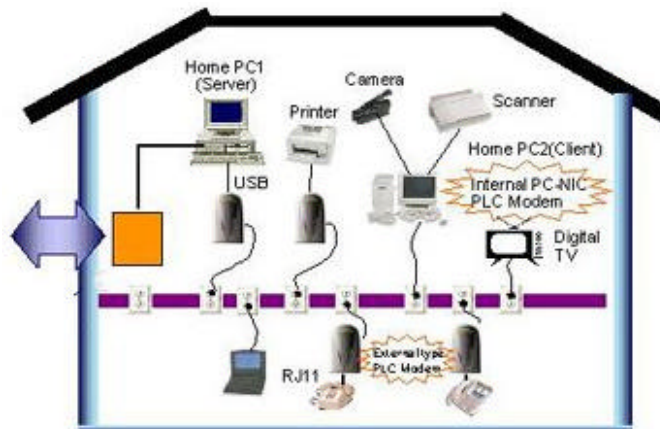




Research Proposal

Powerline Communication Systems – (1), (2)

Powerline Communication Systems use the existing AC electrical wiring as the network medium to provide high speed network access points almost anywhere there is an AC outlet. In most cases, building a home network using the existing ac electrical wiring is easier than trying to run wires, more secure and more reliable than radio wireless systems like 802.11b, and relatively inexpensive as well. For most home and small office applications, this is an excellent solution to your networking problems.



Introduction

Connecting to the Internet is a fact of life for business, government, and most households. The lure of e-commerce, video on demand, and e-mail has brought 60 million people to the Internet. Once they get to the Internet, they find out what it's really like. That includes long waits for popular sites, substantial waits for secure sites, and horrible video quality over the web. Nonetheless, Internet users persevere.

Industry Overview

However, the companies who provide Internet services have not been carrying on as usual. They realize that users of the Internet are hungry for faster service than phone lines and 56k modems currently provide. Additionally, many Internet service companies seek to increase their profitability by offering Internet access, local phone calls, cable TV, and perhaps long distance phone services to their customers in one relatively inexpensive package. The solution is a high bandwidth network with links to each customer's location. Implementing this type of network has not proven to be easy.

Telephone companies have offered high bandwidth lines for many years. For the most part, the cost of these lines and the equipment needed to access them has limited their usefulness to large businesses. The lone exception has been ISDN (Integrated Services



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Digital Network) which has won over some residential customers. ISDN offers fast Internet access (128k) at a relatively low cost.

Telephone companies have begun to replace the phone lines that connect residences and business to the standard telephone network with higher bandwidth lines. However, this process is costly and time consuming. Such higher bandwidth networks won't be operational for several years.

Cable television companies have also jumped into the Internet access market. The lines that carry cable television are much faster (1500k) than standard phone lines or even ISDN. The major problem with cable TV's attempts at providing Internet access has been the unidirectional character of cable TV lines. Cable TV lines are only designed to bring information to the customer, not to get input from the customer. This fundamental flaw in cable TV lines has increased the costs of developing Internet access services based on them. Thus, most cable TV Internet access systems will not be ready for several years. (Currently, Internet access over cable TV lines is available, but a phone line handles messages from customers to the Internet.)

Wireless solutions have also been proposed, but have run into problems. First, the performance and reliability of wireless solutions has not been up to the level of any of the wire-line solutions described so far. Second, the ability to send data from a customer to the Internet requires much more equipment than simply receiving data. This additional equipment makes wireless Internet access much more expensive than wireless cable TV.

A Solution

None of the available Internet access services offer the right balance of cost, convenience, and speed. Digital PowerLine technology could change all that. It gives customers high speed Internet access through electrical networks. Lower costs are achieved because the service is implemented on standard electrical lines. The service is also convenient because it's already in your home. Internet access through Digital PowerLine would be at 1Mbps, 20 times faster than a standard phone/modem connection.

Most high bandwidth Internet access schemes fail at the point of connection to residences and businesses. The cost of connecting many individual points usually overwhelms the project. Digital PowerLine services are already connected to almost all residences and businesses through electrical lines, thus making the service more economical for both providers of the service and customers of the service.

Using electrical lines also makes the service very convenient. There is no need for the bulky apparatus associated with wireless access. The service does not tie up phone lines like standard phone/modem connections, current implementations of Cable TV services, or other phone line based services. Additionally, the system features constant access to the Internet and much of the apparatus is already in your home.



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Digital PowerLine offers very high speed Internet access. Its performance far outclasses phone/modem connections and even ISDN. At 1Mbps, customers of Digital PowerLine services could explore the Web, talk on the phone, and watch a video-on-demand movie at the same time. All of these services are available through the innocuous looking electrical lines currently in your home. Evidently electrical lines were manufactured with more forethought than phone lines.

Overview of Technology

Digital PowerLine, developed by Northern Telecom and United Utilities, is capable of transmitting data at a rate of 1Mbps over existing electricity infrastructure.

Through "conditioning" of the existing electricity infrastructure, electrical utilities can transmit regular low frequency signals at 50 to 60Hz and much higher frequency signals above 1MHz without affecting either signal. The lower frequency signals carry power, while the higher frequency signals can transmit data.

