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A Broadband Wireless Framework for 2003: Which Wireless Technologies Deliver Broadband

Mock Deployment Case Study: Clearwire

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Introduction

The term "Broadband" has been around for decades, but somehow, when most of us weren't looking, it has been redefined by a large number of entities – from the FCC looking to set broadband policy, to vendors looking to differentiate their products, to service providers looking to spruce up their offerings. While everyone talks about "broadband," you can't put three telecom analysts in a room and ask them to define it, and get the same answer.

Yet broadband Internet technologies are fully entrenched in the everyday lives of people. The adoption of broadband Internet access has moved into millions of businesses and homes the past few years. By the end of 2002, there were almost 14 million broadband connections in the U.S. People are becoming more and more dependent on broadband for email, Web surfing and other applications, particularly as the size of attachments grow. Let's face it – they're hooked.

They're also acutely aware of any deficiencies, as they grow more and more reliant on broadband connectivity. And one big deficiency is broadband coverage while away from the home or office. Just as cellular phones filled a need to allow communications when not connected to a wireline phone, wireless technologies have the potential to play the same role in the data realm. And just as some people are now using their cell phones as their primary voice connection, it is not difficult to envision wireless broadband also providing the primary data connection for these same users.

But this begs the question as to what defines broadband? There are many criteria we believe to be important, but the primary ones are:

- **Maintaining an Always-on Connection.** Customers should be able to power up their computers or simply launch their browsers and have a connection for as long as they are on-line.

- **Bandwidth Speed.** So how fast is fast? Speed must include a minimum of 384kbps downstream and 128kbps upstream to be considered broadband today, relative to available cable modem, DSL, and satellite offerings, but also must be flexible to extend upwards in the future.

In the near future, the computing and home entertainment domains will be tightly linked, and this will only serve to increase the bandwidth demand that service providers should prepare to handle. Clearly, multimedia will be a driving force for higher bandwidth in these networks and for a higher adoption rate on the end user side of the equation. As time goes on, 'broadband' speed requirements will increase and rise above the 1 Mbps downstream level, easily. Wireless is going to play a big role in this.

Finding wireless technologies and services that meet this minimum level of quality is tough. The various wireless technologies that are currently available, or have been available in the past, have created a lot of confusion in the industry. Some of these may appear to qualify as broadband on the surface, but digging a little deeper reveals they aren't broadband at all. In fact, some would have a hard time qualifying as narrowband.

These technologies include (summarized in Table 1):

- **1xRTT:** This is a CDMA-based third-generation (3G) licensed spectrum alternative that is available from providers such as Sprint and Verizon. This is a wireless data offer that today does not actually provide broadband speeds. Billed as supporting up to 144kbps downstream (or comparable to ISDN), actual users experience 60-70kbps in reality. A few service providers currently offer this service on a national basis with a host of wireless data applications being supported. This technology is a good step forward for mobile users, but is still not a broadband solution.

- **GSM/GPRS:** This is similar to 1xRTT but based on GSM spectrum and offered by T-Mobile and AT&T Wireless. This technology supports up to 115kbps downstream with users experiencing 40-60kps in reality. Again, a good step forward versus 2G alternatives, but still not qualified as broadband.

- **First-generation Fixed Wireless:** These were fixed wireless line-of-sight solutions requiring the modem to have a clear view of the base station. Obstructions such as trees or buildings prohibited the solution from working. Service providers implementing this solution type had to dispatch technicians to perform the installation, resulting in high installation costs. Many times it was determined the service would not work properly due to an unknown obstruction. These problems led to little or no success for first-generation equipment vendors. While this technology is considered broadband, the technical limitations prevent it from becoming a viable alternative to service providers. (However, second-generation solutions, discussed in detail later, have resolved many of these first-generation limitations and present viable options for providers.)

- **Ricochet:** Today this service is only available in two markets with the average speed of 176kbps downstream and half that speed for upstream. Although it may burst up to 400kbps, this does not qualify as a sustained broadband speed option. It does offer the fastest of today's mobile connectivity options and the service can be self-installed and moved from location to location. The lack of coverage area prevents it from being available to many potential users today. It is also important to note that it operates in unlicensed spectrum bands that will have increasing contention for bandwidth over time.

