Sustainable Computing and Communications

Internet Broadband Network of Things Applied to Intelligent Education

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Abstract: Intelligent cities may be defined as territories characterized by a high capacity of learning and innovation, comprising in its structure the “Internet of Things”, developing, therefore, the creativity of its population, its institutions of knowledge generation and its digital infrastructures to communication and management of the knowledge. This structure has a great performance in the role of digital inclusion, allowing the possibilities to integration, social well-being promotion (e-inclusion), supplementary education (internet toward software application with great capacity to education) or in distant (e-learning) and professional development. Multimedia communication, it may reach the most remote points and be available full-time, benefiting, in addition, students with deficiencies and walking limitation to go to school, or with special needs of differentiate teaching to educational development, creating and promoting the intelligent education. The main Target to develop this study is to present a solution to network service bandwidth, considers media world speed and projects the implementation of GPON (Gigabyte-capable Passive Optical Networks) technology in access optical networks in the Brazil. Presenting an outcome comparison analysis obtained from the project performed to implement in Holambra city, São Paulo, Brazil, relating to the perspectives and standards of connectivity in the use of broadband networks in the world, showing the viability in the use of such modern technologies in the GPON broadband.

1 INTRODUCTION

The new forms of knowledge need a suitable broadband network connection. Digital activism has reached the streets in cities all over the world, and much of its proliferation took place through social networks disclosure (Gorshe et al. 2014) (Lekamge & Marasinghe 2013). Recent past has revealed that people have new forms of organizing themselves, either in teaching institution, in clubs, in open spaces, etc. Applications such as Facebook, Twitter, YouTube and WhatsApp, collect and send data in real time and help to improve considerably the aspects of modalities (Saad & Khan 2013).

Public environment are entirely responsible for the evolution of its citizen. As we understand better the behavior of the citizen from the intellectuality extracted from collected data, for example, through social networks, public architecture shall become more communicative and provides better conditions of connectivity and intelligent education (Fortino & Trunfio 2014) (Jin et al. 2014). In this context motivating, intelligent education is characterized by the change of the educational environment, generating individualized, active, flexible and collaborative learning, with frequents use of tables and applications and digital contents, that is what we can call them up school without walls (Imrattanatrai et al. 2014) (Majumder & Saha 2014). Technological advance has changed computational capacity and expanded the possibilities to be use and applications to a horizon of immeasurable perspective when everything is connected properly and efficiently (McEwen & Cassimally 2013) (Guinard et al. 2011).

Intelligent city presents as one of its features the connectivity and communication between the several devices (Jin et al. 2014). This ability allows us to understand the contents and behaviors of people, process information and share data in real time, allowing a better use of resources. The way the

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distribution of digital content and education must go through a revolution as profound as the industrial revolution and the multimedia industry has recently suffered (Pfister 2011) (Downton 2008).

In the context an example of this constant change in network traffic management systems, the evolution of new models of sensors (inductive, position, capacitive, magnetic field, ultrasonic, photoelectric, identification, positioning, vision, security, etc.) and the network infrastructure allowing a better quality of the connections as well as their management through the routers that connect networks in the cities (Gaglio & Re 2014). This fulfills the need for adequate connectivity applied to smart education in line with the changes in more flexible structures (Perera & Zaslavsky 2014) (Bessis et al. 2012).

To allow this kind of behavior, you need to invest more in networks and high-performance equipment, so in our study we use the GPON technology, a concept of smart cities, enabling better connectivity of users to a smart education environment.

The motivation to develop this study is to present a solution to network service higher bandwidth at the best rate recorded worldwide (Thompson et al. 2014). This solution considers media world speed and projects the implementation of GPON technology in this scenario.

After analysis in previous studies (Mesquita et al. 2013) updated and expanded deployments recent information these networks, comparing trends of these technologies applied to Internet of Shings Worldwide, focused on smart education (Oliveira 2014).

2 BROADBAND TECHNOLOGIES IN BRAZIL

Current broadband technologies have impairments regarding the features in its architecture. Finding architecture with a suitable solution may be a thorough engineering project, wherein we have to take into account many interfaces and factors that are engaged on the study. Decisions must be taken with certain care so that the network cost is not out of financial provisions and hinder its implementation, being, thus, necessary to consider characteristics of some network technologies (Gorshe et al. 2014) (Mesquita et al. 2013).

We may mention PON (*Passive Optical Network)* comprising the EPON (*Ethernet Passive Optical Network)* or GPON network (Gorshe et al. 2014).