Digital PowerLine use a network, known as a High Frequency Conditioned Power Network (HFPCN), to transmit data and electrical signals. A HFPCN uses a series of Conditioning Units (CU) to filter those separate signals.

The CU sends electricity to the outlets in the home and data signals to a communication module or "service unit". The service unit provides multiple channels for data, voice, etc.

Base station servers at local electricity substations connect to the Internet via fibre or broadband coaxial cable. The end result is similar to a neighbourhood local area network.

The Server

The Digital PowerLine base station is a standard rack mountable system designed specifically for current street electricity cabinets. Typically, one street cabinet contains 12 base station units, each capable of communicating over 1 of 40 possible radio channels. These units connect to the public telecommunications network at E1 or T1 speeds over some broadband service.

Several options, with different costs, can provide broadband Internet service to each base station. The simplest solution is connecting leased lines to each substation. This solution is potentially quite costly because of the number of lines involved. A wireless system has also been suggested to connect base stations to the Internet. This option reduces local loop fees, but increases hardware costs. Another alternative involves running high bandwidth lines, along side electric lines, to substations. These lines could be fibre, ATM, or broadband coaxial cable. This option avoids local loop fees, but is beset by equipment fees. The actual deployment of Digital PowerLine will probably involve a mix of these alternatives, optimized for cost efficiency in different areas and with different service providers.



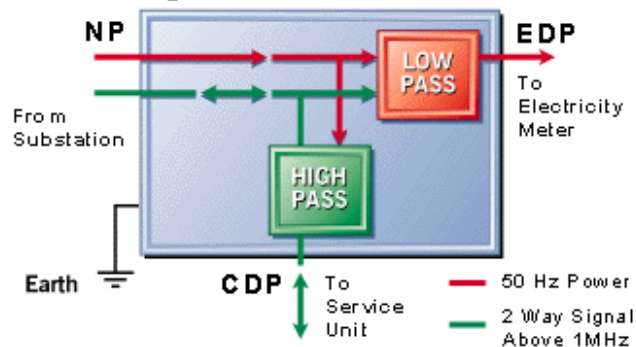
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These base stations typically serve approximately 50 customers, providing over 20 MHz of usable spectrum to near end customers and between 6 and 10 MHz of useable spectrum to far end customers. The server operates via IP to create a LAN type environment for each local service area.

The HFPCN Conditioning Unit

The Conditioning Unit (CU) for the Digital PowerLine Network is placed near the electric meter at each customer's home. The CU uses band pass filters to segregate the electricity and data signals, which facilitate the link between a customer's premise and an electricity substation.

Conditioning Unit



The CU contains three coupling ports. The device receives aggregate input from its Network Port (NP). This aggregate input passes through a high pass filter. Filtering allows data signals to pass to a Communications Distribution Port (CDP) and a low pass filter sends electric signals to the Electricity Distribution Port (EDP).

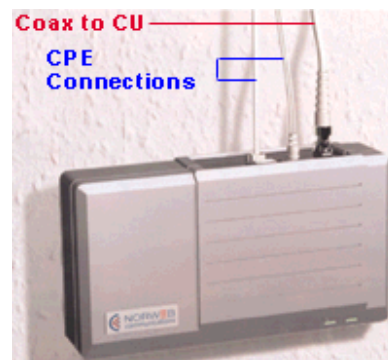
The 50 Hz signal flows from the low pass filter, out of the EDP and to the electricity meter. The low pass filter also serves to attenuate extraneous noise generated by electrical appliances at the customer premises. Left unconditioned, the aggregation of this extraneous noise from multiple homes would cause significant distortion in the network.

The high pass filter facilitates two way data traffic to and from the customer premise. Data signals flow through the CDP to the customer's service unit via standard coaxial cable.

Service Unit

The service unit is a wall or table mountable multi-purpose data communications box. The facilitates data connections via BNC connectors cable modems and telephone connections via standard line termination jacks.

The service unit provides its own line power for ringing and contains a battery backup in case of power outage. Alternative Differential Pulse Modulation (ADPCM) is used for speech



unit to

Code



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sampling.

Because Digital PowerLine allows for the termination of multiple radio signals at the customer premises, the service unit can facilitate various Customer Premise Equipment (CPE) simultaneously. In a manner similar to ISDN, data (computers) and voice (telephones) devices can coexist without interfering with each other.

Potential Advantages of Digital PowerLine Technology

This telecommunications model has multiple advantages over others including speed, an established local loop, and dedicated connections. These advantages make Digital PowerLine technology an attractive alternative for telecommunications systems.

In the Digital PowerLine model, small LANs are created; they terminate at each local electricity substation. These LANs will share a T1/E1 connection to the Internet, similar to a corporation leasing a T1 line. Individual users should experience tremendous speed increases over conventional 28.8kbs or 56kps dialup connections, even at peak usage.