- **Wireless LANs (802.11, WiLAN):** Just as wired Ethernet has migrated from the office domain to the access environment, WiLAN has moved from the enterprise to the home and now to public access. The majority of WiLAN deployments to date have been, and should r(a)1..1(r)uW Theh 7.4(y)4.3(47.6(f)-6.3(f)5.8.1(r)u

up speeds, which is a positive step forward. But to qualify these services as broadband-capable would be a misnomer. First-generation fixed wireless solutions can be considered broadband but have technical limitations that prevent it from being a long-term viable solution. Ricochet is launching its service on a city-to-city basis but is still very limited. And WiLAN has inherent technical limitations, which preclude it from being a viable WAN access technology. As a result, many service providers are looking at a technology called second-generation broadband wireless. These solutions build upon the first-generation solutions, but overcome their technical deficiencies.

Item	*1XRTT*	*GSM/GPRS*	*1st Gen Fixed Wireless*	*2nd Gen Broadband Wireless*	*Wireless LANs (802.11)*
Maximum Speed	144kbps but 60-70kbps reality (downstream)	115kbps but 40-60kbps reality (downstream)	1.5Mb (downstream)	Varies by technology; max is 6 Mb down/3 Mb up	802.11b – 11 Mbps 802.11a – 54 Mbps
Access Device	1XRTT capable phone or PCMCIA card	GSM/GPRS capable phone or PCMCIA card in device	PCs and/or laptops	Networks, PCs and/or laptops	Networks, PCs and/or laptops
Pricing	$10 per month up to $99 per month	$40 per month to $99 per month based on Mb	Typically $50 and up	$40 and up depending on speed and services	802.11b: Access points $150, PC cards $50 802.11a: access points $400, PC cards $150
Technology Advantages	Standards based, nationwide availability	Standards based, nationwide availability	Broadband speeds	Broadband speeds, NLOS, mobility	Inexpensive solution, broadband speeds, standards based
Technology Limitations	Speeds not broadband	Speeds not broadband	Expensive equipment, complex installation	Unproven technology, Coverage	Range limited to 300 ft., security, interference
Deployment Status	Sprint and Verizon are largest providers with national networks.	T-Mobile, AT&T Wireless and Cingular are largest providers with national networks.	Sprint, WorldCom and Clearwire did deployments in 2000 but stopped due to technical limitations.	Initial deployments are underway and expected 1st quarter 2003, various operator trials are in progress.	Used primarily as a wireless LAN solution, not access solution. Public hotspots are becoming abundant, however.

Table 1: Comparison of Current Wireless Data Options

Market Expectations and Requirements

One thing is clear thus far – the present market offerings are not satisfying user expectations for wireless data, much less broadband wireless data. The path to truly mobile broadband will evolve in steps, as the marketplace weeds out the inefficient and insufficient wireless options in favor of ones that get traction.

Most people currently associate broadband technologies with a fixed location, since cable, DSL and satellite broadband services are fixed position services. Whether they are in the office or at home, their broadband access stays in one location.

Similarly, broadband wireless solutions had gotten its start in the market as a *fixed solution*, given the mass deployment of 802.11b access points in homes and businesses, providing a very localized log-on experience. As people take advantage of this wireless capability, they quickly find the boundaries of those wireless solutions, and therein lies the growing demand for wider geographic coverage of wireless broadband services. Indeed, the wireless aspect of the solution will quickly create end-user demand for portability and eventually true mobility.

There is a great opportunity to offer broadband wireless service where DSL and cable are not yet available, which is still a substantial percentage in the US. A broadband wireless solution also has some compelling characteristics in scenarios where either DSL or cable is available in an area. These include:

- **Competitive Pricing.** Deployment costs of broadband wireless solutions tend to be less expensive than wireline deployments so service providers have some additional flexibility in the pricing to attract users.

- **Convenience.** The wireless and self-installation aspects of the solution enables the end user to get the service up and running quickly in the location desired – in most cases with no wires to install.

- **Speed.** Speeds are similar between all the broadband solutions today, but as we move forward the price-point-per-speed-achieved factor could heavily sway toward a broadband wireless solution.

