EION WIRELESS

White Paper

Broadband Fixed Wireless Solutions—An Enabler for Service Providers

1 Introduction

Today there is an increasing demand for access bandwidth that is being fueled by high utilization applications such as those associated with the Internet. In the past only traditional wireline access had been available to consumers and businesses, but recent advancements in wireless technology now allow wireless local loop LL services to compete with Digital Subscriber Lines (DSL), coax, and fiber-based architecture solutions. This White Paper explores these advancements and the opportunities that Broadband Wireless technologies enable for service providers.

1.1 Organization of Document

The remainder of this White Paper is organized as follows:

Section 2 describes the use of Broadband Wireless technologies to provide customer high-speed data access to homes and businesses. This use of radio spectrum is referred to as a Broadband Wireless Local Loop or Fixed Wireless Access.

Section 3 describes the market opportunity for FWA service providers.

Section 4 examines some value-added services that can be offered to customers using FWA.

Section 5 discusses some of the advantages of EION's technologies over other wireless technologies. EION's technologies help make the dual Broadband Wireless Local Loop (described in Section 2) competitive with wire- in based technologies (described in Section 7).

Section 6 continues the discussion from Section 5 by exploring additional INTERNET characteristics of fixed wireless architectures that provide advantages over RGE wireline technologies.

Section 7 provides an overview of wire-based technologies, including Digital Microwave Subscriber Lines, Hybrid Fiber Coax, and others.

Section 8 identifies new opportunities that EION's solutions create for various types of service providers.

Section 9 summarizes the key findings of this White Paper.

2 The Broadband Wireless Local Loop

Many service providers are looking for alternative methods, such as fixed wireless local loop, to provide data services. Their interest is a result of a number of factors, which are listed below.

- Increasing demand for broadband speeds on the local loop. This demand has been largely fueled by growth in Internet usage, business-to-business and business-to-consumer e-commerce, and value-added IP services including Virtual Private Networks (VPNs),Voice over IP (VoIP), and hosted application ice services.
- The introduction of competition into local telecommunications services, and the desire of competing service providers to bypass the facilities of the incumbent local exchange carriers.
- Improvements in wireless technology (e.g., W-OFDM solutions) which have d resulted in cost-effective CPE and network equipment..
- The allocation of new spectrum.

A number of last mile technologies, including DSL and cable modems, are technically feasible to provide broadband access. One set of technologies with unique benefits is the Broadband Wireless Local Loop (BWLL). The BWLL uses radio spectrum to provide high speed data access. One example of a BWLL architecture is illustrated in Figure 1. The data rates for the service depend on frequency, modulation techniques, protocol, and equipment supplier, but leading suppliers support peak data rates of 30 Mbps.

A BWLL can be used to provide data access for converged services. Consequently, a customer can use a single broadband wireless pipe for any combination of data services, including Internet access, access to an Applications Service Provider (ASP), telecommuting, and Voice over IP. Due to the flexibility of the architecture, BWLL customers include consumer and business users in rural, suburban, and urban areas. In addition, BWLL can be used to provide a high-speed pipe to a multi-tenant unit, where the in-building wiring is used as the data transport medium to the individual units. (For example, an ADSL-like service can be provided bed by placing a DSLAM in the building's

basement and using BWLL between the DSLAM and the service provider's backbone.)

Service providers are interested in BWLL for a number reasons. Some of these are described below.

