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WHITE PAPER

The Benefits of 60 GHz Broadband Wireless Communications Technology

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Abstract

The watchword for digital communications today is "bandwidth". When it comes to deploying high-speed wireless links to extend the reach of fiber-optic or copper cabling, more and more companies and service providers are taking a look at 60 GHz wireless solutions that can deliver gigabit speed connections using currently available technology. They are discovering that for many applications, solutions based on 60 GHz wireless connectivity provide a range of attractive benefits, such as license-free operation, high immunity to interference, and ease and cost efficiency of installation.

In this paper, we will discuss the capabilities and benefits of 60 GHz technology as it relates to wireless communications and applications such as fiber-optic extensions and mobile wireless backhaul.

Introduction

In every aspect of networking and data communications, we are witnessing a seemingly never-ending demand for more and more bandwidth. Smartphones and mobile devices are moving to fourth generation Long-Term Evolution (4G/LTE) speeds. Local-area networks (LANs) are moving to 2.5 and 5 Gigabit Ethernet (GbE) implementations. And data centers across the globe are rapidly adopting 100 GbE technologies.

While the demand for increased bandwidth is ubiquitous, there are some places in the network where it is simply too difficult or expensive to provision additional bandwidth using hardwired alternatives such as fiber or copper cabling. Broadband wireless radio technology has traditionally filled the gap in some of these areas, such as fiber-optic cable extensions or wireless base station backhaul applications.

However, traditional broadband solutions based on wireless fidelity (Wi-Fi) LANs at 2.4 and 5 gigahertz (GHz) technologies have now reached bandwidth limitations as well, as network demands continue to grow. So where do we go from here?

One cost-effective alternative that is generating substantial interest is 60 GHz wireless radio links that can deliver bandwidth of 1 Gbps using today's technology, with the promise of even greater bandwidth in the future. Some of the leading use cases for 60 GHz wireless technologies include:

- Network connections where it is cost prohibitive to run cable or fiber
- Rooftop-to-rooftop connections with line-of-sight path
- Campus extensions and large venue arenas
- Gigabit Ethernet network extensions
- Fiber-optic cable extensions
- LANs, metropolitan-area networks such as Metro Ethernet, and wide-area networks (WANs)
- Wireless backhaul for 3G and 4G/LTE mobile networks

Overview of Radio Frequencies

The 60 GHz wireless frequency is part of the electromagnetic radio spectrum, a continuous band of radio waves or frequencies, some of which are used to transmit communication signals. On the lower end of the spectrum, at a frequency range of 550 kilohertz (kHz) to 1.5 megahertz (MHz), is the venerable amplitude modulation (AM) broadcast band. The frequency modulation (FM) broadcast band ranges from 88 MHz to 108 MHz. The available bandwidth of the AM band is only 1 MHz, whereas the total FM bandwidth is 20 MHz.

Other wireless protocols include LTE from 0.7 GHz to 2.6 GHz, as well as traditional Wi-Fi that uses two bands, one at 2.4 GHz and another at 5 GHz. The amount of Wi-Fi bandwidth available in the United States is 50 MHz at 2.4 GHz and 800 MHz at 5 GHz.

At the higher frequencies is the 57 to 64 GHz range, which has 7 GHz of useable bandwidth. This particular band is located within what is referred to as the millimeter wave (mmW) segment of the electromagnetic spectrum, with wavelengths ranging from one millimeter to ten millimeters.

Licensed vs. Unlicensed Operation

An important distinction between these broadband frequency allocations is whether users require a license to operate within a specific band (as is the case with AM and FM broadcasters) or whether unlicensed operation is allowed (as is allowed with 60 GHz communications as well as traditional Wi-Fi routers).

Unlicensed operation still requires that communications equipment to be certified for usage in order to meet the technical requirements specified by the Federal Communications Commission (FCC). However, once such unlicensed products are certified, they can be sold and deployed on a license-free basis.

An Evolving Environment

The ever-changing landscape of mobile communications due to demands for more bandwidth, more data and greater speeds, along with increasing congestion at lower frequencies, has led to innovation advancements that utilize the 60 GHz frequency for full duplex communications at data rates that could not previously be achieved wirelessly.

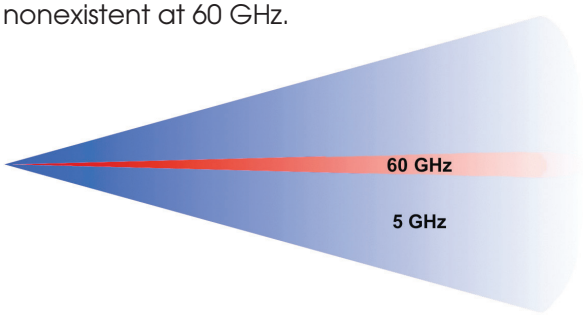
Mobile phones use licensed frequencies to guarantee that mobile operators and carriers have exclusive use of certain spectrum channels without interference. This is because interference can be an issue if transmitting stations are located within the same area and they attempt to use the same frequencies.