Any or all of these might make the broadband wireless solution more attractive over the wireline technologies in fixed location installs. But more importantly, the real advantages of broadband wireless truly emerge in the market as the portable and mobile service extensions are offered and adopted by users.

Indeed, as dependence on broadband increases, the need to maintain access while moving locations will become more important. This type of *portable* technology allows users to "pick up and take" their broadband access with them. Portable functionality is the second phase of the evolution. As user broadband-driven devices become more portable, portability without boundaries will become even more important.

For business users, laptop computers are a big driver for portability. Already, laptops represent a substantial portion of the computing market and are growing each year. This is especially true for businesses. Laptops create the need for broadband portability by

allowing users to carry their access with them to check email, access the Internet or utilize various applications. Other new devices such as the new tablet PC will increase the need for portability.

Residential customers want the ability to roam around the house and maintain access wherever they go. This includes interactive sessions while watching television, relaxing on the patio or in the living room, even in the bedroom. These things can easily be implemented using either a portable broadband solution or by adding a wireless LAN solution to a broadband connection.

One thing to note is that until a portable solution has nationwide coverage, it will be geographically limited to specified areas within a service provider's coverage. As such, public wireless LANs/hotspots directly compete with localized portability-focused services.

The next logical step beyond the portable solution is a *mobile solution* – that is, fixed -> portable -> mobile. The mobile solution does not require users to be in a fixed location, but rather they can be moving – and no matter where they go, they have coverage.

There are two main requirements for a solution to be considered mobile:

1. Broadband speeds while on the move, and

2. "Everywhere" coverage.

The broadband wireless mobile solution has similarities to the cell phone – coverage is everywhere and you can use it on the move or standing still. This allows a user to check email, Web surf, perform stock transactions, chat, etc. while moving in a car, taxi or train. Similar to the portable solution, the laptop, PDA and other mobile wireless devices will help drive this market. The devices, however, need to be small and have long battery-life capabilities in order for them to be useful on the road.

Mobility enables businesses to provide their mobile workers broadband access while on the move. Consumers can utilize this technology in cars and vans to allow passengers access to the Internet for watching video, playing network games, listening to music – all while traveling at highway speeds.

The next sections discuss each of the broadband wireless technologies and how they fit into these various market requirements.

Broadband Wireless Categories Defined

As mentioned earlier, second-generation broadband wireless technologies provide a

mobile functionality over time as their coverage area grows. The basic technology does not necessarily mandate an either/or choice between these options.

Premises-based

Premises-based is the technology predominantly being utilized today for wireless broadband access. It is the first step in the broadband wireless evolution. Premises-based, for purpose of this paper, is a second-generation broadband wireless solution that can be implemented in the MMDS, unlicensed or WCS bands.

Premises-based is designed to overcome the challenges the first-generation fixed wireless technology possessed:

- First-generation equipment required direct line of sight. Second-generation premises-based equipment does not have to have a direct line of sight to the base station. Advanced signaling techniques are utilized to allow the signals to work around trees, buildings, walls and other objects.

- First-generation deployments required a mounted external antenna and resulting truck roll to install the antenna. This dramatically increased acquisition costs, prolonging return on investment for service providers. Second generation products do not require externally mounted antennas.

- First-generation solutions were unable to serve up to 40% of the market because the user did not have an unobstructed line of sight to the tower. Revenues were limited and acquisition costs were driven even higher since the installer was dispatched only to find out later the customer could not get service. The new generation CPE (Customer Premises Equipment), which serves as the wireless modem and sometimes a router, can be self-installed by the end user. This eliminates truck rolls and greatly reduces customer acquisition costs.

The premises-based broadband wireless service is meant to stay stationary and is therefore less complex than the other categories discussed later. Service providers looking at premises-based solutions should consider the coverage over a wide area and also the capacity of the network. In order to compete in the broadband service market for residential and small businesses, a technology must be able to compete with existing wireline technologies in terms of cost, throughput and capacity. Capital expense per user is an important consideration for wireless broadband solutions to compete with wireline broadband solutions.

