The Business Case for Wireless Broadband Access

White Paper

Executive Summary

Wireless broadband access affords a major business opportunity for any service provider or carrier. The International Data Corporation expects the market to experience a compound annual growth rate of 65% over the next several years, with a particularly strong showing in the small and medium business segments. Annual service revenues are expected to grow to as much as $42 billion worldwide by 2005, according to the ARC Group. Owing to the enormity of the opportunity, an estimated 16% of internet service providers in North America already have at least some wireless broadband access offering. But there is still plenty of time—and space—for getting a "first mover" advantage in this fast-growing market in most locations.

The rapid market growth is being driven by the inherent technological advantages of wireless broadband access, which in most cases, results in faster, more flexible deployment at a lower total cost than wired alternatives. Wireless has the ability to go anywhere and everywhere fast, in terms of both bandwidth and time-to-market. Analysts use the term "wireless local loop" to describe its many advantages over both copper and fiber optic cabling. For example, wireless enjoys a longer and broader reach than DSL, while delivering a higher throughput. Consider this simple fact: a single wireless point-of-presence with a range of 9 miles reaches all line-of-sight customers in an area up to 250 square miles, and provides coverage for areas where it would be impractical or impossible to install wiring or run fiber optics lines. And wireless does so with none of the legal or other complexities that encumber use of infrastructures or rights-of-way owned by others. These and other advantages are making wireless the first choice in "last mile" solutions.

The financial advantages enjoyed by wireless broadband access derive from the freedom and flexibility found in the underlying technology. The initial capital expenditure for deploying a wireless infrastructure is often less than with copper or fiber optic systems on a per-subscriber basis, particularly in higher bandwidth applications. But the real cost-savings of wireless exists in the long-haul—in terms of both time and space—with much lower operating expenditures. Another significant wireless cost advantage is the quickly and fully re-usable nature of the infrastructure, where any reserve or recaptured capacity can be made available immediately to serve another subscriber in the area. The bottom line? Wireless communications delivers a low total cost of ownership and a high return on investment. Indeed, the profit potential, low barriers to entry, minimal risks and broad market appeal, all combine to make wireless broadband access a powerful addition to any service provider's portfolio.

This white paper presents a basic business case for wireless broadband access. The next section outlines the overall market opportunity and identifies the top three target markets. This important background is followed by an introductory overview of wireless technologies, which includes a summary of the qualitative advantages of wireless communications. The discussion then turns to the economics of wireless with a quantitative assessment of costs, complete with a sample cost model. The material concludes with an introduction to Proxim's wireless solutions and services that together can help any service provider launch a successful and profitable wireless broadband access offering.

The Market Opportunity for Wireless Access

Wireless broadband access affords a major opportunity for all service providers—from traditional Internet service providers (ISPs) to cable companies and the full assortment of local exchange carriers: ILECs (incumbents), CLECs (competitive), BLECs (building) and DLECs (data). The tremendous flexibility and other advantages of wireless access have even attracted some new entrants to the industry, including ISPs focused exclusively on wireless (so-called WISPs) and businesses not normally associated with high technology, such as building owners and utility companies. Indeed, it seems that just about any business with a wired infrastructure

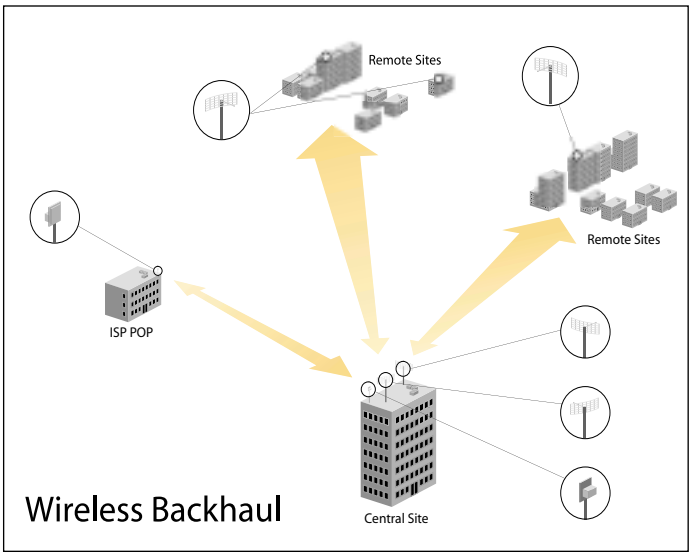
or a facility in some strategic location has recognized the profit potential of wireless broadband access.

