Approximation Hierarchy Model approach into B-PLC based on ATM

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Abstract. In this paper, we present applications using *Broadband-Power Line Communications* (B-PLC) networks in low voltage conditions; improving multi-objective paths as a function of base station (BS) and channel allocations (CA). Considering the B-PLC network hierarchy model approach based on ATM Networks, we identified the basis for *Generalized Base Station Placement* (GBSP), minimizing costs and maximizing coverage as well as the *Signal Noise Rate (SNR)* and *Channel Frequency Response (CFR)*. The development of an Approximation Hierarchy Model considered modulations aspects to achieve B-PLC operation. This work considers Frequency Division Duplex/ over Time Division Duplex (FDD/TDD) and Time Division Multiplexing Access (TDMA), within a B-PLC electrical network, and the SNR was maintained without important variations. The behavior of different communication channels of the same B-PLC network with different technology permitted observing its complete compatibility.

Key words: MV-LV, networks, B-PLC, GBSP, SNR.

I.INTRODUCTION

A B-PLC network access consists of CPEs (*number of user terminals*) that transmit and receive traffic in a shared medium from an Electrical CS (*centralized station*).
The REP (*repeaters*) are normally inserted in the B-PLC network in order to retransmit the signal and thus increase coverage, as the signal is too weak to reach all CPEs from the same CS (*centralized station*). Repeaters can be either TDR (*Time Domain Reflectometry*) or FDR (*Frequency Domain Reflectometry*).
Network topologies are commonly expressed as ring shaped; but in the LM and MV, are reduced to a CS (*centralized station*) considering the repeater structure. Therefore, the topologies considered by B-PLC access network are based on tree-like descriptions, depicted in figure 1, in which a central node called a CS (*centralized station*), concentrates all up and down stream traffic.

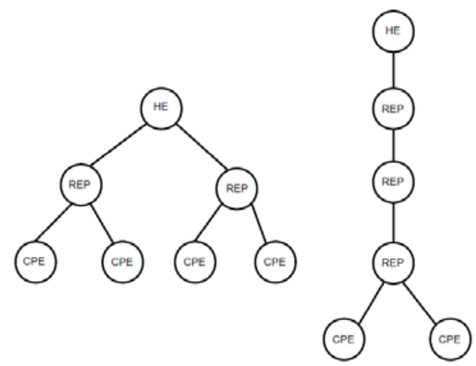


Figure 1. Typical Access Scene.

The B-PLC is a tool used to provide telecommunication services such as: internet, IP-telephones, etc, using LV and MV lines, thus saving in investment, installation costs, and network access. Therefore, most MAC (*Media Access Control*) techniques are candidates to be used in B-PLC environment communications, that provide: accessibility, proactive containment and arbitrary protocols. Normally, these topologies are described as busses or trees, but the last processing step for MV and LV requires the tree model.

Gateway traffic communication in B-PLC terminal service network is usually located in a MV transformer, allowing it to operate within a WAN (*Wide Area Network*).

This paper does not focus on the enormous complexity that exists in creating topology communications or telecommunication networks, leaving experts to research this area, considering the aspects such as: control versatility connections and low costs involved in installation.

B-PLC network which functions *in* "*the last mile concept*" is integrated by an MV-LV electrical network as a WAN hybrid solution. This methodology uses a physical grid area, supported by VCP (Virtual Connection Path).

The first part of the grid is based on the ARQ technique (*an engine for Java framework building Semantic Web applications*) oriented by point-to-point connections. The second adapts the Hierarchy Model Approach to ATM [1]. So that, this carries out the base station placements and channel allocation model considering multi-objective concepts [2].

The B-PLC methodology requires stage numbers, based on the Hierarchical Model Approach identifying and scheduling stages by medium and low voltages, with respect to the topology proposals.

A typical B-PLC access network is shown in Figure 2, where the BS (base station) is built into the transformer station by MV (medium voltage), inserting the information signal in the low-voltage line cable, using a modem device to connect the terminal end-user power cables [2].

The network efficiency operations depend on a set of design parameters where one is the optimal routing for medium and low voltages. The efficient routing design policy has enormous complexity, because it is a function of: a) uncertain variables and unknown parameters sets, b) bandwidth and performance that the network must support, and c) SNR parameters. The policy routing has traffic supplies and topology changes.

