A Study On: Electric Power Line Networking For A Smart Home

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Abstract

Electrical power line networking is a home networking system that can interconnect computers within the smart home. This uses thrilling power outlets and AC wiring to relay data around a home or small offices. It is based upon the 'no new wires' concept. Power Line Communications is a fairly new telecoms area. PLC uses full duplex methods to transmit data through power lines as the medium for transmitting electrical signals over a grid. For advanced meter reading, home control and street lighting, PLC systems are used. Several PLC technologies listed according to their operating frequency range, are explored in this paper. Power line networking uses power line communications (PLC) to connect computers using existing home power outlets, turning any electrical outlet in the building effectively into a network connection. Power line networking is one of home networking's cheapest types, and has low start-up costs and minimal IT workload. Power line networks can transmit phone calls and faxes as well as Internet services over regular electrical wiring.

Keywords: Electrical, Powerline Networking, Networking, Power Line Communication, PCL, and Smart Home.

I.   Introduction

A lot of new networking technologies have been introduced in recent years and powerline communications (PLC) is one such technology, this paper provides a detailed overview of PLC. Firstly there is a brief history of the PLC. Here is a summary of the different PLC technologies, a comparison of PLC with other networking technologies, including Ethernet, wireless and another no new wires technology known as phoneline networking. Power-line communication (PLC) carries data on a conductor which is also used simultaneously for transmission of AC electric power or delivery of electric power to consumers. It is also known as Powerline carrier, Powerline Wireless Subscriber Line (PDSL), Powerline Telecommunications (PLT), or Powerline Network (PLN).Different applications require a wide range of power-line communication technologies, ranging from home automation to Internet access, which is often called broadband over power lines (BPL). Most PLC technologies are limited to one form of wires (such as wiring premises within a single building), Yet others can converge between two levels (such

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as the distribution network and the wiring of the premises). Transformers usually prevent signal propagation, which involves several technologies to construct very large networks. For different cases different data levels and frequencies are used.

Essentially, a powerline network is a wired network of (mostly) hidden wires. Let's presume the broadband router in the lobby and a smart Samsung HD TV in the lounge. Let's say this particular telly isn't wireless, either, So the only way, to watch catch-up TV is by trailing an Ethernet cable from the router, down the hallway, and across the floor of the living room to the Set.. Here trying to cover a large cable wall-to-wall carpeting over it. It just doesn't really work. [1]

Electrical power line networking is a home networking device that can interconnect computers within smart home. This uses thrilling power outlets and AC wiring to relay data around a home or small offices. It is based upon the 'no new wires' concept. Some of the following are:

- Web access

- Printers

- PC hard drives

From any plug in smart home or office.

Networking of electric power lines eliminates the need to place PCs near a phone outlet. Alternatively, computers and other devices are connected via a power outlet. Only plug in, homes are networked. The power line networking is based on the Homeplug 1.0 principles of the Homeplug Powerline Alliance. Through power line networking a homeowner may build a whole home network that links his / her own,

- Personal computers

- Printers

- Music equipment's

- Internet access

Without getting any new wires going. Wires and sockets are used for power and data at the same time, without interrupting one another. Thus power line networking provides a cost efficient home networking solution. With power line networking, will be able to put the desktop PCs anywhere like in smart home. Many tools would also be easier to buy and network.