Such equipment technologies are commercialized in a wide range with definite parameters. Among the main manufactures and researchers of such technologies, we can highlight: CPQD (Centro de Pesquisas e Desenvolvimento em Telecomunicações | *Research Center and Development in Telecommunication*), Padtec (Produtos de Alto Desafio Tecnológico | *High Technological Challenge Products*) e CIANET (Mesquita et al. 2013).

In GPON networks comparing to EPON, we have:

Advantages

- They are run in different rates of downstream and upstream;
- • They work in various transceivers systems with low cost, low maintenance and a network of easy operation and maintenance together with competitive costs of equipment;
- Can take advantages from the laser ONT decrease in the costs when asymmetrically set.
- Warranties of interoperability with ONT (Optical Network termination) with a management standard in the service level.

Disadvantages

- Complexity in their encapsulation model layers;
- Ethernet / GEM / GTC have a very complex management;
- It is more expansive when compared in comparable rates with EPON technologies.

Due to advances and evolutions of studies in these technologies, it is possible to be found in scientific documents enhanced parameters regarding the aforementioned, that has been exceeded continuously for academic experimental work (Mesquita et al. 2013).

3 EVOLUTION OF THE SPEED OF THE BROADBAND NETWORKS

In the technological framework and broadband services recent studies disclose the "State of the Internet" report that lists the average speed of the fixed Internet connections of each country in the world in megabytes per second (Mbps). In 136 countries evaluated, the global average is 4,6Mbps, so the global average connection speed had a significant growth in the second quarter of 2014, increasing 21% and passing well of 4Mbps the first time (Thompson et al. 2014).

On a global scale, the fastest Internet in the world is South Korea with an average speed of 24,6Mbps followed by Japan (14,9Mbps), Netherlands (14,3Mbps), Hong Kong (15,7Mbps), Switzerland (14,9Mbps), Czech Republic (12,6Mbps), Sweden (13,6Mbps), Ireland (12,6Mbps) and United States (11,4Mbps) (Thompson et al. 2014). See the complete data in Figure 1:

The numbers are disappointing in relation to Brazil, which is in 84th position in the ranking. The national average speed of the Internet in Brazil is 2,9Mbps, for the last three months of 2014. In the analysis Brazil was the smallest country to increase the average speed in the measured period, an acceleration of only 0,2%. Reflecting a decrease of four positions in the world ranking (Thompson et al. 2014).

The speed is constantly increasing among the ten countries with the highest average speed of the internet, however it is important to highlight the Uruguay as the country with the highest annual growth rate that consists of 197% thus reaching the average speed 5,6Mbps (Thompson et al. 2014).