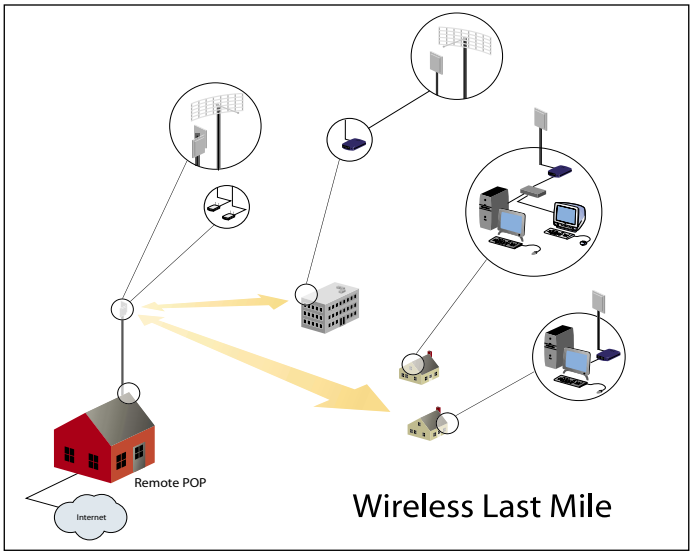
Of course, the supply side of wireless broadband access would go nowhere if not for the tremendous demand from business and residential users alike. Some are attracted by the higher speeds—from 1.6 Mbps to 100 Mbps. Others like the expediency of getting "connected" in a matter of days, not weeks or months. And many simply do not have access to broadband any other way, via either copper or fiber.

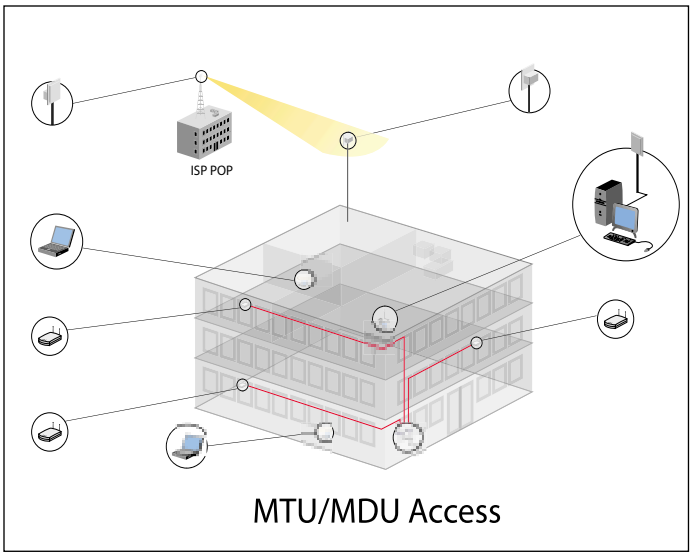
Currently, the demand for broadband access exceeds supply in most metropolitan, suburban and rural markets throughout the world. But industry analysts anticipate that leading service providers will quickly address this pent-up demand with aggressive roll-out plans and with wireless playing a significant role. Emarketer, for example, expects wireless broadband access to grow from 230,000 users in 2000 to 3.9 million by 2003. The International Data Corporation (IDC) forecasts a similar compound annual growth rate of 65% with the market reaching $7.4 billion in service revenues by 2003 in the United States alone. IDC expects to see much stronger growth in commercial applications with annual growth rates of 150% in the small business segment and 80% in the medium to large business segment. IDC believes residential subscriptions will increase at about 40% per year—still a quite respectable growth rate.

Strategis Group expects service revenues for wireless broadband access to reach $16.3 billion worldwide by 2004. The breakdown by major region in the Strategis Group forecast is as follows: 40% in North America, 25% in Europe, 18% in Asia-Pacific and 17% in Latin America. The ARC Group has a slightly more optimistic long-term outlook with expectations for a global wireless broadband market reaching 28 million business and residential users by 2005 when service revenues will reach $42 billion. The ARC Group forecast shows growth outside of the US being particularly strong with the following regional breakdown: 24% in North America, 27% in Western Europe, 33% in Far East, China and South America, and 16% elsewhere.

These and other analyst studies depicting major opportunities in wireless broadband access have motivated a significant number of ISPs to enter the market. For example, the Boardwatch Directory of North American ISPs shows that 16% (750 out of a total of 4700) are already offering wireless broadband access. But because many are just getting started in wireless, perhaps with trials or through wholesale arrangements, there is still time to get a "first mover" advantage in most geographic areas.







