Network Design Manual

Wireless Broadband and Other Fixed-Wireless Systems

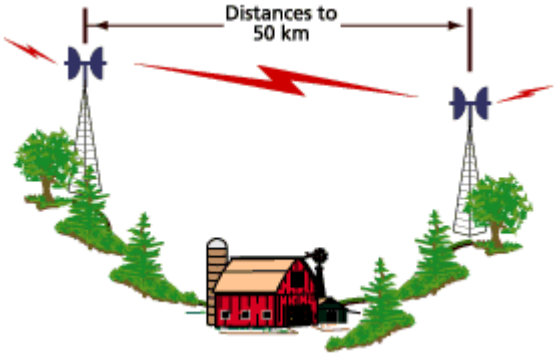
Network Computing: http://www.networkcomputing.com/netdesign/bb1.html

By Peter Rysavy Our appetite for bandwidth is insatiable. And now, just as wireline modems are topping out at 56 Kbps and ISDN service is finally available in most locations, new technologies, such as DSL (Digital Subscriber Line) and cable modems that offer transmission speeds of megabits per second, are beginning field trials. Meanwhile, old standbys, such as corporate T1 connections at 1.54 Mbps, are being upgraded by many companies to T3 fiber connections. But as quickly as LECs (local exchange carriers) and competitive access providers lay new fiber, many companies are finding high-bandwidth connections difficult to obtain or prohibitively expensive. Wireless has always been an alternative for high-speed connections, but never has the range of choices been as great nor the rate of innovation as rapid. This chapter delves into the world of wireless broadband and other fixed-wireless connections that deliver data rates from T1 to 155 Mbps. These wireless connections serve the same function as a wireline--interconnecting private networks, bypassing a local exchange carrier or connecting to the Internet.

In our first chapter on wireless networks (http://www.networkcomputing.com/netdesign/wireless1.html), we examined wide-area wireless networks, covering data over PCS (personal communications systems), packet data networks and Metricom Ricochet. In our second chapter, we surveyed wireless LANs (http://www.networkcomputing.com/netdesign/wlan1.html). Both chapters concentrated on mobile computer communications. This chapter focuses on communications that are fixed and at higher data rates. A simple form of such a system might involve a private microwave point-to-point connection; a more complex system might involve a carrier that has deployed a complete network using sophisticated point-to-multipoint hubs. A LEO (low-earth-orbiting) system of satellites would be even more complex. There are as many variations in high-speed wireless systems as there are variations in wireline systems.

Fixed-wireless systems have a long history. Point-to-point microwave connections have long been used for voice and data communications, generally in backhaul networks operated by phone companies, cable TV companies, utilities, railways, paging companies and government agencies, and will continue to be an important part of the communications infrastructure. Frequencies used range from 1 GHz to 40 GHz. But technology has continued to advance, allowing higher frequencies, and thus smaller antennas, to be used, resulting in lower

costs and easier-to-deploy systems for private use and for a whole new generation of carriers that are planning to use wireless access as their last mile of communication. The terms wireless broadband and broadband wireless are not used consistently, but generally both apply to carrier-based services in which multiple data streams are multiplexed onto a single radio-carrier signal. Some vendors also use the terms to refer to privately deployed networks.



(A backhaul connection is a company's internal infrastructure connection. For example, a phone company's backhaul might be from one central office to another.)

The goal of this chapter is to show how fixed-wireless systems are no longer a communications tool restricted to large or specialized organizations. They are available to almost any size company in a variety of ways for a variety of purposes. You'll find that you have a wide range of choices, including whether to use licensed or unlicensed spectrum, whether to deploy a private network or use a carrier network, and whether to use a terrestrial network or a satellite network. In some cases, you may not even know that your service provider is using wireless technology. This chapter discusses the options available, how the various technologies work and how to go about implementing a fixed-wireless solution.

