WHITE PAPER

The cost and performance benefits of 80 GHz links compared to short-haul 18-38 GHz licensed frequency band products

Introduction

As service providers and private network operators seek cost effective solutions to high capacity connectivity, wireless systems are ideal because of their flexibility, speed of deployment, and lower overall life-cycle costs compared to leased-line services. Long distance links require the use of lower licensed frequencies, e.g. 6 or 11 GHz, while short-haul links in the 18 to 38 GHz range can provide highly available services with transmission rates approaching 400 Mbps in a single RF channel. The 80 GHz frequency band offers highly reliable, multi-gigabit transmission at a comparable cost to 18-38 GHz alternatives. This paper discusses the choices when considering licensed band links for short-haul applications, and the performance and cost benefits provided by 80 GHz gigabit wireless systems.

Performance of traditional microwave systems

Conventional fixed wireless systems operating in the 18-38 GHz licensed frequency bands provide data rates from a few T1s/E1s (e.g. 4 – 8 Mbps) up to two OC-3/STM-1 (311 Mbps) and top out at around 400 Mbps for Ethernet transport in a single radio channel. The maximum transmission capacity of any radio system is determined by: 1) the RF channel bandwidth permitted by the regulatory agency, and 2) the type of modulation used. RF channels are typically defined by their carrier frequencies and antenna polarizations. As these systems are usually FDD (Frequency Duplex Division), the RF channel bandwidth is referred to in both the "go" and "return" pairs. For example, a system operating in the 23 GHz frequency band may use up to 56 MHz of RF channel bandwidth (50 MHz in North America) in each direction. In a 56 MHz channel, a simple modulation scheme such as QPSK yields throughput in the 60 Mbps range, while more a complex modulation such as 256QAM could provide almost 400 Mbps. Figure 1 summarizes the throughput capabilities of a typical high capacity, short-haul licensed radio based on the RF channel bandwidth for a given modulation.

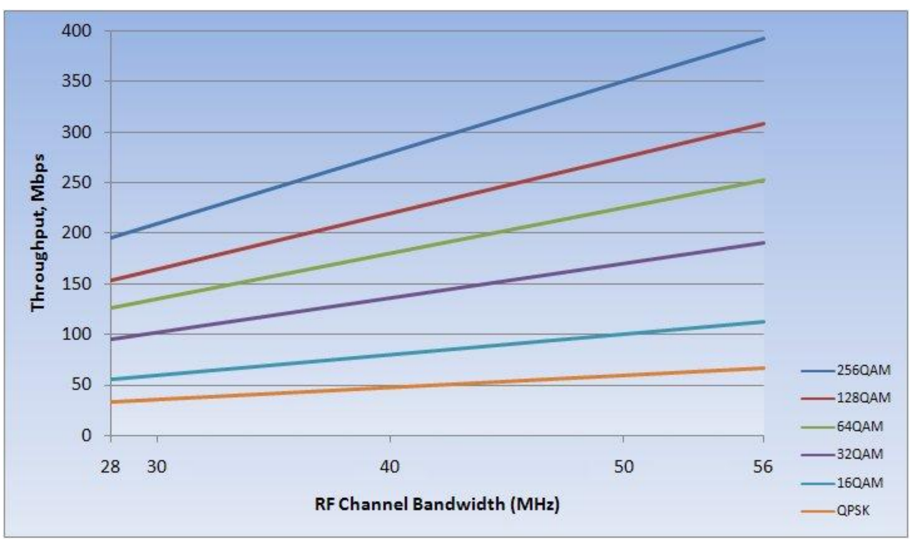

Figure 1 - Throughput vs. RF Channel Bandwidth

While many solutions available on the market today include GigE interfaces, the reality is that because of their bandwidth and modulation constraints, they simply cannot provide full-rate gigabit data transport over a single RF channel.

Radio systems in the 18 to 38 GHz frequency bands typically consist of an indoor unit and an outdoor unit, with a single coaxial cable to interconnect the two. In most applications, the outdoor unit is affixed to the back of a parabolic antenna. The demarcation point for all data, power, alarm, and management interfaces is at the indoor unit. Figure 2 depicts typical short-haul, split mount configuration using a 56 MHz RF channel for capacity approaching 400 Mbps.