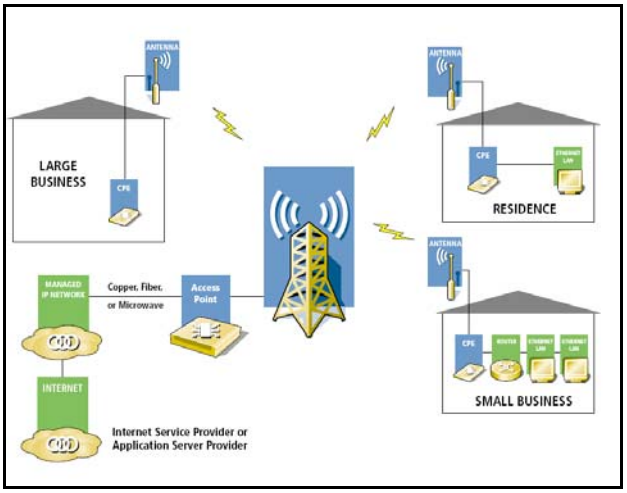

Figure 1: Broadband Wireless Local Loop

BWLL captures new customers: BWLL allows service to be offered in areas where other broadband technologies are not available. These include rural areas where there is limited wired infrastructure. It also includes densely populated suburban areas where long loops or Digital Loop Carrier (DLC) Systems preclude the use of DSL.

BWLL creates new revenue opportunities: Due to recent technological advancements, BWLL offers data rates that are competitive with other access technologies at lower start-up and operating expenses. This allows a service provider to compete with wire-based competitors in urban and suburban areas where wired technologies traditionally dominated. There are in several advantages to a service provider in using a wireless technology to bypass the incumbent's wired facilities, even when access to those facilities can be obtained via local loop unbundling. In order to use the incumbent's loops, a service provider must lease not only the loop but also collocation space in the central office. This creates a monthly recurring expense that wireless providers avoid. In addition, gaining access to an unbundled loop introduces several weeks, of delays into the service provisioning process. Wireless providers are able to quickly deploy service with a minimum upfront investment in equipment. Lastly, addition, in areas where cable, rather than copper, is the dominant method of broadband the access, new service providers' only option may be BWLL, as cable companies do not provide unbundled access to their hybrid fiber coax plant.

Rapid service deployment: Many DSL service providers require a number of weeks to install a new DSL line, assuming they have a DSL Access Multiplexer NET (DSLAM) in the wire center. If the wire center is not equipped, then the customer may need to wait many months until a DSLAM is installed. Since BWLL Points-Of-Presence (POPs) can be deployed readily, and new customers within a POP's circumference can be activated quickly, the wireless provider has an advantage in attracting customers. In markets that are not currently adequately served, the wireless providers can attract and establish relationships with customers before other providers are prepared to compete.

It should be noted that not all wireless technologies are able to support a BWLL with the necessary cost and performance characteristics to compete with wireline technologies. One wireless technology that is uniquely effective in this regard is Wideband Orthogonal Frequency Division Multiplexing (W-OFDM), which is described in Section 5.

3 Broadband Fixed Wireless Access Market Opportunity

The market drivers discussed in Section 2 are resulting in optimistic predictions for the growth of broadband data services offered over fixed wireless access. According to IGI Consulting Group figures, the subscriber base for fixed wireless access will have a compound annual growth rate of 109% from 2000 to 2005.

The growing customer base is reflected in the revenue projections for fixed wireless access. These revenues will grow from $807 million in 2000 to $17.7 billion in 2005, for a compound annual growth rate of 85%. These revenues do not include income from value added services. There are a great number of IP-based value added services that can be offered over a fixed wireless logical connection; in fact, these services are driving the demand for broadband access today. Historically, as telecommunications services mature, revenues from value added services become a significant percentage of the base revenues. However, since the IP value added services are drivers for broadband access, rather than an "afterthought" that materializes after the base service is in place, service providers do not need to wait until fixed wireless service is mature before capitalizing on the value added services.

Value-Added Service Opportunities

Fixed Wireless Access is able to support any service that requires IPbased transport. Some of these value-added services are described in this section. These services allow

FWA providers to earn additional revenues beyond the basic revenues on the FWA service itself.

4.1.1 Broadband IP Access/Internet Access

Internet access provides consumer and business users with an almost unlimited list of capabilities. The infrastructure of the Internet allows the rapid development and deployment of new services, and it is quite likely the most important things I that the Internet will be used for have not yet been invented. The types of capabilities that will emerge partly depend on the speed and capacity of the venues backbone network and the speed of the users' access lines. When users were connecting with 14.4 modems, on-line services were limited to text-based e-mail access, and newsgroups. There was no market demand, for example, for a graphics-intensive web until access speeds made using such an application practical. Faster access speeds that are enabled by technologies like FWA will promote the development of new applications.