Broad Fundamentals

Before delving into the types of fixed-wireless systems and how to use them, let's look at some of the fundamental concepts and issues involved. These include:

Fixed-Wireless Applications | Wireline versus Wireless | Private versus Carrier
Unique Aspects of Wireless | Radio Spectrum

Fixed-Wireless Applications

Fixed-wireless systems can be used for almost anything that a cable is used for, whether the cable is a T1 circuit, a cable television cable, an Ethernet cable or a fiber optic cable. Fixed-wireless systems are designed so that they emulate cable connections, and they use the same

type of interfaces and protocols, such as T1, frame relay, Ethernet and ATM. For this chapter, we'll assume that your application is data, and we emphasize wireless systems designed for data communications. Keep in mind that fixed-wireless systems are also used for voice communications as well as for carrying television programming. But most new development in fixed-wireless systems is data-centric, such as for Internet access, or is flexible in supporting both voice and data communications. Fixed-wireless systems match cable-based systems for all important parameters, including delay, bit-error rate (1 in 100 million or better) and throughput (1 Mbps to 155 Mbps). Consequently any application that operates over a cable should be able to operate over a fixed-wireless system. The only exception is communication involving geosynchronous satellites where delays can exceed a quarter of a second.

Wireline versus Wireless

In some cases, a fixed-wireless system is the only wireless option. So you must decide if a fixed-wireless connection is practical and if it is competitive with available wireline connections. Today fewer than 10 percent of buildings have fiber to them, and only about 50 percent are close enough to a central office (12,000 feet or 3.5 km) to take advantage of DSL technology. Thus in many cases, a wireless connection could be the only option for high-speed communications. This is especially true in more remote areas. In some areas, the only option for communications will be by satellite.

When both wireless and wireline options exist, the potential reasons to consider wireless include lower costs, faster deployment, greater flexibility and better reliability. Unfortunately costs and deployment have to be evaluated on a case-by-case basis and actual costs will depend on the particular circumstances. In developed countries, a wireless system won't be more reliable than wireline options, but in developing countries wireless communications may be much more reliable.

Private versus Carrier

A fundamental distinction is whether you deploy your own wireless connection or whether it is supplied by a wireless carrier. In the past, most fixed-wireless connections were private, but with new spectrum licenses a number of companies are deploying or planning to deploy networks in most major metropolitan areas. Don't think of these companies as "wireless" companies, though. Think of them as CLECs or ISPs that happen to be using wireless technology. Instead of running fiber to a building, they are using wireless links that may be less expensive to deploy than fiber.

Once one of these companies, Winstar (http://www.winstar.com) and Advanced Radio Telecom (http://www.art-net.net) are two examples, has a wireless connection to a building, often to the roof, they can then market their communications services to the tenants of the building. These services look like standard networking services, and interfaces include frame relay, ATM, T1, and Ethernet using the same connectors, such as BNC and RJ-45. These services also can include value-added services, such as network management, Internet access, Web hosting and e-mail. The fact that these carriers use wireless technology will be transparent. (See the section How To Use a Wireless Carrier for a list of some tough questions you can ask to ensure

dependable service. For instance, terrestrial wireless carriers only have regional licenses so you should ask whether the carrier can provide service to all of your locations.)

Figure: wireless broadband providing last mile of connectivity to buildings not having fiber connections.

Satellites are another form of carrier service, offering broadband services using geosynchronous satellites today and higher capacity LEO satellites in the near future.

Unique Aspects of Wireless

Fortunately, you do not need to be a radio engineer to take advantage of fixed-wireless communications. But it is helpful to understand what makes wireless different from other forms of communication, particularly when qualifying and specifying service parameters.

Wireless communications offers tremendous flexibility and ever-improving performance, but it does have some limitations. First and foremost, wireless uses radio spectrum, a finite resource. This limits the number of wireless users and the amount of spectrum available to any user at any moment in time. The amount of spectrum available equates almost directly to data bandwidth, with 1 Hz of spectrum typically yielding between 1 bps and 4 bps of throughput depending on various factors, such as the type of modulation used and environmental factors. The amount of spectrum actually available varies from radio band to radio band, but suffice it to say that fiber optic cable offers far greater overall capacity. Despite this capacity limitation, wireless offers more than sufficient bandwidth for many applications. But it is important to know the capacity of a particular wireless system in order to understand how it can satisfy your requirements if they should expand in the future. Another limitation is that fixed-wireless systems operate at frequencies that almost always require line of sight and that are restricted to distances that vary from a few miles to tens of miles. It is no mystery why microwave dishes are located at tops of towers, hills and buildings. Unlike cellular and other mobile wireless systems, fixed-wireless systems use fixed antennas with narrowly focused beams. A 3 degree to 4 degree beam is not uncommon. And unlike cellular systems, in which base stations communicate with dozens of mobile stations, broadband systems usually operate in a point-to-point manner, though a number of point-to-multipoint systems are in development.