The problem of propagation is a limiting factor for each type of communication over the power line. An exception to this restriction is a new discovery called E-Line that allows a single power conductor to act as a waveguide on an overhead power line to provide low attenuation transmission of RF through microwave energy lines while providing information rate of multiple Gbps.
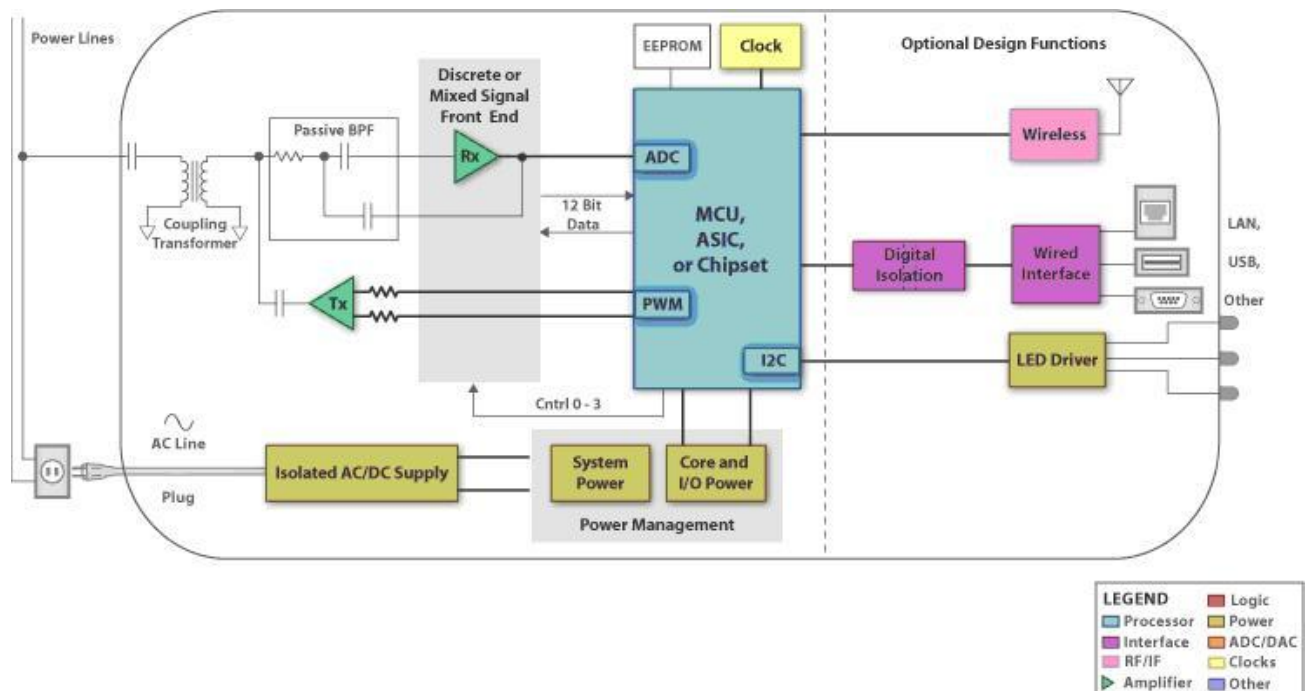
Figure 1: Powerl ine Communication

The above (*Figure1*) determine the data rates over a communication system with power lines vary widely. Low-frequency (around 100-200 kHz) carriers impressed with high-voltage transmission lines can carry one or two analog voice circuits, or telemetry and control circuits with an equivalent data rate of a few hundred bits per second; however, those circuits can be several miles long. Higher data rates typically mean shorter ranges; a local area network running at millions of bits per second can cover just one floor of an office building, but prevents dedicated network cabling installation. [2]

Features:

A power line network is having the following features,

• There is no need for extra wiring and wire repairs because it uses thrilling electrical wires for network operation.

• Uses traditional plug / outlet. So the network can be reached everywhere at home.

• The power outlet is used to make it easier for users to move PCs, switches, routers and servers to print.

• Connecting to internet or exciting home network is simple with an Ethernet switch or router.

• It provides high security DES 56-bit encryption in data transfer.

• To safeguard previous investments, it coexists with current technology. And consumers don't have to throw away their fun network solutions.

- It has a maximum bandwidth of 14Mbps over normal home for knowledge sharing, multimedia and gaming applications.

- Low interference frequency band 4.3 to 20.9 MHz from other electrical appliances;

Technology of PCL:

Like home PNA, power-line networking is based on the "no new wires" principle In this case, the comfort is much more evident, because while not every room has a phone jack, there is often an electrical outlet near a computer. Through power line networking, to connect smart computers by the same outlet. Because it doesn't require new wiring, and the network doesn't add any costs to extra electric bill, power line networking is the easiest way to connect computers in different rooms.

There are twodifferent power line networking systems. The older technology called Passport, which was developed by intellon called Intelogis and a new technology called Powerpacket. Let's now find out how each of these technologies operates.

This system relies on the frequency-shift keying (FSK) to transmit back and forth data over smart home's electrical wires. FSK uses two frequencies for transmitting digital information between the computers on the network, one for 1s and the other for 0s. The frequencies used are located in a narrow band just above the point where most line noise is present.

It is somewhat fragile though this method works. Anything that impinges on either frequency will interrupt the flow of data, causing the data to hate the transmitting device. That may affect network performance.

