POWER LINE COMMUNICATION: THE IMPLEMENTATION IN MALAYSIA

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Abstract: Over the past years, broadband power line communication (PLC) has received great accomplishments for delivering high speed Internet access and other IP-based applications. PLC or DPL (Digital Power Line Communication) technology operates by transmitting a high frequency signal through the existing infrastructure in power distribution networks. As of today, many utility companies around the world have decided to move forward from small and large scale trials to commercial stage. In Malaysia, the nation's leading power utility company, Tenaga Nasional Berhad (TNB) under its ICT division has put their first effort to formalize PLC installation. To comply with the PLC standards, TNB is now undergoing changes and modification in experimental trial to suit both DPL and TNB equipment. TNB is then targeting higher data rates over 1Mbps. Implementation of DPL seeks consideration of selecting several parameters such as cable type, distance, noise, topology and cross bonding to ensure a stable communication channel. Hence, sensing the increasing demand for multimedia services by customer who require ease of use and speed, broadband Internet access solution over power line offers a promising future. The high data rate performance of the latest technology and advanced digital signal processing extends a practical benefit of communicating over the electrical network, not only in-building but also for access and transport (medium voltage). Moreover, low voltage (LV) power lines could be used to carry high frequency (>1MHz) communication signals. Thus, the concept of broadband PLC is introduced. Nevertheless, unlike twisted-pair or coaxial cables, LV power lines present an extremely harsh environment for high frequency communication signals. Despite the enormous potential, there is some skepticism about the technology and its commercial viability. This is due to several technical problems and regulatory issues that are yet to be solved. This paper gives an insight to the practical implementation of PLC/DPL in Malaysia subjected to some technical considerations.

Keywords: Power line communication, Broadband LAN

INTRODUCTION

Digital communications over power lines has been around for decades ago way back in the early 1920s. Since then, utility companies around the world have successfully utilised this technology for common applications like remote metering and control purposes. These applications, however, require only very low bit rates. As of today, there has been a significant usage of the Internet, and hence requires high speed data transmission.

Until recently, there has been a rising interest in the prospect of exploiting the power grid to offer broadband Internet access to residential customers. The attractive aspect of this idea is the presence of a vast infrastructure in place for power distribution and the service could reach more users than any other wired alternative. Access to the Internet is becoming more indispensable access to electrical power. Since devices that access the Internet are generally plugged into an electrical outlet, the unification of these two networks seems a convincing option.

There is a remarkable outlook for power line communications to bridge the gap. There is also a growing interest in the prospects of reusing in-building power line cables to provide a broadband LAN within the home or office. No new cable installation is needed as this is the major benefit offered by power-line-based-home networks which is the availability of an existing infrastructure of wires and wall outlets. There is some doubt about the technology and its commercial viability despite its wonderful potential. This is due to several technical problems and regulatory issues that is yet to be solved. The power line channel is known to be a very harsh environment that needs lots of research on modeling the right channel suitable for transmitting data. Hence, there comes products like LonWorks, CEBus and X-10 as well as proprietary systems for transmission and control. However, power lines

have been put to a cool off period as to its noisy nature as well as unpredictable to be useful for practical high-speed communication channel. Until recently, thanks to recent advances in communication and modulation methodologies and adaptive signal processing and error correction techniques, the path for intensive PLC network development at speeds comparable to those obtained from specially wired and wi-fi has been initiated. This paper highlights significant progress in high-speed communication over power lines and its implementation in Malaysia.

MATERIALS AND METHODS

The information gathered for this research study is obtained from various sources. The process of getting the information is by means of literature study and from site. Literature study is conducted by attaining information from library and Internet search. Most of the materials gathered for this study come from conference papers and magazines and then tailored towards comparing with Malaysian scenario.

RESULTS AND DISCUSSIONS

Power line communication field reopens the opportunities to enhance related major research areas and applications in communications and signal processing. Nevertheless, one can ponder on the feasibility of services built on this platform to be competent with other technology like DSL and cable in terms of quality and cost. However it looks quite promising for rural or remote areas where power cables are made available. In Malaysia, it is still considered an early stage of realizing power line communication network implementation. As to create an environment of necessity, studies are to be carried out to find a viable solution to supplying data at a high-bit rate transmission.