The best opportunities available in wireless broadband access involve so-called "fixed" outdoor services where strategically-located access points cover a large geographical area. The popular services include Internet access and public/private LANs throughout a metropolitan area network (MAN). Three target segments are particularly attractive in this nascent marketplace:

- Commercial enterprise sites, consisting mostly of Small to Medium Businesses (SMB) and Small Office/Home Office (SOHO) environments as an alternative to T1/T3, digital subscriber lines (DSL) and fiber optic-based services
- Residential single-family homes as an alternative to DSL in the local loop and cable-based Internet access or telecommuting services
- Multi-tenant Unit (MTU) and Multi-dwelling Unit (MDU) facilities in the form of business offices and residential apartments/condos where a single wireless access link serves multiple subscribers, all wired to a central concentrator

In each of these "Top Three" market segments, the wireless broadband access services can be offered retail (that is, directly to business and residential customers) or wholesale via other service providers—or both. Of course, there are numerous other wireless opportunities available, which are not addressed here. One involves wireless "hot spots" in public places (such as airports, hotels, convention centers, etc.) where travelers can log-on to get e-mail, access the corporate virtual private network (VPN) or just surf the Web. Another opportunity involves wireless broadband access within an MTU/MDU facility through a wireless LAN serving multiple subscribers. The building itself could be connected by either a wireless or wired access service. Finally, the wireless LAN could also serve a single premises, whether a business or a home, as an extension to a wireless or wired access service. Pardon the pun, but the sky really is the limit when it comes to the opportunities afforded by wireless networking.

Wireless Broadband Access – An Overview

Wireless technologies serve as a proven foundation for all forms of mobile communications. Two-way voice band radios have been around for over half a century. In just the past decade, the mobile wireless telecommunications phone infrastructure has progressed to the point where cell phone service is available virtually everywhere in the civilized world. In data communications, the fundamental wireless technologies have been used for years in high-speed point-to-point microwave transmission systems and in low-speed telemetry and control applications. What is new in the world of wireless today is its use for delivering high-speed Internet connectivity.

From a regulatory point of view, wireless broadband access is similar to other wide area radio frequency (RF) applications, including AM/FM radio, TV, CB/FRS, satellite and terrestrial cell phone services. The major difference among all of these is the frequency band allocated to each. In the United States, the Federal Communications Commission (FCC) is responsible for assigning different frequencies to different needs. Of course, every country has an equivalent agency, and all of them coordinate their efforts to foster assurance of global interoperability, eliminate conflicts or interference and drive the advance of technology.

For wireless broadband access there are several bands allocated as either licensed or unlicensed spectrums. In a licensed spectrum, a single party is given exclusive right to a narrow frequency range in a specific geography. Such a "regulated" environment ensures that no two carriers or services will interfere with one another. But the licensed approach suffers from two major disadvantages: the high cost to procure spectrum rights at auction or from the current licensee, and the excessive time-to-market awaiting auction results or negotiating with the current license holder. Examples of licensed technologies used in wireless broadband access include Local Multipoint Distribution Service (LMDS) and Multipoint Multichannel Distribution Service (MMDS).

In stark contrast to the formality and expense of licensing, the unlicensed spectrums create an open market for buyers and sellers of broadband access. For this reason, an unlicensed solution is much easier and substantially more affordable when getting started in the world of wireless. An unlicensed solution can also be used as a tactical or interim approach awaiting a future licensed offering. Of course, unlicensed offerings can also be strategic as long-term solutions for many target market zones or cells. The only potential disadvantages of unlicensed spectrums are security concerns and possible interference from other providers, which can both be minimized with available state-of-the-art solutions. Examples of popular unlicensed wireless broadband access technologies include Direct Sequence Spread Spectrum (DSSS) and Frequency Hopping Spread Spectrum (FHSS). As both tactical and strategic solutions, the unlicensed spectrums warrant a bit more understanding, which can be found in an appendix.

Both licensed and unlicensed wireless broadband access services share some common design elements. Each deployment must be engineered, taking into account the basic nature of RF transmissions. Design considerations include site selection for best line-of-sight coverage, zone size and spacing, cell size versus bandwidth trade-offs, the potential for interference from other zones or services, desired over-subscription ratios, tower or rooftop rights, backhaul options, and so on. But as with any engineered system, the optimal design readily emerges from a structured process that balances given constraints with available options.