The network slowed down when one was using more energy in the home, including running the washer and dryer. With its network kit, Intelogis provides line-conditioning power strips and allowsto install them between the wall outlet and withincomputer networking equipment to help reduce the amount of electrical air noise. [3]

Smart home technology, also often referred to as home automation or domotics (from the Latin "domus" meaning home), provides homeowners security, comfort, convenience and energy efficiency by allowing them to control smart devices, often by a smart home app on their smartphone or other networked device. A part of the internet of things (IoT), smart home systems and devices often operate together, sharing consumer usage data among themselves and automating actions based on the homeowners' preferences. (Figure 2)
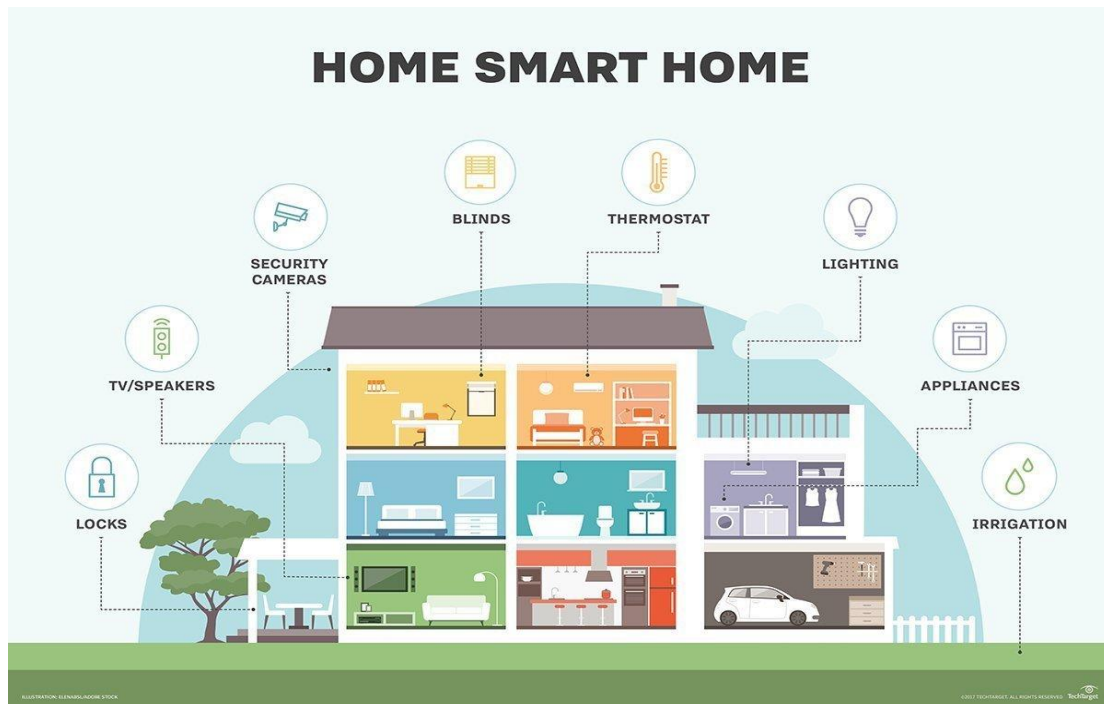
Figure 2: Smart Home Technology

Powerline networking is a system that uses the electrical wiring in smart house to transmit data. That may sound a little odd, but as long as the right protocols are in place, the process is actually quite simple. It will provide a wired Internet connection to devices that cannot be accessed by Wi-Fi when installed. This is why Powerline Tech is commonly seen as an alternative to Wi-Fi. [4]

Examples of smart home technologies

Almost every area of life where technology has reached domestic space (lightbulbs, dishwashers, etc.) has seen the introduction of an alternative smart home:

• Smart TVs connect to the internet to access content through applications, such as on-demand video and music. Some smart TVs also include voice or gesture recognition.

• In addition to being able to control smart lighting systems remotely and customized, such as Hue from Philips Lighting Holding B.V., it can detect when occupants are in the room and adjust the lighting as needed. Smart lightbulbs are also able to regulate themselves based on availability of daylight.

• Smart thermostats such as Nest from Nest Labs Inc. come with built-in Wi-Fi, allowing users to plan, monitor and control home temperatures remotely. These apps often learn the habits of homeowners and automatically adjust the settings to ensure optimal comfort and productivity for residents. Smart thermostats can also monitor the energy consumption and, among other items, alert users to change filters.

• Using smart locks and garage-door openers, users can grant or deny access to visitors. Smart locks can also detect when residents are near and unlock the doors for them.