Today, most premises-based deployments are in tier 2 and tier 3 markets where infrastructure for DSL or cable modems have not been installed. However, the premises-based solution has the capabilities to effectively compete with both DSL and cable modems. This will soon lead to deployments in large markets. In some cases, local governments have subsidized the build-outs of these wireless networks to make their communities more attractive to both businesses and consumers.

Portable Wireless

The portable wireless solution is an extension of premises-based wireless and is viewed as the next step towards true mobility. It has many of the same technology and

deployment considerations as premises-based. It provides the same speed, features and functionality as premises-based.

The primary difference is that the solution is portable. This means the solution can be moved from location to location within a given area. Increased functionality in both the network and CPE is necessary to make the solution portable. To allow the customer to move locations, the CPE must be small, lightweight and not mounted to a fixed location. The modem must be able to run efficiently on battery power. This provides customers with even more flexibility.

One of the key aspects of this solution is that even though the solution is portable, the end user needs to be at a static region. In other words, portable wireless does not work efficiently in a car or while moving because it does not handoff between cell sites. Portable functionality needs to be more intense than the premises-based solution. The ability to place the modem at virtually any location within the cell and get a sufficient signal is essential. The solution will not be successful if it requires end users substantial time to set up each time they move. Some vendors are working on a PCMCIA card, which can be placed in a laptop providing additional portability and convenience. This is the desired form factor today from an end-user standpoint.

Portable wireless provides additional functionality to allow end users to utilize the same Internet service at work and at home. They can also go to a library or coffee shop and take their access with them. (These situations assume that both locations are within the service provider's serving area. Until the serving area includes many wireless cells that cover a large area, the distance to which an end user can relocate the service is limited.)

Wireless LANs hotspots will compete with the portable wireless solutions. They offer similar functionality but their range is limited to locations where public access points reside. Portable wireless will work in all locations within a service provider's coverage area.

Mobile Wireless

Mobile wireless is the ultimate wireless data solution. It is different than the portable solution in that it can work everywhere including the ability to be used in a mobile fashion – including a car, train, bus, etc. This model is very similar to the way people use cellular phones for voice.

Mobile wireless data systems can be broadly defined by a few criteria:

- They are based on a cell infrastructure, like mobile voice services.
- They must provide ubiquitous service coverage throughout a service provider's footprint (unlike, for example, WiLAN services which cover only limited area or "hotspots").
- Mobile wireless solutions are typically integrated directly into portable CPE (like mobile phones or handheld devices), through PC cards and other compact form factors.

- Mobile wireless services must provide service to end users in a variety of locations – indoor and out, stationary and in-motion (including users in cars, trains).

- Mobile wireless solutions must be able to seamlessly "hand off" mobile users when they pass between cell coverage areas, without requiring the customer to "log in" and reconfigure their CPE or without dropping data packets.

- They must provide the infrastructure to support roaming between different operator networks, as well as in different markets.

Mobile broadband will allow users to stay connected at all times whether in a fixed location or moving. This market will primarily be driven by laptops with PCMCIA cards or embedded modules. This enables the business traveler to have broadband access while on the road. Initial deployments of mobile broadband will include specified areas where mobility will only work in certain areas, similar to the early days of cellular and PCS. Ubiquitous coverage will not be possible until the necessary infrastructure is in place worldwide. This will only be possible through the use of standards, such as UMTS, that all service providers utilize. Thus, the mobile solution is a few years out, but service provider coverage in pockets will be popping up in the near future.

Technology Considerations

Service providers interested in deploying broadband wireless technology have many options to consider. The technology chosen will have an impact on many different aspects of the solution. Following is a list of technology considerations and how they might impact the solution.

Air Interface Techniques

- **UMTS (Universal Mobile Telecommunications Service)/WCDMA (Wideband Code Division Multiple Access):** UMTS represents an evolution in terms of services and data speeds from today's "second-generation" mobile networks. UMTS is a member of the "global family" of 3G mobile technologies identified by the ITU. It is the natural evolutionary choice for operators of GSM networks. WCDMA is the radio access or air interface technology.

- **1XEV-DO:** Qualcomm's technology for 3G mobile data services, 1XEV-DO builds on the company's CDMA mobile telephony systems. Like UMTS, 1XEV-DO is a packet-switching system designed for broadband data throughput. 1XEV-DO is the 3G evolution for CDMA-based networks.

