Overcoming the Limitations of Fixed Broadband Wireless

Changes in deployment economics are critical to moving towards truly pervasive broadband wireless access.

BridgeWave Communications
Fixed Broadband Wireless Access (BWA) systems provide the means to deliver services to subscribers who do not have access to low-cost wired alternatives based on Hybrid Fiber Cable (HFC) or DSL technologies. However, today's fixed wireless solutions only address a limited portion of the potential subscriber base, because each available technology has limitations in either deployment costs or performance. For instance, a wireless solution that is optimal for the dense metropolitan market may not be practical in lower-density markets. In the same manner, a solution that meets the economics for residential markets may not offer the performance required by the Small to Medium-Sized Enterprise/Small to Medium-Sized Business (SME/ SMB). This cost vs. performance conflict opens a market niche defined by deployment economics.

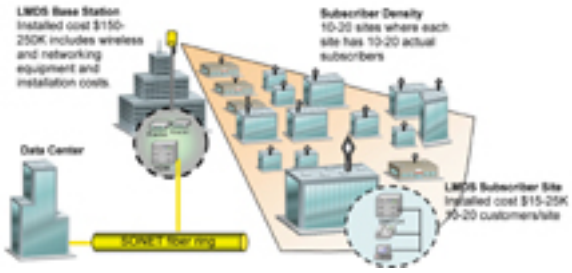

Figure 1. An LMDS deployment scenario.

Changes in deployment economics are critical to moving towards truly pervasive broadband wireless access. This article will examine the benefits and limitations of the today's fixed broadband wireless technologies, Multi-channel Multipoint Distribution Service (MMDS), Free Space Optics (FSO), Local Multipoint Distribution Service (LMDS), and unlicensed spectrum. The deployment economics for a traditional high-capacity system will illustrate the trade-off between cost and ubiquitous coverage. A new approach, using Millimeter Wave (MMW) wireless technology to expand broadband wireless access, will change the deployment economics for broadband access carriers serving the large &#151 and largely untapped &#151 small to medium-sized business market.

Current Solutions

Carriers and small service providers have implemented several wireless solutions to provide broadband services today. These wireless solutions include the high-performance Local Multipoint Distribution Service (LMDS) and Free Space Optics (FSO), the less costly Multichannel Multipoint Distribution Service (MMDS), and the

inexpensive unlicensed band radio systems.
LMDS and FSOs&#151 Are high-capacity solutions designed for large subscriber sites needing the ultimate data-rate performance. LMDS uses bandwidth-rich millimeter wave frequencies, while FSO relies on the massive spectrum available at optical frequencies. Due to their high performance and cost, they are best suited as wireless extensions to an existing fiber network in very high-density downtown markets.

Figure 2. Layer 1 interoperability between broadband wired and wireless networks.

For example, LMDS and FSO are ideal for bridging the Local Area Networks (LANs) between buildings or connecting a remote building to a fiber backbone. Strong candidates for LMDS/FSO are large high-rise buildings housing at least 50 to 100 small-business tenants or a smaller number of large tenants. As will be illustrated later, a critical mass of subscribers is necessary to bear the significant costs of installing these systems.
MMDS&#151 Is a medium-capacity system that is gaining traction in specific metropolitan markets. In terms of deployment economics, current MMDS technology approaches a cost point that is acceptable for small businesses, and may become economical for residential units when equipment prices drop by another 50 percent. Even though the MMDS deployment economics seem like they can offer ubiquitous coverage by using 35-mile radius supercells, there is a trade-off. MMDS spectrum allocations are typically limited to 100 - 200 MHz. Therefore, it is not possible to offer multimegabit services on a pervasive basis without reengineering an MMDS infrastructure, moving from large supercells to a microcellular topology.
Unlicensed Band Radios&#151 Are inexpensive and easy to deploy. Their deployment economics lend themselves to medium-distance links in low subscriber density areas or short-distance links in medium-density areas. Because they operate in shared frequency bands, the risk of service degradation due to interference from other operators (or even end subscribers) is significant. These radios can provide reliable services over short distances between buildings, or within a campus environment where sources of interference can be controlled, or over longer distances in areas where there are few potential interference sources. Like MMDS systems, there is only a limited amount of spectrum allocated for unlicensed band radios (typically 100 - 300 MHz total) to be shared by all users. Sharing this unregulated spectrum limits the ability of carriers to use these radios to provide pervasive multimegabit services without deploying an expensive pico-cellular backhaul infrastructure.
Each of these existing wireless technologies can serve important roles in an overall network deployment. However, none of them on their own are able to economically provide multimegabit services on a large-scale basis.
Deployment Economics: LMDS
To illustrate the importance of deployment economics, consider this typical LMDS installation. The LMDS service provider maintains a data center that provides the access to a telephony network and/or Internet backbone. The data center relies on a fiber transport such as a SONET ring as the primary connection to the LMDS base

station. An LMDS base station will need network equipment, such as a fiber Add/Drop Multiplexer (ADM), an ATM switch, and finally LMDS transmission equipment.
The cost of this equipment adds up very quickly, and can range anywhere from $100K to $200K per base station. Because of the expense of this equipment, operators strive to install as few base stations as possible to cover a given area, so they seek out the tallest buildings with the best line of sight to other downtown buildings. Installing equipment on these tall buildings &#151 including the wiring between the roof and basement equipment room &#151 can add another $50 - 100K to the installed equipment costs.