- People can track their homes when they are out or on holidays using intelligent security cameras. Smart motion sensors can also detect the difference between people, tourists, pets and burglars and can notify authorities if suspicious behaviour.

- With paired feeders, pet feeding can be automated. And can water house plants and lawns by means of attached timers.

- Kitchen appliances of all kinds are available, including smart coffee makers that can brew a fresh cup as soon as an alarm goes off; smart refrigerators that keep track of the expiry dates, make shopping lists or even build ingredient-based recipes currently on hand; slower cookers and toasters; and washing machines and dryers in the laundry.

- For example, household system sensors can sense an electrical surge and turn off appliances or sense water failures or frozen pipes and shut off the water so there is no flood in the basement.[5]

How to install Powerline Network:

The physical connection between each computer and the networks of the intelogis power line uses the parallel port of the computer. A wall unit is directly plugged into the power outlet.

A parallel cable is inserted into the computer's wall unit and parallel port. The last element to be connected to the parallel port must be the power-line network. Of this reason, to have something else connected to the parallel port, such as a scanner or Zip drive, the parallel port needs to have a pass-through. Unless it is a second parallel port on smart computer, printer must be connected to the network through a wall of its own.

One thing to remember is that the older intelogis technology doesn't support bidirectional printing. "Bidirectional" means data is sent in both ways, allowing printer to send information back to all machine, such as how much ink is left and if a paper jam is present. This will not keep smart printer from working, but it is worth noting that will lose the use of such features.

Initial Power Packet devices connect from the computer to a small wall adaptor via a USB or Ethernet cord. Subsequent devices will have built-in circuitry, meaning the power cord would be the only connection required.

Powerline Networking & its Need.

Powerline networking, or powerline communications, is a form of communication that uses electrical cable to transmit electrical data and alternating current (AC) via existing electrical infrastructure. Powerline networking can take on a variety of uses. In the home, it is mostly used for home automation (smart house) and internet access, but it is also used within industrial and commercial settings to perform tasks such as remote meter readings, for example by utility companies.

Figure 3: Network Adapter

Showing above (figure 3) the powerline is capable of transmitting data to the power wave via the superposition of a low-energy information signal, meaning they can pass through each other without being disrupted. To ensure the power wave does not interfere with the data signal, data is transmitted at a minimum of 3 kHz. In-home electrical wiring can transmit signals at a variety of frequencies. Electricity typically travels at frequencies of 50/60 Hz, which means data can use the same wires, but at a much higher frequency, so that the two do not influence one another.

Powerline communications can be used in home automation systems to power lighting, heating, air conditioning, cameras, and safety systems. Since the 1970s, when a Scottish company developed X10, a system that allowed compatible home devices to communicate via the existing wiring, the idea of a smart home has been around. A transmitter, such as a keypad or remote control, could send a message in numerical code over the existing wiring to a receiver, for example to turn off a lamp (the receiver) in another room. The message sent over the wiring would include which device the message was being sent to and the command for the device. X10 apps are able to accept a range of commands, such as turning off all cameras, turning on all lights or dim lighting. In many households, the technology is still in use, but some smart-home systems are now using radio waves instead to send signals using Bluetooth and Wi-Fi networks.[6]