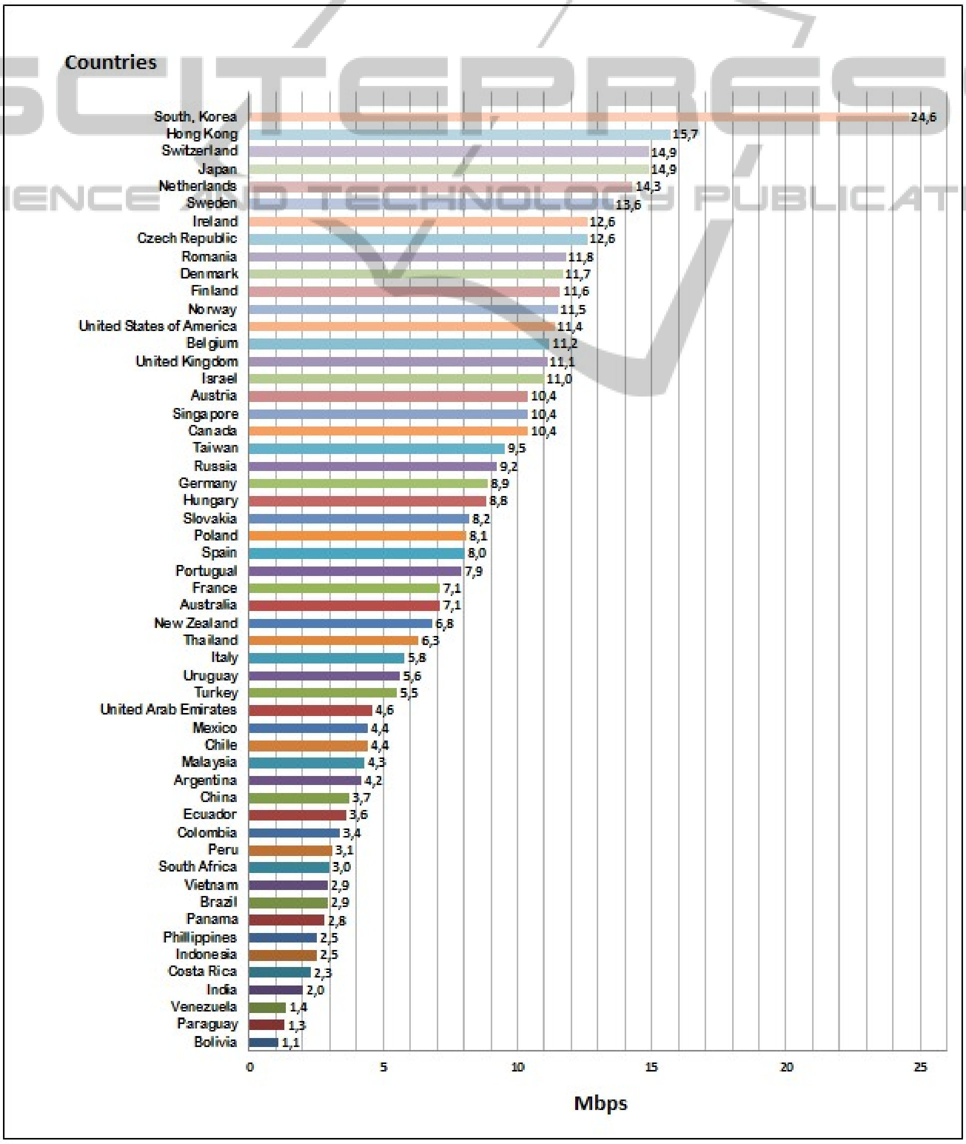

Figure 1: Average internet speed fixed broadband world (Thompson et al. 2014)

4 DEVELOPMENTS OF THE GPON PROJECT

Project was based on a Telecommunication infrastructure consisting in a mixed network of optical fiber and radio projected to an urban area that has a relief differentiation, i.e., straight part and high part that will be integrated by GPON technologies to attend ten (10) points. 80% of the network will be attended by optical fiber and 20% with radio network in Wifi technology. The remote points will be attended with a transferring rate of 300 Mbps, aiming to attend close to 100% of the project (Gorshe et al. 2014) (Mesquita et al. 2013).

The infrastructure of these technological solutions is the next-generation to attend the educational institutions who want to use technologies such as: Broadband Internet, Video Conferencing, VoIP (Voice over IP), CCTV (Closed Circuit of TV), IPTV, distance learning through an integrated solution of high capacity based on innovative technology of networks that is the focus of this work. In this project, we have a distribution of network to attend clients of the chosen test bed (Gorshe et al. 2014) (Mesquita et al. 2013).

From a financial point of view we have to take into account equipment costs and physical facilities to be carried out, for this investment Capex concept was used that joints the cost of capital, also known as fixed assets; and for the installation operations, network maintenance and skilled labor, used the Opex concept, which includes variable expenses, unfixed, called passive (Mesquita et al. 2013).

To the ROI (Return of Investment) we will use further the Payback calculations. The total investment of this project is composed of the network infrastructure of optical fiber and radio, included the civil works and the acquisition of all Epon or GPON equipment, since these devices are not equivalent in terms of performance and cost (Gorshe et al. 2014) (Mesquita et al. 2013).

We also take into account the need to carry equipment inventory to be sold to customers to receive the signal of the technologies under study. In every project we have to have a preparation of an investment proposal, where our goal is to seek product innovation to pent-up demand solutions for broadband in the whole country (Gorshe et al. 2014) (Mesquita et al. 2013).

To the investment project assessment Method: The value of a company depends on its future cash flow. Thinking about this matter, we elaborated the Figure 2 with comparison of the initial investment of the technologies in study (Gorshe et al. 2014) (Mesquita et al. 2013).

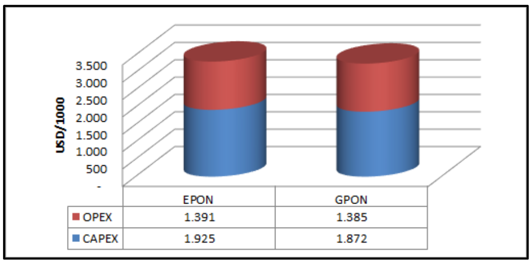

Figure 2: Sales estimate for project implementation.

Making analysis of GPON solution, we found that the GPON network solutions can integrate a complete architecture of broadband services, which can be designed to meet the fixed-mobile network convergence requirements, thus offering resources that can support the broadband access and, in this item, we have the next-generation services and connections, allocating resources through OLT (*Optical Line Termination)*, network converters, posts for receiving switch, splitter, network cables (fiber, coaxial network cable RG11, cat network cable. 5) splitters and ONU (*Optical Network Unit)*performance functions of multimedia conversion (Gorshe et al. 2014).

