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Electric Power Line Networking for a Smart Home

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ABSTRACT
Home automation is an important part of modern life because it monitors and controls electrical devices in the home as well as other aspects of the digital home, which is expected to be the standard for the future home. The home appliance control system allows the homeowner to remotely control devices such as the stove, refrigerator, air conditioner, and lighting while also monitoring the house's status. A personal digital device, such as a laptop, PDA, telephone, or even a cell phone, can be used for monitoring and control. The Power-Line Communication (PLC) protocol for data transmission is one of the technologies widely used by homeowners to connect the home controller with the appliances.

Keywords: *Routing, Smart homes, Wireless sensor networks, Wireless networks, Protocols, Home appliances*

INTRODUCTION

Nowadays, the rapid development of information technology has resulted in significant changes to the structure of automation systems, causing people to place a higher value on home security, comfort, and efficiency. Intelligent household devices have become a research focus in the home automation industry, with the goal of figuring out how to make television sets, refrigerators, lighting, alarm sensors, and other home devices work efficiently and easily. Under such conditions, home appliances should not only function independently, but also in collaboration with other devices, i.e. they should be network-connected for easy management. [1]

For controlling home appliances, there are numerous access methods available, including hard wired lines, telephone lines, Ethernet cables, radio frequency, infrared, and powerline. They are classified technically as two types of networking techniques: wireless data exchange between transmitter and receiver (e.g., Bluetooth, 802.15.4/ZigBee, or Z-wave) and fixed wire line networking (e.g., telephone line, Ethernet cable, and others). Power-line is a specialized media that transports not only alternating current (AC) power to devices, but also multimedia or control data to and from the device; the benefits of using this media include the availability and quantity of electrical outlets in a home, as well as the lack of new wiring required for network construction. The Power Line [2]

Using this technique for remote automation control in the home requires no additional control wiring to be installed. Originally, the application of PLC was primarily to ensure the normal operation of the electric power supply system in the event of malfunctions or faults through the instant exchange of information between the power plant, substation, and distribution center, making this approach a competitive alternative to smart home networking due to the benefits of its robustness, ready connectivity, and availability. [3]

Power Line Communications is a relatively new telecoms technology. PLC transmits data using full duplex methods over power lines, which serve as the medium for transmitting electrical signals across a grid. PLC systems are used for advanced meter reading, home control, and street lighting. This paper investigates several PLC technologies, which are listed according to their operating frequency range. Power line networking connects computers using existing home power outlets, effectively turning any electrical outlet in the building into a network connection. Power line networking is one of the most affordable types of home networking, with low start-up costs and minimal IT workload. Power line networks can carry phone calls, faxes, and Internet services over standard electrical wiring. [4] To transmit data and control signals, PLC technology makes use of the distributed power line infrastructure. The availability of power line outlets in each room of a house, which avoids the costs of additional wiring in most residences, and the convenience of promisingly seamless communication with utilities via power line are the main advantages of PLC technologies over other alternatives.

PLC transmits information signals on low voltage (LV), medium voltage (MV), or high voltage carrier frequencies using existing power line wiring (HV). In terms of the cost of building a communication infrastructure, PLC is comparable to wireless solutions because power lines are already built and available everywhere. Thus, the primary benefit is the saving of funds for the construction of a communication infrastructure. PLC technology is classified into two types. [5]:

Narrowband PLC:
This technology operates in the frequency band 3-500 kHz, which includes the European CENELEC band 3-148.5 kHz, the US FCC band 9-500 kHz, the Chinese band 3-500 kHz, and the Japanese ARIB band 10-450 kHz [5,6]. This technology can be further classified based on the data bit rate:

Low Data Rate (LDR) technologies have a single carrier and a data rate of a few kbps. Lon Work's standards, IEC 61334, X10, Home Plug C&C, and SITRED are typical examples of LDR NB-PLC.

High Data Rate (HDR) technologies have data rates ranging from tens of kbps to 500 kbps. G.hn technologies based on ITU-T standards, IEEE P1901.2, PRIME, and G3-PLC are typical examples.

Broadband PLC:
Broadband technology operates in the 1.8-500 MHz frequency band, with data rates ranging from a few Mbps to Gbps at the physical layer. Broadband over Power Lines is another name for it (BPL). Several organizations cover broadband technology standards, including the Universal Powerline Association (UPA), the Open PLC European Research Alliance (OPERA), the Consumer Electronics Power line Communication Alliance (CEPCA), the Institute of Electrical and Electronics Engineers (IEEE), the International Telecommunication Union (ITUT-T), and the Home Plug Powerline Alliance. [6]

The primary distinction between individual organization's standards is in the methods of access to the shared medium, encryption methods, and transmission robustness. Across standards, the frequency bands, modulations, and injection of the useful signal into the electrical network are nearly identical.