A powerline networking connection has certain benefits over a wireless connection, but how well it performs will still depend on the efficiency of the electrical system in the home. Inadequate wiring and circuit breakers will negatively affect performance and cause interruptions between the connected cables. It can also be influenced by other motorized home appliances, such as vacuum cleaners or fans, which produce noise in the power grid and the connection does not work as well, as the wiring and related switching is designed for AC power. Nevertheless, the device can make it easier to expand a network to remote areas of a house that may be struggling to reach standard Wi-Fi. It can be a low-cost way to increase home connectivity, as all homes already have multiple AC outlets and the only extra equipment required is to add two adapters per unit.[7]
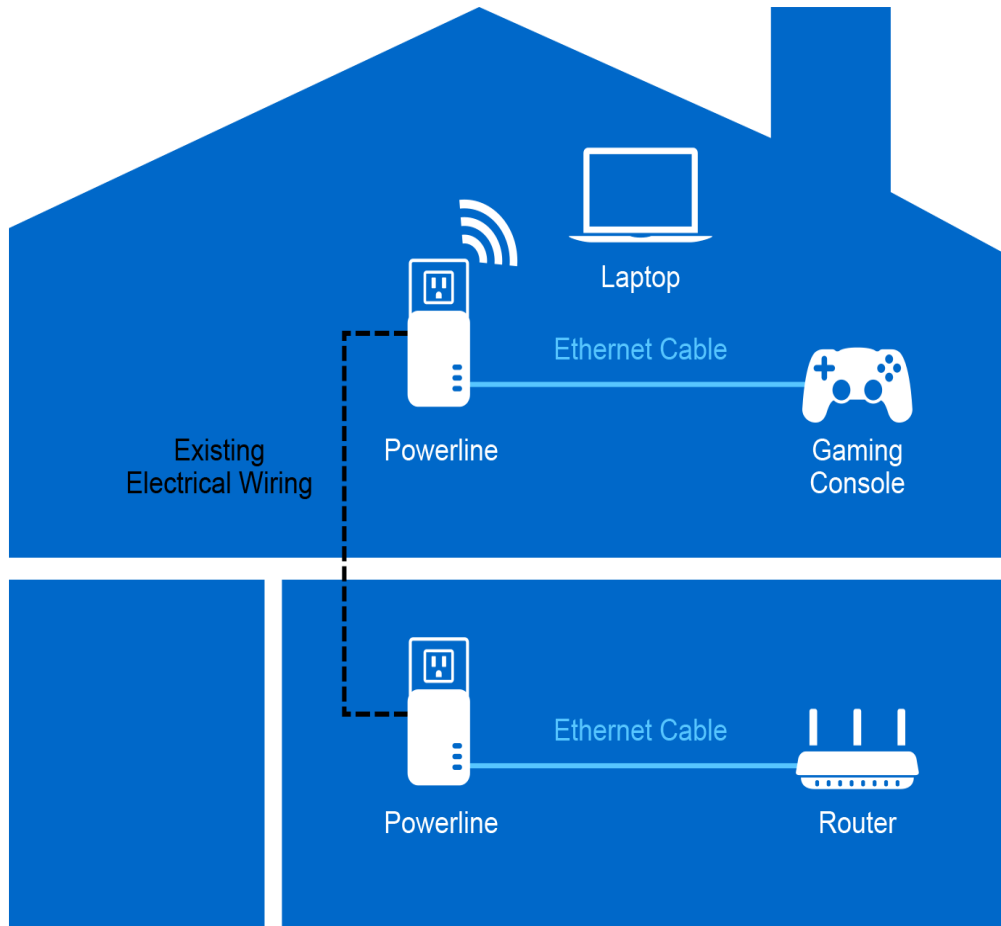
Figure 4: Power Line Network Connection

Power line is a bridging device described in (Figure 4), which is often useful to expand a home network's scope to areas where wireless coverage is low or where it need the fastest possible link − a games console, maybe, or an Apple TV. It's also ideal for connecting old devices to the Internet that don't have built-in Wi-Fi connectivity, avoiding a tangle of Ethernet cables that clutter to living room. Powerline is a stylish and effective solution for networking.

Power line is useful for anyone who wants to expand their coverage over the network. It's also a great way to get the fastest possible connection — for example, to gaming consoles or streaming media players — and connect old devices that don't have integrated Wi-Fi connectivity. It's especially effective in larger spaces or old buildings with thick walls, concrete, metal or other obstructions—all of which interfere with Wi-Fi signals. [8-9]

