Manassas: Lessons from the First Big BPL System

HFBPL—Hybrid Fiber Broadband Powerline—for Only $500,000!

By Guy Swindell, *AFL Telecommunications* and Paul Hood, *Electronic Systems Supervisor, City of Manassas*

Tourists have come for decades to historic Manassas Virginia to view the scene of several bloody Civil War battles. Lately, however, the city has seen an influx of visitors with an inclination to stick around and ask questions of a more technical nature. Manassas has one of the world's first fully commercialized deployments of Broadband Powerline (BPL) technology. Residents in many parts of the city can plug a modem into an electrical outlet and receive DSL-speed Internet access.

The telecom and electric utility industries have taken notice, and the Manassas network has been studied by visitors from around the U.S. and as far away as Tokyo. The attention is well deserved. The discerning visitor, however, will note that the Manassas BPL deployment has a fiber-rich diet. Signals come to the home through the electric lines, but fiber carries the data to the switches in the first place. This is not an incidental fact. The city's fiber optic backhaul solution was a well conceived and thoroughly considered way to further economic development objectives and mitigate the risks associated with new technology. BPL at Manassas includes one of the most clever fiber-to-the-premises (FTTP) deployments in North America.

System Basics

The Manassas Department of Utilities serves 15,000 electric meters in a city that is only a twenty-minute drive from Washington's Dulles International Airport. About 80 percent of the city-owned electrical grid is underground and is supported by nearly 2,000 transformers. That entire underground infrastructure makes the deployment of any new cable a daunting task. That's why BPL is so attractive as an alternative there.

The city installs a device at each of its 600-ampere distribution switches that injects Ethernet data onto the electrical grid. From each switch, anywhere from 50 to 75 customers can receive 500 Kbps service with present technology and up to 1.5 Mbps with next generation solutions.

Between the subscriber and the distribution switch, repeaters are installed at smaller stepdown street-level transformers and occasionally in a resident's home electrical meter base (depending on the home's distance from the transformer). The cost of doing business is attractive. With an average of 7.5 customers per street-level transformer, and assuming a modest penetration rate of 20 percent, it costs between $400 to $650 per customer to build this network from the distribution switch and provide the subscriber with a modem that can be used at any electrical outlet in the city where the service is offered.

Perhaps best of all, the City of Manassas doesn't actually purchase any BPL equipment. A third-party ISP is the actual service provider. The City Utility Department collects a piece of the revenue by allowing access to the electrical grid, providing a telecom connection to the distribution switch, and installing the equipment. In addition to the revenue, the city also gets a substantial benefit from the resulting real-time monitoring of its electrical service – an inherent side effect of piping data over the grid.

The attraction is obvious. What municipal utility wouldn't want to foster local broadband competition while collecting additional revenue from an existing asset? It is even more attractive when you consider that Manassas entered the business by simply enabling an Ethernet data service. The city avoided the protracted legal battles and negative public relations campaigns that often accompany public-power forays into legacy services such as voice and video.

Key Technical Issues

BPL, however, is not without its pitfalls. The interference controversy – the data signal can be broadcast over transformers if allowed to traverse the transformer switches directly -- is well documented. Fortunately, it appears to be solvable, and might have been a little overstated from the beginning.

But another issue looms large for any public power company deploying BPL, and that is an issue of timing. While proponents of BPL sing the merits of easy installation and ubiquitous infrastructure, pundits are quick to point out that BPL is coming into its own just as fiber-to-the-home technologies are hitting their stride. For a public power company, any new business model has to be predicated upon some opportunity for economic development in the community. Towns like Manassas want to compete for high-tech companies that rely on a robust telecommunications infrastructure. Competition in this game is measured by the ability to deliver lots of information-carrying capacity at a better price than the folks next door. So, if your neighbor is installing fiber to every home and business, deploying slower BPL seems a little like bringing a knife to a gunfight.

The management team at Manassas' Utility Department recognized the bandwidth limitations of today's BPL technology, and also recognized the necessity of transporting data from their central equipment room to all of those distribution switches where the hand-off to BPL would occur. Fortunately, two problems can sometimes equal a solution. This "backhaul" network to connect the hand-off at the distribution switch had been supported by T-1 lines from the phone company during the trial stage. For an actual deployment, the T-1's would not be economically practical. Manassas would need to own a physical connection to each distribution switch.