- **Orthogonal Frequency Division Multiplexing (OFDM):** OFDM is a new developing technology that divides the spectrum into a number of different frequencies. Each one of these frequencies travels within its own range so they do not interfere with one another. One very important aspect of OFDM is that the standards are currently being worked on, so there is still much uncertainty. Proprietary technology will prohibit ubiquitous coverage in a mobile solution unless a service provider implements a national or global solution that will most likely not be cost effective.

Channel Systems

- **Time Division Duplex (TDD):** TDD is a duplexing technique in which channels are divided into time slots. The system uses the same frequencies for both subscriber to network (uplink) and network to subscriber (downlink) transmissions. It uses the time slots to perform the uplink and downlink at different intervals. This allows one channel to be used briefly for uplink, then briefly again for downlink and so on. This technique helps make the spectrum more efficient and decreases the complexity of the CPE. Both of these reduce the overall cost of the network and CPE devices. In addition, due to the asymmetric nature of data, TDD is viewed by many as a better technology for data since one channel is used for the entire data stream. Thus, most vendors offering next-generation wireless solutions utilize TDD. One disadvantage is that additional protocol overhead is incurred to manage the communications of the uplink and downlink on the same frequency. This can reduce the speed at which data is transmitted.

- **Frequency Division Duplex (FDD):** FDD is the original technique used in the first cellular systems for voice. Instead of dividing the channels in time slots, it uses separate channels for both uplink and downlink. The channels use different frequencies far enough apart to avoid any interference, so the uplink transmission uses one channel at one frequency and the downlink transmission uses another channel at a different frequency. The CPE must have multiple antennas to account for the separation of frequencies for uplink and downlink, which results in higher CPE costs.

Other Considerations

- **CPE:** Portable solutions need small and lightweight CPE for easy portability. Alternative powering such as batteries should be available. The life of the battery must be enough to allow regular usage, ideally longer than the life of the device. PCMCIA cards with built-in modems provide the ultimate portability and mobility, as no additional set-up is necessary for the end user to move locations. If the platform supports multiple types of CPE (modems and PCMCIAs), the performance must be the same on all the CPE devices or the network will have to be designed to the lowest common denominator. If a PCMCIA has a shorter range than a modem for example – the operator would have to design its cells to the PCMCIA coverage. The CPE should also be built to withstand an increased amount of handling. The chances of the CPE being dropped or handled roughly are increased with the portable solution. CPE that breaks easily will be problematic and costly.

- **Multipath:** Multipath occurs in situations where objects are blocking the direct path between sending and receiving devices. As the signal leaves the sending device, it spreads outward as it travels to the receiving end. If objects move into the path or if there is not a direct path to begin with, the signal will spread further apart as it bounces off objects. The signal can eventually become delayed to the point where it spreads into the next transmission. Access speeds will become slow or even stop if the solution does not have the capability to handle the effects of multipath. This capability is especially important for the portable and mobile solutions since they have

an increased chance of multipath occurring. Portable and mobile solutions must have signaling techniques capable of effectively handling multipath.

- **IP Mobility:** In a truly mobile application, a user may cross through several cells during a single "session." The ability to seamlessly hand off between cells is taken for granted in mobile voice systems, but in an IP environment it is necessary to be able to maintain a "connection" in a connection-less environment. Mobile systems also need to extend this IP mobility beyond just their own network – end users should be able to roam, for example, onto a supported Wi-Fi hot spot while maintaining their current IP sessions. This mobility can even extend onto other carriers' networks – particularly if a roaming customer's IP applications require a pre-identified IP address for security purposes.

- **Mobile Performance:** The key differentiator between a portable and a mobile system revolves around the ability of the mobile system to actually work while the customer is "on the go." A mobile service should be able to maintain a minimum level of performance based on the broadband definition – while the end user is walking, riding on a train, or in a car. This capability also requires the system to be able to handle rapid cell hand-offs.

