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# Enterprise Campus Building-to-Building Connectivity and ROI Analysis of Millimeter-Wave (MMW) Radio Systems

## Introduction

Capacity requirements in enterprise networks have dramatically increased. The vast majority of internal, in-building LAN infrastructure today is Ethernet based and networks are typically running at fast Ethernet (100 Mbps) or gigabit Ethernet (1 Gbps) speeds. CAT5/6 copper cables and/or optical fiber are used to interconnect switches/routers inside the building and to enable the high capacity in-building network infrastructure backbone. However, due to the general lack of a high capacity fiber based outside plant infrastructure, severe networking problems can occur when multiple buildings within an enterprise campus need to be interconnected. This problem is particularly severe because it not only creates a capacity bottleneck, but many bandwidth hungry network applications fail to respond properly when using bottlenecked communication lines.

Interconnecting campus buildings with high capacity optical fiber would be the ideal solution, but a recent study conducted by Vertical Systems Group in the United States revealed that currently only 13.4% of the commercial buildings with more 20 employees are connected to a fiber network. This figure can be even lower for countries outside of the United States. In many cases trenching new fiber routes is not financially feasible due to the high costs associated with the trenching process. In many cases trenching may not even be possible due to right-of-way issues, the existence of natural obstacles, such as rivers or lakes, or other bureaucratic hurdles and restrictions.

For all of the reasons stated above many IT managers in charge of campus enterprise networks have given up on the idea of establishing a seamless high capacity network infrastructure between campus buildings. In many cases, and in particular for financial reasons, IT managers find themselves in a situation where they are forced to lease low capacity T1/E1 connections because this is the only connectivity option readily available from a local service provider. At the same time, these IT managers are aware of the fact that this decision will cause all kinds of headaches when it comes to running the network efficiently. This white paper will explain how millimeter-wave (MMW) radio technology can be used to solve the problem of a non-existing high capacity wireline infrastructure between remote buildings. In particular, it will be shown that a MMW radio solution can be installed in a very short timeframe and at price points that are extremely compelling in comparison to trenching or leasing fiber.

## Millimeter-Wave Technology: Background and Short Technology Overview

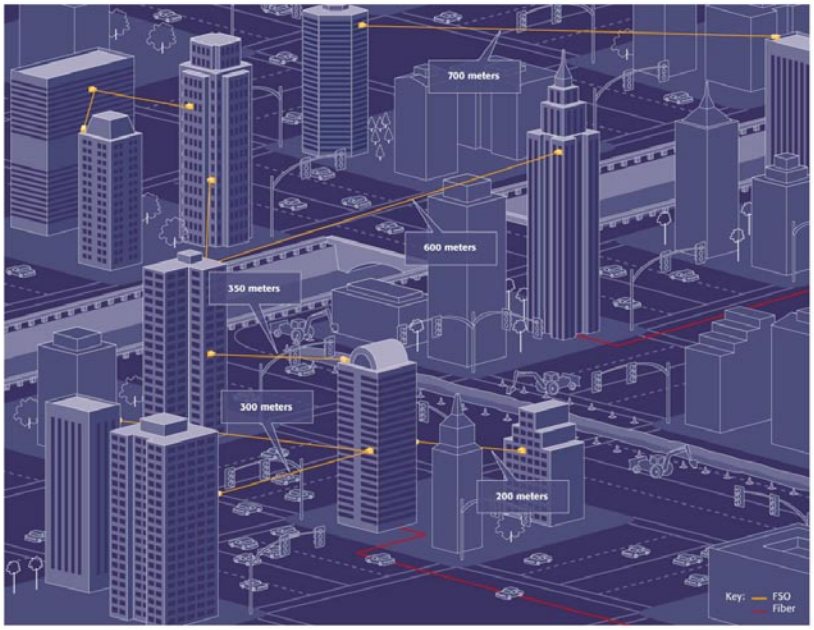
In a 2003 landmark ruling, the North American Federal Communications Commission (FCC) made a significant amount of newly allocated licensed spectrum in the millimeter-wave frequency range between 71 and 95 GHz available for commercial and public use. The release of the spectrum range was also combined with a new Internet based "Light Licensing" process providing long term interference protection of the installed radio link[1]. Due to the Internet based nature of the radio link registration/licensing process, a 10 year license for operation can be obtained on a short notice and within an hour or less for a one-time registration charge of less thanUS$300. The intention of releasing such unprecedented and massive amounts of frequency spectrum for public use, coupled with the simplification of the rather cumbersome frequency licensing process, was clearly meant to counteract the known shortcomings of optical fiber deployment in "Last Mile" networks. Other countries are currently implementing and strictly following the FCC ruling or are in the process of adapting a very similar regulation.

