BROADBAND DATA HITCHES A RIDE WITH AN UNLIKELY CARRIER.

Riding the sine wave

BY MAURY WRIGHT • EDITOR AT LARGE

Proponents of BPL (broadband-over-power-line) technology insist that the best wires for the last mile were strung and connected long ago. But BPL still faces technical hurdles, a potentially nasty standards fight, and angry amateur-radio operators.

To many of us that lived the DSL-versus-cable battles, the broadband fight is history. But as alternative schemes such as WiMax are demonstrating, a place still exists for new last-mile broadband technologies. BPL advocates insist that the power grid is the best option yet. The technology offers the potential advantage of a ubiquitous "broadband outlet" on every wall of a house or a business. Moreover, a smart grid could enable applications such as automatic meter reading, load balancing, and even remote control of power-hungry appliances such as air conditioners—in turn subsidizing the Internet service. Proponents even claim that BPL systems can deliver video and voice over IP in addition to Internet services. Relatively small deployments of BPL are under way worldwide. But let's fully examine the real challenges that BPL still must face to go mainstream.

Depending on whom you listen to, BPL is either a panacea or a plague. Back in early October, ComTek (Communications Technologies) held a press conference in conjunction with the city of Manassas, VA, to announce a citywide BPL network. The hype was thick. ComTek Founder and Chief Executive Officer Joseph Fergus opened saying, "It's certainly a pleasure being here today to welcome you all to this great event, this historic event in the history of this nation ... to announce an achievement of a major national technology milestone—the first citywide commercial deployment of BPL. It is no exaggeration to say that Manassas now has the distinction of being plugged into the Internet in a way that is truly unlike any other city in America."

Others weren't quite so taken with the news. Manassas citizen, engineer, and ham (amateur-radio) enthusiast George Tarnovsky stated, "This entire BPL system is a failure." Tarnovsky's point focused not only on emissions from the BPL system that interfere with ham operations, but also on interference from hams and other sources to the BPL system. He continued, "They have no ingress protection."

Sending data over power lines is not a new concept. The HPA (HomePlug Powerline Alliance) has for years touted power-line-based home networking, and HomePlug 1.0 products from multiple vendors offer 14-Mbps maximum data rates—although actual data rates are in the 5- to 6-Mbps range. New HomePlug 1.0 Turbo products are just emerging that extend the maximum speed to 85 Mbps. Meanwhile, the group is working on a new specification, HomePlug AV, which will focus on moving video around a home and offer 200-Mbps rates. That specification is complete, and chip samples that support HomePlug AV are due late this year.

BPL, however, focuses on using the

AT A GLANCE

- BPL (broadband over power line) will compete with DSL and cable and, through the "broadband-outlet" concept, may prove even simpler for consumers to buy and install.
- BPL technologies for various vendors all rely on baseline OFDM (orthogonal-frequency-division-multiplexing) technology, but no universal standard exists.
- The IEEE P1901 committee is working on power-line networking for access and in-home applications, but three consortiums are pushing different technologies.
- BPL systems generate real interference that can hinder amateur radio and other services, but filtering can eliminate the noise.

power grid for the access side of broadband. The power lines that serve homes will also serve up broadband data. Data will still ride fiber optics or other high-speed network media into neighborhoods but will then jump to the power grid to reach the home, thereby eliminating the need for trenching and new wires (see **sidebar** "BPL backhaul"). Presumably, BPL will reach subscribers that DSL or cable doesn't. And, in some cases, BPL will simply compete with the incumbents (see **sidebar** "BPL: Do the economics work?").

There are two choices for when to couple the data to the power line. In some cases, service providers use only the LV (low-voltage) lines for BPL. Typically, in an LV deployment, data enters the grid at the transformer that serves six to eight houses. The transformer and, therefore, the BPL bridge or router may be pole-mounted or may be in a cabinet on the ground when utilities are underground. LV BPL typically works over 110 or 220V systems. In other cases, service providers also send data along the MV (medium-voltage) portion of the grid—lessening the reach required of fiber or other high-speed media. MV architectures vary greatly by utility and world region, but voltage on such lines varies from 5 to 30 kV. Generally, the broadband stream must couple from the MV to the LV lines at each transformer.