- **Spectrum:** The decision to utilize licensed or unlicensed spectrum has a significant impact on the overall solution. There are tradeoffs for each. Licensed spectrum, which is typically obtained by purchasing the license through the government, provides much less interference since it is controlled and thus much more predictable. Unlicensed spectrum is free for any provider or device to use. This inherently causes problems in that there is a lot of interference and the spectrum is unpredictable. This can create challenges from an end-user standpoint where bandwidth can fluctuate and service is unpredictable. It also makes it difficult for service providers to offer carrier grade services and/or Quality of Service (QoS).

- **QoS:** QoS will become increasingly important as services other than data are offered. Applications such as voice, which do not have tolerance for signal interruptions, interference or latency, will need to have proper technology in place for it to be a viable service. The ability to prioritize based on application traffic will be essential to offer these types of services. QoS can provide the means by which service providers can create new revenue.

Deployment Considerations

The technology used in a broadband wireless solution will have an impact on the speed and ease of product deployment. As with any service launch, there are many additional considerations relating to deployment that need to be taken into account.

Many of these considerations will be dependent on the service providers themselves. Incumbent service providers with existing processes or backoffice systems in place will have different requirements than a new service provider with no existing processes or backoffice systems. The following is a list of factors to consider when deploying a broadband wireless solution:

- **Security:** To attract enterprise customers and move mission-critical data to a mobile system, robust end-to-end encryption is a requirement – both airlink encryption, and support for a variety of VPN protocols.

- **Backoffice / Front Office Requirements**: The requirements for back and front office are largely determined by existing systems. Solutions need to be flexible enough to tie into existing systems. This includes operations, billing, customer support and provisioning.

- **Subscriber Management:** Subscriber management refers to the capabilities to add, change or delete end users. Again, with premises-based solutions where the wireless service is stationary, this is less of an issue. Web interfaces are typically utilized to gain access to end-user management systems.

- **Billing**: Billing should be flexible enough to integrate with existing billing systems if necessary. This will usually require APIs or hooks into the system for easy integration. Vendor solutions tend to be flexible in this regard and are capable of working with most billing systems.

- **Backhaul Issues**: Where simple T1 (or T1-speed) services can adequately handle many mobile voice service backhaul needs, the greatly increased bandwidth of broadband mobile wireless data services requires a greatly enhanced backhaul capability. It is imperative that cost-effective backhaul solutions are available to carry base station traffic to an aggregate point of presence (POP).

- **Network Management and Support**: Requirements vary among service providers. System performance all the way through the network to an end-user modem is necessary for adequate support. The management system should be a distributed architecture that gives service providers an effective way to push changes all the way through the network automatically.

- **Total Cost of Ownership (TCO):** Lower operational and provisioning expenses are the focus of intense efforts by many operators today, but just as important is the TCO equation for a new system. That means that operating and capital expenditures for base stations, routers, network management systems, CPE – all of the network – must be low enough to provide a compelling business case to the operator. Broadband wireless solutions have the capability to provide service providers with a compelling business case to effectively compete with other broadband technologies.

- **Roaming Support:** Tied in to both the overall technological choice and the billing and back office systems mentioned above, roaming is an absolute necessity for a mobile service – particularly for one aimed at higher revenue business customers. Not only should the roaming be seamless from the customer perspective (requiring smooth cell hand-offs, rapid user authentication and perhaps even IP mobility), but also billing and service provisioning systems must be sufficient. This includes reciprocal charges to other carriers so customers receive the services they pay for, regardless of location. Roaming may also incorporate roaming into Wi-Fi hot spots and on

to other network topologies. SIM (Subscriber Identity Module) authentication is proving to be an effective means to handle roaming.

End User Service Opportunities

Service providers can use broadband wireless to offer a whole set of new services to end users. Following is a list of potential offerings that broadband wireless enables. Note that both portable and mobile solutions offer some new and enhanced service opportunities.