II. MEDIUM AND LOW VOLTAGES NETWORK STRUCTURE

Electricity distribution networks are formed by three main levels as shown in Figure 3: a) *High voltage network,* consisting of the highest grid voltages, b) *Middle and c) lower voltages* that transmit *data*.
In this paper we are interested only in showing the half grid and low-voltage access broadband networks.

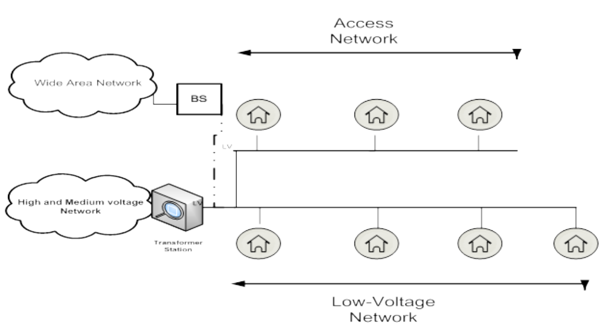


Figure 2: B-PLC access network.

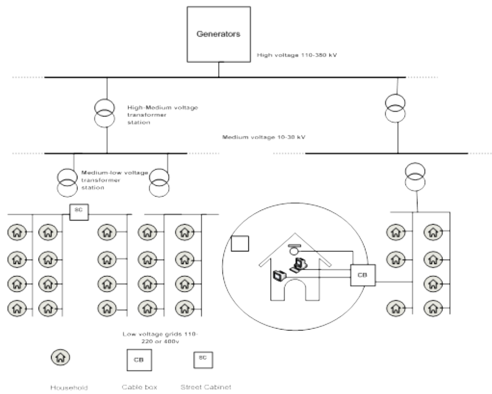


Figure 3. B-PLC power described as grid structures.

Medium-low voltage networks MLV-Ns have different structures for each location, observing the great differences between urban and rural areas, as well as residential or industrial users, changing the operational conditions. Either way, taking into account environmental conditions, MLV-Ns gives a structure classification. An example of this was proposed in [3], categorizing the grid structures for medium and low-voltage lines in agreement with the following type conditions:

A: Scattered building establishments.
B: Villas and mainly agricultural buildings.
C: Small houses with low density establishments.
D: Family homes with high-density establishments.
F: Buildings rows with low density.
G: Tall buildings rows with high density.
H: Separate building blocks.
I: Medieval towns.

The influence of the above conditions in the MLV-Ns considers two grid power structures classified as types B and C, shown in Figure 4 and Figure 5, respectively. These figures show what we call an "island of medium / low voltage." An "island" means that the set (or entity) is formed by a transformer, telephone box or energy user that connects to this system. In this research, we believe that the “islands” are independent in each division, having uncorrelated scheduling.

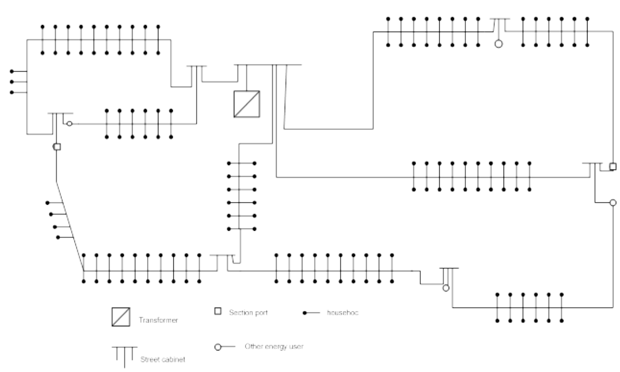


Figure 4. Type C structure established for low-voltage power grid.

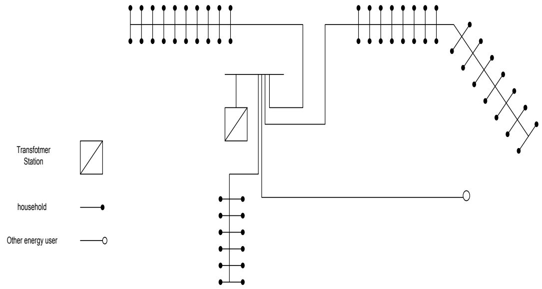


Figure 5. Type B and C structures established for Rural MLV-N.

