Broadband Over Power Lines: Internet Everywhere

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Abstract-The Internet is the ever growing industry and is destined to stay so. The service providers are trying to cover as much geography as they could. This is possible with Broadband over Power Lines. The BPL uses the utility power lines to carry internet signals to the users, thus increasing the area covered. Hence internet is made available to places where conventional access technology can't reach.

Keywords: Internet, Power lines, Injectors, Repeaters, Extractors, Modems, HomePlug.

1. INTRODUCTION:

Broadband over Power Line (BPL) is a technology that allows the voice and internet data to be transmitted using the existing power lines. Thus, internet service providers can provide addition connections without digging up grounds and erecting poles. BPL is based on Power line communication technology that was developed by the American telecommunication company AT&T in 1928. Also, the development of technology was motivated with implementation of Supervisory Control and Data Acquisition (SCADA) technology. SCADA technology is use to send signals to monitor and control systems that are located in far remote places such as power grids, water purification plants, waste management plants etc. It sends the data used for control and maintenance of systems using the power lines or telephone cables. Thus development and implementation of this technology helped people to control and monitor systems at a great distance.

There were many efforts made to develop systems to transmit data in both directions in early 1800's, this is how the BPL came into existence. The main difference between the old and this new technology was that latter can be used to send data in both direction.

2. WORKING:

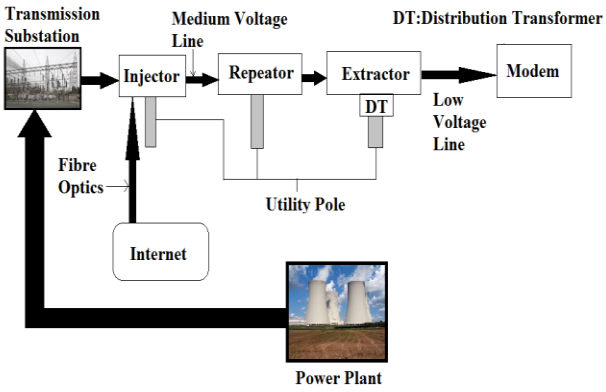

Figure 1: Architecture of BPL.

Power lines are most important components in BPL. A power grid consists of many devices such as generators, substations, transformers and power lines to carry power from power plants to consumers. High voltage cables are used to carry power from the power station to substation. From a substation it is distributed to different places using medium and low voltages lines. High voltage lines carry highly alternate power in order of millions of volts. Hence data cannot be sent on this high voltage lines as there is too much electrical noise. BPL injects the Data directly in the low or medium power transmission lines which carry voltages in order of thousands of volts. Thus the power signal doesn't interfere with the BPL data signal. BPL signals are in the range 1.705-30 MHz or in some case 80 MHz. These frequencies are unlicensed, that are allocated by the FCC just for the use of BPL.

Devices called as injectors are used to inject the signals into the medium voltage lines. Injector is a device which serves as head end to access BPL and it is mounted on a substation. The Internet signal is fed to the input of the injector using a T1 line or fiber line and medium voltage line is connected to the output of the injector. Injectors have three sectors receiver, signal convertor, and transmitter. Injectors are used to convert the internet signal into format that can be used to transmit data over power lines; these are Orthogonal Frequency Division Multiplexing (OFDM) or Spread Spectrum (SS) format. OFDM is widely used by the most of the developers.

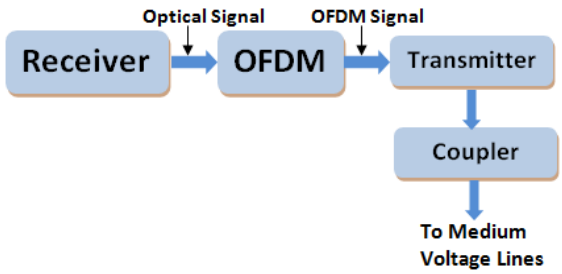

Figure 2: Injector Block Diagram.