For those who want to learn a more about unlicensed wireless technologies, see the attached appendix "Unlicensed Wireless Broadband Technologies," as well as the Proxim Web site, www.proxim.com. Expert assistance is also available on a consulting or project basis.

The Wireless Advantage

Wireless communications affords a freedom and flexibility that can never be achieved with wires. Consider the local loop used for DSL, T/E-carrier (DS-xx) and Frame Relay services. Unshielded twisted pair (UTP) wiring is ubiquitous, but the infrastructure remains under the control of incumbent LECs. Despite the intent of the Telecom Reform Act of 1996, access to the local loop has been slow—and expensive. Coaxial cable, used in many areas to deliver TV programming and now Internet services, can provide more bandwidth than UTP wiring, but its deployment to date has been mostly residential, not commercial. And fiber optic cable, used in 10/100-BaseF and OC-xx services owing to its substantial bandwidth advantage over both forms of copper wiring, reaches precious few buildings because its installation is exorbitantly expensive.

Wireless has the ability to go everywhere fast, both in terms of throughput and speed of deployment. Analysts often use the term "last mile" to portray the many challenges involved in reaching customer facilities with UTP, cable or fiber optics. But with wireless, every customer in the last mile—actually, the last several miles—can be reached easily, often with a single, well-placed access point. The long reach and high throughput of wireless make it suitable for metropolitan, suburban and even rural access applications, as well as for high-speed backhaul from a wireless point-of-presence (POP) to a Network Access Point (NAP). And although wireless access normally serves multiple subscribers over a fairly large area, its flexibility and affordability also make it suitable for serving a single subscriber's campus environment.

Here is a summary of the many advantages of wireless broadband access. Note that the focus here is on the technical and business advantages only. Financial matters—where wireless really has the advantage—are covered in the next section.

- Rapid deployment of infrastructure for an accelerated time-to-market
- Easier and virtually instantaneous customer installation, particularly vs. DSL with no long wait for an ILEC to install the service
- Extended service area with total line-of-sight coverage, including those areas where it would be impractical or impossible to install wiring or fiber optics
- Longer and broader reach—well beyond the 15,000' limitation of UTP in the local loop
- Higher throughput, particularly beyond the relatively short-distance, higher speed versions of DSL
- Tremendous flexibility with none of the legal or other complexities that encumber use of the local loop or cable infrastructures
- Greater dependability with no marginal or deteriorated wiring and faulty connections, which eliminates the need for reconditioning or pair selection to get and keep customers connected reliably
- Greater overall market appeal as customers, now in love with their cell phones, have learned to appreciate the many advantages of wireless communications

These and other advantages are making wireless the first choice in last mile solutions. Indeed, it may surprise some to know that, according to IDC, DSL and cable serve only 3-5% of potential users today in the US. That leaves a huge market opportunity for bringing broadband to businesses and homes—the profitable wireless way.

The Wireless Return on Investment

The real advantage of wireless broadband access is financial. While wireless customer premises equipment (CPE) may cost a little more than wired solutions, the enormous savings and efficiencies in other areas more than compensate for this relatively minor extra expense. Service providers who look beyond this inherent difference have been pleased to discover that the net result of wireless is substantially less total cost of ownership (TCO) and much greater long-term profit potential.

The financial advantages enjoyed by wireless broadband access derive from the freedom and flexibility the technology affords. The capital expenditure (CAPEX) for getting started is generally about the same with wireless, and usually less in higher bandwidth applications. There is no need to install fiber or cable to each and every prospective subscriber. The high construction and other costs, especially obtaining rights-of-way, of laying fiber optic cabling place this option well out of reach for all but a handful of service providers with deep pockets and long-term financial strength. But with wireless, a single access point reaches hundreds or thousands of potential subscribers, making the overall per-subscriber CAPEX for wireless quite low, despite the higher cost of CPE. For example, a single wireless POP with a range of 9 miles reaches line-of-sight customers in an area up to 250 square miles. And by using unlicensed frequencies, service providers avoid the initial expenditure of procuring a spectrum from the governing agency or current license holder.