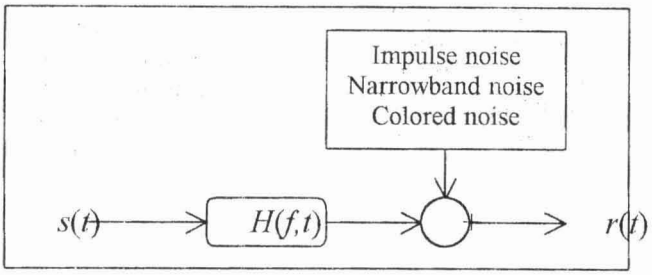
Power Line Communication: An Overview PLC or Digital Power Line Communication (DPL) is a utilization of existing power line cable infrastructure as a communication technology for home network and Internet access. PLC operates by transmitting a high frequency signals through the existed power line. PLC offer users a broad spectrum of applications and services including broadband Internet access, Voice Over IP (VoIP), multimedia services, home automation and energy management. The motivation of the wide interest in PLC or DPL is the presence of a vast infrastructure in place for power distribution. Also, the access to the service could be much higher than any other wired communication offered nowadays. What is more inviting is that new cable installation is averted as of the availability of existing structures of wires and wall outlets.

In spite of the enormous potential, there is some doubt about the technology and its commercial viability. This is due to several technical problems as the power line channel is proven to be a very harsh and noisy transmission medium generates challenges in opting for suitable modulation, coding and detection schemes. Moreover, regulatory issues naturally arise due to the unshielded nature of power line cables, which are both the source and target of electromagnetic interference.

The power lines, being a hostile medium, makes it difficult to design a system that is capable to cope with the problems especially noise and attenuation [2]. Thus, channel modeling comes in to optimize the usage of the power line to adapt for sending data in higher transmission rate. A serious channel modeling by means of understanding the power network is an intriguing problem as to no standardized models made available. Also, communication signals at low frequency that propagates along the low voltage power causes interference to other communication services. There are various types of noise sources; with channel noise varies strongly with frequency, load, time of the day and geographical location [11]. Figure 1 shows some significant noise spectrum in the frequency ranging up to 145 kHz. It comprises four types of noise [1, 12] that adds to a channel modeling:

- Colored background noise, which is the summation of low power sources like universal motors. Its power spectral density is frequency-dependent and decreases for increasing frequencies.
- Periodic impulse noise (Synchronous and asynchronous to the power frequency) stemming from appliances that produce harmonics of 50 to 100 Hz.

- Narrowband noise consisting of sinusoidal signals with modulated amplitudes i.e. radio stations, the horizontal retrace frequency for television etc.
- Asynchronous impulse noise from switching operations.



Source: IEEE Communication Magazine, April 2003.

Figure 1: Communication model of a power line channel

Besides noise, attenuation is also being included as a factor to signal degradation that is intolerable for a long distance. Hence, this surely bids for a range of modulation and coding solutions towards suiting the PLC for efficient data network [2]. Among the most popular ones are Orthogonal Frequency Division Multiplexing (OFDM) and spread spectrum. In Lancaster University, an ongoing research includes space-time coding for this purpose. In [7], the latest evaluation of modulation scheme that optimizes PLC design is discussed. Advanced signal processing techniques such as turbo coding and code division multiple access (CDMA) too are being utilized to combat the adverse communication environment on power lines to enable reliable high speed data communications [4].

Though it has not been so much talked about in Malaysia, one of an important issue that is to be addressed is concerning the debate of radiation emission from power lines that comes from upstream signals at customer premises and downstream signals at the substation. Similar issue in other countries like Europe and the United States are further discussed in [3,5].

In terms of market potential, expansion of PLC is quite tremendous [14]. There are some applications that have already been using the technology including automatic meter reading (AMR) and programmable controllers. TNB has already been using PLC to obtain real-time information that is in line with a strong foundation towards an effective data management. The marketability of PLC in home networking is discussed in [11].

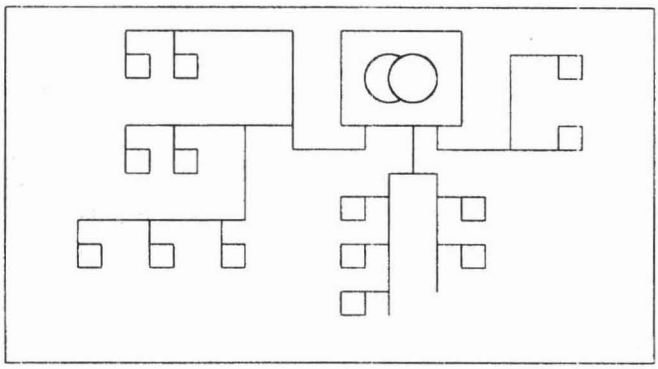
Implementation of PLC System in Malaysia.

The scene in Malaysia seems to welcome PLC home networking considering that we have an established National Grid system. Also, it is worth to note that there are so many Internet subscribers in this country but only a handful would have gained access via DSL or wireless. The following table shows a definitive comparison between PLC and some other network technologies.