The Fiber Trick

Although a number of solutions were considered, fiber was deemed the technology of choice. Fiber optic mediums are not susceptible to electromagnetic interference, and therefore can fully leverage the existing power utility right-of-way. The fiber can be laid next to the power lines.

Furthermore, the virtually limitless bandwidth of fiber would provide a robust launching pad for today's BPL equipment and practically anything else that might come down the road. HFBPL (Hybrid Fiber Broadband Powerline) had been born. Manassas would use BPL to offer a differentiated service and capture customers for least cost. In the process, it would deploy a fiber backhaul to every corner of the city – thereby enabling subscriber access to the ultimate telecommunications infrastructure should BPL ever prove insufficient.

The fiber optic backhaul project would begin with a big advantage. The city had installed over sixty miles of fiber some years earlier to provide communications between all municipal government facilities and to enable controls of electric substations and water facilities. In the process, Manassas had built a fiber optic infrastructure that passed by a good portion of town.

The Human Element

Perhaps as important, the city had

A typical fiber-to-powerline conversion point, installed in a pad-mounted transformer (left) and the E-PON Optical Network Unit (ONU) opened to see the inner workings (right). Each node location services anywhere from 10 to 40 customers with BPL service.

developed a power utility team with skills in splicing, testing, and troubleshooting fiber optic networks. Consequently, the backhaul project would begin with a significant piece installed, and all planning and construction to finish the project would happen with internal resources. This would be fiber-to-the-premises on a limited scale and a tight budget.

While the existing fiber infrastructure passed through much of the city, it did not service the distribution switches where it was needed to feed the BPL equipment. The task of the Utility Department was to connect those switches to the existing plant, but without exhausting the capacity of the available unused fiber.