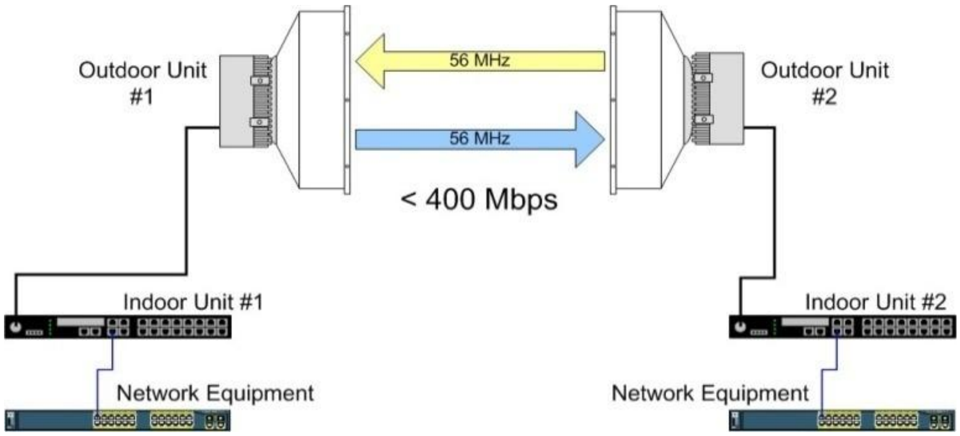

Figure 2 - Single RF Channel Configuration, Split Mount

Newer generations provide for an “all-outdoor” architecture, simplifying installation. Figure 3 depicts typical short-haul, all-outdoor configuration using a 56 MHz RF channel for capacity approaching 400 Mbps.

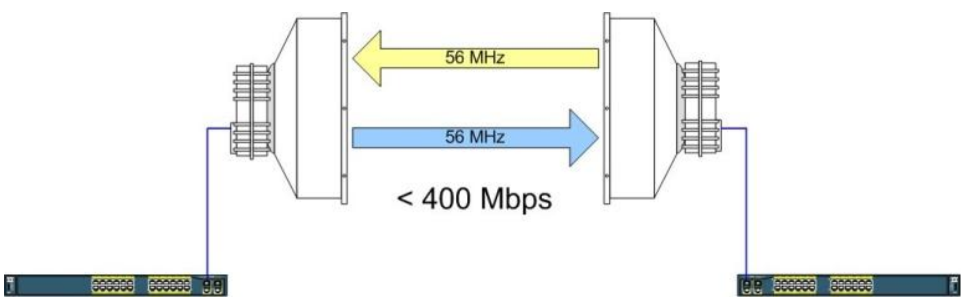

Figure 3 - Single RF Channel Configuration, All-Outdoor

In order to scale beyond the 400 Mbps single channel limit at these frequencies, it is necessary to combine two or more carriers over the same path, each with their own RF channel. As shown in figures 4 – 6, although vendors may implement their solutions differently, the reality is that two carriers are needed, requiring two licenses. Adding a parallel link doubles the system capabilities at the expense of increased licensing costs.

In figure 4, two complete links are required to implement high capacity transport, by far the most expensive in terms of hardware. In this implementation, the terminating Ethernet switches must support Link Aggregation Control Protocol (LACP). The outdoor unit coupler provides the common interface to the antenna for both outdoor units; however losses in these couplers yield lower link budgets.