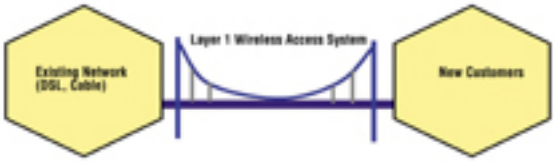

Figure 3. Layer 1 wireless bridges existing broadband network to new customers.

Furthermore, the LMDS subscriber site may require similar network interface equipment (excluding fiber interfaces) and an LMDS subscriber radio. Depending on the physical interfaces (voice, data, video) and bandwidth requirements, the deployment costs on the subscriber side can range from $15 - 25K, including $5 - 10K of shared transceiver equipment, $5 - 10K of installation costs (for a moderately tall building), and another $500 - 1000 of per-subscriber interface equipment. Recurring expenses include revenue sharing with landlords, roof rights, and equipment rental space.
To achieve a timely return on investment, the operator must quickly install 10 to 20 subscriber sites per base station, where each building generates monthly revenue based on 10 to 20 actual subscribers paying $200 - 300 per month for data services. Carriers can generate more revenue by selling voice services, but this requires additional equipment costs for voice interface and gateway equipment. LMDS provides excellent data-rate performance, but its deployment economics are most suitable to dense subscriber populations found in central downtown metropolitan areas.

Economics for Pervasive Deployment

The challenge facing wireless vendors today is to meet the economics needed for pervasive deployment. Wireless vendors have a market in small to medium-sized businesses that are currently not well served by existing broadband networks. It is estimated that 90 percent of all commercial buildings have less than twenty tenants. The new broadband wireless system must provide high broadband data rates that can be deployed inexpensively and easily in the low-cost networks that serve these potential customers.
To serve this large market segment, the wireless broadband vendors should strive to meet the following objectives:
&#149A base station cost of less than $20,000
&#149A subscriber site cost of not more than $5,000 per building
&#149A subscription rate of 10 sites per base station, with 1 - 2 subscribers (average) per site
&#149A breakeven point of 18 - 24 months

&#149A cost-effective wireless network solution should also minimize the amount of networking equipment required to interface wireless to wired networks.

Layer 1 Interoperability:
The Cornerstone of Pervasive Deployment
A major portion of the cost in broadband wireless deployment, especially at the base station, is the amount of networking equipment needed to interface the wireless to wired networks. Either the wireless vendor provides a costly &#151 and sometimes proprietary &#151 network interface as part of its system, or the network provider must purchase additional media conversion equipment. To meet the deployment economics of a pervasive system, the wireless system should work directly with the existing wired network.

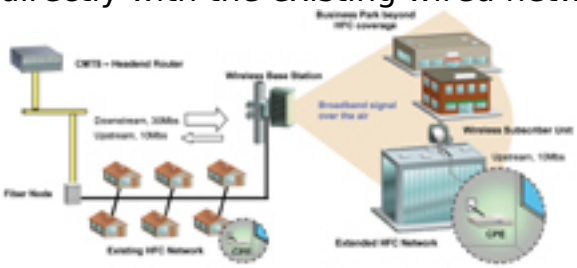

Figure 4. HFC network extension using Layer 1 wireless system.

Layer 1 (physical layer) interoperability meets this objective. By building Layer 1 interoperability into the wireless equipment, the existing wired infrastructure can be seamlessly extended without regard to protocols and networking standards. As shown in Figure 2, wired network equipment consisting of headend router and Customer Premise Equipment (CPE) are transparently connected by a wireless segment. The CPE and headend router are not aware of the wireless segment interconnecting both ends. The underlying data rates and services of the wired broadband network remain intact as they are delivered over the air. A wireless system that provides true physical-level interoperability (Layer 1) allows the potential to minimize costs of the overall deployment.
In addition to meeting a broader range of deployment cases through lower costs, Layer 1 interoperability provides the following significant benefits:
&#149It meets deployment economics for low cost, rapid deployment, and fast payback.
&#149It supports all features and protocols of wired networks.
&#149It isolates service providers from changes in protocols.
&#149It maintains vendor neutrality.
&#149It reduces the management complexity of the network.