Both BPL and in-home power-line networking rely on the same baseline OFDM (orthogonal-frequency-division-multiplexing) technology that DSL and 802.11 wireless LANs use. HomePlug 1.0, for instance, uses 84 equally spaced OFDM subcarriers in the band between 4.5 and 21 MHz.

Unfortunately, OFDM is the only commonality when it comes to competing BPL schemes. There are three main BPL camps today, organized primarily around IC companies. Intellon has long touted power-line networking and has been a leader in the HPA since its inception. Intellon is the leader in HPA chips, although Conexant also offers products, and Arkados is just entering the market. Although HomePlug 1.0 was designed for in-home networking, manufacturers are deploying HomePlug 1.0 chips in LV BPL systems.

Spain-based DS2 (Design of Systems on Silicon) was also once an HPA member but left the organization because of a disagreement over the technology road map. But DS2 has an advantage in working products. The company has chips in production for both in-home and BPL networks that operate at 200-Mbps rates. The third player is Israel-based Main.net Communications. But, although there are BPL deployments based on Main.net chips, the company is supposedly in financial trouble. Representatives did not respond to *EDN*'s requests for an interview.

STANDARDS MURK LURKS

Although the HPA is arguably a standards body and European organization Opera (Open PLC Research Alliance) has adopted DS2 technology, a standards battle is still on the horizon. The IEEE P1901 committee is working on both BPL and in-home power-line networking. Jean-Philippe Faure of Schneider Electric and Jim Mollenkopf of Current Communications Group act as co-chairmen of the committee. Current Communications Group includes both Current Communications, a BPL-service provider, and Current Technologies, a BPL-equipment vendor. Today, Current is clearly in the HomePlug camp; Schneider would probably lean toward DS2.

Still, Faure and Mollenkopf are charged with building consensus and impartial development of the best technology. Mollenkopf, chief architect at Current but speaking in his role as co-chairman, says, "We will choose the best solution. We will choose whatever works best." According to Mollenkopf, the BPL focus is now on the LV flavor, although, he states, "We probably will address the MV side over time." The group is looking for a technology that delivers raw data rates in excess of 100 Mbps.

Mollenkopf admits that three industry consortiums are active in the P1901 committee, including the HPA; the UPA (Universal Powerline Alliance), of which DS2 is a key member; and the CEPCA (Consumer Electronics Powerline Communication Alliance). Panasonic and other consumer-electronics companies drive CEPCA, which primarily focuses on in-home networks. According to Mollenkopf, Main.net is not participating in the committee.

DO STANDARDS MATTER?

In any case, a standard is not forthcoming from the IEEE any time soon. The organization began working on one this summer, and Mollenkopf hopes for a ratified standard by the end of 2006, but he admits that his time line is optimistic. In many ways, the process is no different from other communication technologies for which multiple flavors existed. In the early days of DSL, for instance, there were at least three flavors vying for market share. Vendors shipped multiple flavors while the players worked out the standards issues, and the market succeeded with minimal impediment from the standards carnage.

But BPL is fundamentally different from other broadband flavors. In the case of DSL and cable, for instance, the broadband-access network is completely separate from the in-home network—whether the in-home choice is Ethernet, 802.11, or even HomePlug. In the case of BPL, the technology has to work even if the in-home network is also power-line-based. And no gateway separates the access and in-home networks. Mol-

lenkopf states, "Our biggest focus is on the low-voltage wire for both access and in home. There is not a clean demarcation point that the wires respect."