Another inherent advantage to the Digital PowerLine model is the fact that it works well over the existing electric power infrastructure (at least in the UK, see the Limitations section below). Only the substation server equipment and customer conditioning/service units need to be installed in order to establish a Digital PowerLine network.

Dedicated, multipurpose communication lines make the Digital PowerLine model an attractive option for the information age. Wide bandwidth and frequency division multiplexing allow for multiple lines to a single household. Ideally, an entire family could utilize their own communication devices simultaneously, whether telephone or PC, without interrupting one another.

Potential Extensions to Digital PowerLine Technology

There are many possible extensions to the Digital PowerLine model. Those mentioned in reviews and technical journals include "the wired home" and remote customer information services.

Since Digital PowerLine creates a LAN type environment by running IP, people could theoretically control all of the appliances in their home from their PC or a remote device. Each home on the neighborhood LAN would operate as a sub-network of the LAN and each electrical outlet could be treated as a node on that sub-network.

The Nortel web site predicts, "It could also be feasible to have an Internet address for every plug in the house, through which you could e-mail, for example: 'fridge@home' and study the picture relayed by the video camera to see what shopping you require; or you could remotely turn the lights off and the burglar alarm on using your own password."



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Remote services such as remote metering have already been tested under this model and many more services are possible. Because the service provider can keep track of electricity and bandwidth usage via the network, customers will also be able to monitor their usage, reliably predict billing and keep an eye on household usage (i.e. the teenager's phone usage).

Current Limitations of Digital PowerLine Technology

Several implementation issues have held back Digital PowerLine in North America and the UK. Respectively, the problems are the numbers of users per transformer and the size and shape of light poles.

In North America, a transformer serves from 5 to 10 households while in Europe a transformer serves 150 households. Digital PowerLine signals cannot pass through a transformer. Therefore, all electrical substation equipment needed for Digital PowerLine has to be located after the transformer. Since there are fewer households per transformer in North America, predicted equipment costs are prohibitive. However, this conclusion has been debated. Analysts suggest that 100% subscription rates are possible in the US, and that at such rates Digital PowerLine is profitable. Conventional wisdom suggests that there is a way to make Digital PowerLine profitable in North America, whether it is through bundling a variety of services or higher fees.

Soon after the first trials of Digital PowerLine in the UK, some unanticipated problems arose. Certain radio frequencies were suddenly deluged with traffic, making it impossible to transmit on those frequencies. BBC, amateur radio, and the UK's emergency broadcasting service were affected. The apparent culprits were standard light poles. Then it became clear that by pure chance British light poles were the perfect size and shape to broadcast Digital PowerLine signals. This situation posed problems not just because of the frequencies involved but also because anyone could listen in on the traffic. Nor.Web is addressing the problem by proposing to lease the frequencies involved from their owners and offering amateur radio operators a new frequency. Negotiations on this topic are currently taking place in London. The privacy issue has not been fully addressed at this point, besides suggestions that all sensitive information should be encrypted.

The Market for Digital PowerLine

Trends in both the electric and telecommunications industry have led to a climate where Digital PowerLine should be a big player. These trends include customer demand for affordable and high speed Internet access, deregulation of electrical utilities, and the repercussions of a variety of telecommunications legislation.

Customers want cheaper, faster, and more reliable access to the Internet right now. Not only can Digital PowerLine provide that type of service, but it will be available before other broadband access technologies. Therefore Digital PowerLine has both a time to market and cost advantage. This may be too much for the other broadband access technologies.



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The utility industry is facing deregulation in North America, Europe, and some parts of Asia. Deregulation means increased competition in the slow growing electricity market with little protection for utilities. Consequently, many utilities are actively seeking to diversify into other, more profitable, industries. For many utilities telecommunications and Internet services have been a sensible choice. That option can only become more popular as Digital PowerLine matures.

Digital PowerLine offers a deregulated utility several options and advantages. The utility can either lease the rights to implement Digital PowerLine on its electrical grid or develop the technology itself. The advantages include the low cost of the local loop, differentiating the utility from other utilities, and bundling a variety of services.

The most recent telecommunications act has tried to make it easier for all types of telecommunications firms to sell local services and long distance services. However, Regional Bells actually have control over local lines and charge other companies who place calls on their lines. Many of the larger phone companies have sought to get around these charges by building or leasing their own networks to connect to local points. Digital PowerLine is an existing network that fits those needs. Expect to see smaller telecommunications companies partnering with electrical utilities to provide alternative local phone service.

Conclusion

Digital PowerLine technology is an exciting alternative to connecting to the Internet via phone and modem. Though this technology is not commercially available yet, it should be available before other broadband technologies due to the relatively low cost of its local loop. Moreover, its high speeds will provide Internet access, video on demand, local phone, and long distance phone services to customers.

It is the aim of the commission to raise interest in this technology with a view on initiating research into the use and applicability of powerline technology in developing countries with a view on providing the last mile infrastructure.

[1] "*Powerline Carrier (PLC) Communication systems*", Khurram Hussain Zuberi, September 2003, http://www.it.kth.se/~iw01_zkh

[2] "*Powerline communication systems*" - <http://www.ipcf.org/powerlineintro.html>