Table 1: Comparison between Ethernet, wireless and power line network

Ethernet & Phone Line	Wireless	Power Line Network
▪ Fast, reliable services	▪ Can provide nodes anywhere	▪ Uses existing power line at home
▪ Require cables to each connection	▪ Ideal for handheld devices	▪ Nodes are already made available
▪ Considerable renovation required to retrofit older homes	▪ RF conversions hardware causes inherently costlier solution	
	▪ Security concern	

Power line communication is favorable as it follows a real network structure and the following presents the key elements that support a sound network environment. A typical PLC distribution network can be seen in Figure 2. The low voltage (LV) power line could be used to carry high frequency (>1MHz) communication signals. Hence, the concept of broadband PLC is introduced. Unlike other wired communication mediums such as the twisted-pair, or coaxial cables, LV power lines is considered hostile for high frequency communication signals. The three critical channel parameters namely noise, impedance and attenuation; are found to be highly volatile and vary with time, frequency and location. PLC signals are injected between phase and neutral in the access domain. The transfer function between two points of power line network is basically determined by three parameters: cable length, cable type and degree of branching [6].



Adapted from: IEEE Communication Magazine, April 2003.

Figure 2: A PLC distribution network

At the high voltage (HV) side, power lines come from power plants and represent a wide meshed long-distance nationwide network. The next lower level's task is to bring electrical power into cities, towns and villages. Here, medium voltage (MV) is utilized, constituting a finer meshed network in comparison to HV. Eventually MV is transformed down to LV with levels below 1 kV for distribution to customer premises. The LV grids represent a finer meshed network that specifically adapted to the density of consumer loads. This is certainly an advantage to TNB in implementing PLC/DPL in Malaysia as the country can be networked through the National Grid.

The power systems have never been designed for communication, and in terms of cabling, any power supply grid transports electrical low-loss power at frequencies of 50 or 60Hz. Using them for PLC means that they will have to carry signals at frequencies between 9kHz and 30MHz. In these frequency ranges, power cables become leaky, which means apart of the high-frequency signal, power emanates in the form of electromagnetic radiation. There exists an interference whenever PLC signals overlay frequency ranges of wireless services. Due to the used frequency ranges, there might be considerable contribution to the far field, as the wire structures carrying the PLC signals will form an antenna array. Moreover, cable length, being a limiting factor, shall introduce higher impedance (due to cable properties) thus increasing signal attenuation or loses. The longer the cable results in a lesser signal to noise ratio (SNR).

Since we are expecting much higher data rate, the frequency band is very high, 2-38 MHz. Higher frequencies introduce higher attenuation hence limiting DPL communication performance for a shorter distance. If compared to other technology, dedicated Cat5 cable can reach up to 100 metres at 10/100Mbps, wi-fi technology achieves over 50Mbps around 300 metres. Nevertheless, the performance reduces dramatically within a building. Not only DPL technology suffers the same problem, but it also has to deal with the existing power line topology which in many cases is longer than it can handle especially in MV network. A similar comparative study on PLC systems is seen in [8,10].

In Malaysia, TNB, being the main player of PLC technology, is in a stage of research on furnishing their power line infrastructure. PLC's technology has been utilized by TNB for quite sometime but its mainly in control purposes. Realizing the overwhelming response of PLC around the world, TNB has put this initiative under newly establish ICT division that consists of a dedicated DPL team. This team is to study, to evaluate, to coordinate and to conduct technical trials as well as planning for deployment in the end of 2004.

A test conducted in Putrajaya recently has managed to achieve over 40 Mbps at 260 metres on LV network, while 35 Mbps at 500 metres on MV network. Though MV network is more straightforward in terms of power line network itself, it is much more complicated to implement as compared to LV network. In addition, TNB substations vary in voltages, i.e. 11/0.415kV, 33/11kV, and etc. At a substation, DPL equipment and couplers must be in place to bypass the signal across the transformer as it causes tremendous signal loss. If MV is to be for transporting the traffic to the backbone, a diligent study of scenario demand per substation must be carried out. This is due to the fact that if for example there are 12 substations "above" the substation before reaching the backbone, it requires 12 DPL equipment and 12 couplers to bypass the entire substation, which would result in an inefficient cost solutions.

The implementation in Malaysia must also consider the different environment if a DPL system is to be installed. Malaysia is a country that experiences a weather that is different from that of Europe or Japan. Thunder storm with lightnings often causes the electrical network susceptible to cable fault and this calls for a change in deployment requirement. In order to design a communication system or selecting DPL system, it is useful to have as much knowledge as possible of some known parameters. The development of power line communication systems requires detailed knowledge of the channel properties, such as transfer function, interference scenario, and channel capacity in order to choose suitable transmission methods. If the noise level or the attenuation is too high, any communication system surely susceptible to breakdown.

Therefore, further trials and experiments must be carried out on communication performance based on the variety of the latest DPL technologies using different modulation techniques, complex digital signal processing and coupling technology to verify their actual performance in Malaysian environment. Nevertheless, there is still some pros and cons regarding the implementation of PLC. Hopefully there will be a more research that contributes to the development of the exciting new field of broadband PLC especially to a successful implementation in Malaysia.

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