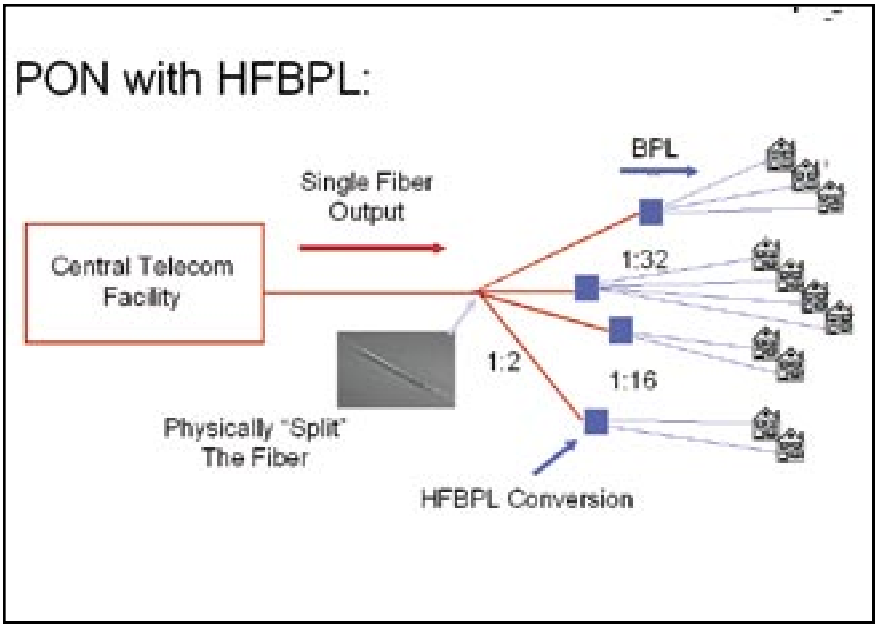
PON Versus ATM

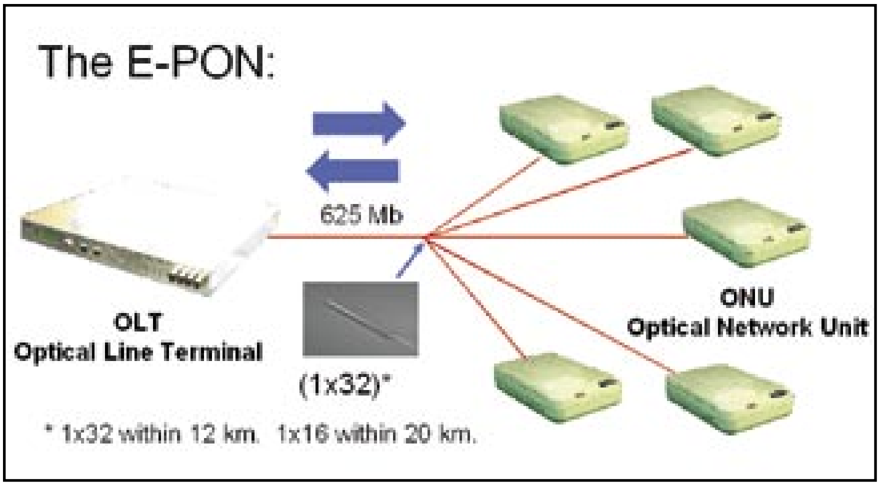
Connecting to the BPL network with a traditional dedicated fiber pair from the central equipment room was not a viable option. Such an unimaginative approach would have quickly depleted the available fiber resources, and made necessary an overbuild of the entire infrastructure. This could not happen. Therefore, the city began looking for solutions and quickly discovered PON, or "Passive Optical Network" technology.

PON is a standards-based fiber solution that was originally conceived to support fiber-to-the-home. This technology allows a carrier to physically "split" a single optical fiber so that it can serve up to 32 locations with high-speed data. It is the same basic concept that is employed in the fiber-to-the-home deployments of Verizon, SBC, NTT (Japan), and countless smaller carriers. From a fiber conservation standpoint, the PON idea was a slam dunk for Manassas. However, PON as implemented by the typical telephone company had some shortcomings in a HFBPL deployment.

Most PON technologies deployed in North America are based on ATM

Left: City map of Manassas showing how the city has been divided into several "BPL areas" to assist with network planning. Right: Map of BPL area 303 (it is southernmost area on city map). Orange line indicates the E-PON fiber route, red circles indicate the HFBPL node locations (where E-PON meets the BPL). Blue lines indicate BPL network operating over the existing power grid.





Top: *Diagram of a typical HFBPL network. Fiber infrastructure is built as a standard Passive Optical Network (PON) and connects the network core to the HFBPL conversion points.* **Bottom**: *Diagram of an Ethernet Passive Optical Network (E-PON). AFL Telecommunication's 625 Mb E-PON platform is pictured. Note symmetric bandwidth and 1 by 32 split ratio.*

protocols. BPL is Ethernet. Also, most ATM-based PON solutions employ asymmetrical bandwidth. That is, more bandwidth can be shared by subscribers on the receiving end than can be transmitted by those same subscribers. BPL, on the other hand, allows bandwidth to travel both directions at the same speed. If PON were to be used for backhaul where BPL data from 50 subscribers was being concentrated, PON could potentially become the network bottleneck. Furthermore, many of the ATM-based technologies, while potentially operating at higher bandwidths have sensitivities to optical reflectance and a somewhat constrained optical loss budget – issues that could have created considerable problems for the Manassas team.

The solution came from across the Pacific. Fujikura manufactures an Ethernet-based platform that operates over a standard PON physical infrastructure. It was originally developed to support Japan's fiber-to-the-home market – a market that adds over 90,000 subscribers to fiber every month. Fujikura's E-PON offered symmetrical bandwidth and a seamless Ethernet connection to Manassas' BPL technology. Furthermore, its high optical loss budget and insensitivity to reflectance opened the door to creativity in leveraging the existing fiber plant.

Engineers from AFL Telecommunications, Fujikura's joint venture with Alcoa, helped Manassas crews develop unorthodox tactics for "tapping" a single fiber to serve multiple BPL hand-offs. Therefore, the level of fiber conservation achieved was even more than anticipated. Also, because the E-PON is built as an Ethernet delivery device, the city paid for what was needed and nothing more. When the entire HFBPL network is completed, the additional cost to deploy a fiber optic backhaul will be only about $15 per subscriber.