As technologies have progressed, new methods of handling interference have emerged, making exclusive licensing of specific frequencies less essential than before. In addition, as various applications begin to move up within the frequency spectrum, there will be even less potential for interference due to the inherent characteristics of the higher frequencies.

Initially, the 60 GHz band was used mainly for high security, military and satellite-to-satellite communications. This was due to the fact that oxygen molecules present within the atmosphere absorb electromagnetic energy at a much higher rate at 60 GHz than they do at other frequencies. Signals transmitted at 60 GHz are absorbed more quickly, so the signals have a shorter transmission distance.

How 60 GHz Works

An important characteristic of 60 GHz solutions is that typical antenna beamwidths are less than 5° due to the millimeter wave frequencies. The narrow beamwidth means that many links can be put on the air in the same area just by having them point in slightly different directions. This is known as spatial discrimination or spatial division multiplexing. Self-interference or other wireless interference is basically nonexistent at 60 GHz.



This narrow beamwidth contrasts with comparably sized 5 GHz solutions that have a beamwidth that is more than ten times as wide, thereby transmitting signals that are beyond the location of the intended receiver. In addition, a 5 GHz antenna risks the possibility of receiving interference from other 5 GHz radio links or Wi-Fi routers.

Wireless link products based on 60 GHz technology can utilize frequency division duplex (FDD) operation due to the large amount of spectrum available. This is important to know when considering throughput claims, because FDD delivers maximum throughput in both directions since the transmitter and receiver operate simultaneously and independently.

An alternative multiplexing technique is time division duplex (TDD) operation, which is used in Wi-Fi, for example. It has a real throughput that is less than the aggregate total of its up and down links, because the transmitter and receiver cannot operate at the same time.

The duplexing scheme also impacts latency. TDD-based Wi-Fi solutions may have up to several milliseconds of latency simply due to the TDD operation – switching time between transmit and receive modes. In contrast, well-designed FDD solutions generally incur less than fifty microseconds of latency.

Interference-Free Operation

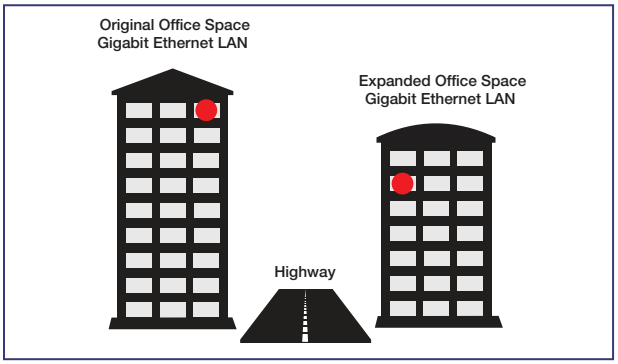
60 GHz communication technology provides an inherent advantage in terms of offering cost-effective, license-free operation without the interference risks associated with lower-frequency license-free links. The technology's narrow antenna beamwidths combined with the link-protection effects of 60 GHz oxygen attenuation means that it is very unlikely that one 60 GHz wireless beam will interfere with another link.

60 GHz Use Cases

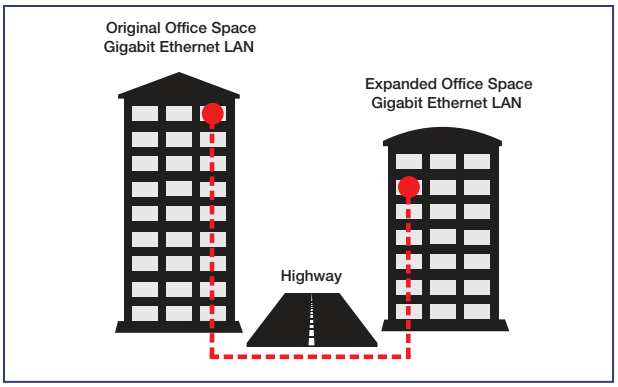
60 GHz broadband wireless deployments can provide ideal solutions for a number of different communications applications. Such scenarios typically involve providing a line-of-sight data connection that would otherwise be impossible or cost prohibitive to undertake with fiber-optic cable.

Extending LANs Between Buildings

For example, one typical scenario might involve a company in a high-rise office building that has opened a second office in an adjacent building. Both offices house employees who need to share data on the company's LAN or access databases in real time.



This required connectivity could have been provided by the owners of the buildings if they had established a fiber-optic cable run between the two buildings. But often there is no such level of interconnectivity between buildings. So, a second option would be to run dark fiber (i.e., privately operated optical fiber) between the two offices.