How it works

Powerline Communications (PLC), also known as **Power Line Telecommunications** (PLT), is the networking system that **uses existing public and private cabling for signal transmission**. High-speed data, voice, and video are transmitted through low-voltage power lines using PLC communication signals. (Figure 5).
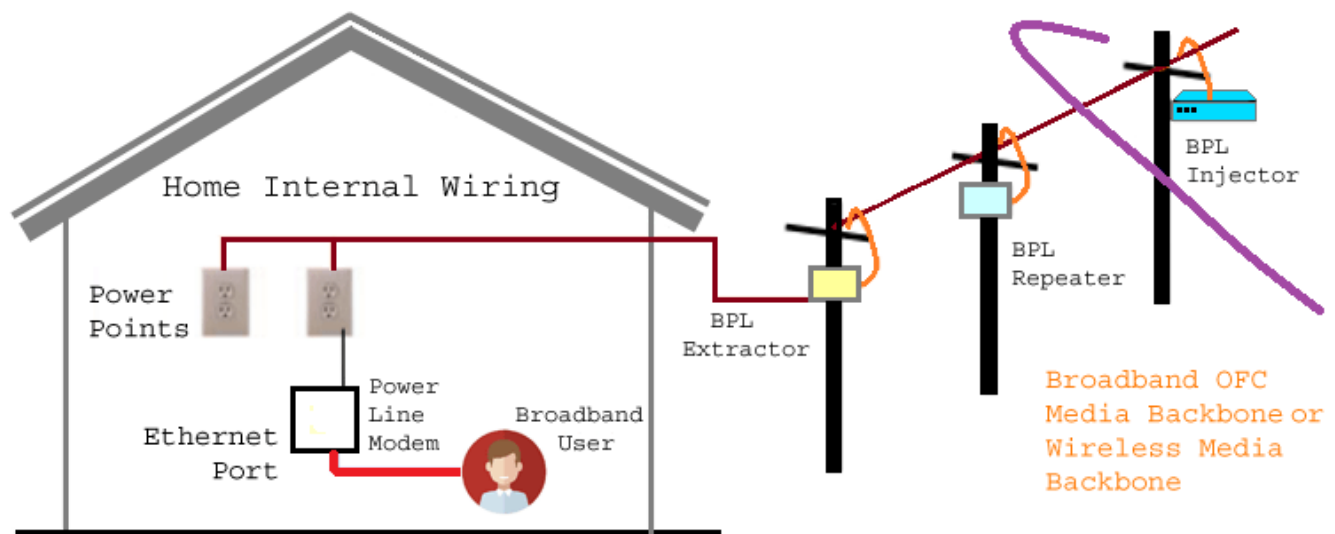
Figure 5: PLC Technology

PLC is a technology that has been in use for years but has now become more in demand following the introduction of new communication technologies assisted by PLC i.e. PLC can be a robust means of communication for applications such as Internet-of-things (IoT) and Smart Grids.

A smart home is not isolated mobile devices and appliances but those that work together to create a network that can be remotely controlled. A master home automation system, also called a smart home core, controls all of the systems. The smart home hub is a hardware unit that serves as the centerpiece of the smart home network and is capable of sensing, processing data and wireless communication. It combines all the different apps into one single smart home app which homeowners can control remotely. Types of smart home devices include, among others, the Amazon Echo, Google Home, Insteon Hub Pro, Samsung SmartThings and Wink Hub.[10]

II.   Types of Powerline Technologies:

Basically, there are four types of PLC:

- **In-house networking:** high-speed data transfer can be carried out using in-house power cables for home networking.

- **Broadband over Power Line**: Broadband internet access is available via outdoor power cables.

- **In-house applications for narrowband:** low-bit data services such as home automation and intercoms can be managed and used for communication via in-house power supplies.

- **Outdoor applications for the Narrowband:** Narrowband outdoor devices can be used for automatic meter reading and remote monitoring or control.

Advantages of Powerline Technology:

(Figure 6) describes the data connector to smart homes and following advantages are following:

- **Low Implementation Cost:** PLC does not require any installation of new wires which as a result, would significantly reduce the deployment costs.