A power line network is having the following features,

- No additional wiring or wire maintenance is required because it uses the exciting electrical line itself for network operation.
- It requires a standard outlet/plug. As a result, you can connect to the network from anywhere in your house.
- It makes use of power outlets to allow users to more easily relocate PCs, switches, routers, and print servers.
- It is simple to connect with an Ethernet switch or router to gain access to the internet or an exciting home network.
- It uses 56-bit DES encryption to ensure data transfer security.
- It coexists with current technology in order to protect prior investments. As a result, customers will not have to abandon their exciting network solutions.
- It has a maximum bandwidth of 14Mbps over standard home for sharing information, multimedia applications, and gaming.
- Frequency range of 4.3 to 20.9 MHz to minimize interference from other electrical appliances. [7]

Review of Literature
With the rapid development of network technology and communication technology in recent years, people not only pay attention to the degree of automation and home of the increasingly high demand, but also the flexibility and convenience of home appliances control of external information obtained higher requirements. (Jeet, 2015[8]; Yu, 2015 [9]).

As a result, smart home system research and development has become a hot topic in the information industry. Simultaneously, power line communication technology has been rapidly developed (Sarathi, 2013) [10]. After several years of research and development, some technical bottlenecks have been successfully overcome, allowing low-voltage power line high-speed data transmission (Tong and Zhou, 2014) [11]. As a result, this article presented the overall programme smart home system based on power line communication technology in the current understanding of the development of smart home system, the full use of the power line to act as a smart home system data signal transmission media (Vasan and Long, 2014) [12]. Electricity networks have an advantage everywhere; using the power grid can reduce the large investment in network construction, which is a key factor limiting broadband applications (Wang, 2015) [13]. PLC networking is

extremely simple; simply connect the power socket and the required network communications equipment, and digital devices can communicate with one another. And any power outlet in the room where the Internet can be permanently connected and online. As a result, power line communication technology has a wide range of applications (Subramanian, 2015) [14]. Once technology has reached the commercialization stage, it will be easier to change the telecommunications market, and the popularity of the Internet has created a lot of development space (Ding, 2013[15]; Yi, 2015[16]).

Objectives

- To investigate communication over power lines;
- To investigate Energy Management Networks in Smart Homes; and
- To investigate smart Grid domains and their electrical and communication interconnection.
- Research the power line network

Research Methodology

A research methodology is a method for solving a research problem in a systematic manner. It can be thought of as a science that studies how scientific research is conducted. In it, we look at the various steps that a researcher takes when studying a research problem, as well as the logic behind them. The researcher must understand not only the research methods/techniques but also the methodology. A close reading and detailed analysis of secondary sources is required in order to apply the analytical and descriptive methods to the research. It is critical to obtain additional perspectives in order to expand on the textual analysis, which would necessitate close reading analysis of a few secondary materials.

Result and Discussion

Given the concept of a combined network, we created an experimental model in NS-2 v2.33 to assess network traffic and energy consumption on sensor-enabled nodes in smart homes, as shown in Fig. 1. Our full simulation model includes a Radio Broadcast Data System (RBDS) network for communication between utilities and smart homes/residences, as well as an indoor network combining ZigBee/IEEE 802.15.4 with Home Plug C&C, resulting in a multi-interface and multi-channel environment. In our model, the Home Plug C&C protocol stack is a clone of the IEEE 802.11 WLAN protocol stack that exists in NS-2, with the date rate reduced to a low value (25Kbps) in comparison to ZigBee/IEEE 802.15.4. (250Kbps at 2.4GHz). [17]