So, here we have one of BPL's potentially strongest value propositions and a potential Achilles' heel. The HPA promotes the concept of the broadband outlet. In its vision, every power plug is broadband-enabled. A subscriber needs no gateway or router. A subscriber can connect a game console in the family room using a HomePlug modem, a set-top box in the living room using a HomePlug modem, and a PC in the office using yet another HomePlug modem. Current Communications has one of the largest North American BPL deployments in the Cincinnati area in partnership with the Cinergy utility. Current's products rely on HomePlug 1.0 chips, and the company is selling BPL based on the broadband-outlet model. Customers buy HomePlug 1.0 products and install one for each PC or other Internet appliance. The process is purely based on self-installation, and the products sell for as little as $30 at major retailers. BPL offers symmetrical bandwidth, and each modem communicates directly with the bridge/router at the transformer. The HPA and Current claim that this architecture offers better performance than cable or DSL. Current offers the service in Cincinnati for $27 per month regardless of how many modems a customer owns.

The disadvantages of the broadband-outlet concept include security issues, and the absolute requirement of a standard that considers the interaction between the access and the in-home networks because they are physically one and the same. Say you want to share files over your home network and that the connection between two computers is the power line that also serves up your Internet. The files move on a network that you also share with your neighbors. The same concern could hold true with cable modems, but most cable subscribers connect the cable modem directly to a fire-

BPL: DO THE ECONOMICS WORK?

Although most of the buzz surrounding BPL (broadband over power line) has been technology-centric, it's fair to ask whether the world needs yet another broadband-access scheme. In fact, the same question holds for fixed-wireless schemes, such as WiMax. But the WiMax crowd can point to Third World countries where there are no DSL or cable incumbents as markets. Presumably, BPL could serve in those places, as well, although the power grid in such areas more than likely lacks the reliability to serve. So, where will BPL win and at what cost?

In the long term, the success of BPL may depend on power-centric features that a smart power grid enables. Automatic meter reading alone could save utilities major amounts of dollars and help subsidize Internet services. In areas such as California, where rolling blackouts are a threat each summer, the ability to remotely control customers' appliances may be a major money saver.

Oleg Logvinov, president and chief executive officer of start-up IC vendor Arkados, states, "I'm a skeptic of BPL as a pure-play technology." But Logvinov, who comes from the power industry, can give you a dozen reasons that BPL will succeed. He claims that utilities will use the distributed intelligence to do preventive maintenance and better understand where losses occur in the grid. He believes that utilities will ultimately manage reactive power to save energy. Logvinov states, "It's possible to save more than 10% just by optimizing your distribution."

Other players believe that the dollars do add up for BPL as a pure-Internet play. Motorola Business Development Manager Mary Ashe states, "From a pure revenue perspective, from a cost of equipment perspective, it's a very strong business case."

The major BPL deployments that you can consider as examples appear to be competitively priced. The ComTek (Communications Technologies) deployment that covers the city of Manassas, VA, will go head to head against DSL and cable alternatives. ComTek is pricing the service at $29.95 per month. You may find DSL or cable cheaper–especially if you swap carriers and make a long-term commitment–but the ComTek price is competitive. The service passes 12,500 homes and 2500 businesses and, so far, has 700 paying customers. The Current Communications deployment in Cincinnati costs $27 per month.

Note that, in the ComTek case, the deployment is not a pure-Internet play. The Manassas utility is taking advantage of the smart grid to control traffic lights, to connect cameras that enable remote monitoring of substations, and to automatically detect outages. The city is still exploring automatic meter reading.

Ultimately, however, BPL faces an obstacle that cable and DSL don't. A BPL system requires a bridge/router at the transformer to serve a customer. The typical transformer serves only six to eight power customers. If only one customer buys the Internet service, that bridge becomes expensive. Cable and DSL plants don't require gear to be so granular in most cases. In fact, cable and DSL service providers just don't offer service when they can't cost-effectively distribute their investment across many customers. Perhaps those are the types of customers that BPL will win. But will BPL service providers be able to afford to serve customers that the other broadband players can't?

wall/router, and home-network transfers occur behind the firewall. In the HPA scenario, only the built-in 56-bit DES (Data Encryption Standard) keeps the data passing between two HomePlug modems private—although the HPA will later add more robust security.

As for compatible access and in-home standards, the HPA has simply decided to use the same MAC (media-access-controller) and PHY (physical) layers for both. The HPA has announced that the HomePlug BPL specification due in mid-2006 will use the MAC and PHY that are already parts of HomePlug AV.

