BridgeWave

Gigabit Wireless Applications Using 60GHz Radios

White Paper

INTRODUCTION

The adoption of each successive generation of Ethernet technology has been driven by the rate at which the cost of the new generation has approached the previous. As the cost of 100Mbps Ethernet approached the cost of 10Mbps Ethernet, users rapidly moved to the faster speed. Within the last year, gigabit Ethernet became affordable (below $200) for server connections, and desktop gigabit connections have come within $10 of the costof 100Mbps. As such, gigabit Ethernet is the standard for servers, and business PCs are now routinely ordered with gigabit NICs.

In the wireless realm, true (full-duplex, low-latency) gigabit Ethernet inter-building/site links have historically cost in the $40,000-60,000 range, whereas true100Mbps Ethernet links have been priced in the $20,000 range. Recently, 100Mbps links have dropped to the $15,000 range while gigabit links have plummeted to below $20,000. Just as has happened in the wired world, as the prices of gigabit links approach the prices of100Mbps links, users are switching to the higher-performance product, both for traditional wireless applications, as well as for applications that only become practical at gigabit speeds. For many applications, 60GHz radios have become the technology of choice, based on being license-free, highly immune to interference, and easy to install. The achievable distance is the main limitation of 60GHz radios. Based on the geographic area of deployment and link availability requirements, 60GHz radios can be confidently deployed at maximum distances ranging from 400 to 1000 meters.

TECHNOLOGY

License-free 60GHz radios have unique characteristics that make them substantially different from traditional 2.4GHz or 5GHz license-free radios, as well as setting themapart from licensed-band millimeter-wave radios.

The attributes of 60GHz radios that arise from these characteristics include:

- License-free deployment
- Multi-gigabit operation
- Ability to co-locate multiple radios on a single roof or mast
- Immunity to interference
- Security from signal interception
- Ease of installation

License-Free Spectrum

The FCC allocated an un-precedented 7GHz of un-channelized spectrum for license-free operation between 57-64GHz – this compares to only about500MHz of spectrum allocated between 2-6GHz for WiFi and other license-free applications. For the first time, sufficient spectrum was allocated to make possible multigigabit RF links.

Narrow Beam Antennas

A 10-inch dish antenna can achieve 40dBi of gain with a halfpower beamwidth of 1.4 degrees. A corresponding 5.8GHz antenna would have beamwidth ten times larger. This narrow beamwidth allows multiple 60GHz radios to be installed on the same roof-top or mast, even if they are all operating at the transmit and receive frequencies. All that is required is that the radios are spaced apart on the roof and/or are aimed in slightly different directions. While the beamwidth is much narrower than for other license-free radios, it is still wide enough to be accurately aligned by an untrained installer with the use of a visual sighting device. Note that these beamwidths are much wider than those of free space optic systems, and are not affected by building sway from wind nor tilt from sun heating.

Oxygen Absorption

This is a unique property that does not affect lower-frequency radios. Oxygen attenuates 60GHz signals by 12-16dB per kilometer (i.e., half of the energy is absorbed for every 200 meters the signal travels), which is the main reason that 60GHz links cannot cover the distances achieved by other millimeter-wave links.

The impact of the small beam sizes coupled with oxygen absorption makes the links highly immune to interference from other 60GHz radios, since another link in the immediate vicinity will not interfere if its path is even moderately different from the first link, and any radio operating beyond the immediate vicinity (even on the exact same trajectory) will have its signal severely attenuated by the oxygen attenuation. These same two factors make the signal highly secure – in order to intercept the signal, one would have to locate a receiver lined up on the exact same trajectory, and in the immediate locale of the targeted transmitter. It would typically be easier to dig into conduit and tap into a fiberoptic cable than to find a way to install a rogue receiver to intercept a 60GHz transmission without being detected.

Rainfall Limitations

Like all radio links that operate above 10GHz, intense rainfall significantly limits the distance over which 60GHz links can transmit data error-free. Rainfall statistics have been extensively studied throughout the United States to support millimeter-wave link deployments. These statistics allow us to determine how many minutes per year a 60GHz link of a given distance will be impaired due to short periods of intense rainfall. Based on the availability requirements of the application, the maximum link is determined based on the rainfall zone where the link is to be deployed using the following chart that already includes the effects of oxygen attenuation. Note that BridgeWave radios outperform other 60GHz radios due to the inclusion of a strong forward error correction (FEC) code that is transmitted with the data. This FEC code corrects most of the errors (due to rainfall) that occur when the link is near its operating limit, which allows longer distance links to be deployed using similar-sized antennas.

