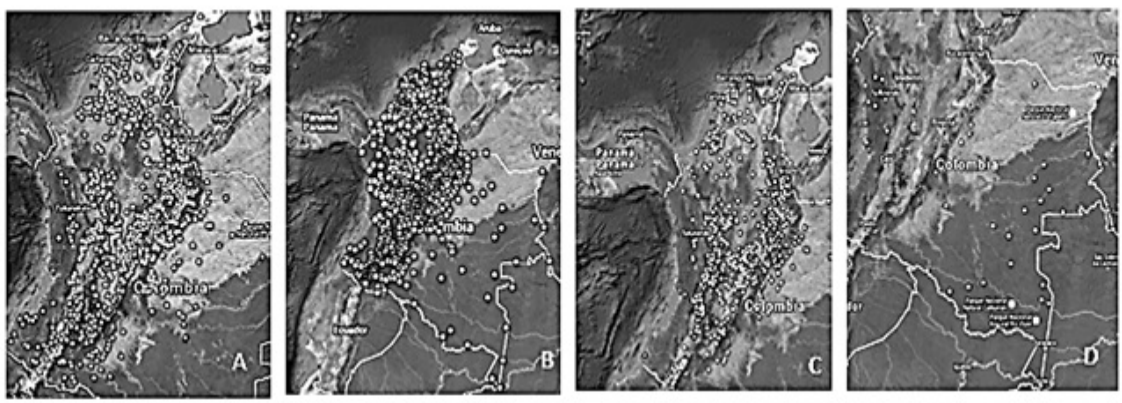

Figure 7. A. National Optical Fiber Project, B. Kioscos Vive Digital, C. Vive Digital Points, D. High-Speed Connectivity to the Amazon, Orinoco and Choco regions. Modified from [33].

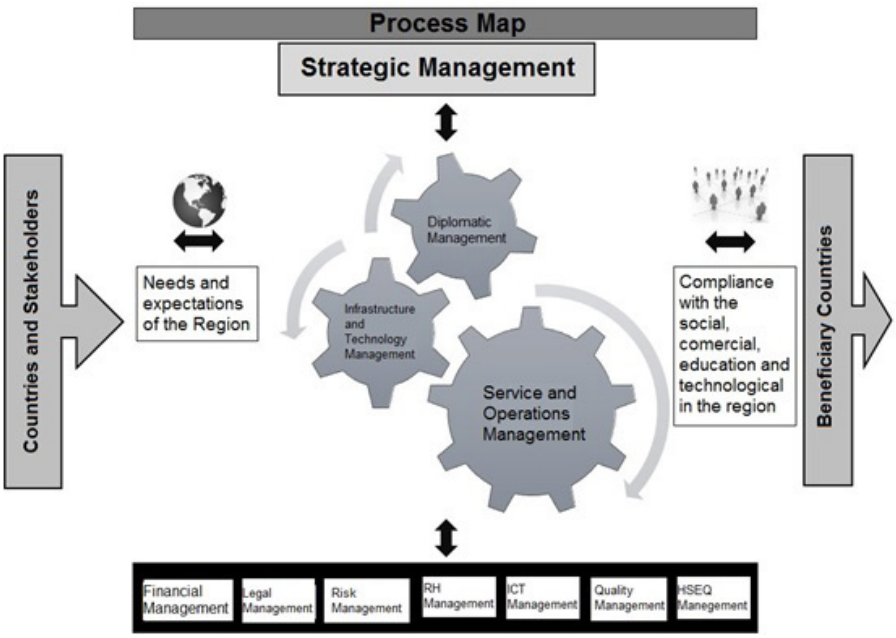

Figure 8. [7]Process map. Source: own

tion, not only in the local environment, but also around the world. The exploitation of this resource is a big step that led the rural areas to have a closer relationship with global world. We have an example: how a farmer can make more technical its cultivation by means of methods used in other countries, by people with a higher level of experience that through the Internet can find help by providing valuable information and as a result to obtain a better quality product. Another case is that of flower growers, in which Colombia is privileged by its high variety of flowers. They tell how they have learned to better treat their crops, to use less pesticide, and get better flowers, [34].