The real cost-savings of wireless exists in the long-haul—in terms of both time and space—with a much lower operating expenditure (OPEX). With wireless, there is no need to lease local loop wiring at the $15-20 per month per line that ILECs typically charge. Services employing the local loop also incur on-going central office co-location fees that ILECs have set equally high. Leasing fiber optic strands or bandwidth can also be prohibitively expensive. The enormous bandwidth capacity of fiber optics commands a premium price in the marketplace, which makes wireless cost-effective even in point-to-point configurations where it can deliver up to 100 Mbps of bandwidth at up to 7 miles. Finally, the intangible—but very real—savings from fewer management and legal complexities help contribute to keeping wireless operating costs as low as possible.

Another major financial advantage enjoyed by wireless is the quickly and fully re-usable nature of the infrastructure. The reserve or recaptured capacity at any access point is readily and immediately available to serve any other subscriber in the area. There are no wires to pull, and no long wait for another party to install the service. Savvy service providers realize that this flexibility affords another advantage. With no need to recover per-site costs lost with a cancelled subscription, wireless providers are able to attract new customers more easily with service contracts that offer friendly terms and conditions. Wireless really does make broadband access business profitable to win, and painless to lose. Considering the churn in this marketplace, this can be a powerful combination.

An Example Wireless Business Model

The advantage of wireless broadband access is easily seen in financial terms. Start-up capital costs for the wireless network points-of-presence (POP) can be low, and the per-customer costs of service delivery are competitive with DSL and cable modems.

The wireless business opportunity looks different for an ILEC or a cable company with existing broadband facilities versus a CLEC, which leases broadband facilities, or a wireless ISP building out a green-field infrastructure. Nevertheless, the wireless cost model enables a profitable endeavor in all cases. To understand the wireless cost model it is helpful to categorize all costs as either fixed and variable.

Capital costs include the common access equipment at wireless POPs, and the equipment at all customer premises (CPE). POP costs are typically amortized over the entire customer base. Some services providers retain ownership of the CPE and amortize its cost through subscriber revenues, while others sell a portion of the CPE to the end-user, effectively removing that portion from the cost model.

Operating costs include leases for tower or rooftop space for each POP and, potentially, the rights for using a licensed wireless spectrum for some or all POPs. Rights for a licensed spectrum can be prohibitively expensive and may be unavailable in many areas. This is a distinct advantage for the unlicensed spectrum, which is widely available and incurs no up-front or on-going usage fees.

The cost of backhaul transmission facilities to supply bandwidth to each wireless POP can be treated as either a capital or operating cost item. Wireless backhaul is typically more cost-effective than the tariffed fees of multiple T1 or T3 lines from another carrier.

Consider the following example, based on a solution powered by Proxim OpenAir technology. A service provider in a suburban setting contracts with the county's water agency for exclusive rights to place wireless access points on each of the 15 water towers that serve a population of 75,000 in a 300 square mile area comprised of residential and commercial buildings. Initially placing 10 OpenAir wireless access points with 36º sector antennas, coverage is extended to subscribers within a 4 mile radius. With OpenAir frequency hopping, the number of access points per water tower can be doubled or even tripled later as needed to meet demand. Using a 30:1 over-subscription ratio (subscriber CPE supported by an access point), each tower supports 300 subscribers initially and can grow to 900 subscribers.

Note that 30:1 is at the conservative, low end of CPE-to-AP ratios; many service providers deploy using ratios of 60:1 or 90:1.

The table below presents the example business case showing the costs, revenue and profit of a single wireless POP with multiple access points. The capital start-up costs include installation of the access point equipment and a wireless backhaul link from the wireless POP to the service provider's central location. More access points are added each year to serve new subscribers; the high-speed backhaul originally installed is sufficient to serve all new and existing users. A fault-tolerant power supply system should be considered, but is not included here. Capital costs to terminate service at each customer location includes the purchase of CPE and a single "truck roll" for its installation. The operating costs include the water tower lease, but does not include spectrum fees because the OpenAir equipment operates in the unlicensed band. Revenues are derived from both residential and business subscribers at $50 and $100 per month, respectively.

This conservative example becomes profitable in a little over a year and shows a return on investment (ROI) of nearly 100% over the three year period. A conservative approach is used because the model does not show all operational costs, such as management and marketing expenses. Nevertheless, the return could be improved in a number of ways. For example, a greater focus on higher-paying business subscribers, perhaps with a 50/50 mix, would achieve profitable operation sooner and a much higher ROI over time. The over-subscription ratio could be increased, which would require fewer access points. Customers could be charged some reasonable amount for the CPE and/or its installation to offset a substantial portion of these costs.