The allocation of millimeter-wave spectrum, commonly known as E-Band spectrum, offers over 250 times the bandwidth of the widely used, lower frequency microwave band allocations. Even without using sophisticated and more expensive radio signal modulation schemes, the released spectrum provides enough capacity for high quality multi-gigabit per second (Gbps) communications. Data rates of 1.25 Gbps and beyond in cost-effective point-to-point wireless configurations at carrier-class (99.99…99.999%) availability levels are achievable in typical North American, European or Australian climate zones over distances of 1 mile (1.6 km) or even beyond[2]. At these data rates and availability levels MMW radio solutions are a clear alternative to optical fiber connections in "Last Mile" enterprise campus networks. In addition, installing a wireless radio solution eliminates the time consuming and expensive process of trenching fiber, and connectivity between remote buildings can be established in hours/days rather than months, as is the case in trenching optical fiber.

Figure 1 visualizes a campus network with high capacity MMW radios interconnecting campus buildings in a redundant ring network configuration. This specific scenario depicts a typical campus scenario where one main building is already connected to a high capacity, fiber-based, wide area network (WAN) or metropolitan area network (MAN). By using MMW radio connections between the main building and the remote buildings, all users at the remote locations will not only be able to communicate at high speed between the campus buildings, but also get high speed access to the WAN/MAN fiber network.

[1] For more detailed information on the licensing process, please download the white paper "MMW Licensing" from the LightPointe webpage at www.lightpointe.com

[2] For more detailed on system availability in a specific geographic region, please contact LightPointe. For a general overview, please download the white paper "MMW Technology" from the Lightpointe webpage at www.lightpointe.com




Commercial MMW radio systems are priced at such levels that they can be implemented at a fraction of the cost associated with trenching fiber. The payback period compared to leasing higher capacity fiber connection is typically far less than 12 months. This extremely short return-on-investment (ROI) period makes the economics of gigabit connectivity very attractive. In the next section of this white paper we will discuss the economics of MMW radio solutions vs. trenching or leasing fiber in more detail.

***Figure 1: Enterprise campus network with campus buildings interconnected by high capacity MMW radio links***

## The Economics of LightPointe's MMW Radio Systems in Campus Networks

Outlined in this section is a typical application scenario of a company that needs to connect two buildings in a business park. This application is common and the majority of enterprise applications are based on such a simple requirement. Figure 2 illustrates a typical enterprise campus connectivity scenario in a business park that could be located anywhere in the world.

In this example the company is trying two connect two buildings, Main Building A and remote Building B, and the buildings are 0.65 miles (1.05 km) apart. Like many companies, the internal traffic between the main building and the remote building has constantly grown over the last couple of years due to the installation of a new ERP system, a general upgrade of the in-building infrastructure to GbE, and a consolidation of servers into the main building to cut down on network maintenance and administration costs. The company has also converted the internal voice network to VoIP and about 100 employees located in the remote building B are now connected to the main PBX switch in building A. Additionally, the company has recently implemented a spatially diverse disaster recovery strategy that requires backup of all main server discs every night to a secondary server located in Building B. With all of these changes the IT department of the company has estimated that the connection between buildings should run at least 100 Mbps or, preferably, at gigabit speed. Standard copper based T1/E1 connections or even multiple T1/E1 connections do not scale on the bandwidth and cost side.

To get a high capacity connection in place, the options for the IT department are:

1.) *Trenching of a private fiber connection between Building A and B*

2.) *Leasing a fiber connection from a local service provider*

3.) *Using a millimeter-wave radio system to interconnect both buildings*


## Option 1: Trenching a Private Fiber Connection

Trenching fiber is not always a realistic option and many cities have put moratoriums in place because of the massive disruptions the physical digging process causes the general population. However, some cities will potentially allow trenching, particularly in low traffic environments, and if certain other conditions are met. In these cases fiber routes are typically trenched along the street perimeters. The drawback is of course that the actual fiber run will be longer when compared to the direct line-of-sight distance between the locations to be interconnected. In the specific case shown in Figure 2 the easiest fiber route would require trenching about 0.93 miles (1.5 kilometers) of fiber while the actual line-of-sight between the buildings is only 0.65 miles (1.05 kilometers).

***Figure 2: Typical building-to-building connectivity scenario in a Campus network. Building A and Building B have clear line of sight and the line-of-sight distance is 0.65 miles (1.05 km). The alternative direct fiber run between the buildings has to follow the street layout and the total length of the fiber run to exceed the line of side distance by roughly 50%.***

The actual cost of trenching about one mile of fiber in a suburban area or business park will run around US$150,000. Inside metropolitan areas, these costs can escalate to US$250,000. In the event that the company ever needs to change office locations, this investment in infrastructure would be simply lost because the likelihood that a new tenant would want to connect the same two buildings is extremely low.

