Multimedia Transmission over Optic, DSL and PLC Systems

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***Abstract*—This work presents an analysis based on an multimedia transmission generated on optical fiber backbone and two combined access technologies, PLC (Power Line Communications) and ADSL2+ (Asymmetric Digital Subscriber Line), called of pDSL. This paper points a case study of multimedia traffic using pDSL combination with intention to present measured and simulated results that prove the proposal solution viability.**

Keywords- DSL systems, pDSL, PLC, multimedia communication.

I. Introduction

The growing dissemination of information via digital mediums throughout the world brings new realities to the surface such as new technologies, increasing the feeling of dynamism in the information diffusion process and also improving the quality of life of its population. In order to supply a true increase in services to the citizen and/or to provide its social/digital inclusion in regions of typical, end-user low availability infrastructure, including geographical specificities, it is vital to take note of prior studies that represent the cost/benefit relation that is favorable to specified telecommunications solutions.

New services are based on multimedia applications, as voice over internet protocol (VoIP), video on demand (VoD), and internet protocol television (IPTV). Such services use digital broadband networks such as ADSL2+ to transmit the data, however, in regions with poor infrastructure of telecommunications, there is a natural difficult to implement acceptable technique solutions to provide these new services. Technologies that inherited the available infrastructure from other technologies can reduce the implantation impact. Access technologies like ADSL2+ and PLC, for example, have its favor the fact of ADSL2+ to be an access infrastructure already sufficiently consolidated in market, given that it uses the telephonic line for transmission of data; and PLC possesses great capillarity, being considered as an ambiguous technology, since uses energy line for data transmission. Hence, a combining solution with PLC indoor and ADSL2+ is understood as the most viable network access to promote actions on digital inclusion in regions like Amazon.

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There are some researches about multimedia transmission using PLC and pDSL for areas with poor telecommunication infrastructure [1]-[3]. In [1], authors present a study on the PLC technology as a proposal for a feasible access network for Brazilian Amazon. In [2] [3], authors present an analysis based on an IPTV transmission using pDSL as last mile technology.

This paper is organized as follows. In section II we explain some concepts DSL, PLC and pDSL systems. In section III the simulated scenario is discussed. In section IV is presented the used methodology for the tests. In section V the measured and simulated results for a pDSL system are presented. We conclude the paper in section VI.

II. DSL, PLC and pDSL Systems

DSL system is a technology that provides transport of high-bit-rate digital information over telephone subscriber lines. The term xDSL covers a number of similar yet competing forms of DSL, including ADSL, ADSL2, ADSL2+, SDSL (Single-Pair DSL), HDSL (High-Bit-Rate DSL), RADSL (Rate-Adaptive DSL), VDSL, and VDSL2 [4].

DSL technologies have being considered the most dominant broadband technologies, not only in Europe, but also in Latin America and in developing countries such as India [5]–[7]. DSL technology is responsible in Latin America for around 77% of all current broadband access, whereas in Brazil, this value is as high as 85%. In quantitative terms, at the end of 2005 there were almost 5,300,000 Latin American ADSL technology sign-ups [6].

Standardized in 2005, ADSL2+ is normally bundled into one upgrade to the ADSL system by the service provider. This upgrade has opened the door to new video service support capabilities and a host of new service offerings from the service providers [8]. ADSL2+ use double the downstream bandwidth as compared to the ADSL2 transceiver defined in ITU-T Rec. G.992.3. Systems support a net data rate ranging up to 16 Mbps downstream and 800 kbps upstream [9].

PLC technology uses the existing electrical infrastructure to provide data communication. This technology has shown to be sufficiently competitive in the broadband access market, disputing with other traditional ones, such as DSL. PLC has an additional advantage of having a significant wide infrastructure and with relatively little associated cost [10].

However, PLC, as well as other data communication technologies, has some inconveniences. The physical environment is very hostile for the data due to the fact, that it was not conceived for this purpose. Thus, there are many properties of the power systems which affect negatively the high speed communication (losses in the cable, propagation in multiple paths and the noise, for example) [11] [12].

Electric energy is not the most indicated or suggested environment for data communication, given the physical characteristics of the conductor and its nature. The propagation of the signal through the power transmission line provokes attenuation and a delay in the signal, which increases with the distance and the frequency.

The topology of the power distribution networks considerably differs from the traditional communication networks, such as twisted pair, coaxial cable or optical fiber. Numerous reflections of the signal are received and occur mainly due to the junction of cables of different impedances.

pDSL network consists of a high speed links configuration between PLC gateway and multiples pDSL devices. Such devices use channel training procedures to place bandwidth for each virtual link. In [13] was carried through a study that describes the criteria for excellent performance of bandwidth allocation for links in pDSL networks.