Very few standards exist for fixed wireless systems, and you will need to purchase equipment from the same vendor for both sides of the connection to ensure interoperability.

Radio Spectrum

Fixed-wireless systems use frequencies allocated for such use from about 900 MHz to 40 GHz. The number of different bands can be bewildering, with multiple frequency bands assigned for private use and multiple bands assigned for carrier use. In addition, some bands are designated for licensed use while others can be used without a license.

Should you care what frequency you use? Yes, but only in a general sense. Higher frequencies have some advantages over lower frequencies, but also suffer some drawbacks. The principle advantage of higher frequencies is that there is more spectrum available for broadband applications. Most higher bandwidth systems use frequencies above 10 GHz. Antennas at these frequencies are smaller due to the smaller wavelengths, making systems easier to deploy. But with higher frequency, components demand more sophisticated technology, so systems cost more. Also, propagation distance for reliable communications decreases and the signal is more susceptible to weather conditions like rain and fog. Higher frequency systems, those above about 30 GHz, are sometimes referred to as millimeter wave because the wavelength of these signals is on the order of 1 millimeter.

Both private and carrier systems have a choice of using licensed or unlicensed spectrum. The main advantage of unlicensed spectrum is being able to deploy a system without applying for a license from the FCC (or equivalent body in other countries). The disadvantage is that you could experience or cause interference, though the type of technology used in these frequencies minimizes this possibility.

The principal frequencies of interest in this chapter are:

· 900 Hz, 2.4 GHz and 5.8 GHz: unlicensed systems using spread-spectrum techniques
· 2.5 GHz: licensed to carriers for MMDS (Multichannel Multipoint Distribution System)
· 5 GHz: new unlicensed band referred to as UNII (Unlicensed National Information Infrastructure) band
· 23 GHz: commonly used for microwave LAN systems
· 28 GHz: licensed to carriers for LMDS (Local Multipoint Distribution Service)
· 38/39 GHz: licensed to carriers for general purpose communications services

A good resource for additional information about frequency allocations is a book called "The Spectrum Guide" by Bennett Kobb. See http://www.newsignals.com for details.

Types of Fixed-Wireless Systems

There are many different types of fixed-wireless systems available; here we concentrate on the most important ones. We emphasize radio frequency systems, though optical systems are also available. The discussion includes both private and carrier systems:

Private Licensed Links (Microwave) | Private Unlicensed Links (Spread Spectrum)
38-GHz Carrier Service | LMDS (Local Multipoint Distribution Service)
Satellite Systems | And the Rest

Private Licensed Links (Microwave)

Microwave links are the traditional workhorse of fixed-wireless systems and have been around long before the term wireless broadband was coined. These connections are point-to-point and require licenses. Frequencies available range from 1.7 GHz to 40 GHz, with most of the lower frequencies being used by carriers for backhaul networks, such as T3 connections at 45 Mbps. Many of these are multihop systems and commonly operate at 2, 4 and 6 GHz. A 155-Mbps

connection (OC-3) represents the high end for microwave communication today, but there is no inherent upper limit.

If you aren't a telephone company with a backhaul network or a PCS carrier connecting thousands of base stations, and instead are looking to bridge a LAN between two points, the FCC has allocated a frequency band specifically for private use: the 21.2-GHz-to-23.6-GHz band. The license-application process is streamlined, affordable products are available and systems are relatively easy to deploy. For about $30,000 you can purchase a fully installed 10-Mbps connection with a five-mile (eight-km) range. Note that Ethernet type of bridging is less expensive than deploying T1 links because it can operate in a half-duplex asynchronous manner. Of course, if you need to carry voice or video, you may need a T1 or other form of synchronous connection.