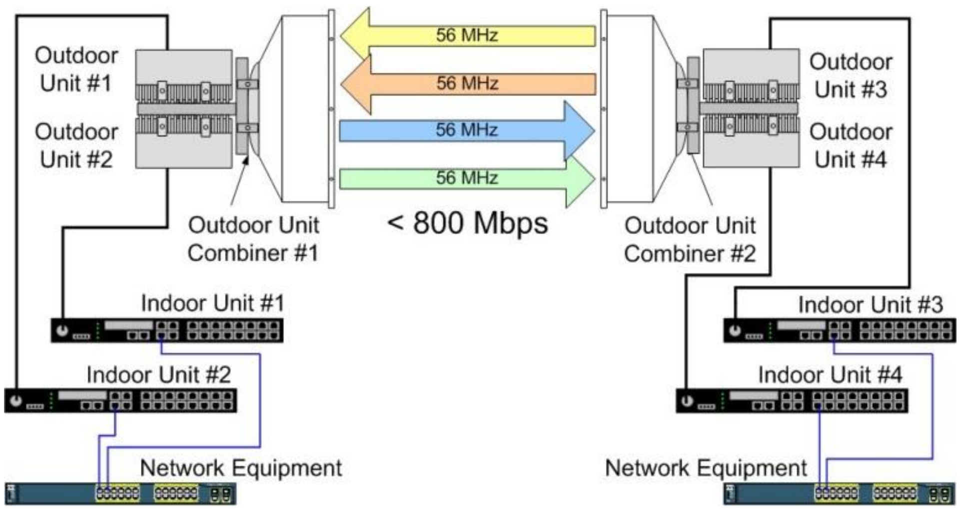

Figure 4 - Dual RF Channel Configuration, Implementation "A"

In figure 5, each indoor unit provides separate interfaces to their respective outdoor units and is capable of two individual data streams. This saves rack space and hardware costs of one complete indoor unit, however two ODUs and the ODU combiner are still required to interface to a single antenna.

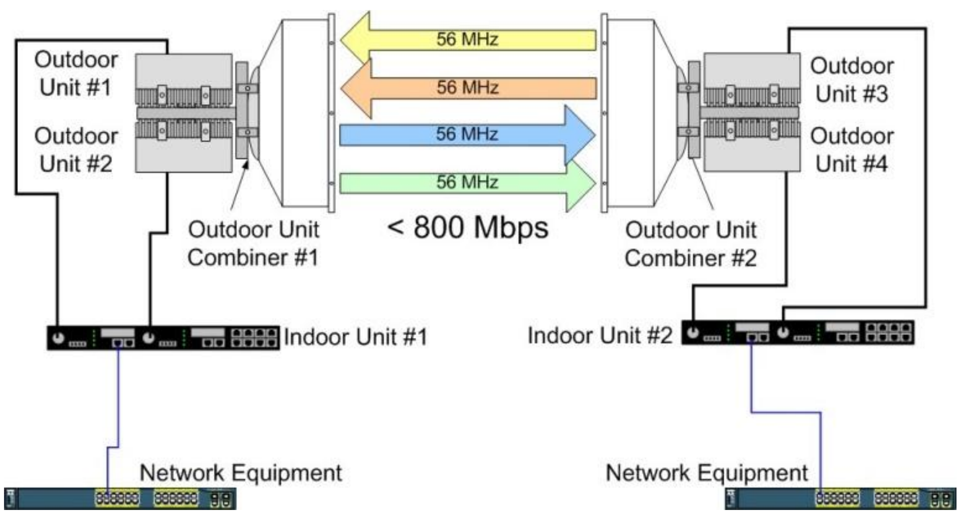

Figure 5 - Dual RF Channel Configuration, Implementation "B"

In figures 4 and 5, the ODU combiner can be eliminated, with each ODU connected to its own antenna, improving system gain at the expense of an additional antenna to align and maintain. This could double the rooftop or tower space rental fees paid by the user.

In figure 6, two intermediate frequencies (channels) are provided over a single interface cable. Since the single outdoor unit is transmitting two separate RF channels, its transmitter power must be reduced from single carrier limits to avoid distortion and signal quality degradation. This reduction in transmitter power effectively lessens the distance between the transmitting and receiving stations compared to its single intermediate frequency counterpart.

