AN OVERVIEW OF PLC NETWORK PERFORMANCE IN PRESENCE OF HOUSEHOLDS INTERFERENCE

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Abstract: This paper presents an overview of PLC. In addition the paper shows the performance of a PLC using an experimental LAN network in presence of different types of noise caused by households. This paper also presents the experimental results to find the best TCP window size to be used in a PLC network. The performance investigation was accomplished in the Telecommunication laboratory of Federal University of Mato Grosso, Brazil.

1 INTRODUCTION

Power Line Communication (PLC) is growing interest in the prospect of reusing in building power line cables to provide a broadband LAN within the home or office. The major advantage offered by power line based home networks is the availability of an existing infrastructure of wires and wall outlets. The use of this medium for communications at higher frequencies presents some technical challenging problems (Ferreira and Grové, 1996) (Philipps, 1998) as interference. Electric appliances with brush motors, switching power supplies and halogen lamps are examples that produce impulsive noise that can reduce the reliability of communication signals (Gotz , Rapp, and Dostert, 2004) (Sutterlin and Downey). The objective of this paper is to present the performance of PLC network and evaluate it with different households' interferences.

2 AN OVERVIEW OF PLC

PLC is a set of equipment, software and management services that when overlaid on the electric grid provides users with communication means over existing power lines (cables transmitting electricity) (Paulidov and Han Vink, 2002).

In Brazil we have only 14,49% of houses with computers that access internet. Half of this value uses broadband internet. Therefore PLC will have many opportunities to offer broadband to homes and small offices. On the other hand, power lines have many problems to overcome. Noise in power lines is a significant problem for data transmission (Ma and So, 2005). This is because it rarely has similar properties to the easily analyzed white Gaussian noise of the receiver front ends.

Typical sources of noise are brush motors, fluorescent and halogen lamps, switching power supplies and dimmer switches. The noise in power lines can be impulsive or frequency selective in nature and, sometimes, both. The noise in power lines can be classified into four categories (Hrasnica and Haidine, 2004): Colored noise, narrowband background noise, periodic impulsive noise and impulsive noise.

Due to the above mentioned power line channel characteristics, it is necessary to carefully select modulation schemes and sophisticated error correction and detection technologies for forming up reliable physical layers as a basis for robust PLC. In this paper the PLC equipments work with multi carrier modulation in the form of orthogonal frequency division multiplexing (OFDM)

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(Sugimoto, 2002) (Langton, 2004) (Pinto and Albuquerque, 2002).

3 PLC NETWORK ELEMENTS

PLC network uses the electrical supply grids as a medium for the transmission of different kinds of information and the realization of various communications and automation services. The basic network elements are PLC adapter, PLC base/master station and filter.

4 THE PLC ADAPTERS CHARACTERISTICS

In this paper the adapter used was an AV200 power line Ethernet adapter and a filter. Both from Corinex. This Ethernet adapter supports distribution of video, voice and broadband internet access over premise existing electrical wires. The AV200 PLC Corinex features are (AV 200, 2007):

- 10/100 Base T Fast Ethernet interface;
- Physical data rate in the power line up to 200 Mbps with distances up to 300 m;
- OFDM technology and powerful error correction system
- Frequency operation from 13.3 to 33.3 MHz.
- MAC filtering can discard Ethernet frames if they come from source MAC address which is not present in a list of allowed MAC addresses.
- Integrated 802.1 Q VLAN.

5 PLC NETWORK CONFIGURATIONS

In order to investigate the PLC network performance, this paper uses a simple LAN network configuration illustrated in figure 1. The filter was used in PLC network to isolate this network from noise, or traffic, from the rest of the electrical grid.

A test was accomplished to verify the performance results using a configuration showed in the figure 2. It was used to verify and certify that the filter really isolates the electrical noise produced by household appliance. Two analyzers were used simultaneously to guarantee that the result during the FTP process was almost the same.

6 EXPERIMENTAL RESULTS

In this paper were investigated the PLC performance in a best condition and normal condition and in the presence of households interference. It was also accomplished an evaluation related to the efficiency result considering the increase of the TCP window size. All parts of the tests were run five times and the average result will be showed in this paper.