OFDM is developed for wideband digital communication. In OFDM the data is encoded on multiple carrier frequencies. A large number of orthogonal subcarriers which are closely spaced are used to carry data on parallel data channels. Placing closely also helps in reducing the bandwidth required. Conventional modulation schemes such as QAM, PSK etc. are used to modulate each sub-carrier. Each sub-carrier is orthogonal to each other so as to avoid interference. Sub-carries are then divided for Uplink and Downlink communication. Selection depends upon the service provider. The frequencies are selected such that they won't interfere with other radio frequencies.

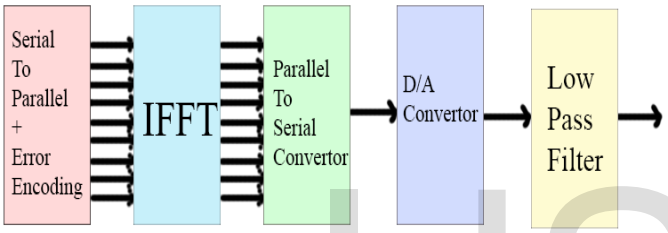

Figure 3 (a): OFDM transmitter.

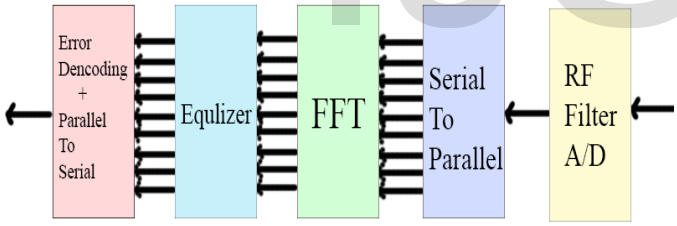

Figure 3 (b): OFDM receiver.

Couplers are used to connect the fiber line to medium power line. There are two types of couplers capacitive and inductive. Capacitive couplers are more efficient as compared to inductive couplers but they require to be physically connected to the electrical lines, which is not the case for inductive couplers. The inductive couplers are connected using ferrite cores. Also the use of couplers depends on the voltage carried by the power lines. There are LV couplers that are small in size and can be used with low voltage lines that carry 220 or 110 volts. MV couplers are larger than LV couplers since they have to withstand much larger voltages.

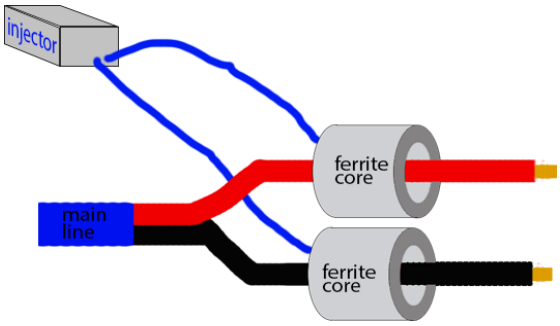

Figure 4: Inductive coupling

Due to high frequency operation the distance covered by the BPL signal is very limited. This problem is overcome by the use of repeaters. These repeaters are connected at the poles of the power supply lines. The signal is regenerated at the repeater and is retransmitted. The BPL signal travelling through power lines comes across many channel impairments such as noise, which reduces the bandwidth available to the user. The repeater has encoder/decoder and regenerator. The repeater decodes the OFDM signal, regenerates it and then again converts it to the OFDM signal and transmits it again. The uplink and downlink frequency are kept different to prevent co-channel interference.

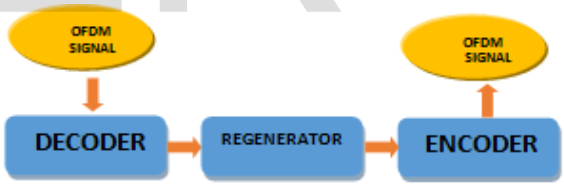

Figure 5: Repeater Block Diagram.