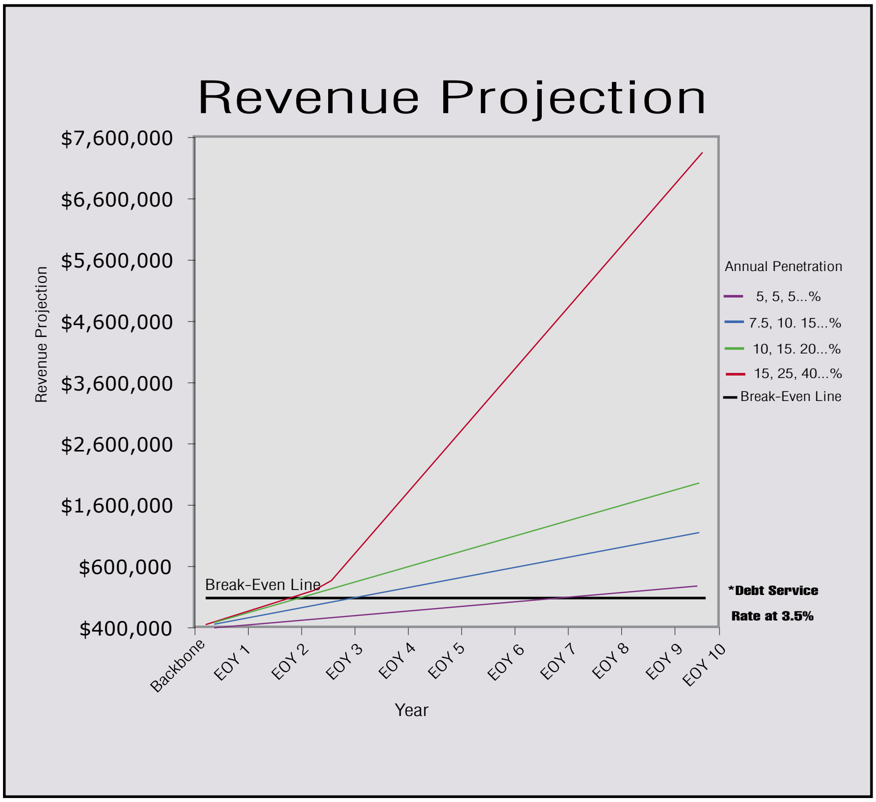
The low cost to provide the fiber backhaul for the BPL network is impressive. It is equally impressive to ponder what this means as a fiber-to-the-premises deployment.

When the relative low cost of the fiber solution became apparent, Manassas re-engineered the original backhaul design. Today, there is twice as much E-PON capacity as required to give every resident in the city a BPL connection.

Furthermore, there is still ample room to expand the existing fiber network using the PON architecture. Therefore, a new business considering Manassas for a location could easily receive a fiber connection anywhere in the city. In addition, Manassas is currently engineering the use of both PON and BPL to network portions of its traffic signal system, traffic cameras, and SCADA (supervisory control and data acquisition) system.

Manassas has the network capacity, the geographical coverage, and the crews who know how to get it done. BPL is being sold, but if you need fi-

Two City of Manassas employees at an HFBPL node, a transformer where the fiber and BPL networks meet. Each node location services anywhere from 10 to 40 customers with BPL.



Projection of revenue for various market penetration scenarios. Note the wide variation. But all exceed the low breakeven point.

ber it is only a phone call away. For that matter, engineering for the symmetrical attributes of BPL yielded impressive benefits for high-bandwidth clientele: Manassas can deliver virtual LAN capabilities and across-town connection speeds that are not available in most fiber-to-the-home deployments across the United States. Most importantly, it was all done for a price tag just under $500,000!

Manassas is still on the frontiers of BPL. The promise of Ethernet over the electrical grid is being fulfilled, but lessons remain to be learned about deploying this new technology across a broad coverage area.

As that happens, however, the observant will note that Manassas has already delivered a vital message about requirements to become a fiber-connected community.

Massive investments in legacy services and huge financial risk are not always mandatory. Public power communities across the nation have fiber infrastructure lying fallow, and local Internet service providers paying for access from the incumbent carriers.

The fiber backhaul recipe adopted by Manassas could just as easily represent a low-cost technique to provision academic institutions, local businesses, and any number of last-mile technologies for residential customers.

The cost for any public power community to adopt a fiber-based economic development initiative is surprisingly low. It has been proven, and is now one more history lesson from Northern Virginia. ◆

About The Authors

Guy Swindell is a Business Development Engineer at AFL Telecommunications, P.O. Box 3127, Spartanburg, SC 29304. He can be reached at 864-486-7236 or at Guyton.Swindell@alcoa.com. The firm's web site is at www.afltele.com.

Paul Hood is Electronic Systems Supervisor of the City of Manassas; he can be reached at phood@ci.manassas.va.us.