The Wireless Bottom Line

The bottom line is this: wireless communications delivers a faster payback and a greater return on investment (ROI) than other broadband technologies. With its shorter time-to-revenue, the return on the wireless investment can begin immediately. There is no need to wait for major portions of a huge infrastructure to be completed before revenue is realized, which is inevitably the case with fiber optics. Similarly, there is no need to wait for the ILEC or other operator to provision DSL, leased line or cable connections. And with attractive equipment leasing programs, wireless can be profitable from day one. Wireless also preserves profitability long-term with demand-based, pay-as-you-grow expansion of the fully re-deployable infrastructure. Finally, with low-cost access points and no exorbitant monthly fees for local loop or fiber optic cabling, the wireless profits continue to mount month after month.

Wireless communications is proven enough to be utterly dependable, but the wireless broadband access business is new enough to make the sky the limit when it comes to the possibilities for creativity and profit. The profit

OpenAir ISP Business Case (per POP)		Year 1	Year 2	Year 3
Number of POPs		1	1	1
New Access Points Each Year		10	10	10
Over-subscription Ratio		30	30	30
New Subscribers Each Year		300	300	300
Total Subscribers		300	600	900
Capital Cost - POP	Unit Cost			
Backhaul Equipment	$19,950	$19,950		
Access Point Equipment	$975	$9,750	$9,750	$9,750
Installation	$250	$2,500	$2,500	$2,500
Subtotal		$32,200	$12,250	$12,250
Capital Cost - CPE				
Customer Premise Equipment	$475	$142,500	$142,500	$142,500
Installation	$150	$45,000	$45,000	$45,000
Subtotal	$625	$187,500	$187,500	$187,500
Operational Costs				
Tower (Rooftop) Annual Lease	$12,000	$12,000	$12,000	$12,000
Total Annual Cost		$231,700	$211,750	$211,750
Annual Revenue	Mix			
Residential @ $600 per Year	80%	$144,000	$288,000	$432,000
Business @ $1200 per Year	20%	$72,000	$144,000	$216,000
Total per POP		$216,000	$432,000	$648,000
Annual Profit (Loss)		($15,700)	$220,250	$436,250

potential, low barriers to entry, minimal risks and broad market appeal, all combine to make wireless broadband access a powerful addition to any service provider's portfolio.

Getting Started in the World of Wireless

Proxim can help any service provider get started quickly and profitably in the world of wireless broadband access. A wealth of additional information is available on Proxim's Web site at www.proxim.com or by calling Proxim at (800)229-1630. Proxim also provides free technical training on wireless technology, and offers expert consultation on a project basis. And Proxim is so confident in your success that we even furnish no-risk, free product trials and extend 100% financing on all equipment. No other wireless vendor makes it as easy and affordable to get started—and stay profitable—as Proxim. So why wait any longer to get the first mover wireless broadband access advantage in your service area by establishing a strong presence in the premiere locations now?

The Proxim Advantage

- Proxim has the broadest offering of wireless products available today
- Proxim products lead the industry in ease of deployment, price/performance and scalability
- Proxim products also enjoy industry-leading low total cost of ownership
- Proxim is the market leader in wideband frequency hopping technology with over one million systems operating worldwide
- Proxim has the only investment-protecting, multi-standard solution with the Harmony family of products
- Proxim has the fastest and most secure point-to-multipoint 1-10 Mbps solution with the Stratum MP
- Proxim has the most cost-effective, ultra-fast unlicensed wireless point-to-point bridges with the Stratum 100 and Stratum 20
- Proxim was the first manufacturer to deliver OpenAir solutions and compact flash radio technology
- Proxim products are approved for use worldwide with support for international standards
- Proxim's affiliate program enables wireless revenues with no need to stock products
- Proxim is the only wireless networking vendor to offer 100% financing
- Proxim offers comprehensive technical training and expert consulting
- Proxim eliminates start-up risks with a no-cost evaluation program

Appendix A:
Proxim's Wireless Broadband Access Solutions

Proxim has a proven and profitable solution for three of the most promising opportunities in the wireless broadband access marketplace. For business and residential customers needing access in the range of DSL and T1 data rates, Proxim offers the Harmony family of products supporting multiple wireless standards on a single platform. Support for OpenAir's frequency hopping technology allows Harmony to provide 1.6 Mbps multipoint access with a 9 mile range using the unlicensed 2.4 GHz ISM spectrum. A single Harmony AP Controller typically manages 10 or more access points controlling access, security, configuration and performance parameters. A fully-configured Harmony access point-of-presence can handle hundreds of business and residential customers. The Harmony architecture also affords a built-in migration path to other higher speed wireless technologies with full investment protection for and leverage of the initial system. Harmony's tremendous flexibility, ease of operation and economies of scale make it a great way to get started in the world of wireless.