III. HIERACHICAL APPROACH MODEL AND ITS TOPOLOGY APPLICATIONS

The hierarchical approach design is a reference model where the strategic design of the communication networks has many layers. For example, the OSI model allows intercommunication between two computers through layers. This modular concept has many elements to be used reducing the design complexity and providing fault diagnosis locations [4].

The hierarchy model approach is shown in Figure 6.

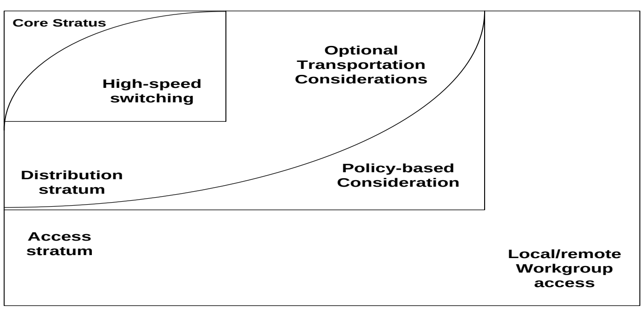


Figure. 6. Hierarchical model approach.

a. Heart level

This level is defined as part of the ridge of the available high-speed network. In this part we assign the topological arrangement of the medium voltage network. It is described as the backbone of the switches and its operation is based on the established virtual path connections between switches. This determines the necessary connections provided by each B - PLC subnet [4].

b. Distribution Level

This level refers to the demarcation boundary between the access layers and the network core. This includes management aspects such as: traffic routed to specific interfaces, security, broadcasting definition domains, and communicating between different protocols. It can also specify limit and dynamic routing protocols.

Therefore we believe that BS (base stations) with a link to the end users, mark the distribution level, and determine the B-PLC technology for medium and low voltage. The first level indicates a routing environment and assignment working groups as well as the allocation of signaling protocols. The number of BS and their locations should be optimally chosen in order to be available to serve all users with minimal costs. Within the BS we find the right position and determine the users sub-set to be served. In some cases, one user needs a repeater to enhance the quality if the distance is longer than the coverage. All these tasks are related to its placement [6].

c. Access Level

At this level, the users have access to local segments on the network. Assuming that the B-PLC system uses the OFDM [7] system, each BS must have a certain number of B-PLC channels, which can be used to communicate to the subscribers. The number of channels should be allocated to cover traffic generated by users on the BS. Furthermore, the channel allocations must not cause harmful interference to the nearby BS. This problem is not taken into account by the B-PLC and B-channel allocation (CAP - PCAP). The B-PLC M-LVN network structure determines the outcome of the approach model network hierarchy. Finally, this classification determines the scheduling operability for multi-objective problems.

IV. SCHEDULING ACCESS AND BASE STATION PLACEMENT

The main task for B-PLC scheduling transforms the M-LVN applying the Approach Hierarchical Model into B-PLC, as shown in figure 7.

An example of a LVN typical structure considered in [4] is shown in Figure 8, where a B-PLC site is a set of nodes or cells. Figure 9, shows a node or cell as an entity composed by BS users, repeaters and a B-channel subset.

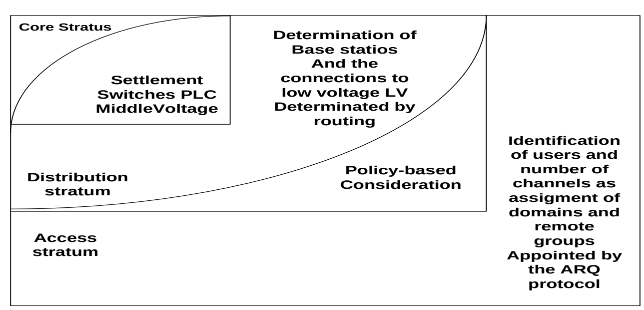


Figure 7: Hierarchy B-PLC network standard approach.

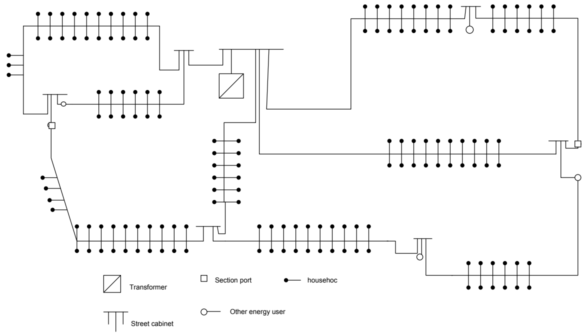


Figure 8. Type C structure established for low-voltage network topology.