Microwave links are very reliable and using licensed frequencies virtually eliminates any potential of interference. Unlike spread-spectrum connections, they offer considerable headroom for increasing throughput if your requirements expand in the future.

Private Unlicensed Links (Spread Spectrum)

An alternative to a microwave link is to use spread-spectrum bridging products. Many wireless LAN vendors offer such products because they incorporate much of the required technology within their access points. These wireless bridges, mostly operating in the 2.4-GHz band, offer rates of 1, 2, 3, 4 and 10 or 11 Mbps and distances up to 10 or 25 miles (16 to 40 km) depending on the type of antenna used. For longer distances you may not be able to achieve as high a throughput. Some products also operate in the 5.8-GHz band.

Government regulatory agencies, including the FCC, mandate the use of a spread-spectrum radio technique that minimizes interference by making radio signals appear like background noise to unintended receivers. Spread spectrum can employ frequency hopping or direct sequence.

These bridges offer the same types of features offered by wireline bridges: interconnection with Ethernet or token-ring networks; Spanning Tree Protocol support; remote configuration via telnet, FTP, SNMP, HTML; automatic configuration using BOOTP or DHCP; and SNMP compliance supporting standard MIBs.

38-GHz Carrier Service

Between 38.6 and 40.0 GHz, the FCC has made 14 pairs of 50-MHz-wide channels available for carriers to offer wireless last-mile communications. This band is also referred to as the 39-Ghz band.[2] The primary license holders of this spectrum at this time in the United States are Advanced Radio Telecom, Teleport and Winstar. Forthcoming auctions for this spectrum will inevitably produce new wireless-broadband competitors as well. These carriers manage the entire wireless link themselves, using the wireless connection to extend the reach of their fiber networks. Placing wireless hubs centrally in higher-density population areas the carriers then make wireless connections to other buildings with which they have line of sight. This involves

securing roof rights and installing antennas, radios and interface equipment. The carriers usually target buildings that do not have fiber available. The carrier can then market high-speed connections to tenants of the building. The protocols and interfaces are standard communications interfaces such as T1, E1, frame relay, Ethernet and ATM. To the customer, the service is indistinguishable from a wireline service. All he or she sees is a jack in the wall.

Different carriers emphasize different services. One approach is to offer basic telephony services to end users, bypassing the local exchange carrier. Another approach is to offer Internet access and associated services, such as Web hosting and mailboxes. Another approach is to sell connectivity to existing LECs, CLECs, IXCs, long distance service providers and ISPs, essentially being a carrier's carrier. Although service is available on a limited basis in dozens of cities in the United States, this market area is so new that no dominant business model has emerged.

LMDS (Local Multipoint Distribution Service)

LMDS, another type of wireless-broadband system, has recently received tremendous press attention, and for good reason. The FCC recently auctioned a larger block of spectrum than ever before in history: 1.3 GHz. The specific bands include 27.5 to 28.35 GHz, 29.1 to 29.25 GHz and 31 to 31.3 GHz. One band, called the A² band, is 1,150 MHz wide, and the other, the B² band, is 150 MHz wide. The smaller B band is available to any company, but restrictions on the A band have prevented incumbent LECs and TV operators from obtaining the spectrum. Although actual LMDS service is extremely limited at this time, it is projected to become a multibillion-dollar industry within five years, with nearly every large telecom and networking vendor having some involvement today.

The services planned for LMDS are quite similar to those of the 38/39-GHz band, namely Internet access, telephony, CLEC services, and resale via LECs, CLECs, long distance service providers and ISPs. The proposed architectures is point-to-multipoint with centralized hubs communicating to fixed-antennas and radios on neighboring buildings. Effective range is about 3 miles (5 km). Downstream radio channels will typically be 20 Mhz or 40 MHz wide and upstream channels 10 MHz, resulting in about 20 to 50 Mbps of downstream bandwidth and 10 Mbps of upstream bandwidth. The carriers will be able to reuse frequencies efficiently in a cellular fashion. Using a TDMA (Time-Division Multiple Access) approach, multiple customers will be able to share the same radio channel. Like 38/39-GHz service, carriers will support standard networking and telephony.