**Option 2: Leasing a Fiber Connection from a Local Service Provider**

Because of the enormous upfront expenses, potential bureaucratic hurdles, the time it takes to trench a fiber connection, and the potential risk of sunken costs that can't be recovered, many enterprises elect to lease a high speed connection from a Local Service Provider (ILEC). However, and as a matter of fact, according to a recent published research study by the Vertical Systems Group only 13.4% of the U.S. commercial buildings with more than 20 employees are connected to a fiber network. This figure shows that statements such as "Fiber is everywhere" is clearly a myth when it comes to "Last Mile" fiber building connectivity.

In our specific scenario of leasing a fiber connection, we have to assume that both buildings are connected to fiber and that a local service provider can easily light up the connection on relatively short notice. If fiber connections are not already installed, the customer would probably not find a service provider willing to spend the enormous amount of money for trenching fiber between the individual buildings and the next available fiber hub or point-of presence (POP) without asking the customer to sign a very long term lease agreement. For obvious reasons, most enterprise customers are reluctant to do this.

In the USA, the typical monthly leasing charges for higher bandwidth connections are shown below. These charges can vary within parts of the US. In particular, the ability to get access to higher capacity connections beyond a DS-3 capacity level will greatly depend on fiber availability[3].

| Connectivity Option | Remark | Monthly Leasing Cost |
|---|---|---|
| | | |
| Fast Ethernet | variable bit rate up to 100 Mbps | US$2,000 |
| Fast Ethernet | dedicated full rate 100 Mbps | US$3,500 |
| OC-3 | 155 Mbps | US$5,000 |
| OC-12 | 622 Mbps | US$9,000 |
| Gigabit Ethernet | variable bit rate up to 1 Gbps | US$6,500 |
| Gigabit Ethernet | dedicated full rate 1Gbps | US$15,000 |

From the capacity and $/Mbps transport cost point of view, circuit switched SDH/SONET connections provide slower speed access and, in general, these connections are more expensive when compared to Ethernet based connectivity of similar bandwidth. Packet switched gigabit Ethernet connections, and/or fast Ethernet connections are typically less expensive from the $/Mbps point of view, and besides dedicated full access speed connections, the service offerings typically include variable bit rate connections providing a "peak bandwidth" up to a specified bit rate.

[3] The monthly lease rates are typically for a simple connection from the service provider's POP to the end customer building. To establish a connection between two buildings, the monthly leasing charges can double because a separate connection between each building and the service provider POP might be required. These monthly charges also do not include one-time setup fees and especially higher speed fiber connections can be subject to longer term lease agreements.

**Option 3: Installing a Millimeter-wave (MMW) Radio System**

Similar to trenching a fiber connection, the installation of a MMW radio solution is a capital expense. To compare the cost of a MMW radio solution versus trenching or leasing a fiber connection, the standard suggested retail pricing of LightPointe's AireBeam™ 100 Mbps and 1.25 Gbps 70 GHz MMW radio solutions is used. Both systems are capable of achieving carrier-class 99.99….99.999% statistical availability over a distance of 0.65 miles (1.05 kilometers). Therefore, the availability and QoS performance is similar to a fiber based connection. The total cost of ownership (TCO) calculation includes the equipment costs, average installation cost, and a one-time license fee based on the U.S. MMW license fee structure. Possible installation charges by a landlord for roof access are not included. Many landlords are waiving any extra fees these days because of the huge competition in the market for commercial real estate.

**Fast Ethernet Connection (dedicated 100 Mbps, full-duplex operation)**

| | |
|---|---|
| Radio System (both ends) | US$21,900 |
| Radio license | US$300 |
| Installation * | US$4,000 |
| **TOTAL** | **US$26,200** |

**Gigabit Ethernet Connection (dedicated 1 Gbps, full-duplex operation)**

| | |
|---|---|
| Radio System (both ends) | US$25,900 |
| Radio license | US$300 |
| Installation * | US$4,000 |
| **TOTAL** | **US$30,200** |

*Includes path planning, zoning, installation and commissioning.

Just by looking at these numbers, it is obvious that the wireless solution has a clear economic advantage over trenching fiber. Even in the fiber lease scenario, the payback period is far below a 12 month timeframe without having to sign a long term lease agreement.

## Summary and Conclusion

This whitepaper compared the options of trenching or leasing fiber versus using a MMW radio solution to establish a high speed building-to-building connection in a typical enterprise campus or business park.