7. Process map

The following process map, Figure 8, developed by the GIDENUTAS Research group, describes a set of factors which can be used by the institutions, stakeholders, and general academic and technological organizations, in order to guide them in an analog implementation.

8. Perspectives and Conclusions.

Considering the above, it is understood that the network "Clara" is the only regional network of Advanced Internet in Latin America. Its backbone consists of ten main nodes connected in a point-to-point topology. Each node represents a PoP (Point of Presence) for the

7 **Read from the top to the bottom:** 1.Strategic management. 2. Diplomatic management. 3. Infrastructure and technology management. 4. Services and operations management. 5. Financial management. 6. Legal management. 7. Risk management. 8. RH management. 9. ICT management. 10. Quality management. 11. HSE management. 12. Countries and stakeholders. 13. Needs and expectations of the region. 14. Compliance with commercial, educational and technological development of the region. 15. Benefited countries.

8 National Research and Education Network (NREN)

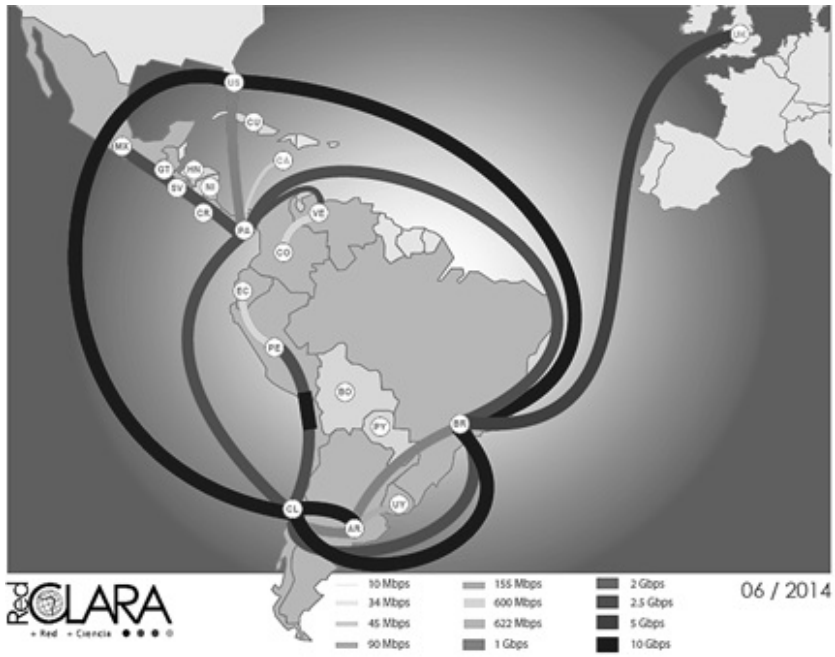

Figure 9. Connection topology RedClara 2014. Source [36]

network. Nine of them are located in major cities in Latin America: Sao Paulo, Buenos Aires, Santiago, Lima, Guayaquil, Bogota, Panama, San Salvador, Tijuana, and the last one in MIH, [35].

All connections from Latin American national networks (RNEI[8], as per its acronym in Spanish) to RedCLARA, are made through one of these nine nodes. The backbone of RedCLARA is interconnected with the Paneuropean network.

Advanced networks allow scientists, researchers, academics, teachers, and students to collaborate and share information and tools through a series of network interconnections. These networks make a different area from the commercial or public Internet. An area that coexists in a reserved parallel space around the world only and exclusively for education and research communities.

Thus, an objective of the integration of telecommunication services is the development of social capital through access of the society to knowledge and the promotion of applied research to increase business and entrepreneurship competitiveness, both in universities and specialized centers, among others.

The MIH provides, with the same objective, an opportunity for the governments to coordinate efforts in order to integrate their societies into the information and knowledge age, and create network economies by means of integrating both existing and under construction systems at a regional level. It also seeks the efficient use of the new opportunities offered by the ICTs. Taking into account the above, there is a possibility to integrate the Clara network and the MIH network, coordinating efforts in order to interconnect advanced information networks. Figure 9, [36].

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For research groups GIDENUTAS and SciBas

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