Satellite Systems

Why include satellites in a discussion of fixed-wireless systems? Satellites are anything but fixed, but the ground stations are. Satellites were first used for intercontinental telecommunications before undersea fiber was available and for communication in remote areas, including to remote islands and ocean-going ships. By the end of 1997, more than 180 communications satellites were deployed, and today satellite systems represent a sizeable industry. A variety of new LEO systems are in development and deployment, and they will result in an estimated 1,700 additional satellites by 2005. These new satellite networks will

vastly increase the types of services available for both mobile and fixed use, but even now there are many instances when a satellite connection is the best option.

From a broadband perspective, companies, such as Comsat (www.comsat.com) in the United States, already offer flexible service ranging from 56 Kbps to 155 Mbps with E1/T1, frame relay and ATM interfaces operating via a geosynchronous Intelsat satellite. 2-Mbps service, for example, requires a 1.8-meter dish antenna that is relatively easy to install. Connection reliability matches landline quality though there is a somewhat greater delay of about a quarter of a second for the signal to travel to and from the satellite. This delay can affect protocols, such as TCP at data rates exceeding 1 Mbps. See When To Use Satellites, below, for scenarios in which a satellite connection makes the most sense.

And the Rest

If all of the systems described above were not enough, there are a variety of other systems, both private and carrier-oriented, that are offering or about to offer broadband service. We quickly survey these, first private systems and then carrier solutions.

Laser

Laser technology can be used for reliable point-to-point communications. Like all the other systems discussed in this chapter, they require line of sight. For just a little more than $10,000 you can purchase a link offering 10 Mbps and a range of 1 km. Much higher data rates, e.g. 45 Mbps, are also available. Lasers offer the advantage of not requiring licensing anywhere in the world. They also can be extremely secure because any interception of the beam will block the transmission, which can instantly be detected. No wonder lasers are sometimes used by financial institutions. However, because of the small lens size and tightly focused beam, lasers are sensitive to moisture on the lens, though this can be solved by heaters. They also are subject to vibration, and the signal can easily be momentarily blocked by birds. Finally, direct sunlight also can affect signal reception and must be factored into the deployment.

UNII (Unlicensed National Information Infrastructure) Band

The FCC recently allocated 300 MHz of spectrum for unlicensed use from 5.15 GHz to 5.35 GHz and from 5.725 GHz to 5.825 GHz, a swath of spectrum far larger than all the other unlicensed bands combined. Though no products are yet available, intended uses include wireless LANs as well as communitywide networks thanks to the higher power of 4 watts EIRP (effective isotropic radiated power) allowed in the 5.725 to 5.825 portion of the band. Expect both private-link UNII products as well as carrier-based UNII services in the future.

MMDS (Multichannel Multipoint Distribution System)

This is a carrier service, initially intended for broadcast of television, and is commonly referred to as wireless cable. In the United States, this service is available at 2.5 GHz. MMDS service is usually analog and one way (transmit only), with a range of about 30 miles (50 km), and has been deployed in the United States, the Middle East, Latin America, Eastern Europe and Asia Pacific.

Carriers have not been widely successful with television programming and some have obtained waivers from the FCC to be able to offer two-way service for Internet. Others offer Internet service by using a hybrid approach with a PSTN (public switched telephone network) connection for the return path. Meanwhile the FCC is in the process of relaxing rules to allow two-way use of the band, which will facilitate data services. Two-way service reduces the effective range of MMDS to about 6 miles (10 km).

High-Altitude Long Endurance Systems

So far we have seen radio transmitters and receivers on buildings, towers and on satellites. Why not put them on specially designed aircraft that can fly in a circle above a coverage area for a long period of time? That is exactly what some companies are planning, including Angel Technologies Corp. (http://www.angelcorp.com). Such systems will offer broadband services with comparable protocols and interfaces as 38 GHz and LMDS carriers.