Layer-1 interoperability enables true network transparency. This transparency allows an existing wired network operator to easily add wireless physical links to extend the network without requiring infrastructure changes. Because the wireless equipment interfaces with existing broadband networks at the physical level, evolutions in the wired standards are transparently supported. In other words, changes in wired equipment are just as transparent to wireless equipment as it is to the wired equipment.
Leverage the Existing Low-Cost Broadband Networks
Cable and DSL are the predominant low-cost wired broadband technologies. Service

providers have made a considerable investment in infrastructure. These existing broadband networks are designed to provide multimegabit services at a price point that satisfies the highly competitive residential and small business markets. The vendors have adopted common standards for infrastructure equipment, such as headend and customer premise equipment. Volume production has driven down the cost of the subscriber equipment. The price/performance value will continue to improve as the technology evolves.

Yet, despite excellent deployment economics, this approach will only cover a portion of the total potential customer base, due to limitations in technology and network reach. As illustrated in Figure 3, wireless broadband can bridge the gap between the broadband haves and have-nots. Moreover, a wireless broadband system that provides Layer 1 interoperability with the existing low-cost wired networks, meets the economics needed for pervasive deployment.

HFC Broadband Wireless Extension

The example illustrated in Figure 4 shows how a Layer 1 interoperable wireless access system can cost-effectively extend an existing HFC cable network. The headend router (also known as a CMTS, or cable-modem-termination-system) transmits a 30 Mbps 64QAM downstream signal in a 6 MHz cable channel to be shared among the cable modems located at the subscribers' premises. The return upstream path from the cable modems is a 10 Mbps 16QAM signal in a 3.2 MHz cable channel. The signals are carried by a combination of fiber and coax referred to as a Hybrid Fiber Coax (HFC) network. The fiber-optic transport delivers the cable TV channels, along with downstream broadband data, over long distances with strong noise immunity.

Note that the fiber technology typically used by cable operators is designed to transparently carry analog modulated video and data signals through an analog optical-electrical conversion process that can cost less than an order of magnitude to deploy than SDH/SONET fiber infrastructure used in the previous LMDS scenario. As shown in Figure 4, the fiber terminates at the fiber node where the cable TV video channels and data signals are converted back to coaxial cable (coax). The coax cable is the inexpensive last-mile distribution system used to deliver the video and data into each subscriber's premise.

To reach a business park located beyond the reach of the existing HFC network, the cable operator uses a point-to-multipoint wireless access system to extend the service area from any point on the HFC network that has line of sight to the business park. The wireless access system is Layer 1 interoperable with the HFC network.

In other words, no additional network equipment is required to interface the wireless equipment to the HFC network. The &quotbase station&quot can be installed anywhere in the HFC network, and is really just a simple radio transceiver, lacking the traditional rack of costly indoor network conversion equipment. A subscriber unit is installed at each subscriber site, which is shared by all broadband subscribers residing at the site. The subscribers' CPE devices are the same low-cost ($100) cable modems that are used in the existing residential portion of the HFC network, or else the operator can choose high-end cable modems that include telephony ports, VPN support, and firewall capabilities.

Because the base station and subscriber unit are Layer 1 interoperable with HFC, the wireless access system is transparent to the HFC infrastructure. The HFC broadband signal (downstream and upstream) from CMTS enters the base station

where it is transformed at the physical level to a wireless transmission. The subscriber unit receives the wireless transmission and reconstructs the original wired broadband signal for delivery to the CPE. The CPE(s) and CMTS are unaware that a broadband signal traversed a wireless base station and subscriber unit.
This cost-effective approach uses the existing network infrastructure to extend service beyond the wired service area. No significant changes are needed to offer new service. Instead of costly or custom equipment provided by the wireless vendor, low-cost mass-market cable modems serve as the network interface.
This approach benefits not just cable operators, but also wireless operators seeking to extend the reach of their fiber backbones to small businesses and multi-dwelling units. By adopting the network equipment topology from the cable industry, rather than the traditional Telco topology, a wireless operator can use wireless links to connect pockets of high-value subscribers to its fiber backbone. And they can do so at a cost point that is consistent with the subscriber densities found throughout metropolitan areas, rather than central downtown areas.

Conclusion

Physical-layer interoperability can significantly broaden the deployment economics in today's wireless broadband solutions. Enabling the seamless integration of wired and wireless network technologies allows operators to leverage their sizeable investment in existing wired broadband networks. High-value small to medium-sized business customers that were once beyond the reach of wired networks can be served with the best mix of performance and cost. By using Layer-1 interoperability with low-cost broadband technologies, the promise of pervasive deployment can be realized.
*For a copy of complete article containing all charts and images, please e-mail Web Editor at jwalkup@cahners.com [1].

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