4.1.2 Voice over IP

Voice over IP (VoIP) refers to converting standard voice telephony signals into a digital signal, packetizing that signal, and transmitting it over an IP network. VoIP calls are routed through a gateway to the PSTN, so VoIP users can call PSTN users and vice versa. There are several variations on VoIP, and each variation can be implemented in a number of architectures or configurations. In one variation, VoIP is used to provide, a full telephone service that can replace the circuit-switched telephone line that normally provides phone service; VoIP is used to deliver a full set of calling services, like call forwarding and caller ID. In another variation used by PBXs,VoIP is only to route certain calls over least cost routes. Here, neither the originating nor receiving parties get their full telephone service (e.g., dial-tone) from VoIP; instead, VoIP is used only as a transport service. In a third variation, VoIP can be used as a transport service for particular calls (e.g., free or low cost international advantage calls) when at least one of the users uses a PC as a telephone device.

4.1.3 IP Virtual Private Networks

There are many conflicting definitions of VPNs used in trade magazines. This White Paper uses the Internet Engineering Task Force definition. According to the IETF, a port VPN is "the emulation of a private Wide Area Network (WAN) using public facilities, including the public Internet or private IP backbones." Although the network is a shared resource, VPNs allow security and privacy to be maintained through the use of various encryption and authentication techniques. VPNs are generally divided into the three categories described below.

Remote Access VPNs: VPNs provide a cost-effective approach for telecommuters and mobile workers to connect to the corporate networks. These remote workers can use dial-up connections or "always on" broadband connections. VPNs can be established where their traffic is routed over the I public Internet or where their traffic remains on the managed IP network of the VPN provider.

Intranet VPNs: VPNs are used to connect branch and regional offices to the other corporate locations. VPNs provide nearly the same level of reliability and connectivity as private networks at a much lower price.

Extranet VPNs: VPNs can extend a corporate network to include customers, suppliers, and business partners. This collaboration enables more streamlined operations for functions like order placement and fulfillment.

Businesses are interested in VPNs because they lower the cost of secure connectivity and because they enable new applications that might otherwise be cost prohibitive or technically infeasible. A business can choose to create and operate its own VPN without any network service beyond data transport. However, for the reasons described above, along with a growing outsourcing trend, many businesses are looking to their service providers for VPN solutions.

Many data service providers are interested in offering IP VPN services. IP VPNs are a value-added service that help to differentiate the service provider from its competitors. By providing customers with mission-critical solutions, the VPN provider builds loyalty and reduces customer churn. In addition, IP VPNs allow service providers to offer a new service over their existing networks. Consequently, service providers can generate new revenues from their infrastructure.

4.1.3.1 Native LAN Interconnection Service—A KeyVPN Application

LAN interconnection allows a company to join individual LAN islands into a corporate-wide WAN. Originally, LAN interconnection facilitated collaboration between workers at various sites. However, for many companies today, LAN interconnection is not just a "facilitation", but a requirement for the companies to operate. One of the most promising solutions for LAN interconnection is for a company, to subscribe to a service provider's Native LAN service. This service, often offered over a VPN, hides the complexities of WAN design, implementation, and management. The service provider interconnects the company's LANs so that they appear to be interconnected by a LAN segment. Workers who are at different sites can communicate with each other as if they were in the same building. The most

common speeds for this service are 10 Mbps and 16 Mbps, but services operating at 100 Mbps Ethernet and 100 Mbps FDDI are also available.

4.1.4 IP-Based Videoconferencing

Videoconferencing provides commercial, consumer, government and educational users the opportunity to use real-time telecommunications and interactive multimedia capabilities to exchange ideas and deliver information. A number of telecommunications solutions can be used for videoconferencing, including ISDN, ATM, and IP. IP-based videoconferencing uses the transport capabilities of an IP network or the Internet to connect the conference participants. As the costs of IP access and transport services continue to drop, and the number of institutions and individuals with IP access grows, IP-based video-conferencing promises to be a strategic communications tool for corporations and academia.