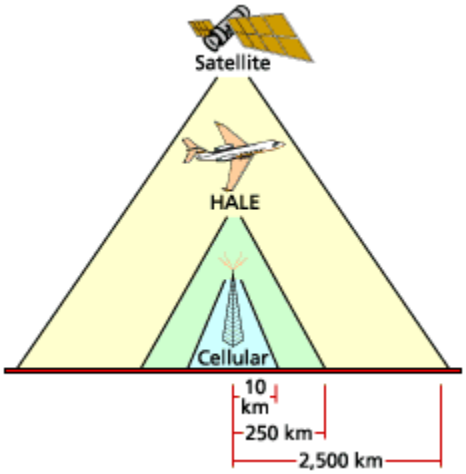


Figure: High altitude long endurance system with airplane as base station.

Using Fixed-Wireless Systems

Now that you are an expert in how fixed-wireless communications work, here are some practical pointers on how to determine whether one of these systems is for you, which one to use, and the questions to ask your prospective vendors. In this section we cover:

Licensed Microwave

Choosing Between Private and Carrier | How To Deploy a Private Connection
How To Use a Wireless Broadband Carrier | When To Use Satellites

Choosing Between Wireless and Wireline

In many instances both wireless and wireline alternatives will be available. Here are some guidelines for choosing which to use.

· **Remember line of sight.** You must be able to see the point with which you wish to connect, whether it is your own site or a wireless carrier. Depending on the technology used, effective range is from about three (5 km) to about 20 miles (30 km). Multiple hops also are an option but add complexity.

· **Consider wireless if there are no good wireline options available.** Perhaps you are in a suburban area and need high-bandwidth connectivity, but no fiber runs to your building. Even if wireline options exist, the length of time to obtain wireline service may be prohibitive.

· **Consider wireless if you need to bridge LANs in two buildings in close proximity.** An unlicensed spread-spectrum or licensed microwave connection could be cost-effective, particularly if you have to pay $500 or more for a monthly T1 connection. Wireless equipment providers claim a typical payback of two years.

· **Consider wireless if crossing wireline service boundaries.** Wireline service might be exceptionally expensive if crossing different LEC areas and a wireless connection could be cost-effective.

· **Consider wireless for temporary or backup connectivity.** If you need a temporary connection between two nearby sites, or if you need a backup connection, wireless might be

your best option.

· **Compare offerings between wireless and wireline carriers.** If a wireless carrier is offering service to your building, investigate its pricing because it may be undercutting wireline providers to develop its business. Wireless carriers may also have greater flexibility in their offerings, such as the ability to easily increase bandwidth on demand.

Understanding Geography and Climate

With most data communications you don't care if there is a hill between you and another location, or whether it is sunny or raining. But with wireless communications, you must consider both geography and climate. This applies both to private and carrier systems. First the geography.

We have already emphasized line of sight. But what does this mean exactly? It means the two antennas must be clearly visible to each other. So beware of items like foliage or future construction. If your sites are separated by miles, how can you even tell if you have line of sight? There are companies that specialize in wireless integration that will be able to assist you with a site survey. Software packages that characterize the terrain of particular areas also may be helpful. Low technology approaches, such as flashing a mirror, also work. The advantage of a carrier service is that the carrier does all this work as part of the deployment.

Weather should not be a factor for the unlicensed 2.4 GHz and 5.8 GHz bands. But it is a factor in the millimeter wave bands of 28 GHz and higher. A three-mile (5 km) link operating at 38 GHz in heavy rainfall of one inch per hour will suffer a degradation of 1,000 times the received signal strength. Carriers design margin into their links to account for weather, but you should review their design parameters and ask what

link reliability to expect over a course of a year.

Choosing Between Private and Carrier

This is relatively simple. If you need to interconnect your own sites and have line of sight, consider a private wireless connection. If you want Internet or telephony services, consider a carrier solution. But there are other topologies as well. For instance, the wireless carrier might offer a cost-effective wireless Internet connection to your site "A." If your site "B" has an Internet connection, you could then consider a VPN (virtual private network) connection between the two sites. Another option is where the wireless carrier provides coverage to both your sites. You could obtain a private virtual circuit between your two sites that never leaves the carrier's backbone network. Think of this as a public frame relay or ATM network that happens to use wireless links in its infrastructure. The bottom line is you will need to research all the options available, including whether wireless carrier service is even available. Service options are limited today but will be expanding rapidly over the next two years.