- **Large Reach:** PLC can allow contact with hard-to-reach nodes where the wireless RF signal is subjected to high attenuation rates, such as underground structures or buildings with obstructions and metal walls, or wherever the wireless signal is undesirable due to EMI problems in places such as hospitals.
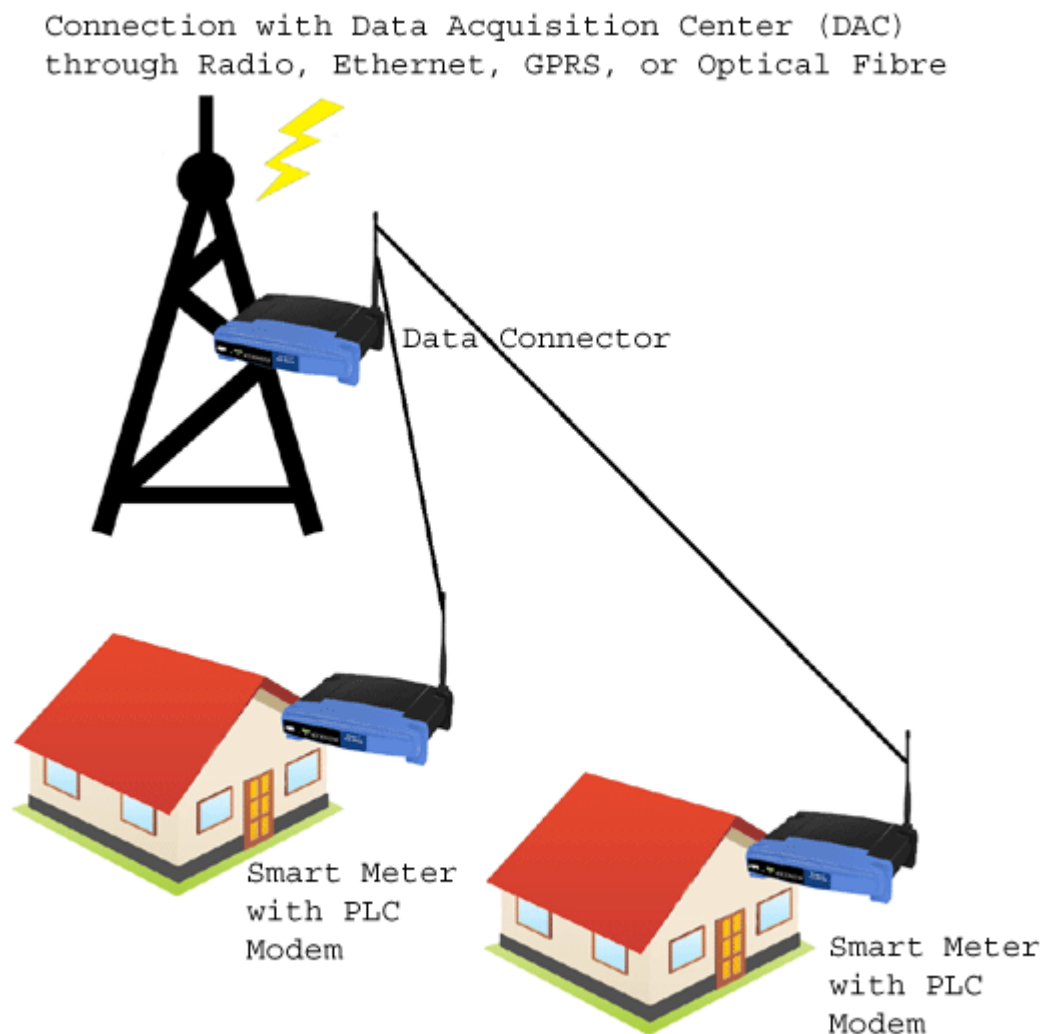

Figure 6: Powerline Technology with Smart home

- **Lower Running Cost:** PLC provides a low-cost solution compared to the other existing technologies such as RF wireless or visible light communication (VLC) systems.

- **Indoor High Speed:** Recently, the implementation of integrated PLC & VLC technologies has received considerable research attention, allowing a new generation of high-speed indoor communications for a wide range of applications.

These advantages lead to more implementations of PLC networks in various industries. But with advantages there also comes some disadvantages.

Disadvantages of Powerline Technology.

It also has some disadvantages such as:

- Low transmission speed,

- interference sensitivity,

- Nonlinear distortion and cross-modulation between channels,

- Large size and

- High capacitor and inductor prices used in the PLC network.

Due to these disadvantages, PLC is still not preferred in some applications.