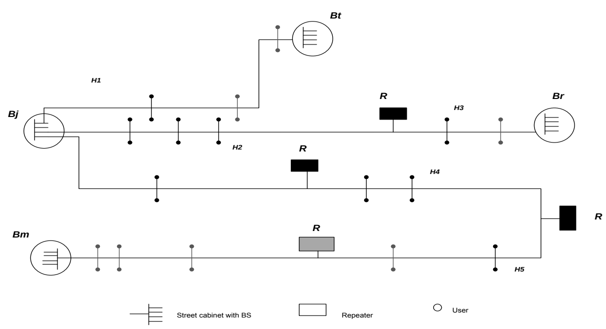


Figure 9. B-PLC site described as battery cells.

B-PLC integrated cells are connected to a Base Station (BS) as a backbone telecommunications network also called Wide-Area Network (WAN) giving provision services. Integration cells and connectivity depend on the following tasks. The first defines the optimal Base Station (BS) placement with respect to PLC cells. The second identifies the repeater placement (RP), and the third schedule serves as a base for signal limits coverage, place locations and repeater stations.

All of these tasks assume that the Wide-Area Network access points (WAP) are available and known, operating through optimal lines or wireless, or a combination of both.

The BS access problems are classified as:

- Base station placement (BSPP).
- Repeater placement (RPP).
- WAP.

This solution using electrical lines lowers cost investment with respect to other WAP applications, thus accomplishing the following conditions:

- Minimize costs and hindrance or postponement.
- Maximize coverage, network ability, effective use capacity and scope.

Therefore the solution of BS identification is primarily focused on the hierarchy model approach according to type C topology in order to have acceptable quality service levels and network performance. Figure 10 shows the BS problems, considering the electrical panel and its details, and specifying the correct location.

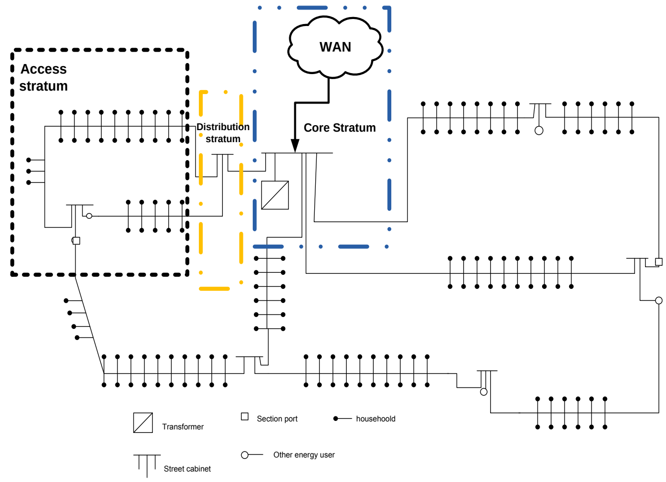


Figure 10. The BS hierarchy model approach.

This scheme contemplates B-PLC technology using the FDD/TDD modulation. Considering there are other modulations applied to B-PLC modems, it is possible to use the Approximation Hierarchy Model in a strict sense, solving the compatibility problem between different B-PLC modulation channels. In this experimental development, a scenario was established in which the operation was successful with two modulations in the same PLC network.

V. Experimental Development

According to previous sections, the first three stages HE explain an arbitrary location in the grid, and the second locates the correct position of HE according to the hierarchy model approach. The noise ratio with respect to the first stage is less in B-PLC cells, considering 20 meters as an average distance [8]. The third stage was monitored obtaining 30 dB on average for SNR transmissions. Model 1 considered the Communication Center for Television and Radio located in Mexico City, shown in Figure 11, followed by its line diagram, identifying the CPE and HE locations. The SNR and CFR (Channel Frequency Response) are shown in figures 12 and 13, showing local and remote measurements, respectively under Low Voltage [9].