How To Deploy a Private Connection

If you have determine that a private fixed-wireless system addresses your communications requirements, there are a number of decisions you will need to make. One important decisions is whether to use licensed or unlicensed bands. The following table summarizes the principal characteristics of each.

	Unlicensed Spread Spectrum	
Ease of deployment	Simpler. No licensing required.	More difficult. License

	Simpler antennas for shorter distances. End-user installable in many instances.	required.Frequency coordination sometimes required. Generally need services of integrator.
Performance	1 to 11 Mbps. Error rates match wireline.	1 to 10 Mbps typical, but higher rates to OC-3 (155 Mbps) available. Greater flexibility for increasing throughputs. Error rates match wireline.
Interference	Potential for interference because bands are unlicensed, allowing multiple simultaneous users.	Potential for interference very low.
Costs	Equipment costs are comparable to microwave, but installation costs can be lower.	Slightly higher due to higher installation costs.
Number of vendors	Greater. Many wireless LAN companies offer bridge products.	Fewer.
Security	Spread-spectrum signal harder to eavesdrop, but proper security still requires encryption of the data.	Easier to eavesdrop.

You can think of microwave systems as offering higher performance with a lower potential for interference, but costing more and being slightly more difficult to install.

In choosing a private link, you should have determined that you have line of sight. But you will also need to check vendors specifications for trade-offs between distance and throughput. For example, a spread-spectrum product might offer 4 Mbps at distances to 10 miles (16 km) but only 2 Mbps at 25 miles (40 km).

You must also decide where to mount your antennas and what type of antennas to use. There are many types of antennas available. At shorter distances of a mile (1.6 km) or less when using spread spectrum you may be able to use a patch antenna that mounts on the inside of a

window. At even smaller distances of a hundred meters, you could use an omnidirectional antenna. For longer distances to 20 miles (30 km), you will need an antenna that needs to be carefully aimed, usually on a roof or suitable tower. Some products, for example, have an LED that lights when the antenna is aligned correctly. Check with your vendor for their antenna options and installation procedures. In all cases, the antennas you will be working with will be compact, generally about a half meter in diameter or smaller.

Don't just choose a wireless solution based just on distance and throughput. Make sure it provides the data interfaces you need, supports the protocols you need and supplies suitable network management functions.

Various value-added resellers and systems integrators specialize in wireless communications. Some of these offer both licensed and unlicensed products. They can help you choose which technology to use, obtain licenses, determine how to factor in local climate conditions, conduct site surveys and install your equipment.

Proxim Directional spread-spectrum antenna.

How To Use a Wireless Broadband Carrier

Using a wireless broadband carrier is easy. You may not even know that the carrier is using a wireless infrastructure. In many instances, the carrier will provide comparable services to a CLEC or an ISP. Or their services might be resold by existing LECs, CLECs or ISPs.

Nevertheless, there are a number of questions worth asking if you are considering wireless-broadband services.

1. **What carriers are available?** Since wireless broadband carriers are only now deploying service, you may not even be aware that a wireless carrier is offering service to your building or area.

2. **Where does the carrier have licenses and what is their deployment plan?** Carriers only hold licenses on a regional basis. And most are deploying their networks building by building. Find out also what kind of license they have. Are they operating on the basis of a license waiver and if so, what are the terms of that waiver?

3. **Is the deployment on a network basis or customer basis?** Some carriers have a rigid deployment plan. Others will respond to individual customer demand.

4. **What value-added services do they offer?** Some carriers will be telephony-centric. Others are Internet-centric with Web hosting, mailbox services, network management and so forth.

5. **What interfaces, protocols, data rates, error rates do they support?** Because broadband services have an inherent upper end in throughput because of the width of radio channels, find out what options exist for increasing your throughput.

6. **What reliability do they guarantee?** Because wireless broadband signals at 28 GHz and 38 GHz are affected by weather, ask to see an analysis of reliability that takes regional weather patterns into account.

7. **What networks to they interconnect with?** If they connect to the Internet, who is their backbone provider? Do they interconnect with existing frame networks?

In summary, the wireless carrier will provide services that look very much like wireline services, and the wireless portion of their infrastructure should be mostly invisible to you. But nevertheless, obtaining answers to the questions above could head off potential difficulties.