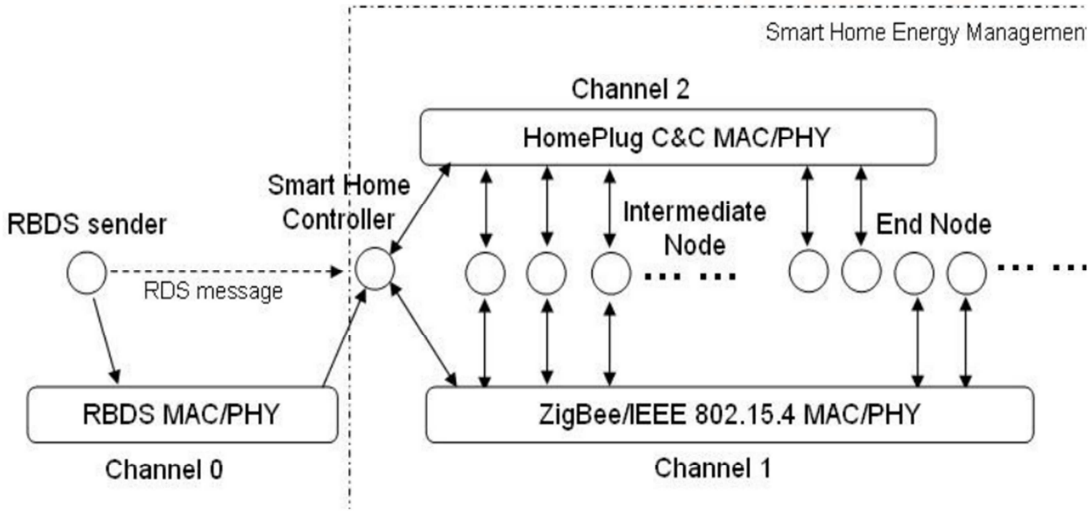


Fig. 1 Energy Management Network in Smart Homes