The connection of medium and low power line is done with the help of distribution transformer. A device called as Extractor is used to bypass this transformer. An extractor also has a repeater which boosts the signal before transmitting onto power lines. The Low voltage power lines carry the electricity to houses, they carry 120/240V.

The user has to use a BPL modem to extract the data from the AC line. The second layer of ISO 7-Layer model is provided by this modem. This modem can be plugged into power sockets and Ethernet cable or USB cable can be used to connect devices to internet. Modem needs to extract high frequency signal and need to block the low frequency signal. Hence a capacitance coupler is used.

3. TYPES OF BROADBAND OVER POWER LINE System:

Due to the various technological advancements in the field of Broadband over Power Line has resulted in the new systems which are being developed for the same. The various types of system are

i) Access BPL: Access BPL uses the power distribution network which is owned, operated and controlled by the electricity service provider. The access BPL system uses injectors, extractors and repeaters to provide internet services to the customers. The access BPL can be implemented in the following ways:

End-To-End Access BPL: In this system we either use a combination of Medium Voltage (MV) and Low Voltage (LV) or a LV power line. In this system the signal is directly injected into the power line and through the LV transformer is directly delivered to the end user.

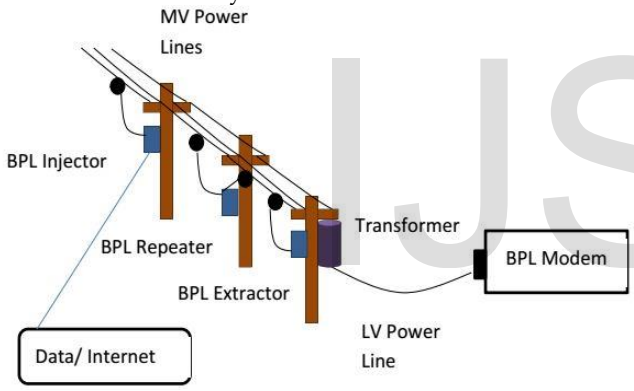

Figure 6: End-To-End Access BPL.

Hybrid Access BPL: In Hybrid System a combination of MV power lines and wireless transmission. The signal is injected wirelessly and then using an extractor is transmitted onto a MV power line which delivers it to the end user.

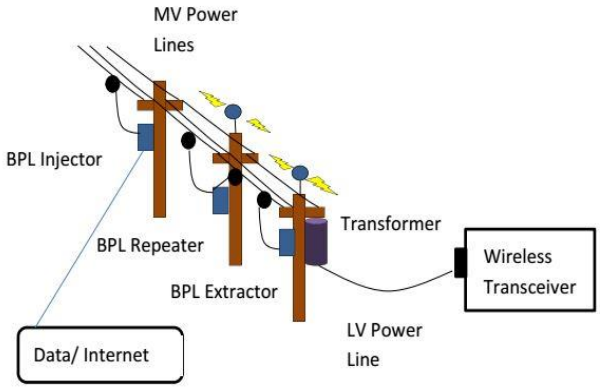

Figure 7: Hybrid Access BPL.

ii) In-House BPL: In this type of system the power lines which are used does not belong to the electricity provider. They are directly connected to the in-building wiring and uses electrical sockets as access points. It makes use of wireless transceiver to access the broadband network.

4. COMPARISON BETWEEN BPL AND OTHER ACCESS TECHNOLOGIES

i) TYPE OF ACCESS TECHNOLOGY: DSL

Uplink speed of DSL is 128 Kbps – 1.5 Mbps. Downlink speed of DSL is 144 Kbps– 9Mbps.Approximate monthly cost per user is $15 - $20. It uses the same pair of copper wires as POTs.DSL is distance sensitive. Maximum distance it can cover is 18000 feet. This is a major drawback of DSL.