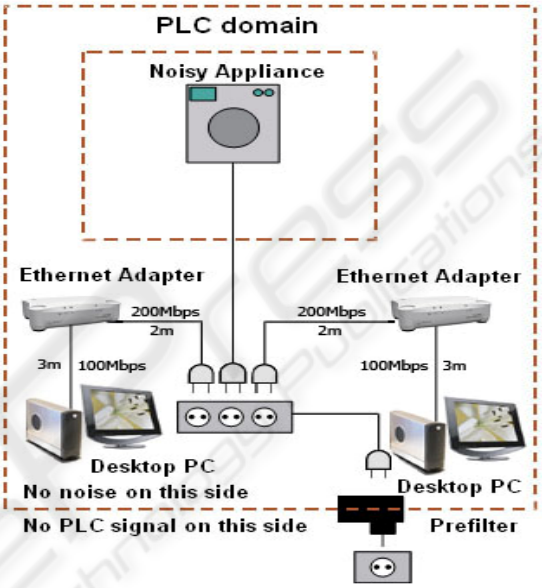

Figure 1: Simple network configuration.

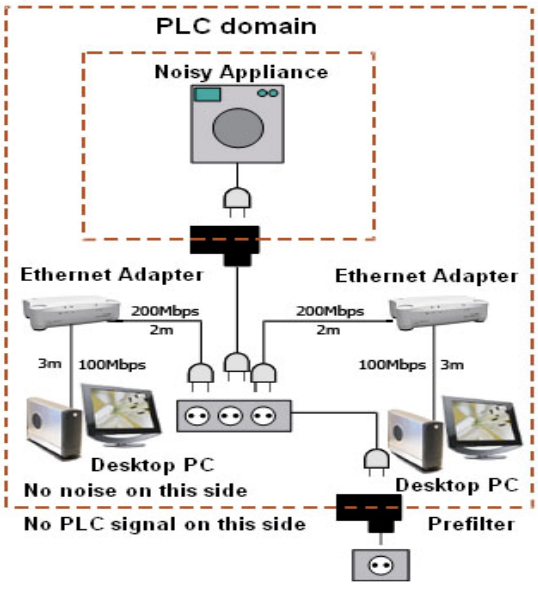

Figure 2: PLC network configuration with an electrical appliance noise over a PLC filter.

6.1 PLC Performance Considering the Best Condition

The first experimental tests were used to verify the performance of the PLC network using the network configuration of the figure 1 without electrical noise appliance and using an appropriate filter. The result is shown in figure 3.

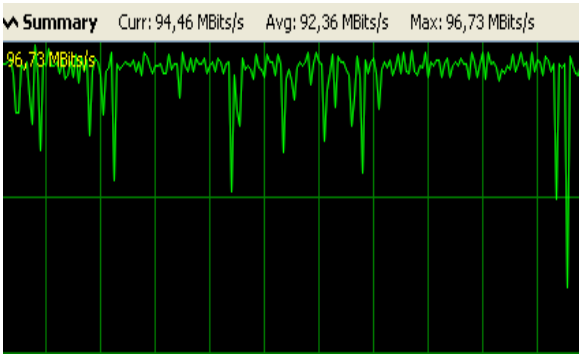

Figure 3: Throughput result of PLC network without noise presence and using a noise filter.

Analyzing the graph it is possible to note that the average throughput was 92.36 Mbps and the maximum throughput obtained was 96.73 Mbps. Therefore the efficiency result is 92.36%. The PLC channel bandwidth is 100 Mb because it is limited by 10/100 Base T Fast Ethernet interface that interconnects the PLC adapter with the computer. In the computer it was used GB Ethernet board. In this condition the efficiency is almost the same of using an Ethernet LAN. The reason is that the noise filter is really able to avoid external interference provided by households.

After this, it was used some electric household as mixer, TV, ventilator, blender, electric razor, hairdryer, dimmer, halogen lamp and switch power supply to generate noise on the PLC network and to evaluate the result performance. The throughput result is showed in figure 4**.** It was used the network configuration of figure 1. The analysis made with halogen lamp and mixer showed that they also affect the performance of the PLC LAN network.

Analyzing the graph, it is possible to verify that the use of TV with ventilator together operating in the LAN network offer very low noise and therefore the efficiency reached was almost near the best condition obtained. While the best condition efficiency is 92.36%, the result with the presence of TV and ventilator reached 90.6% of efficiency. Then the conclusion is that these two households produce low noise that does not damage the computers during data transfer using a PLC network.

On the other hand, the others electric equipments affect directly the PLC network efficiency.

This happens because these households produce impulsive noise that is very damaging to PLC networks. The worst results were obtained using switch power supply. The efficiency result was less than 1%. Therefore the use of noise filter is necessary to protect the network communication avoiding a drastic reduction of the PLC LAN network efficiency.