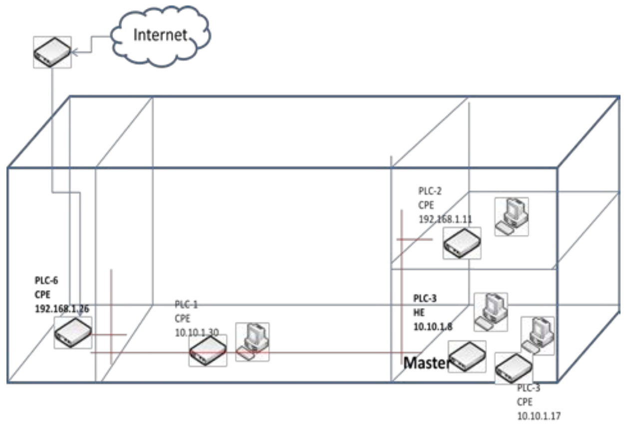


Figure 11. The distribution area considered for Model 1.

These costs have acceptable guarantee levels, quality and network performance services.

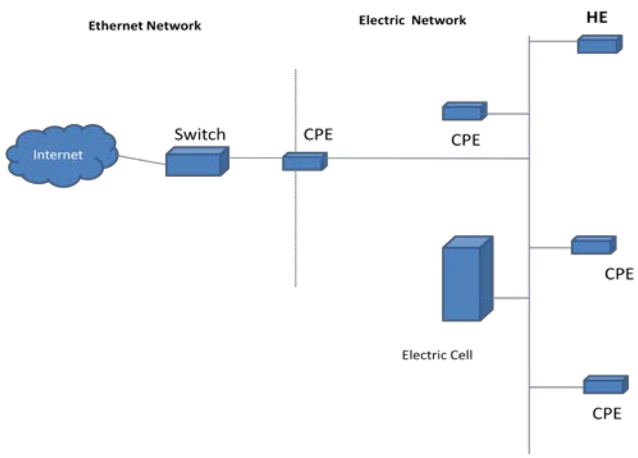


Figure 12. First scene considering diagram lines.

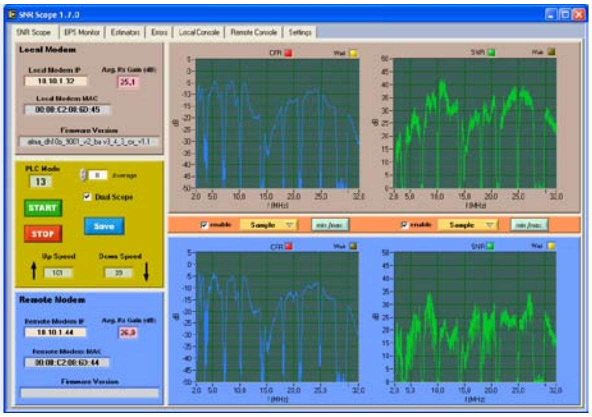


Figure 13. SNR and CFR readings.

In the second scene the line diagram is shown in figure 14 and CFR and SNR are shown in figure 15. Applying the hierarchy model approach the distance from the electric board and HE is greater than in the first scene.

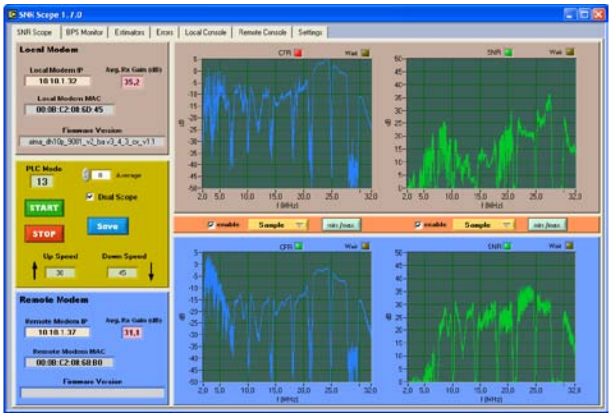


Figure 14. Second scene diagram lines.