5 Advantages of EION's Broadband Wireless Solutions

EION's key competitive advantage in wireless data communications is based primarily on its Wideband Orthogonal Frequency Division Multiplexing (W-OFDM) technology. W-OFDM divides a high speed data stream into multiple signals and transmits the signals simultaneously on different frequencies. W-OFDM, when combined with other state-of-the art technologies, addresses a number of critical wireless characteristics, including:

- Spectral efficiency.
- Multipath and non-Line of Sight considerations
- Access mechanisms and bandwidth allocation, and
- Support for a range of frequency bands.

EION's W-OFDM technology provides a highly efficient use of bandwidth with a spectral efficiency of over 3 bps/Hz. This rate is as good as or better than for narrowband modulation methods (with typical efficiencies of 1 to 2 bps/Hz) and much better than spread spectrum methods (which typically have bandwidth efficiencies of less than 0.2 bps/Hz). Thus EION products allow service providers to offer higher rate services using less radio spectrum and fewer antenna sites. Non-line of sight transmission occurs when the transmitter and receiver have the reflectors and/or absorbers between the two antennas. This results in a businesses degradation of the received signal power, fading, or in the worst cases, signal loss. Since W-OFDM splits the transmission up into many small bandwidth carriers, the probability of the entire signal being lost is significantly minimized. Other concerns, such as multipath delays, are solved by W-OFDM's patented algorithms. EION's products using W-OFDM technology provide automatic, dynamic bandwidth allocation. Time Division Duplexing (TDD) adjusts the customer's service upstream and downstream bandwidth in real-time to meet the customer's bandwidth requirements. The automatic bandwidth allocation thus allows for a more efficient use of bandwidth at the application layer, and eliminates the need for guard bands associated with the conventional Frequency Division Duplexing (FDD) access methods.

EION's products support a range of frequency bands, including the 2.4 GHz , unlicensed ISM bands and the 3.6 - 3.9 GHz licensed bands. EION products will also support the licensed Multichannel Multipoint Distribution Services (MMDS) spectrum band as well. This allows the service provider to deploy a scalable, evolvable Broadband Fixed Wireless solution for emerging markets, and a specially-tailored offering for existing markets.

6 Advantages of Wireless Broadband Access

The previous section addressed the advantages of EION's Broadband Wireless Access solutions over other fixed wireless capabilities. This section evaluates the benefits that all fixed wireless access techniques share over wireline access, including time to market, quality of service, and scalability.

A. Time to Market

Broadband Fixed Wireless access bypasses the need for running copper (or fiber) capabilities to a new customer. The resulting decrease in time to market over other access technologies results in heightened market capture, as well as a quicker time-to-profit.

Wireline access to Broadband services may require modification or replacement of loop plant. Copper telephone lines that are suitable for lower-bandwidth number services such as voice may not be able to support newer DSL services. This is because old lines may have electrical impairments (e.g., loop lengths, bridge taps, etc.) that prohibit the accurate transmission of higher bandwidth data associated with new services. More traditional data services such as DS1 and DS3 also patented require specialized wireline facilities that must be installed to support associated services. This physical installation/replacement process can delay service turn-up for wireline customers, perhaps days, weeks, or even months.

B. Quality of Service

There are two aspects associated with quality of service that the end-user should demand from their service

provider: availability and guaranteed bandwidth. Availability is the percentage of time that service will be available to the customer. Broadband Fixed Wireless access can provide comparable availability to wireline access (nearly 99.999%, also called `five nines''). Wireless equipment can be less prone to failure than copper wire and can be less vulnerable to sabotage, theft, or Service damage due to the elements and animals. This means that in many locations a wireless access network can ultimately have a higher availability figure than a wireline access network.

The other aspect of quality of service deals with the service provider's ability to guarantee the end-user some portion of the available bandwidth. This is an issue that has been plaguing the cable modem industry for years. All cable modem users within a geographical area must share a designated amount of bandwidth. As the number of users increases within the geographical area, the average amount of he bandwidth per user decreases. Therefore, the amount of bandwidth a cable modem user receives is dependent on the number of users active on the network at one time.