An indoor pDSL network has two device categories that are connected to its terminal point (electrical plug), they are: digital equipment that requires high speed transmission (known as pDSL devices), such as computers; and devices that do not make use of such services, even using the same force line.

III. Simulated Scenario

In order to verify the feasibility of the pDSL technology for digital inclusion purposes, a fictitious scenario of a Regional Training Center (RTC) was used. The RTC implantation is part of a set of governmental actions being made in the State of Pará, in partnership with the Power Suppliers of the North of Brazil S.A. (Eletronorte); which is making a high investment in network infrastructure, thus seeking ways to spread the education and the digital inclusion in currently unprovided areas. Using the Eletronorte fiber-optic backbone (showed in Fig. 1), an infrastructure could be created to provide high speed internet in distant cities, which would need a last mile technology to receive these information; fact that motivated this paper. More details about others studies involving this project can be found in [2].

Figure 1. Eletronorte backbone.

A RTC is composed by one computation laboratory, with ten (10) computers, one of them serving as a gateway between a PLC indoor network and ADSL2+ access network (pDSL). Similar RTCs laboratories would be distributed around the State of Pará.

Fig. 2 shows the simulated scenario using three technologies: optical fiber, ADSL2+ and PLC.

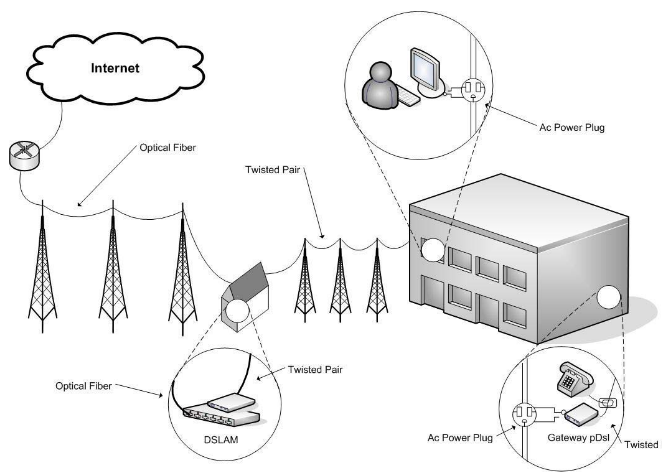

Figure 2. Simulated scenario.

IV. Methodology

The used methodology in this work was divided in two parts: measurements and simulations. First, a set of measurements was made in order to characterize each technology individually. After that, the results were used into a simulation scenario to evaluate the performance of the pDSL system.

In order to obtain the measurements, it was used the equipment AX4000 from Spirent Communications. This equipment generates and to analyzes the upstream and downstream data flow. Using AX4000 it was collected three metrics: packet loss, delay and throughput. These metrics were used as an input file for a simulation script of the Network Simulator (NS) [14].

There are two measurements scenarios: DSL and pDSL. DSL scenario was composed by an ADSL2+ modem, a real cable of 1,500 m length and 0.5 mm gauge, and a DSLAM (Digital Subscriber Line Access Multiplexer). PLC scenario was composed by an indoor PLC gateway and an indoor PLC modem.

V. RESULTS

A. PLC Measurements

Table I shows the obtained results for data transmission on PLC system. These results were used to characterize the pDSL system simulation.

TABLE I. MEASUREMENTS ON A PLC SYSTEM

Downstream		**Upstream**	
Rate (Mbps)	Delay (ms)	Rate (Mbps)	Delay (ms)
6.158	12.469	6.141	12.520
6.155	12.498	6.150	12.499
6.135	12.538	6.138	12.520
6.142	12.518	6.129	12.540
6.144	12.511	6.157	12.474
6.137	12.524	6.127	12.505
6.136	12.510	6.130	12.537
6.131	12.550	6.125	12.547
6.141	12.508	6.149	12.482
6.140	12.510	6.142	12.526
Mean Values			
6.1419	12.5136	6.1388	12.515
Standard Deviation			
0.008595	0.021971	0.010952	0.024563
Confidence Interval (α = 0.05)			
0.005327	0.013617	0.006788	0.015224

The packet loss rate for downstream and upstream was 1.87E-3 packets/s and 2.50E-3 packets/s, respectively. Fig. 3 shows the packet loss during 5 minutes of observation. This behavior was due to the noise in the transmission line.