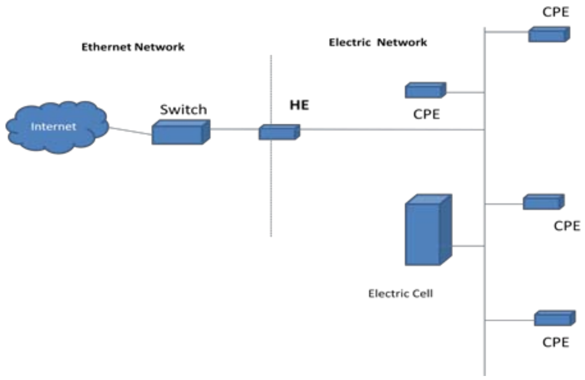


Figure15. CFR and SNR readings.

The third scene shown in figure 16, uses the most accurate hierarchy model approach with other electrical networks, using the CNM electrical school net (located in Mexico city), where the larger structure in wiring has about 400 meters, shown in figure 17, which obtained an average reading of around 30 dB and SNR around -5 dB, CFR as shown in figure 18.

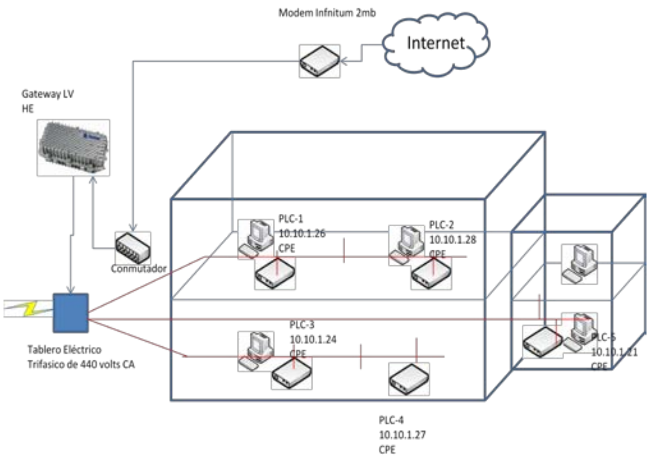


Figure 16. Third scene

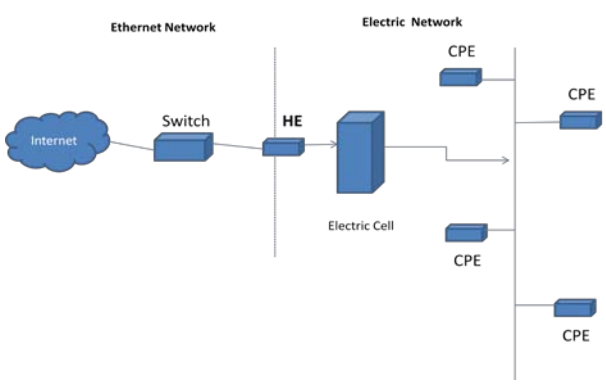


Figure 17. Third scene diagram lines.

Figure 18. SNR and CFR readings.

In figure 19, we plan a fourth scenario which proposes two PLC networks with different modulations. Network 1 FDD/TDD modulation and network two, TDMA modulation.

In our study the installation process is implemented according to the Approximation Hierarchy Model (figure 20) [10]. The result is compatibility between both technologies, and the transmission channel assignation that does not provoke interference with respect to the MAC directions assignation.

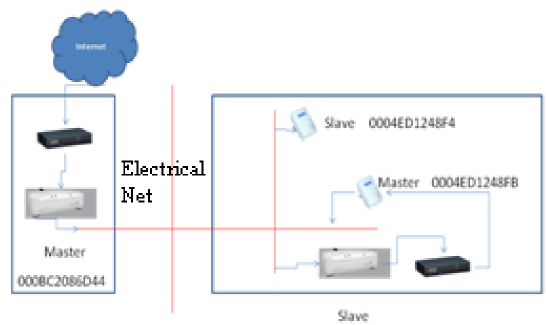


Figure 19. The Approximation Hierarchy Model approach using B-PLC.