Applications of Powerline

PLC is commonly used in (Figure 7) Smart Grid and Micro-Inverter technologies. Through familiarizing the technology with more consumers, PLC will soon have more functionality for applications such as lighting (for traffic light control, LED dimming, etc.), industrial applications (for irrigation control, etc.), Machine-to-machine applications (such as vending machines or hotel-to-room communications), telemetry applications (such as offshore oil rigs), transport applications (such as electronics in cars, trains and aircraft) and many more.[11]
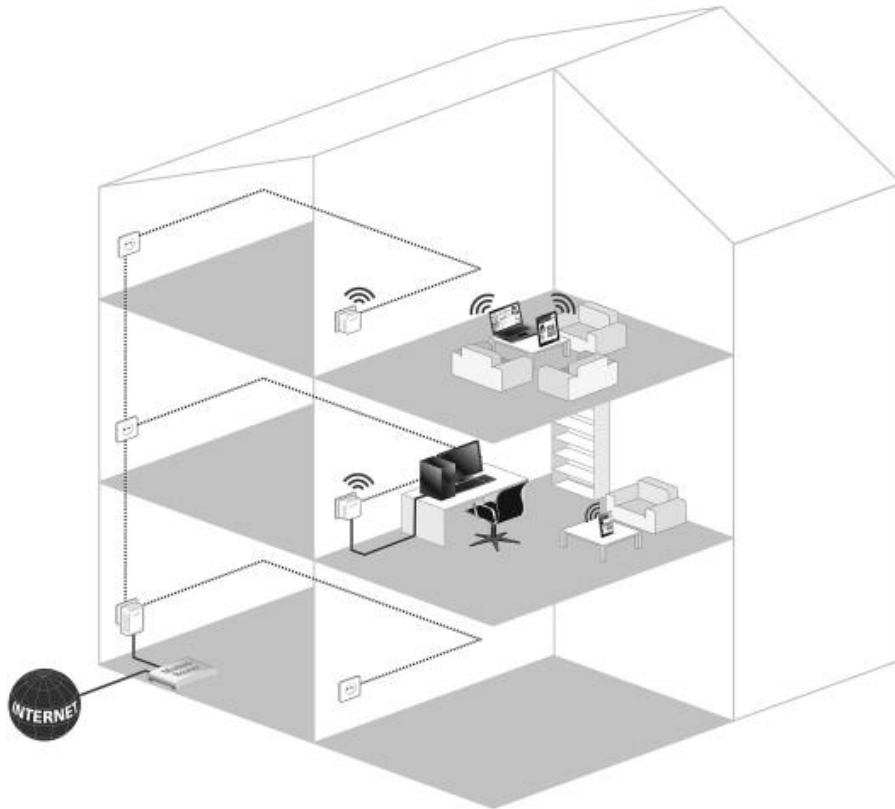
Figure 7: Smart Grid and Micro-Inverter technology

Current Powerline Devices:

So how do adapters to the powerline work? The idea is simple and crafty. To extend a wired internet connection in smart home, not by running new cables but by transmitting the signals already in inside the walls along the electrical wires. It just have to plug in an adapter where it needed.[12]
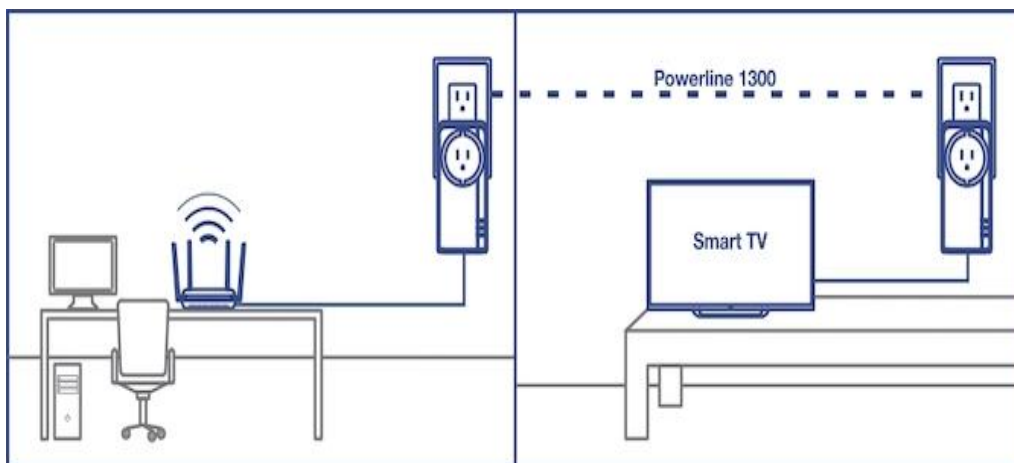

Figure 8: Power Line Adapter

(Figure 8) Powerline Ethernet is perfect for:

- Network extension in homes where a single Wi-Fi router is not sufficient;

- Connecting computers not endorsing Wi-Fi.

- Providing faster network access to rooms where it is not feasible to run an Ethernet cable.

If powerline networking sounds useful to all, It should learn a few things before to dive in.

III.   Conclusion

The Power Line Communications (PLC) market continues to evolve. At the research level, major resources still exist to be exploited. PLC is seen as an emerging technology with significant market potential on the application level. The important issues of interference to other radio frequency spectrum consumers and the finalization of guidelines need to be resolved satisfactorily before broader adoption and deployment can take place. It refers in particular to wireless PLC. In addition, PLC is a reality both in current environments, e.g. home networking, and excellent market opportunities. Electrical PowerLine technology provides an innovative alternative to telephone and modem connection to the Internet. While this technology is not yet commercially available, due to the comparatively low cost of its local loop it will be accessible before other broadband technologies. [13]

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