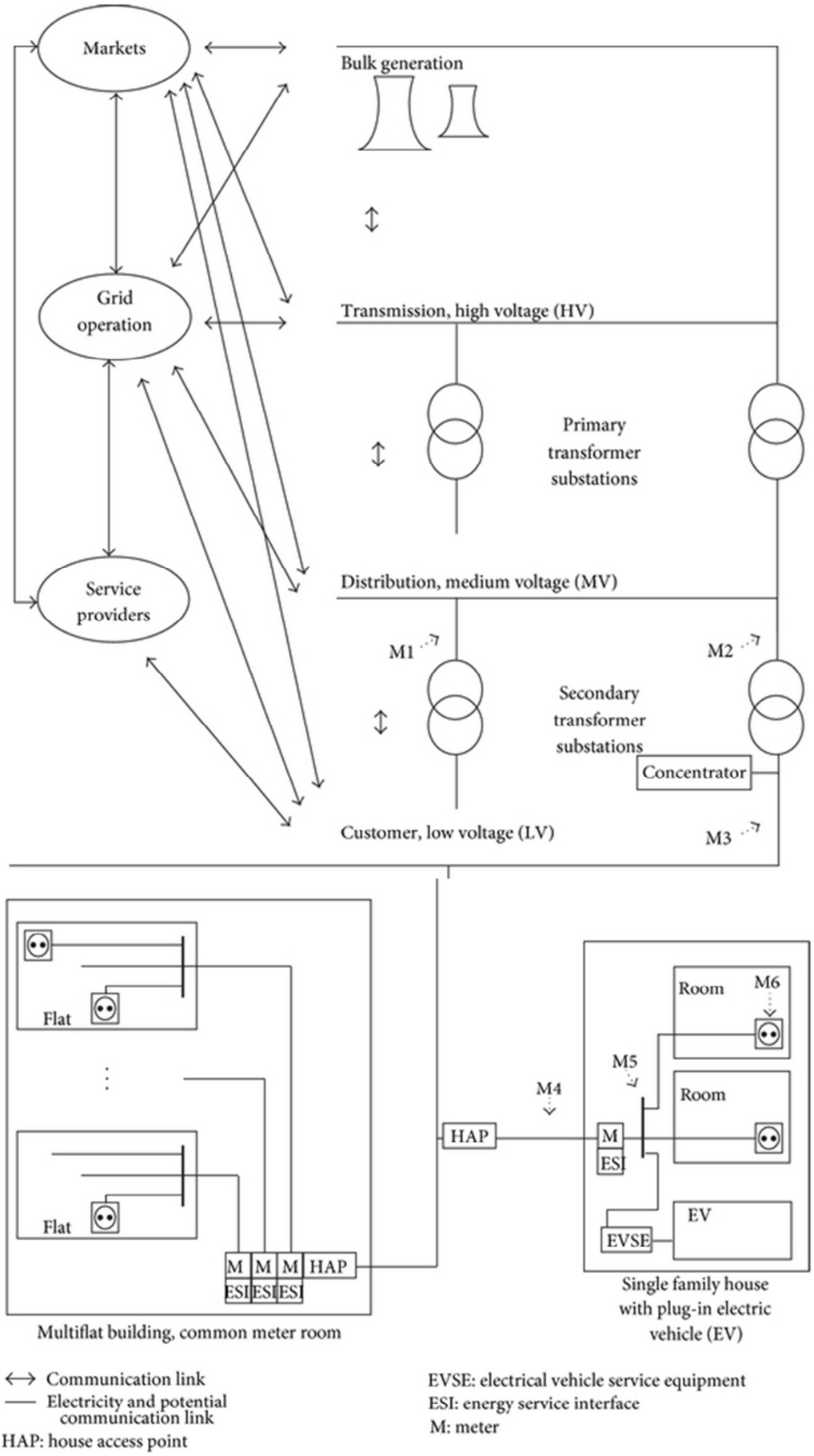
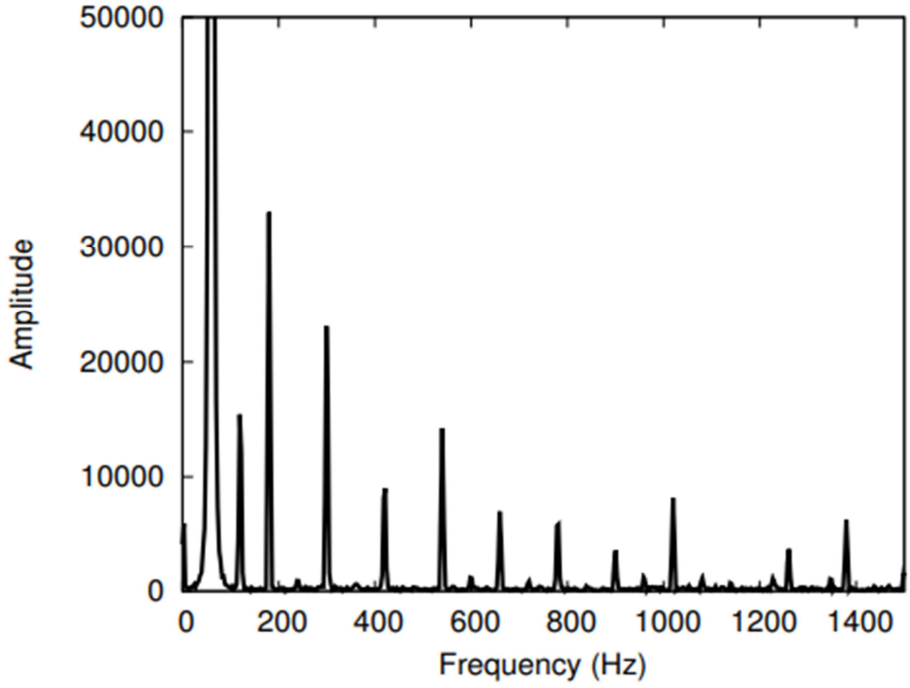
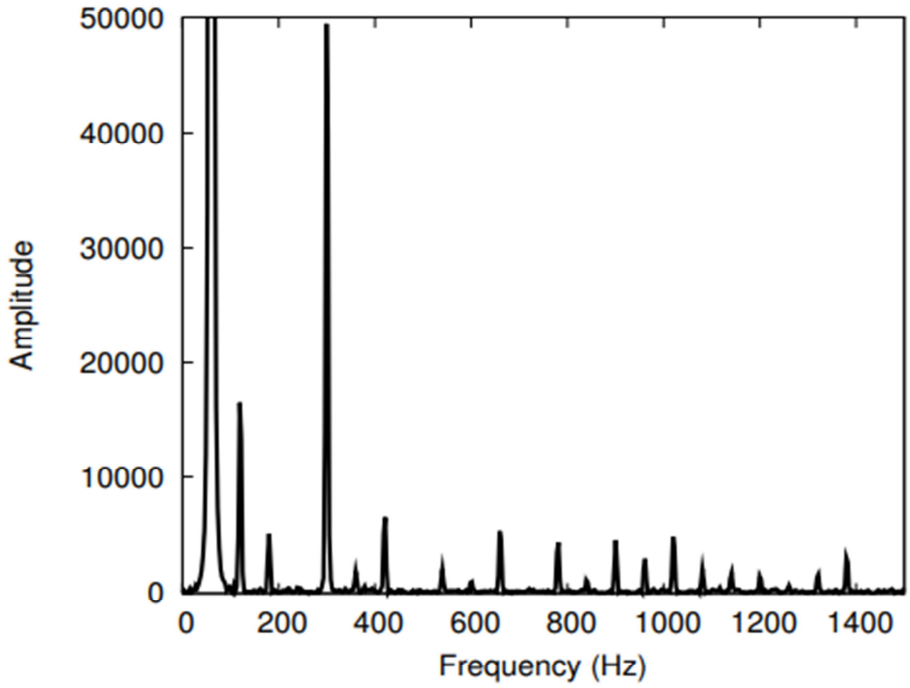