When To Use Satellites

A variety of satellite systems are available today for broadband communications to 155 Mbps. Today these all involve geosynchronous satellites, but soon LEO systems also will be available. Satellites today are not usually competitive when good landline communications options exist. Rather they make the most sense in the following types of situations:

· There are no good terrestrial options. This is especially true in developing nations or out at sea.

· You are deploying a mesh network of more than fix or six nodes that spans a large geographic area, e.g. multiple countries.

· You are broadcasting data to a large number of locations.

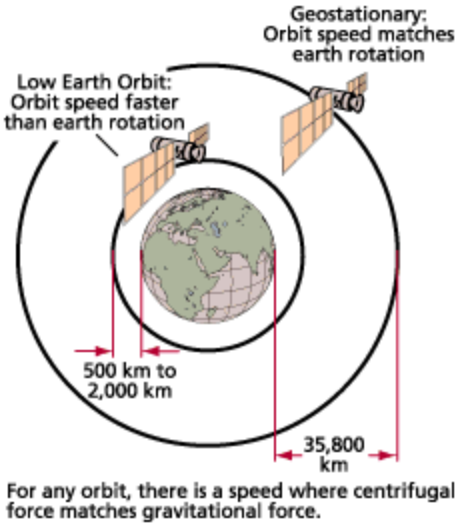


Figure: Geosynchronous versus low earth orbit satellites.

Service and Equipment Providers

Wireless broadband is a rapidly evolving area with new products and services appearing daily. This section presents a sampling of products and services that is representative but not exhaustive. Use these lists as a starting point.

Microwave Products | Unlicensed Wireless Bridges | Wireless Broadband Carriers

Microwave Products

While many other companies provide equipment for microwave communications, the ones listed here have products designed for interconnecting LANs.

Digital Microwave, 408-943-0777, http://www.dmcwave.com

Microwave Bypass, 781-337-2005, http://www.mbypass.com

Sierra Digital, 916-624-7313, http://www.sierra-digital.com/sdci

Southwest Microwave, 602-968-5995, http://www.southwestmicrowave.com

Tadiran Microwave Networks, 281-263-6500, http://web.microwavenetworks.com

Unlicensed Wireless Bridges

Aironet, 800-247-6638, 330.664.7900, http://www.aironet.com

AMP, 800-835-7240, http://www.amp.com/networking/wireless/prods/wrl_prod.html

BREEZEcom, 760-431-9880, http://www.breezecom.com

C-SPEC Corp., 937-439-2882, http://www.c-spec.com

Lucent Technologies, 800-928-3526, 937-445-5970, http://www.wavelan.com

OTC Telecom, 800-770-6698, 408-245-6888, http://www.ezylink.com

Proxim, 800-229-1630, 415-960-1630, http://www.proxim.com

Solectek, 800-437-1518, http://www.solectek.com

Wave Access, 508-653-3646, http://www.waveaccess.com

Wave Wireless Networking, 800-721-9283, 941-358-9283, http://www.the-wave-wireless.com

WaveSpan, 650/919-0190, http://www.wavespan.com

WinDATA, 978-952-0170, http://www.windata.com

Wireless Broadband Carriers

Note that there are a large number of LMDS license holders preparing to offer service, but that have not yet announced their offerings.

Advanced Radio Telecom, 38-GHz carrier service, 425-688-8700, http://www.art-net.net

Angel Technologies Corp., http://www.angelcorp.com

Comsat, satellite broadband service, 301-214-3420, http://www.comsat.com

Teledesic, future LEO satellite service, 425-602-0000, http://www.teledesic.com

Teleport (now part of AT&T), 38-GHz carrier service, 800-889-4TCG, http://www.tcg.com/

Teligent, 24-GHz carrier service, 1-88-TELIGENT, 703-762-5100, http://www.teligent.com

Wavepath, MMDS-based ISP, 650-237-9744, http://www.wavepath.com

WebCel Communications, LMDS carrier service, 202-466-7600, http://www.webcel.com

WinStar, 38-GHz and LMDS carrier service, 888-WINSTAR, http://www.winstar.com/

Wireless One, MMDS-based ISP, 1-888-947-3663, http://www.wireless-one.com

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