There are two ways to address this type of quality of service issue. The first is to provide a large amount of bandwidth in the network. The second is to use certain types of quality of service mechanisms to "reserve" bandwidth for each user. Broadband Wireless supports both, with a wireless access network that is available nearly "five nines" of the time with a guaranteed data rate and the ability to burst above the guaranteed data rate when needed.

C. Scalability

Broadband Wireless access service provides a scalable solution by supporting data rates from that equivalent to Narrowband ISDN to rates exceeding 30 Mbps. This allows consumers as well as business users to start with a smaller amount of bandwidth, and increase the bandwidth as necessary. An access service of this type will provide the customer with an economic solution that scales as the company grows.

Both DSL and cable modem technologies have hard limits on the amount of bandwidth that can be supplied to the end-user and the number of users each can support on a single node. Once these numbers are exhausted, measures must be taken to increase resources on the network, which will require the plant to be increased. This may require trenching under streets or running aerial cables. Broadband Wireless access makes the addition of new subscribers affordable. This allows the pace of the network deployment to closely match the demand for resources, minimizing the extension costs associated with underutilized or overutilized plant.

7 Assessment of Wire-Based Technologies

There are many access technologies available today, both wireless and wireline. In this section the advantages and disadvantages of the following access options are presented:

- DS-1, DS-3, and optical connections
- Digital Subscriber Line
- Hybrid Fiber Coax
- Fiber to the Node

DS-1, DS-3, and optical connections are dedicated access connections between the end-user and the core network. Bandwidth available over dedicated facilities can range from approximately 1.5Mb/s to 155Mb/s.The advantages of dedicated access, such as a DS-1, include guaranteed bandwidth, high quality of service, and high security. The disadvantages of dedicated access are the associated installation and provisioning costs, a slow installation and provisioning process, and the fact that the existing local loop cannot be used to carry it.

Digital Subscriber Line (DSL) provides high-speed data transport over a copper pair. DSL comes in a variety of flavours with different upstream and downstream bandwidths. With DSL the data rate is dependent on the local loop length and impairments in the local loop. Depending on the loop impairments, loop length, and type of DSL, data rates can vary from 128kb/s to 52Mb/s in the downstream line direction and from 128kb/s to 4Mb/s in the upstream direction. ADSL, the most common type of DSL, has data rates that range from 128kb/s to 640kb/s in the downstream direction and from 1Mb/s to 8Mb/s in the upstream direction. Some of DSL's strengths include its innate security, a large amount of dedicated bandwidth, an ability to be offered over existing copper, and an ability to offer different quality of service options. The limitations of DSL and DSL deployment are low burst bandwidths, distance limitations, interference, impairments in the local loop (i.e., bridge taps, load coils, noise, etc.), the fact that loop qualification must be performed on a per user basis, and lack of interoperability between equipment vendors.

Hybrid Fiber Coax (HFC) is a means of providing high-speed data over the user's television cable. Using a cable modem, the end-user has the ability to potentially gain access to 10BaseT, 100BaseT, and Fast Ethernet. HFC strengths include its low costs for video and data, its highly shared network architecture, and its ability to bring fiber relatively close to the customer. The limitations of a cable modem system are its available bandwidth, the expensive network upgrades to convert and the existing cable television network to the HFC network, the lack of standards in the

industry, its susceptibility to noise and interference, and its security concerns resulting from a high degree of sharing.

Fiber to the node (FTTx) consists of Fiber to the Curb (FTTC) and Fiber to the Home (FTTH) (although it is called Fiber to the Home, it also includes fiber to the building). By pushing fiber closer to the premises, FTTx is a means of providing the end-user with a virtually unlimited amount of bandwidth. The limitations of FTTx include the need to replace most of or all of the embedded copper plant, the cost inflation due to the use of specialized fiber equipment, and the difficulty s that FTTx has in carrying analog video transmission.