Figure 2 Smart Grid domains and their electrical and communication interconnection

NIST developed a domain-based conceptual model to structure the various areas of the Smart Grid. Each domain contains actors who, with the help of communications, can act across domain boundaries. Figure.2 depicts the interconnections between domains. [18] It has long been common practice to categories power line communication scenarios based on power line operation voltages. This voltage-based differentiation is linked to the NIST conceptual model in Figure 2.



(a) An Apartment Building



(b) CSE Building

Figure 3: A comparison of an apartment building's and CSE's "baseline" noise floor power signatures.

While neither environment has much (any) noise in the 1-30MHz range of Home Plug technologies, the CSE building has a much cleaner line than a home. We conclude that if PLC works in the home, it should work equally well or better in CSE.

PLC has a frequency range of 1-30 MHz. PLC modulation is also on the order of hundreds of millivolts, which is less than 1% of a 120V alternating current line. Thus, the interference caused by PLC for other electrical devices is minimal and well within the noise threshold of Figure 3. However, there is a problem with wireless interference. [20-22] Because PLC operates at such a high frequency, the power lines themselves can act as antenna elements, radiating PLC signals both wirelessly and wiredly.

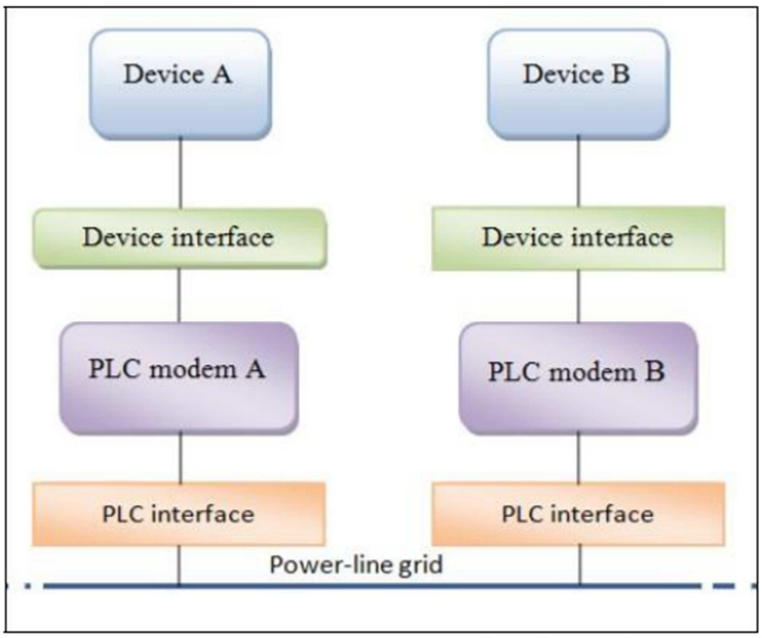


Figure 4 Communication over power-line grid

To control intelligent home appliances, the digital control signal will modulate an analogue carrier signal, which will be propagated through the entire AC power grid *at home on the same distribution system, so each receiver has its own "device address" that designates the control signal's owner. [23] These receivers can be plugged into standard power outlets or permanently wired. A PLC modem converts a data signal received from conventional communication devices, such as computers, PDAs, or Laptops, into a form suitable for transmission over power lines, as shown in Fig 4. In the opposite direction of transmission, the modem receives a data signal from the power grids and converts it before delivering it to the communications devices.

Conclusion

Our findings indicate that PLC is a viable technology for connecting wired devices in a smart building. A larger-scale deployment, however, would be required to validate the preliminary findings at a realistic scale and with realistic workloads. A larger corpus of building noise floor data is required to determine the frequency of this phenomenon and whether it can improve PLC SNR. Under certain conditions, we find excellent connectivity within "electrical" divisions or subnets, but we also notice some peculiarities with today's PLC technology, such as persistent network partitions that must be addressed for the approach to be usable. Using the home electrical system for networking, a home appliances control system based on PLC technology has been successfully implemented. An authorized manager can gain access to the main PLC controller and control the data of the selected home electrical appliance or sensor locally or via the Internet. The user interface is very user-friendly, and this system can be accessed from any platform using an internet web browser. Data security is also provided to safeguard the system against unauthorized access.

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