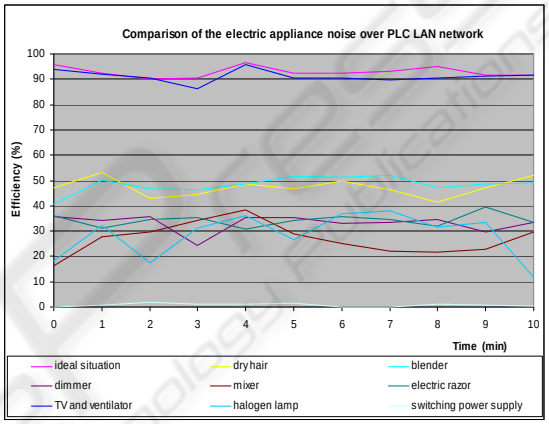

Figure 4: Efficiency result of PLC network considering a noise presence from electrics appliances.

The efficiency reached by them was less than 30%. Then it is important to use a noise filter for each halogen lamp and for the use of mixer. When a dimmer and electric razor was tested the efficiency result was less than 40%. Finally it was tested a hairdryer and a blender which the efficiency result was near of 50%.

These results prove that when there is an incidence of noise it is necessary to use an appropriate filter to avoid low efficiency in a PLC network. The Corinex noise filter tested really solved the interference caused by the analyzed households. Therefore PLC network is indicated to be used at residences and small offices with excellent performance.

6.2 PLC LAN Network Evaluation Related to the Increase of the TCP Window Size

One of the main factors for the TCP/IP architecture over PLC networks to become attractive is to make the available bandwidth in the link capable to be

large used during data transmission. To make this happen it is possible to increase the initial congestion window (Paduri, 1998) (Zattar, 2007). The figure 5 shows the throughput results for each TCP window size.

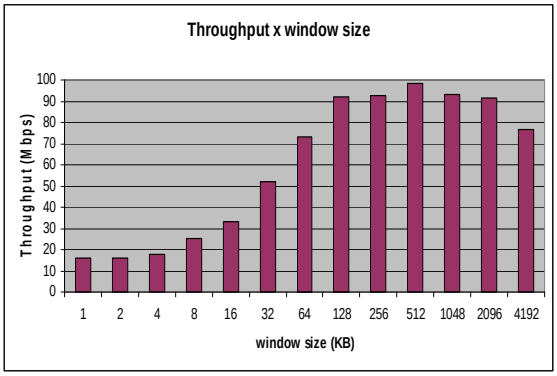

Figure 5: Results from PLC LAN network related to the increase of the TCP Window size.

Taking a look at figure 5 it is possible to note that with the increase of the TCP window size, the throughput results grow. The maximum efficiency is reached with TCP window size of 512 KB. For this situation the efficiency result was upper than 90%. For the TCP window size upper than 512 KB, the PLC LAN efficiency become lower.

6.3 PLC Performance in a LAN without Noise Filter

It was accomplished the analysis of the PLC considering a LAN without noise filter as showed at figure 1 without using a noise filter.

The results obtained are presented in figure 6. The TCP window size was 512 KB. Observing the graph of the figure 6 the throughput average was 86.44 Mbps and the maximum throughput reached was 96.76 Mbps.

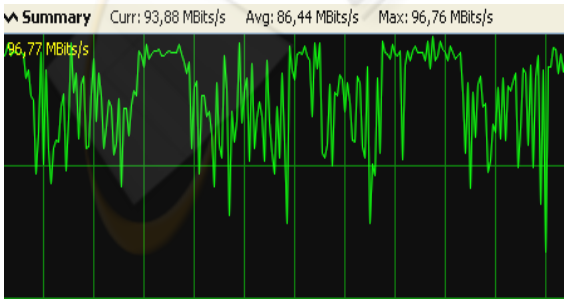

Figure 6: Throughput result of PLC network without an appropriate filter.

7 CONCLUSIONS

This paper showed the analysis performance of PLC network considering a best condition for a LAN. Another analysis was made evaluating the efficiency result considering the interference presence by some households. The worst efficiency was obtained when it was used a switch power supply. The results obtained considering the increase of TCP window size showed that 512 KB is the most adequate size for the PLC LAN network. For an operating of a PLC LAN network it is fact that the noise filter is necessary to reach high efficiency result.

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