As you might guess, not everyone thinks a common access and in-home physical network is a great idea. Motorola, for instance, offers BPL equipment under the brand Powerline LV that the company also based on HomePlug 1.0 chips. According to Principal Engineer Dick Illman, "Our model is still very much like DSL or cable modem. Our intent is one client per house." Motorola Business Development Manager Mary Ashe expects most subscribers to use 802.11 or Ethernet as their home network.

Although Motorola uses HomePlug chips, the company also adds more robust encryption and authentication capabilities. So, customers in a Motorola-based BPL deployment must use a modem from the service provider rather than buy a modem at retail. The result is a more expensive modem, although Ashe claims that prices can still be less than $100. And the system still relies on a self-installation model. Illman claims that the Powerline LV modems will coexist with a HomePlug home network, although the bandwidth of both would suffer. The CSMA/CA (carrier-sense-multiple-access-with-collision-avoidance) MAC scheme would allow both networks access to the wire.

SEPARATE ACCESS AND HOME

DS2, meanwhile, believes in distinct access and in-home networks. Company Founder Victor Dominguez states, "It's impossible to develop a technology for the home if you don't consider how it interacts with the access network." With regard to the HPA's plan to use the same MAC and PHY layers for access and in the home, Dominguez states, "It makes no sense from the PHY-channel, network-topology, or network-performance perspectives."

DS2 is unwilling to share the details of its MAC and PHY layers, but Dominguez believes that the first order of business for

BPL BACKHAUL

BPL (broadband-over-power-line) deployments still rely on some type of high-speed backhaul network to succeed. In LV (low-voltage) BPL networks, only the power line between the transformer and the home carries the data stream. In medium-voltage systems, the data rides the power lines significantly farther, but such systems must still link to the telecommunications infrastructure at some point.

A fiber ring that Manassas, VA, installed over the past five years enables the much-hyped, citywide BPL deployment. The network does rely on both medium-voltage and LV lines to carry data from substations to subscribers.

Motorola, conversely, is promoting LV-only BPL. An LV system would normally require a fairly extensive push of fiber into a service area. But Motorola is solving the backhaul problem with its Canopy fixed-wireless offering. Canopy is available in a variety of unlicensed frequency bands and in point-to-point or point-to-multipoint topologies. The service is similar to WiMax, and Motorola will likely move Canopy to the WiMax standard now that the spec is stable. The Powerline LV system relies on a Canopy antenna and receiver that reside on the power pole with the transformer and feed the LV BPL bridge.

any power-line-standards body should be a coexistence layer. He claims that the UPA already has such a layer in place. In addition, the ETSI (European Telecommunication Standards Institute, www.etsi.org) is working on power-line standards. The IEEE P1901 group has a liaison with the ETSI group. Dominguez claims that the ETSI group will early next year define a coexistence layer and that the HPA rejected such a layer. Mollenkopf from the IEEE states, "A potential solution is a common signaling protocol."

With or without a standard, the BPL movement is going full-steam ahead. Another industry group, The United Power Line Council, has a PDF map of BPL installations on its Web site (www.uplc.utc.org/file_depot/0-10000000/0-10000/7966/conman/BPL+Map+updated.pdf), and the number of deployments in North America is amazing even if some are only trials. And Europe is well ahead of North America in BPL deployment. The utilities involved include stalwarts such as Consolidated Edison and Duke Power. And ISPs (Internet-service providers), such as Earthlink, are signing on as partners to provide the Internet backbone.

WHAT IS INTERFERENCE?

With BPL rolling out, however, ham operators around the world are the leading voices of dissent, because some BPL installations interfere with ham operations. There is no question that BPL systems emit energy that acts as interference to radio communications. The overhead power lines are unshielded and cover a lot of geography—especially when a utility runs data along MV lines. Some in the BPL industry have characterized the ham operators as lunatics with nothing better to do than complain. Some of these "lunatics" claim that the BPL industry will interfere with emergency communications, leading to catastrophe. Others argue that the technology ultimately lacks the capacity to serve the stated goals of voice, data, and video. Fortunately, there are some reasonable people on both sides of the issue.