For higher speed commercial access needs in the 1-10 Mbps range, Proxim offers the Stratum MP product. The higher bandwidth makes Stratum MP ideal for MTU/MDU needs, as well as backhaul applications that connect wireless access points to a traditional POP or NAP. Stratum MP can be deployed in either point-to-point or multipoint configurations where it delivers a throughput of up to 10 Mbps at a range of up to 9 miles using the unlicensed 2.4 GHz ISM spectrum. A single multipoint Stratum MP can connect up to 32 commercial customers with military grade security thanks to its 20-bit Security ID and continuous DS code-changing algorithm. For many business customers, robust security is vitally important.

For ultra-fast wireless access, Proxim offers the Stratum 20 and Stratum 100 that deliver 20 or 100 Mbps of bandwidth, respectively. Support for such high data rates makes the Stratum 20/100 ideal for transparent LAN services at multi-rate T1, T3 or full 100 Mbps service that would otherwise require expensive fiber connectivity. The generous amount of bandwidth enables the Stratum 20/100 to handle even the most demanding access or backhaul needs, including those required by the very largest MTU/MDU facilities. Stratum 20/100 systems are deployed in point-to-point configurations with a range of up to 7 miles using the unlicensed 5 GHz UNII spectrum. By functioning as a transparent bridge, the Stratum 20/100 sits securely and seamlessly in just about any network infrastructure. Each system also has two TDM-based (time division multiplexing) T1 channels to handle voice communications.

In addition to these wireless broadband access solutions, Proxim offers a variety of products for deploying wireless LANs within the business premises or home. The NetLINE Wireless Broadband Gateway creates an 802.11b wireless LAN that allows multiple users in an office or home share a common connection to a cable- or DSL-based network access service. Complementing NetLINE is the SkyLINE family of 802.11b access cards for PC and Macintosh computers. The Symphony Cordless Networking Suite of products, complete with a modem, gateway and a variety of PC and Macintosh interface cards, uses OpenAir to create a wireless LAN in SOHO environments.

Detailed information on these and other Proxim products is available at www.proxim.com.

Proxim Wireless Broadband Access Solutions-at-a-Glance

	Stratum 100 & Stratum 20	Stratum MP	Harmony
Application	Backhaul or Leased Line Replacement	Backhaul and Commercial WBA	Commercial and Residential WBA
Technologies	Point-to-Point	Point-to-Point and Multipoint	Multipoint
Unlicensed Spectrum	5 GHz UNII-2/3	2.4 GHz ISM	Multi-standard
Spread Spectrum Technique	QPSK, Non Spread Spectrum	Direct Sequence	Multi-standard
Data Access Rates	20-100 Mbps (Full Duplex)	10 Mbps (Half Duplex)	Various
T1 TDM Voice Channels	2 DSX-1	None	None
Maximum Range	7 Miles	9 Miles	9 Miles
Number of Subscribers per Access Point	1 (Point-to-Point)	32	Hundreds
Customer Premises Equipment	Stratum 100 or Stratum 20	Stratum MP	Harmony "RangeLAN2" Ethernet Adapter

Appendix B:
Unlicensed Wireless Broadband Technologies

The FCC has established two unlicensed spectrums, or frequency ranges, which are suitable for wireless broadband access services. One is the 2.4 GHz spectrum, originally designated by the FCC for Industrial, Scientific and Medical (ISM) use. This spectrum occupies the frequency range from 2400 to 2483.5 MHz, and has been in popular use since 1992. The other is the 5 GHz spectrum consisting of four distinct frequency bands, two of which overlap each other: 5150–5250 MHz, 5250–5350 MHz, 5725–5825 MHz UNII (Unlicensed National Information Infrastructure) bands, and the 5725–5850 MHz ISM band. The first three bands are also known as UNII-1, UNII-2 and UNII-3, respectively. Because UNII-1 is for indoor use only, it is not relevant to wireless broadband access. Similarly, UNII-2 has limited reach in the US due to ERP restrictions, and has also been restricted to indoor applications in many other areas of the world. UNII-3 is the only UNII band that has been used successfully in point-to-point applications outdoors, and will increasingly be used in the future as new products become available for multipoint applications.

