Power-line Communications (PLC) or Broadband-over-Power-line (BPL)

Introduction

In the 1990s, companies such as Nortel Networks and Siemens recognized the potential of carrying Broadband communications over power-lines. They launched R&D initiatives to send IP packets over power grids. But technology at the time faced hurdles. For example, to transmit data along noisy electric lines, the signals had to be turned up so high that they interfered with transmissions from other devices such as radios and military equipment. Means to pass the broadband signal through the power transformer between the medium voltage (2.4-35 kV) and low voltage (100-600 V) could not be found.

Since then, technology has evolved and complex circuits are available at low cost through volume production. Companies such as Current Technologies (www.currenttechnologies.com) and Ambient (www.ambientcorp.com) bypass the power transformer with special couplers to provide high-speed data access to the customer premise via a standard electrical outlet using existing standard consumer devices such as those promoted by Homeplug or EIA (CEbus). Main.Net (www.powerline-plc.com) relies on packet-chopping technology to slip the data intact through the trash-can-sized transformer. Amperion (www.amperion.com) uses Wi-Fi technologies to bring the Internet signal to the customer from the medium voltage lines before it gets to the transformer.

An Ottawa company (Congency located behind Newbridge) developed integrated circuits for data transmission over home power-line. It uses OFDM modulation to shape the signal spectrum to match the channel. The throughput is around 4-6 Mbps.

At least a dozen utilities are conducting field trials in the US, including, among the 15 largest, the Southern Company of Atlanta, American Electric Power of Columbus, Ohio, and New York-based Con Edison. At least two utilities — Pennsylvania Power & Light and Ameren of St. Louis — are expected to launch service in a few neighborhoods this year. Some utilities in Europe and Asia already offer limited service. In Canada, Sault Ste. Marie Public Utilities Commission is planning to deliver high-speed Internet access by Power Line Communication (PLC) systems.

The regulatory environment

The Federal Communications Commission is excited about the potential of Broadband -over-power-line. Eventually, it can become the third means of bringing Broadband to homes and could compete with DSL and Cable. This would fit very well with the FCC relaxed position regarding service unbundling.

The Federal Communications Commission recently voted to phase out DSL competitors' discount access to the regional Bells' broadband networks. They feel that electric companies could replace that lost competition, helping to hold down retail prices. The FCC is now putting a lot of hopes and is prepared to provide accommodations for this technology. For example, the FCC's Powell believes the service can be rolled out under rules that let unlicensed wireless

services emit tiny amounts of energy. At worst, however, officials say, a waiver or slight change to rules or equipment standards might be needed.

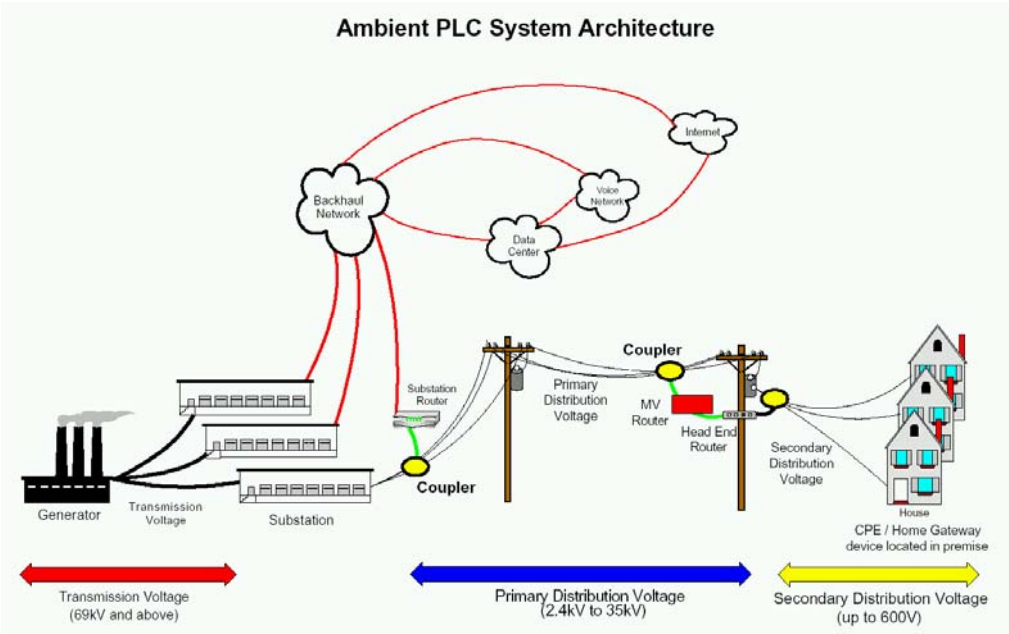
Federal Communications Commission voted on April 23, 2003, to solicit public comment on broadband Internet service delivered over ordinary electric power lines.