The data that makes up the prices are relative: the optical network to GPON equipment and the funding for project implementation.

It was planned to carry out the deployment Pops 10 (Points of Presence), each of which is composed of Pop central and terminal equipment. The amounts used are hypothetical, close to reality. The project composition also had to estimate indirect costs consist of expenses: the need to contract for labor (vendors, operators, attendants), product marketing, advertising and media. These expenses are necessary to start the operation of the network when deploying on call service (Mesquita et al. 2013).

For a real analysis, it is necessary to obtain the values of each equipment performing a RFP (Request For Proposal), which is the RFP performed through a process executed by the contracting company, so that potential suppliers can tender business with at least three (3) equipment suppliers (Mesquita et al. 2013).

It is important to highlight that for the technological development of the country, both the private sector and the government should be aligned in the search for digital inclusion as well as the industry's innovation. In the project, we elaborated a table of the total value of the network where the investor can immediately view the disbursement of Capex and Opex for both active and passive systems. The total value of the investment addressed in the composition of the initial investment Figure 2 presented the following data for analysis: Capex for investment and Opex for equipment maintenance, (we use standard 10% value). The table 1 shows an investment analysis considering the values for decision making using the concept of PAYBACK and VPL (Net Present Value). (Gorshe et al. 2014) (Mesquita et al. 2013).

The Figures 3 and 4, respectively present a comparison between the costs involving revenue generated and fixed expenses of EPON and GPON projects (Mesquita et al. 2013).

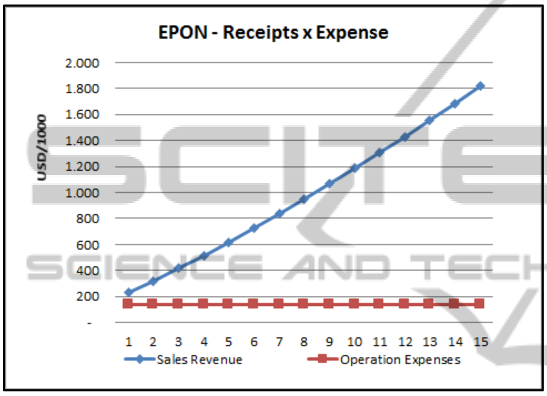

Figure 3: EPON_Receipts x Expenses.

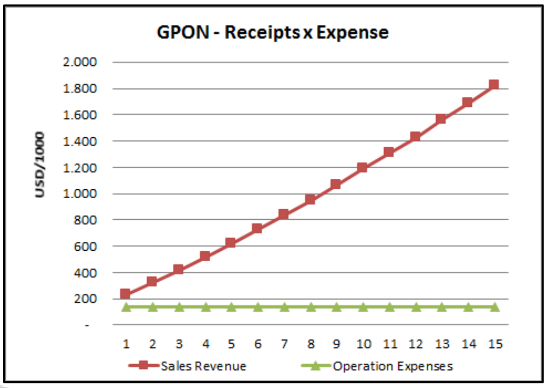

Figure 4: GPON_Receipts x Expenses.

5 ASSESSMENT OF THE OUTCOMES

Total costs of an fixed Internet service available by an International provider involves three shares related to the following stages (Oliveira, Á., 2014):

- GPON access network;
- Main trunk link that connects the access network to the router at the nearest providing international station;

Table 1: Investment analysis of technology EPON and GPON.

CASH FLOW (USD/1000)				
YEAR	NET RECEIPTS - EPON	PROJECT BALANCE	NET RECEIPTS - GPON	PROJECT BALANCE
1	92	- 3.224,04	92	- 3.164,40
2	183	- 3.041,53	183	- 2.981,33
3	277	- 2.764,42	278	- 2.703,66
4	376	- 2.388,78	376	- 2.327,46
5	478	- 1.910,63	479	- 1.848,75
6	585	- 1.326,03	585	- 1.263,59
7	**695**	**- 631,03**	**696**	**- 568,03**
8	**809**	**178,33**	**810**	**241,90**
9	928	1.106,01	928	1.170,14
10	1.050	2.155,96	1.051	2.220,65
11	1.169	3.324,54	1.169	3.389,79
12	1.291	4.615,70	1.292	4.681,51
13	1.418	6.033,41	1.418	6.099,77
14	1.548	7.581,60	1.549	7.648,53
15	1.683	9.264,25	1.683	9.331,73

	EPON PROJECT		GPON PROJECT
Payback	7,78	Payback	7,70
VPL	- 507	VPL	- 451
ROI	3,79	ROI	3,87

- Interconnection of the international provider to the router linked to the backbone of the global Internet.