LAN EXTENSION APPLICATIONS

As 60GHz gigabit links approach the cost of lower-frequency 100Mbps links, gigabit links become a natural substitute for lower-speed links of less than a kilometer distance, providing a future-proof solution at a modest additional cost.

History tells us that application needs grow over time in often-unanticipated ways, and gigabit links provide the performance cushion that can protect customers' equipment investments. Gigabit links can also be used to substitute for lower-speed links when customers face the challenges of co-locating multiple radios on a single roof or tower (which can be difficult using 5GHz radios due to self-interference), or when customers are experiencing interference from other license-free 5GHz outdoor or wireless LAN indoor radios.

However, full-rate gigabit links can address applications that go beyond the capabilities of lower-speed links. Gigabit speed links are required to extend LAN server backbones between buildings at full backbone speed, allowing remote clients to access the servers as if they were co-located at the server site. An immediate cost-savings opportunity is to centralize IT resources in a single building, rather than locate servers in multiple buildings interconnected by slow-speed wired or wireless connections. Eliminating duplicate server and backup hardware and software licenses can easily save tens of thousands of dollars of equipment cost per site, as well as saving on recurring IT staff labor and leased-line charges.

For customers who require highly available server access across multiple buildings, redundant servers can be clustered in a single building, and redundant gigabit wireless links (or a fault-tolerant wireless "ring") can be used to connect remote buildings. Again, the cost of the gigabit wireless links can easily be paid for by savings realized from centralizing redundant servers, especially when more than two buildings are involved. In addition, the fact that the redundant servers are centralized yields improved ease of management and shorter times to recover from server failures.

NETWORK OPERATOR APPLICATIONS

Network operators can use gigabit wireless links to extend the reach of their fiber backbones. The average cost to run fiber laterals from a fiber hub site to a subscriber building is $110 per foot for underground installations in metropolitan areas.

About 40,000 U.S. buildings have direct fiber connections, and about 8,000 of these are very high capacity sites. Within a mile of these 8,000 buildings are 500,000 of the largest commercial buildings which are good economic targets for offering high-speed, differentiated data services, including the ability to inter-connect LAN backbones between distant buildings. Gigabit wireless links are typically much less expensive to deploy than new fiber lateral runs.

Gigabit wireless links can also be used to extend operator service backbones, when there are portions of the network that cannot be easily connected by installing new fiber. This can include right-of-way issues or the need to cross rivers, sewer mains, or highways.Operators who deploy multiple wireless systems can also use gigabit wireless links to backhaul high capacity base station sites or to connect these sites to nearby fiber runs.

EXTENDING DISTANCES WITH HYBRID LINKS

60GHz links offer superior capacity and interference immunity. However they oftencannot be utilized due to the need for longer distance links. This distance limitation can often be mitigated by the use of hybrid wireless links. Two common approaches are to combine a 60GHz link with a free space optics (FSO) link or to combine a 60GHz link with a 5GHz license-free link.

60GHz links are limited by their performance during periods of heavy rain. FSO links are limited by their performance during periods of heavy fog. Because heavy rain and heavy fog to not occur at the same time, a hybrid link that has both a 60GHz link and a FSO link can operate at the maximum distance of the shorter of the two links in clear weather. It is possible to create a very high availability, full-time gigabit speed link at up to one kilometer using this type of hybrid link. Customers also benefit from the hardware redundancy, providing partial protection if one of the two links experiences a hardware failure. The only downside to this type of link is cost, as gigabit FSO links are more expensive than gigabit 60GHz links.

For the more cost-sensitive customer, another hybrid alternative is to pair a gigabit 60GHz link with a lower-capacity 5GHz link. Since the 5GHz link is immune to rainfall, it can be used as a lower-speed fallback for periods when the 60GHz link is impaired by heavy rainfall. If a customer is able to tolerate the lower speed link performance 1% of the time, then the 60GHz link distance can be set at the 99% availability distance, which from the distance chart (above) can be up to 900 meters. For a small premium over the cost of the gigabit link, using a $3,000 24Mbps performance 5GHz link as a fall-back can provide a customer full gigabit performance 99% of the time and 24Mbps 1% of the time.

ABOUT BRIDGEWAVE

BridgeWave Communications is the leading supplier of 60GHz gigabit wireless links. BridgeWave's products are the highest performing and the first and only 60GHz gigabit products below the $20,000 price point. The BridgeWave GE60 Wireless Gigabit Ethernet Link is available through leading VARs and wireless distributors.

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