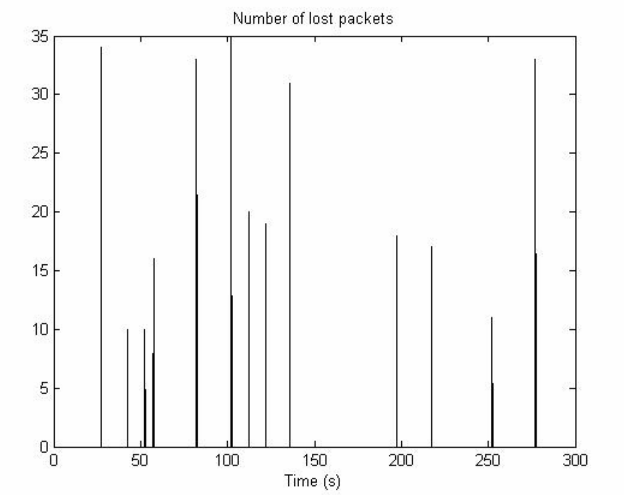

Figure 3. Lost packet for multimedia transmission on PLC system.

B. DSL Measurements

Table II shows the obtained results for data transmission on DSL system. In the same way as the PLC measurements, these results were used to characterize the pDSL system simulation.

TABLE II. MEASUREMENTS ON A DSL SYSTEM

Downstream		**Upstream**	
Rate (Mbps)	Delay (ms)	Rate (kbps)	Delay (ms)
9.799	8.334	939.360	283.882,
9.799	8.334	950.360	283.877
9.799	8.334	950.365	283.894
9.799	8.334	936.180	283.883
9.799	8.334	944.920	283.886
9.799	8.334	941.645	283.863
9.799	8.333	940.703	283.863
9.799	8.332	833.888	283.881
9.799	8.334	936.202	283.826
9.799	8.334	840.197	283.844
Mean Values			
9.799	8.3337	921.3834	283.8686
Standard Deviation			
0	0.000675	44.75214	0.021972
Confidence Interval (α = 0.05)			
0	0.000418	27.73716	0.013618

There was not any kind of impairment (impulsive noise or crosstalk) injected in the loop. Just the background noise was considered. Additional studies about the DSL noise impact on pDSL systems are in progress.

C. NS Simulations

Table III shows the obtained results for simulation using NS.

TABLE III. SIMULATIONS FOR A PDSL SYSTEM

	Delay (s)	Jitter (s)	Throughput (kbps)	Lost packet (packets/s)
Video	0.040820	0.000078	831.20	0.002081
VoiP	0.039001	0.001163	53.08	0.004471
HTTP	0.129976	0.131635	155.71	0.001195

It can be observed that delay and jitter for video and voice transmission have acceptable values [15]. These results indicate that pDSL is a feasible solution to provide multimedia services.

Fig. 4 shows the obtained total throughput in simulations. Video and voice have an almost constant throughput and such characteristic is attractive when there is a SLA (Service Level Agreement) to be achieved by service providers.

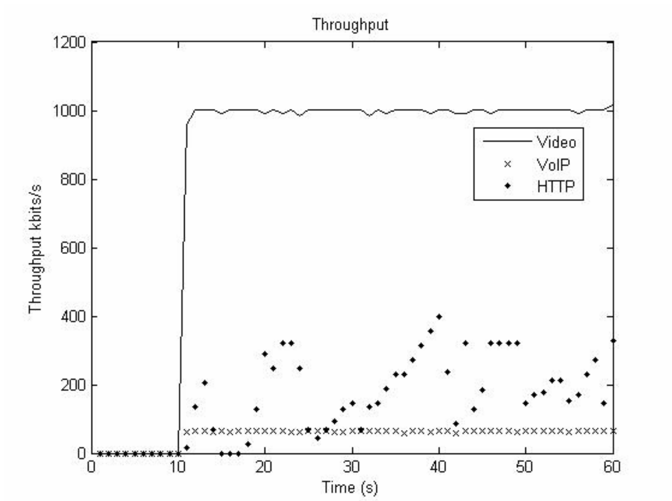

Figure 4. Total throughput on a pDSL system.

VI. CONCLUSION

This work presents results of an experimental and simulated multimedia transmission for an optic system using ADSL2+ and PLC indoor as last mile solution.

Multimedia traffic is a promising service to be provided over broadband access networks. The utilization of the existing electrical infrastructure of the user residence decreases the costs of the service. It can be a differential between to provide or not a service in regions with few infrastructures of communications.

Once the DSL have being considered the most dominant broadband technologies in the world, their utilization together PLC can be a reasonable solution for areas like Amazon region.

The obtained results in this paper indicate that pDSL is a feasible solution to provide multimedia services. Additional studies using other access technologies like wireless broadband networks are in progress.

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