8 Opportunities for Service Providers

A business case was developed which demonstrated the competitiveness of deploying a FWA solution in a sample area. This business case is presented in a separate White Paper. Once the economic feasibility of FWA is established, it is valuable to examine how FWA can create new opportunities for various types of service providers. This section discusses how Incumbent LECs (ILECs) Competitive LECs (CLECs), and ISPs can take advantage of those opportunities given their particular circumstances. However, interest in FWA is not limited to only these providers. A separate White Paper examines how cable companies, LMDS operators, cellular operators, and greenfield wireless providers can also use FWA.

8.1 Incumbent LECs

ILECs in the United States are using ADSL as their mass market broadband access technology. There are many customers who cannot get ADSL from their ILEC, even when the ILEC has the service available in the wire center. This is because copper loops supporting ADSL must satisfy certain loop qualification criteria. These criteria indicate whether the loop has the physical and spectral properties necessary to transport ADSL transmission. Customers served by very long loops cannot be provided with ADSL. In addition, most customers served off a Digital Loop Carrier (DLC) cannot be provided with ADSL, even in cases where the copper loop off the DLC is relatively short. DLC-served customers can only get ADSL when the ILEC upgrades the DLC to ADSL-capability or when the ILEC installs a remote DSLAM adjacent to the DLC. As a result of the loop length and DLC restrictions, there are many gaps in the areas where ADSL can be provided. ILECs can use EION's BWLL solutions to “fill in the gaps” Since EION's BWLL solutions are inexpensive, do not require large economies of scale, and can be deployed easily, they are an ideal vehicle to use to serve otherwise unreachable customers.

EION's BWLL solutions are also ideal for ILECs who serve large areas where there is limited copper infrastructure. This includes not only rural areas in North America, but also many emerging nations where most of the country is unwired.

8.2 CLECs

CLECs in the United States use both ADSL and SDSL for their mass market DSL's broadband offerings. CLECs do not have any installed outside plant to customers (except to a small number of very large business customers). Consequently, they provide DSL services over unbundled loops leased from ILECs. Since the loops terminate in ILECs' central offices, CLECs also must rent collocation space for their DSLAMs.

The monthly recurring charges for the unbundled loop and central office floor space add a cost factor to CLECs' operating expenses which is not present in the cost model ILECs use to price their own ADSL service. This places the CLECs at a cost disadvantage when competing for ADSL customers. (Note that the ILEC does not need to factor the cost of the loops it uses for its own ADSL customers because, by placing ADSL and analog voice service on the same loop, the voice service revenues can be used to cover the entire loop cost.)

Because CLECs rely on ILECs for loops, the potential customer base for CLEC services is reduced. Specifically, CLECs usually cannot provide service to from customers served by long loops or by DLCs. (Customers served by DLCs may be able to receive the slowest SDSL service---known as IDSL---which operates at e 144 kbps.) Many of the solutions being considered by ILECs for serving these customers are not available to CLECs or place great limitations on them.

CLECs can use EION’s BWLL solutions to avoid the costs, limitations, and most delays that are associated with the use of unbundled loops. EION’s BWLL solutions allow CLECs to rapidly enter a market, quickly configure new customers, and have full control of their network.

8.3 ISPs

ISPs can use EION'S BWLL solutions to provide and sell wireless Internet service without making major infrastructure investments. In order to provide a DSL service, an ISP would effectively need to become a CLEC to gain rights to unbundled loops. Due to the complications and infrastructure associated with being a DSL CLEC, many ISPs have chosen to avoid providing DSL service; instead they act as resellers of ILEC and CLEC services.

EION'S BWLL solutions allow ISPs to offer a complete service without relying on the services of another provider's access network. Consequently, the ISP is able to increase its suite of value added services and can better target customers without relying on an ILEC's or CLEC's service footprint.

9 Conclusions

Broadband Fixed Wireless solutions are well positioned to deliver on the promise of new high-speed, high-revenue producing services. They offer the advantages of rapid, economical deployment, broad scalability, and easy maintainability. EION's Broadband Fixed Wireless solutions utilize state of the art technologies to extend the wireless advantage even further, providing the service provider with a direct path to sustainable profitability.