Trenching fiber is an expensive proposition and costs for trenching about 1 mile (1.6 km) of fiber ranges anywhere from US$150k in suburban areas to US$250k in major metropolitan areas. Trenching fiber also involves a lot of bureaucratic hurdles, right-of-way issues, and longer waiting periods before getting a connection in place due to the labor intensive digging process. Some cities even have a moratorium on any new fiber trenching project.

Leasing a high capacity fiber connection from a Local Service Provider is an option, in particular in case the buildings to be interconnected are already connected to a fiber network. In case that fiber is readily available, leasing rates vary with the required bandwidth. In any case the payback period for a typical MMW radio solution operating over a distance of roughly 1 mile is far less than 12 months. However, fiber penetration in "Last Mile" networks is still very low, and the likelihood that at least one of the buildings does not have access to a fiber network is extremely high. In these cases the local service provider typically requires a customer to commit to a long term lease to make the trenching effort worthwhile for the service provider.

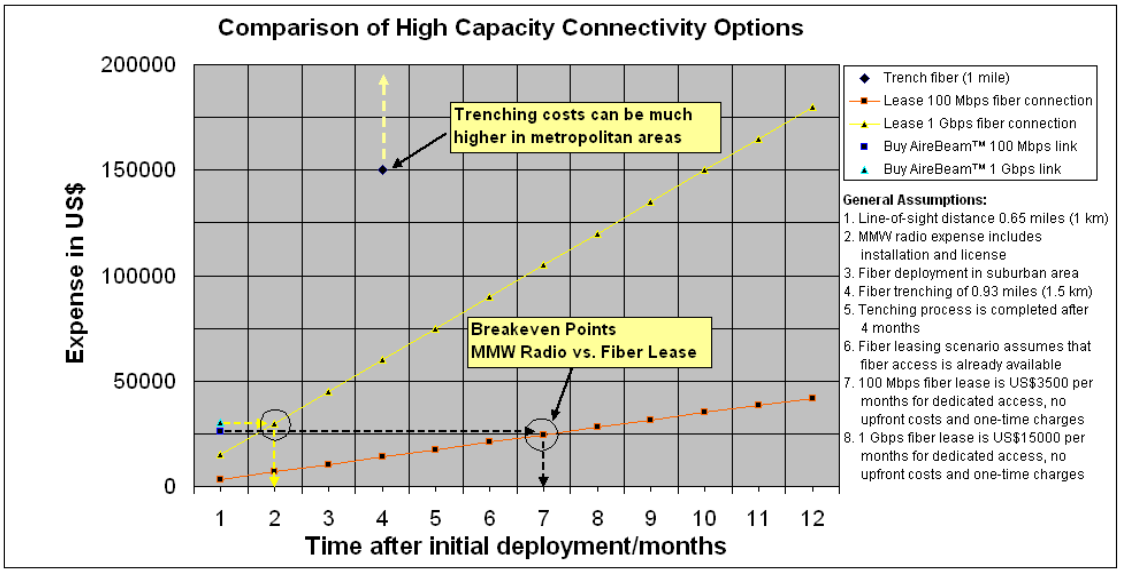



***Figure 3:*** ***A financial comparison of different high capacity "Last Mile" access strategies: Trenching fiber, leasing a fiber connection, using a MMW radio solution.***

Figure 3 compares different connectivity options for the specific application scenario discussed in this whitepaper. While trenching fiber is the most expensive option from the initial capital investment point of view, even leasing a high capacity GbE connection can potentially cost the same amount of money after only 10 months of operation. Deploying a MMW radio solution is not only unbeatable

from the initial capital investment point of view (20% of the fiber trenching costs) but also when compared to leasing fiber: When compared to a dedicated 100 Mbps Ethernet connection, the MMW radio connection reaches the breakeven point after only 7 months of operation. Even more impressive is the fact that in case of a GbE connection, the breakeven point is reached after only two months of operation.

**About LightPointe**

LightPointe was founded in 1998 and has become the global market leader for high capacity wireless outdoor bridges with over 5000 systems deployed in over 60 countries worldwide and in vertical markets such as Health Care, Education, Military & Government networks, large and small campus enterprise networks, Wireline and Wireless Service Provider networks. Over the last 10 years the company has established a unique diversified product portfolio based on high capacity Free Space Optics (FSO) and Millimeter Wave (MMW) technology. With more than 10 patents granted in the FSO, RF/MMW and in the hybrid bridging solution space LightPointe has established a strong IP and patent portfolio position manifesting the company's technology leadership position.

LightPointe has a long list of global customers including but not limited to Walmart, DHL, Sturm Foods, Siemens, Sprint, AOL, Fedex, BMW, Lockhead Martin, Dain Rauscher, Barclays, Nokia, Deutsche Bank, IBM, Corning, Cisco, Huawei just to mentioned a few. For more information please visit the Lightpointe website at www.lightpointe.com