- ✓ **High-speed Internet Access:** This is the primary service offering for service providers and the basis for all other services.
- ✓ **Tiered Services for Speed and Reliability:** Service providers can offer different level of speeds and service level agreements for different price points or to different target customers.
- ✓ **Remote Office Connectivity:** The non-line-of-sight solution is ideal for branch offices of large enterprises or for work-at-home employees. This solution allows the remote worker to connect to corporate databases and presents an opportunity for the service provider to offer secure add-on services.
- ✓ **VPN Add-on:** Extension of remote office connectivity to provide a secure mechanism back to the corporate LAN.
- ✓ **Security:** Added security options include firewalls, anti-virus and content filtering. Service providers can partner with a security solution provider to offer these services to both business customers and consumers.
- ✓ **VoIP Options:** VoIP options require additional equipment and functionality in the network, including CPE. However, non-line-of-sight solutions can provide a cost-effective way to offer a voice solution using VoIP technology to compete with competitors and increase revenue.
- ✓ **Home Extension Service (portable and mobile):** End users who have a wireless solution in their offices might want to utilize the same service in their homes. Users can take their access solution home with them and if within cell range, can simply utilize the same wireless service. Service providers can offer a product where their office solution can be extended to the home and provide personal email addresses, newsgroups, etc.
- ✓ **Integration with Wireless LAN Services:** Mobile operators may offer roaming services to Wi-Fi hot spots, in order to provide customers with higher speed download capabilities when in range of a "hotspot."
- ✓ **Expanded Coverage Areas:** Similar to mobile voice "nation" plans, providers can offer increased coverage in-network, or bundled roaming services out-of-network.

Summing It All Up

Broadband wireless options hold a host of opportunities for today's customers. They truly bridge the options available today between the wireline and the wireless world. They will allow us to move from a wireless LAN infrastructure in the short term to a fully mobile broadband solution. Along the way, premises-based and portable wireless solutions will whet our appetite for full mobility at broadband speeds.

As a service provider there are many options available to choose from. A wireline provider may decide to adjunct its network with these next-generation wireless solutions. Through this deployment they will have access to customers they can't currently reach with their traditional DSL or cable modem solutions and will have the ability to offer new services to these customers to drive additional revenue. The additive results of new customers and services can create an entirely new line of business for some providers.

On the flipside, traditional wireless providers may decide to augment today's slow data rates on their mobile infrastructure with faster mobile broadband data rates to allow for tiered services in lieu of waiting for 3G/4G equipment that may take years to materialize and be extremely costly to deploy. This near-term solution will again allow these providers to reach customers they may not be able to connect to today and offer new services to create additional revenue streams.

For the end user, these options open a world of new choices, new connectivity options at higher speeds, with always-on functionality. These options will allow entertainment choices to enter their homes and business functionality to move with them in an untethered fashion as they move wherever their business needs take them. These services will change the paradigm for how, when, and where business is conducted and entertainment is used.

For the industry, the vision is not a pie-in-the-sky dream, but an available option, today, that can address current demand, with near term revenues. That ought to make a lot of service provider CFOs happy – and their customers ecstatic.

Mock Deployment Case Study Scenario: Clearwire

Service providers considering a broadband wireless deployment have many decisions to make. Although this white paper has discussed many items that need to be considered, a mock deployment scenario will help explain the process service providers need to undergo when deploying a solution. This information, provided by Clearwire, can be used as a guide for future deployments of broadband wireless. It represents the process they utilized for their broadband wireless solution.

Equipment and Vendor Selection

An important early step is the selection of the equipment and vendor. Potential vendors are measured based on a number of criteria including:

- **CPE:** Non-line of sight, self-installation, cost, and form factor are important features to consider. The diagnostic capabilities of the CPE device are a major consideration as well and must meet the level of customer service desired.

- **RF Link:** The equipment needs to be able to handle varying link conditions and distances. Service providers should determine what kind of solution they want to offer. If a mobile solution is desired, the RF link needs to be capable of supporting this model. This is true even if a service provider wants to begin with a premises-based solution and evolve it to a mobile solution.

- **Capacity:** The capacity of the upstream and downstream speeds needs to be sufficient to support desired offerings. It is necessary to look at both the capacity of the CPE device and the base stations.

- **Media Access Control (MAC):** The MAC protocol layer must allocate and manage throughput efficiently under varying conditions. Throughput considerations include how the system handles error control, class of services, quality of services and jitter/latency.

- **Element Management System (EMS):** The capabilities of the EMS must be sufficient to satisfy the support requirements of potential customers. The EMS consists of the necessary tools to monitor the network and ensure it is performing appropriately. Service providers tend to look for an integrated system that contains provisioning, fault management, SNMP alarm management, performance monitoring and diagnostic capabilities.