Industry Canada is following this process very closely and tries to develop an opinion on this issue.

The technology environment

The power grid is a very hostile environment for higher frequency transmission. The overhead power lines are not insulated and no impedance matching is possible over the rather broad bandwidth (2-80 MHz) expected to be used for such data transmission. This, along with the tendency by the overhead wiring to pick-up interfering signals since there is no shielding tends to limit the reach of the medium voltage loop. Repeaters can be used to extend this range. Although there are some rather gratuitous claims that power-line transmission may be able to extend the reach of broadband to rural areas, it is likely that this technology, if proven to work adequately, will compete with DSL and cable technologies in areas with rather high population density.

Some of the systems are to use the low voltage loop to the subscriber's house, allowing broadband connection through the AC outlets. This creates even more challenges with the electric noise generated by any brush electric motors such as those found in vacuum, hair dryer or fan on the same circuit. The local power network is also laid out in branches, with the same wires feeding many customers. That, as well as a collision course of capacitors, switches and other gadgets, will impact on the signal availability.



Reports indicate raw data speeds of up to 45 Mbit/s with real throughputs of approximately 18 Mbit/s to be shared among subscribers on the same medium-voltage circuit. Distance that can be covered on the medium-voltage circuit is about 1.6 km.

All the effects enumerated above are well known and it is expected that, because of the potential market, the various companies will put a lot of effort in optimizing their technology to alleviate these drawbacks. The impact will likely be translated in reduced effective throughput and variable availability. An area where the companies are not likely to put as much effort is on the interference aspect, especially interference to other services operating in the same region of the spectrum.

Interference

It is likely that extensive signal processing will be used by industry to make the transmitted signal as robust as possible to impairments from the power grid and local power distribution in the houses. This will make the signal robust ingress interference such as that coming from TV, radio and mobile (police radios) communication system transmissions and even garage door openers.

It is not clear, however, whether the industry will invest as much energy toward studying interference created by PLC that could affect other communication services operating in the same frequency range (2-80 MHz).

In the High Frequency (HF) band (3-30 MHz), a number of communication systems could be affected: HF broadcasting, radiocomunications (fixed and mobile) services and amateur radio. Other services in the low VHF band will also need to be protected such as TV broadcasting and fixed and mobile services.

The RF signals generated by PLC will easily radiate from the medium voltage overhead wiring and the local AC wiring (except in the case of the Amperion system that utilizes Wi-Fi to bring the signal to homes. The extent of these unintentional radiated emissions will depend on many factors, including differences in the configuration of the AC mains supply systems and the physical layout of the wiring. The management of unintentionally radiated emissions from PLC systems will need to be addressed under the inter-service interference limits and the electromagnetic compatibility (EMC) rules.

CRC contribution

So far, CRC has conducted a study on in-house power-line broadband access, testing operability and performance of the Linksys' PowerLine Etherfast 10/100 Bridge which uses the HomePlug Alliance transmission standard on home AC wiring. Results were positive except for some limitations on throughput and the detrimental effect of noisy electrical equipment on the transmission. No interference potential study has been conducted so far.

Work needs to be done on the emission capability of the medium-voltage power-line circuits. This overhead wiring can become a great radiating structure at these frequencies. Modeling of such 'antenna structure' need to be done using wire-antenna software models to establish the

field-strength generated in various directions. This could also be applied to the low-voltage drop going to the houses.

More empirical characterization of the emission potential of the home AC wiring will also need to be done. These results will need to be compared to the threshold of interference allowed for the acceptable operation of the other communication services utilizing the frequency range and to the acceptable EMC levels.

An estimate of some 4 PY's ($320k) and the necessary modeling and test equipment ($150k) are needed to carry-out this work in a timely manner. The working team would comprise one scientist and an engineer on wire-antenna modeling, one EMC engineer and a team of RF engineers and technologists to plan and conduct measurements on home wiring, low-voltage and medium-voltage wiring and on the proposed PLC systems. Some activities would be long term (i.e., one year) whereas others would be over limited time periods as needed and depending on the availability of the equipment.

G. Chouinard
03.11.04