A variety of modulation techniques can be used in both the 2.4 GHz and 5 GHz ISM bands, depending on the requirements of the application. For example, in the 5 GHz spectrum, modulation is quite straightforward, particularly in point-to-point deployments. In the crowded 2.4 GHz spectrum, however, the modulation technique must minimize the impact of interference. The extra effort to implement a special modulation technique is easily justified because lower frequency systems cost less to manufacture. Spread-spectrum technology, a wideband RF technique developed by the military for its dependability and security, is the most common means for minimizing interference in crowded spectrums, such as the 2.4 GHz ISM band. As the name implies, spread spectrum broadcasts at different specific narrowband frequencies spread across the entire wideband spectrum. Two different spread spectrum techniques are employed: direct sequence and frequency hopping.

Direct Sequence Spread Spectrum (DSSS) was first used commercially in fixed point-to-point microwave systems, then later adopted for use in wireless LANs. DSSS employs a method of converting digital information into a series of "chips" that are transmitted in a defined sequence of different frequencies spread across the available spectrum. Special handshaking protocols synchronize the transmitters and receivers, and handle retransmission of any lost information in the sequence—all transparently to the users. Dispersing signals during transmission has two beneficial and related effects: reduced power concentration and less interference with other systems. Because DSSS spreads across the entire spectrum, the number of independent, non-overlapping channels in the 2.4 GHz band is small; typically there are only three. As a result, only a limited number of co-located networks can operate without interference, making DSSS suitable primarily for highly directional point-to-point systems or for indoor applications.

Frequency Hopping Spread Spectrum (FHSS) transmits on 75 or more narrowband frequencies (typically 1 MHz wide), in a defined hopping sequence. FHSS transmits on each frequency or "channel" for a short duration, then quickly "hops" to another frequency for another short burst and so on. The hopping pattern (frequencies and the order of use) and dwell time (the time interval at each frequency) are restricted by most regulatory agencies. Because of its narrowband and frequency-agile nature, FHSS is more immune to outside interference than DSSS. This is because an FHSS system cannot be blocked by interference from a stationary narrowband frequency. If interference is encountered on one frequency, data is simply retransmitted on a subsequent hop.

Most FHSS products on the market today allow for selection from among several pre-defined orthogonal hopping sequences. Because there are many different hopping sequences available, FHSS allows numerous systems to be deployed fairly close to one another. This is because the likelihood of two or more systems using different hopping sequences occupying the same channel, at the same time, is minimal. If a particular part of the wireless network has more users or requires additional bandwidth, a second access point can, therefore, be added. Users are automatically assigned to one of the two access points, effectively doubling the available bandwidth in that area. This degree of scalability and flexibility are simply not achieved with DSSS.

Although standards are sometimes a key enabler for mobile communications, wireless broadband access applications have benefited little from these industry efforts to date. And the reason is simple: with exception of public hot spots, the main wireless broadband access opportunity involves delivery of services from and to fixed locations. Because interoperable roaming is not an issue in fixed applications, service providers and subscribers alike have opted instead for vendor innovations that deliver superior performance, better affordability—or both.

Popular standards in the unlicensed spectrums include the IEEE 802.11 series and OpenAir. IEEE 802.11b, also known as Wireless Fidelity or Wi-Fi, operates at 1-11 Mbps using 2.4 GHz DSSS. Wi-Fi is great for wireless LANs in the premises, but is not ideal for wireless broadband access applications owing to the potential for interference. In addition, because it is a standard, any 802.11b device could potentially mount an effective denial of service attack on any 802.11b system. The IEEE has recently completed work on a new wireless LAN standard, 802.11a, which employs 5 GHz Orthogonal Frequency Division Multiplexing (OFDM) operating at up to 54 Mbps. The IEEE is also working on another new standard, 802.11g, which will also deliver up to 54 Mbps at 2.4 GHz. But with the continued IEEE 802.11 emphasis on indoor wireless LAN applications, the significant drawbacks for outdoor applications remain the same.

OpenAir, as the name implies, was optimized for outdoor wireless broadband access applications. OpenAir strikes a balance between competing requirements for bandwidth, range and interference immunity. OpenAir operates at 2.4 GHz using FHSS and delivers comparable throughput to a T1 connection using a radio signaling rate of 1.6 Mbps—an ample amount for the vast majority of business and residential access needs. The use of frequency hopping with orthogonal patterns minimizes interference sufficiently to make OpenAir suitable for wireless access in both rural and dense metropolitan environments. The technology is quite successful, with over one million systems having shipped to date.

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