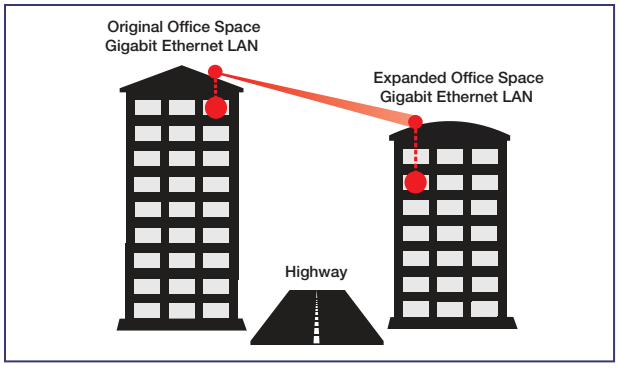


This type of installation requires a special contractor with costs that could easily add up to tens of thousands of dollars for engineering, right-of-way access, permits, trench digging, filler removal, running new fiber, and refilling the trenches. That may be worth it in some cases, but there are other options that do not require such a high capital expenditure.

One of these options would be to lease a circuit from a local service provider, which would typically be connected through the service provider's central office. With today's generation of networks, the typical speeds from a tier-one service provider would range from 1.544 megabits per second (Mbps) for a T1 connection, up to 45 Mbps for a T3 connection.

Lease prices for such a link would be hundreds of dollars per month for the T1 line, up to thousands of dollars per month for the T3 line, requiring a minimum contract period of one to two years. Of course, contracting either of these services would make this link a real bottleneck for even a Fast Ethernet (100 Mbps) backbone network, much less an 1 GbE network.

That brings us to a broadband wireless solution using 60 GHz. If the two facilities are within line of sight of each other and are less than 500 meters (0.31 miles) apart, the company can easily deploy a 60 GHz, one gigabit wireless bandwidth connection. After a relatively modest capital expenditure (of less than $10,000), the company will have a secure, reliable connection with no ongoing operating expenses.



Fiber Extensions for Network Operators

Many network or fiber operators are discovering that 60 GHz wireless connectivity can be a cost-effective way to extend the reach of their fiber backbones. The cost to run additional fiber from an existing fiber hub site to a new subscriber building typically exceeds $100 per foot for underground installations in metropolitan areas.

In addition, sometimes running a fiber extension is simply not possible, due to factors such as right-of-way issues or the need to traverse highways, rivers, or other physical or geographic impediments.

Instead of undertaking such costly and time-consuming expansion projects, network operators are increasingly looking to extend their reach by deploying cost-effective, easy-to-install 60 GHz wireless extensions when the new location is in line-of-sight proximity and less than 500 meters away.

3G and 4G/LTE Wireless Backhaul

60 GHz millimeter wave technology can also provide a practical and low-cost wireless backhaul solution for 3G and 4G/LTE mobile communications networks.

In order to expand wireless network coverage and provide more data capacity for their customers, wireless carriers are rapidly upgrading from 3G to 4G/LTE technology and installing additional small base stations (known as small cells) to extend their reach. This is especially prevalent in densely populated urban and metropolitan regions.

Small cells can be cost-effectively mounted on light poles, utility poles, or buildings. However, they still need high-speed broadband backhaul networks to communicate with one another and with base stations.

As was the case with the previous use cases discussed above, adding fiber or cable is not always feasible or cost justified. That is why wireless carriers are now increasingly deploying 60 GHz broadband wireless backhaul solutions.

The future growth of these carrier networks will require much higher density and smaller base stations. The fact that 60 GHz is the most interference resistant spectrum for this application has led the large carriers and internet service providers to use it for the badly needed short-range backhaul links.

Conclusion

60 GHz wireless broadband solutions enable companies, service providers and wireless carriers to quickly and cost-effectively keep pace with the growing demands for global communications network expansion. Extending the reach of fiber-optic cable installations can be cost-prohibitive or even impossible to accomplish. Since 60 GHz is the first millimeter wave unlicensed spectrum band allocated, it is at the cutting edge of technology development for wireless gigabit Ethernet broadband fiber extension.

In summary, the benefits of this advanced yet practical technology include:

- **High-speed communications:** 60 GHz provides unlicensed broadband technology that can deliver wireless gigabit Ethernet speeds today
- **Secure and interference-free operations:** Due to short transmission distances and narrow antenna beamwidth
- **Cost-effective deployment:** Saves time and money by eliminating the need to install additional fiber or cable
- **Unlicensed operation:** Saves time and money by eliminating the need to obtain a license from the FCC
- **Frequency re-use:** Spatial division multiplexing means that the communication needs of multiple customers can be accommodated within a small geographic area
- **High availability:** The technology allows deployment of carrier-class communication links featuring "five nines" availability

Today, 60 GHz wireless is the ideal solution for any line-of-sight application that needs to deliver a high-speed link with the advanced functionality to meet bandwidth needs as network throughput requirements continues to grow.

About Vubiq Networks

Vubiq Networks, Inc. is a broadband wireless networking company focused on multi-gigabit systems using its 60 GHz millimeter wave technology for metropolitan Ethernet wireless fiber extension, campus building connectivity, and 4G/LTE advanced network backhaul. Vubiq's HaulPass V60™ product is an innovative wireless fiber-optic extension solution delivering quality of service, gigabit Ethernet transport speeds, and advanced networking features.

Vubiq Networks is based in Irvine, CA.
Learn more at www.vubiqnetworks.com.

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