- **Base Transceiver Station (BTS):** Redundant architecture should be available for a high level of service. Also, the base station installation process should not be complex.

Once the above considerations have been decided upon, lab and field tests should be conducted, and the results analyzed compared to the above criteria. Clearwire chose IPWireless as its equipment vendor. The primary reasons IPWireless was chosen include:

- ✓ Standards based technology using UMTS

- ✓ BTS and CPE are frequency synthesized across the entire band, allowing for roaming between markets and operators
- ✓ High sector and CPE bandwidth
- ✓ CPE is a truly portable device
- ✓ Flexible bandwidth and frequency re-use
- ✓ Future product roadmap consisting of higher order modulation, PCMCIA modems for laptops and integration with residential gateways
- ✓ PCMCIA will provide full mobility on the network

Market Selection and Marketing

The selection of markets to deploy is also an important decision. The market(s) chosen should have the characteristics necessary to achieve stated product objectives and strategies. This will be contingent on which markets to serve, population, competing technologies, demographics, etc. Clearwire used the following high-level process to choose its markets:

1. Determine in which markets Clearwire had spectrum access.
2. Filter the list for tier 2 and 3 markets to stay consistent with the business plan.
3. Review coordination and interference requirements of the markets.
4. Perform two types of rankings:
    A. Number of businesses, growth and topography of each market.
    B. Demographics, competition and actual coverage potential to determine how many towers are needed.
5. Visit each potential market including site visits for potential tower sites.
6. Make final decision based on capital requirements, ROI and results of previous steps.

Once the market has been selected, tower locations need to be determined. Towers need to be strategically located based on the geographic makeup of the target markets including density of target business and residential subscribers.

Target Market

Clearwire is primarily targeting the SME segment located in areas where DSL is not present. Next, SMEs using dial-up with 25 or less employees are targeted. Residential customers with incomes greater than $50k are targeted as well but on a secondary basis. Key vertical markets will be targeted to facilitate portable applications. Examples include general contractors, real estate, lawyers, service organizations and other groups

requiring access to files, order entry, dispatch tickets, on-line ordering or access to the Internet while in the field.

Marketing

Clearwire will utilize a variety of marketing tools to reach their target markets. Distribution channels include inside sales, field sales, agent and consultant partners. No wholesale is planned at launch. Direct mail and limited radio advertisements will also be used to reach potential customers. Local marketing programs might also be planned to help create media coverage and target specific vertical SME markets.

Ordering and Installation

Clearwire customers can qualify and order service through a secure Web-based order entry system or through one of the distribution channels. SMEs typically utilize distribution channels whereas residential customers typically use the Internet.

Installation consists of customer self-installation, professional installation and industrial installation. Customers within a specified range are primarily done using the self-installation technique or professional install if a technician is required to assist with the self-install process or network set-up. Industrial installations include a small external antenna and are available for customers outside of this range. About 75% of installations will be self-installed, with the remaining industrial installed.

Customers using the self-installation method receive a self-installation kit either through FedEx (overnight or 2nd day) or UPS (ground). The kit contains all necessary equipment and instructions for immediate hookup. Self-installation requires no special knowledge and is typically done in less than one hour and often in less than 15 minutes.

Customers using the industrial installation are also mailed a kit using the same methods. The key difference is a technician is scheduled and dispatched 3-5 business days after ordering to perform the installation. A separate installation charge is assessed for the industrial installation.

Application/Services

Clearwire's initial deployment consists mainly of the standard offering including Internet access, email, virus scanning and Web hosting. Internet access includes tiers based on speeds and number of users. The speeds range from 512k downstream/64k upstream for single users up to 1.5Mb downstream/768Kb upstream for multiple users. Customers in the upper tier packages also have the opportunity to prioritize their packets to ensure adequate performance. Pricing varies from $49 for the basic service to $239 for the highest service.

User IDs and passwords are required for access to the network. In addition, an IPWireless device is required to authenticate with the network. Packets are also scrambled based on the CDMA technology for an added layer of security.

Voice and content filtering are planned service offerings in the future.