The National Association for Amateur Radio represents the ham operators. The group still uses the acronym ARRL (American Radio Relay League) from its legacy group (www.arrl.org). ARRL Laboratory Manager Ed Hare has been involved with testing BPL systems and has worked with the HPA group and companies such as Motorola to try to make BPL work. Hare states, "My goal is to help BPL succeed. Not all BPL systems will cause interference."

BPL systems operate under Part 15 of the FCC (Federal Communications Commission) rules that cover unlicensed services. Basically, the rule states that such services can't interfere with other authorized radio services. Moreover, the FCC specifically prohibits such systems from using frequencies assigned for emergency service, the police, the military, and others. Last year, the FCC also issued guidelines for BPL systems. For a complete description of the situation, see a review of the FCC rules and order compiled by *Conformity* magazine (**Reference 1**).

According to Hare, both DS2- and HomePlug-chip vendors have worked to minimize interference. To eliminate interference, the chip makers implement "notches" that keep BPL signals out of bands that hams use. The term "notch" is a bit misleading, because it refers to an analog filter. In the OFDM systems, the BPL vendors simply don't use the subcarriers in the frequency bands that the hams use.

Intellon's HomePlug chips come with the notches in place. DS2 offers programmable notches that you can dynamically reconfigure. According to Hare, systems based on HomePlug or DS2 chips are relatively quiet. With the notches in place, Hare claims, an overhead power line would generate a noise level about 15 dB higher than quiet. The noise would not be measurable on underground power lines.

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- For more on BPL, visit the following *EDN* blog postings:
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  - www.edn.com/051110b4
  - www.edn.com/051110b5
- See also "Free from interference: FCC adopts powerline rules" at www.edn.com/article/CA475078.

Many in the BPL industry see the notched systems as quiet. The ham operators have long memories regarding what's acceptable when it comes to interference. Neighbors of ham operators have often blamed them for causing interference on TVs. As Hare points out, a TV viewer that gets a herringbone pattern on his picture is unhappy regardless of whether the measured interference is legal. And ham operators would like even the 15 dB of noise to go away.

Hare points out that Motorola has eliminated interference in its Powerline LV equipment. Interference is yet another reason that Motorola supplies its own power-line modems rather than relying on off-the-shelf HomePlug modems. Motorola's Illman claims that, even with some carriers turned off in an OFDM system, intermodulation still results in a noise floor in those bands. So, Motorola added filters to its modem to further clean those frequencies. The result is a system that emits no interference and completely rejects interference, as well. Hare has extensively tested the Motorola system and affirms both claims.

Still, even the notched systems that do generate a bit of noise aren't the ARRL's biggest target. Systems without notches are. Hare claims that some service providers using DS2-based gear simply don't enable the programmable notches. And it appears that some Main.net-based systems either lack the ability to notch the frequencies in question or require some type of manual configuration of filters.

Manassas, VA, based its BPL deployment on Main.net technology, and it is noisy, according to local ham operators. Tarnovsky claims that a group of local ham operators surveyed the city and found that, generally, a signal-strength meter on a ham radio measures noise of S9 plus 20 to 40 dB. Such meters use a scale of S0 to S9, and S3 to S5 is considered a quiet environment. More than S9 is at the top of the scale.

Tarnovsky claims that the Manassas deployment primarily uses a first generation of Main.net's chips that you can't program to notch the frequencies of interest. Main.net even sent an engineer to meet with the group of ham operators. According to Tarnovsky, ComTek promised to implement notches, but a ComTek employee acknowledged that the company has yet to do so. A ComTek executive did not return *EDN*'s calls to address these issues.

In mid-October, the ARRL formally asked the FCC to instruct Manassas to shut down the BPL system. At press time, the ARRL was waiting for a response. Tarnovsky claims that the system is unreliable in any event, due to lack of filtering from ingress noise. He claims that mobile-ham operators transmitting around town have locked up portions of the BPL system requiring a reset. I wonder whether that's what ComTek's Fergus means when he states that Manassas citizens have a unique way of connecting to the Internet? EDN

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FOR MORE INFORMATION

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