The price for the service mentioned above is USD 7.115,00 monthly for a real and constant transfer rate of 10Gbps. It is worth saying that the approximate price per Mbps is USD 0,7115 monthly (Oliveira, Á., 2014).

Given the growing interest in video streaming 4k ("Ultra HD") it becomes important reference it with a metric. It is known that the ultra HD video content has adaptive bit rate, thus requiring the transmission of your data in a broadband service that provides enough bandwidth for the actual speed between 10 and 20Mbps (Thompson et al. 2014).

6 FUTURE CONTRIBUTIONS

It is being developed an analysis proposal to the implementation of a new architecture of intelligent cities with a network to support the demand of around 30.000 users. The study will be based on the project developed and planned by VIVO mobile phone company in the city of Águas de São Pedro, State of São Paulo, and by the city hall of the city of Rio de Janeiro where there is an integration project of the Marvelous City. At first in our analysis proposal, we chose UNICAMP (Figure 6, included in the appendix) (Federal University of Campinas).

7 CONCLUSIONS

The available real transfer rate of 40Mbps (Mesquita et al. 2013) has a purchasing value of USD 30,12 monthly since the 1Mbps speed matches the monthly fee of US$ 0,7115, so there is the viability of the broadband Internet service in these parameters (Oliveira, Á., 2014)..

The highest average speed of the world broadband fixed Internet consists of 24,6Mbps referring to the country of South Korea, thus we overcome in capacity and quality the aforementioned speed with the proposal made viable at constant rate, i.e., not shared at 40Mbps. This last case study enables, among other 100% guaranteed flow of data with video content 4k emerging interest which is not necessarily the case with Internet South Korea that has world supremacy as the average speed of Internet as to fully the ultra hd video traffic requires a broadband Internet service that provides at least a constant rate of 20Mbps. It is important to remember that only our case study made possible offers constant speed against the other only guarantee the average rate of data transfer. See the Figure 5 showing comparative analysis of the case study with Akamai data (Thompson et al. 2014).

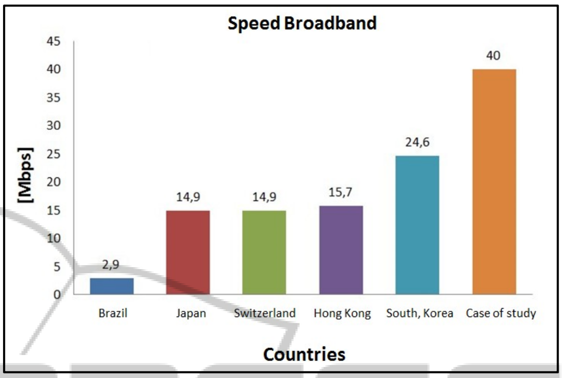

Figure 5: Comparison analysis.

Internet of things allows multimedia resources, classes and conferences on distance, turning this way the learning easier, including in a more interactive and didactic way. Expenditures for transporting the student and the teachers are considerably reduced this way.

Students' safety is intensified. Time saving is sharp. These are some of the resources and advantages that an intelligent city provided thought a broadband network with more capacity and quality, suitable for the connectivity for the internet of things.

In this context, this innovative form of rational use that takes hold of all the resources of the available technology aiming to improve teaching, characterizes what we can define as intelligent education.

Digital inclusion brings numerous possibilities for integration, promotion of social well-being (e-inclusion), supplementary education (internet toward software application with great capacity to education and to e-learning) and professional development of the students. The new educational trends include digital technology to provide better training and more appropriate qualifications for education.

The former view of teacher on the board or only textbook, no longer meets the expectations and the new way of learning in this generation, totally dependent on the use of multimedia and the ability to access to the internet of things. With the evolution of telecommunications networks and the implementation of optical fiber networks in urban and rural access, we can improve education.

The effective application of these technologies depends on techno-economic factors where often the financial interests go beyond the actual demand.

We conclude that a scenario of the best investments and costs of broadband network implementation becomes more convenient to the use of the GPON equipment due to investment values and more attractive costs.

The applications of broadband current technologies are essential and necessary for the citizens, especially the distance education. This work aims to contribute to the discussion the creation of new mechanisms and methods to be developed in order to facilitate access to quality and speed to broadband services.

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APPENDIX

Figure 6: Unicamp University City Area.