ii) TYPE OF ACCESS TECHNOLOGY: CABLE MODEM

Uplink speed of Cable Modem is128- 500 Kbps. Downlink speed of Cable Modem is 1–3 Mbps. Approximate monthly cost per user is $30 - $40. It uses coaxial cables which are used for cable television transmission. Cable Modem is not distance sensitive. Limitation of this access technology is that the speed is affected because of shared bandwidth.

iii) TYPE OF ACCESS TECHNOLOGY: BPL

Uplink speed of BPL is 500 Kbps – 3 Mbps. Downlink speed of BPL is 500 Kbps– 3Mbps.Approximate monthly cost per user is $28 - $40. It uses the power lines to provide Internet service. Interference problem is one of the major drawback of this system. Also it needs repeaters at every 2500 feet. Like Cable Modem speed is affected due to shared bandwidth.

iv) TYPE OF ACCESS TECHNOLOGY: 3G

Uplink speed of 3G is up to 153 Kbps. Downlink speed of 3G is up to 2Mbps. Approximate monthly cost per user is $15 - $35. It uses same cell tower as cellular towers. Also it provides mobility to user. Wireless Nature of 3G is beneficial to users. But its speed is affected due to shared bandwidth.

5. ADVANTAGES OF BPL:

The main advantage of BPL technology is that it can have large geographical coverage and also provide internet access to areas where other broadband technologies do not provide broadband services, urban n and semi-urban areas are well equipped with currently used broadband access technologies like DSL, cable or wireless broadband but

same is not the case with rural areas where these technologies are not yet installed and as BPL technology does not require new infrastructure to be installed as it provides internet over already installed power lines hence it can be used to provide broadband services in rural areas . This means providing broadband services to homes in extremely remote areas. Installing BPL technology will also mean a greater competition in market for broadband service providers and will result in better services and reduced price for consumers.

6. LIMITATIONS OF BPL:

All new technologies face some initial roadblocks and challenges that needs to overcome

i) RF (Radio Frequency) noise Interference:doesn't interfere with the BPL data signal. BPL signals are in the range 1.705-30 MHz or in some case 80 MHz. BPL uses power lines for providing broadband services when these broadband signals which are high frequency alternating current signals are guided through powers lines these lines act as antennas radiating electromagnetic waves which can possibly hinder other radio communications falling in the same frequency range. This problem can be solved by standardizing frequencies to be used by BPL service providers.

ii) Cost: BPL signals operate at high frequency range hence many repeaters may be required to cover large areas.BPL service providers will have to compete with already installed and successful broadband services and has to provide broadband services at competitive rates which is one of the biggest challenges for BPL service providers.

iii) Compatibility issues: As there were no early standards fixed for BPL services providers all companies established different architectures for BPL services hence there are compatibility issues between BPL services in different areas.

7. HOMEPLUG POWER ALLIANCE:

HomePlug Power Alliance was started in March 2000 and comprises of about 70 companies which are involved in power line communication specification. The main goal of this alliance is to connect all the electronic devices to each other and to the internet A.C power lines at the same time making this service fast, efficient and cost effective.

Previously, many companies were simultaneously developing BPL and had their own patented methods. So there were no particular standards for development of BPL. Also the devices were not inter-operable. Hence HomePlug Alliance was created so as to develop the standards for the growth of research and development of BPL.

8. CONCLUSION

The BPL technology is not that easy to implement as it can be thought. As the standards have not yet developed that greatly there are still many obstacles to conquer. We have given two types of BPL access services, Access BPL and In-House BPL. The Access BPL has many issues at hand. There is interference, cost problem as well as repeater problem. So other access technologies like cable, DSl, 3G are preferred over the Broadband over Power Line as they have developed greatly. The In-House BPL on other hand has far more less problems as it distributes the internet using electrical lines in the building. Hence it can still be considered as an alternative to the current technologies which domestically provide internet. All the problems faced by the BPL will be slowly overcome as the standards for BPL will developed further more. Hence it is certain that the Access BPL and In-house BPL will further develop and give competition to other technologies.

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