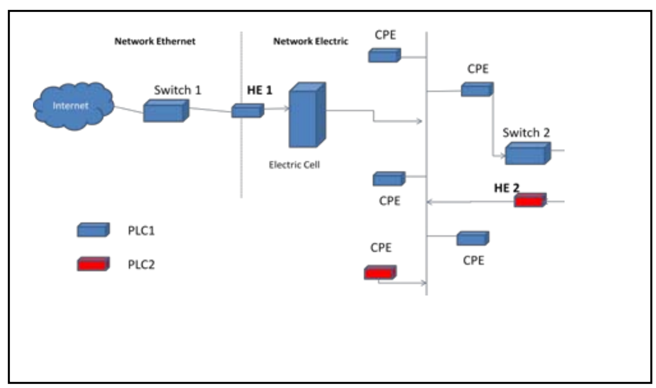
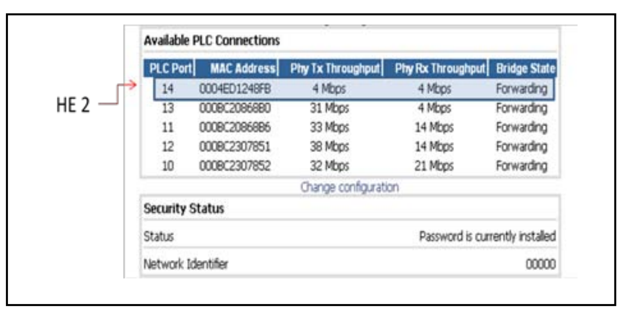


Figure 20. Line Diagrams.

The channel assignation in figure 21, shows the MAC direction and the speed of the PHY transmission level.



Available PLC Connections

PLC Port	MAC Address	Phy Tx Throughput	Phy Rx Throughput	Bridge State
14	0004ED1248FB	4 Mbps	4 Mbps	Forwarding
13	000BC20868B0	31 Mbps	4 Mbps	Forwarding
11	000BC20868B6	33 Mbps	14 Mbps	Forwarding
12	000BC2307851	38 Mbps	14 Mbps	Forwarding
10	000BC2307852	32 Mbps	21 Mbps	Forwarding

Change configuration

Security Status

Status	Password is currently installed
Network Identifier	00000

Figure 21. Communication channel assignation at PHY level.

The SNR study was made using the same values scheme without modifying the measures such that the compatibility of both schemes did not suffer channel interruption, operating as one network. As a future work we can contemplate identifying the behavior of the modulations using the MAC directions [11], [12].

Taking into account the Approximation Hierarchy Model in its original scheme, allows modulating with Core Stratum level, determining the electrical network preparation. We inserted the corresponding frequencies and generated B-PLC modems communication channels with respect to the modulation (Figure 22.)

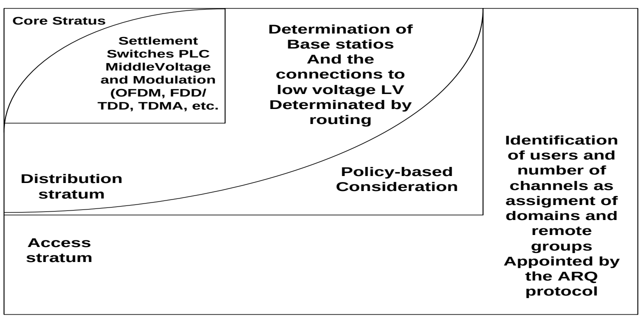


Figure 22. Approximation Hierarchy Model with different B-PLC digital modulations.

V. CONCLUSIONS

In this paper, we analyzed the B-PLC network scheduling implementation for medium and low voltages, using a Hierarchy Model Approach such as ATM network. The requirements and problems were analyzed improving multi-objective paths which are determined by two design aspects of a B-PLC network, minimizing costs, hindrance or postponement, and maximizing coverage, functionality network, capacity in a PLC network approach. This is the focus of a connection-oriented network and its specifications in terms of a medium-voltage connection. The strategy was the basis for the B-PLC network. This obtained a better performance in QoS (Quality of Service), and traffic, linking the physical level to the intervention of B-PLC channels by different nodes.

Hence under this scheme we designed a MV / LV type C security topology using a hierarchy model approach.

Having developed scenarios 1, 2, and 3 we made a fourth, where de same Approximation Hierarchy Model achieved success. Without it the PLC channels were in conflict, but following the ATM networks, we achieved an ideal operation scheme on the same low tension electrical network. Although the transmission speed lowered to 4 mbps being the PHY level speed, maintaining a speed of 100 mbps, registered in the computer equipment by the Ethernet.

Thus, the Approximation Hierarchy Model annexed the correct position of the Core Stratum modulation allowing assignation of the channels and user intervention.

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