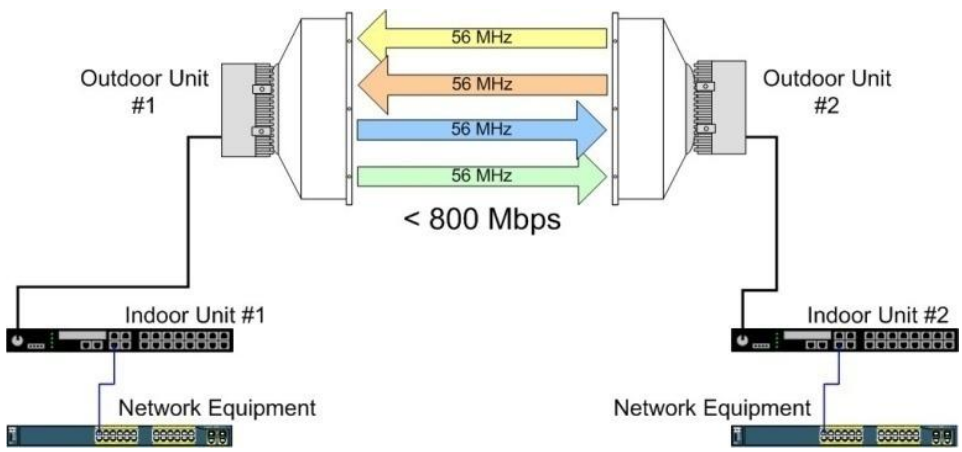

Figure 6 - Dual RF Channel Configuration, Implementation "C"

Performance of 80 GHz Millimeter Wave Links

In the 80 GHz frequency band, an unprecedented 10 GHz of bandwidth is allowed, far exceeding the spectrum allocations in any given lower licensed frequency band. The bands 71 – 76 GHz are paired with 81 – 86 GHz, yielding 5 GHz of spectrum in each direction. Both the U.S. FCC rules and European CEPT Recommendations provide for flexible channel sizes of up to the entire band allocation in each direction. The vast amount of bandwidth available in the 80 GHz band makes it ideal for offering multi-gigabit transmission rates without requiring the use of high-order modulation.

The use of low-order modulation schemes at 80 GHz yields full-rate gigabit transport using only 750-1500 MHz of bandwidth. The performance benefits of using simple modulation methods are that transmit amplifiers can be operated at near their maximum power ratings, while the radio receivers are able to decode much lower RF signal levels than would be possible using high-order modulation.

From a hardware perspective, these millimeter wave links provide the simplicity of a "single box" all-outdoor architecture compared with many of their short-haul licensed band counterparts that are split-mount in design. Gigabit, and even multi-gigabit, capacities can be transported in a single RF channel using one set of hardware. As shown in figure 7, the all-outdoor design eliminates the need to mount terminating equipment in a rack or cabinet, saving not only space in already cramped shelters, but also providing the cost benefit of not having to lease indoor equipment rack space.

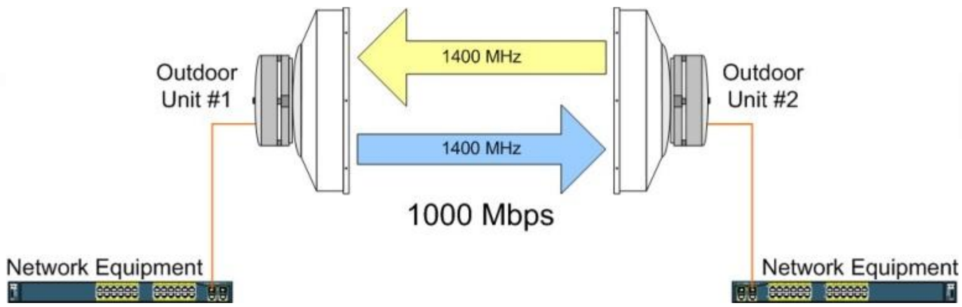

Figure 7 - 80 GHz Gigabit Configuration

Most commercial 80 GHz systems on the market today carry up to a gigabit of traffic over a single channel of approximately 1 GHz, however a single 80 GHz channel using 5 GHz of bandwidth has the capacity to transport 10 gigabits per second (or more) of traffic – 25 times or more than can be carried over a single 18-38 GHz radio using a 56 MHz channel.

Spectrum Availability and Licensing

The benefit of using a licensed frequency band solution is the interference protection afforded due to the registering (licensing) of the link with the regulatory authority. In densely deployed areas, licenses may not be available due to high demand and/or heavy utilization. The problem is severe enough in some cities that regulators are requiring shorter distance paths to utilize higher frequency bands. Even where it's possible to get one 56 MHz channel for transmission capacities up to 400 Mbps, it may be difficult to find two 56 MHz channels to extend these rates beyond 400 Mbps. In the United States, 40 MHz allocations at 18 GHz are hard to come by in congested areas such as New York City. In Europe, where microwave links have been much more widely deployed for cell tower backhaul, many cities are approaching saturation in multiple lower frequency bands.

When spectrum is available, the next consideration is the time and cost to license the link. Before a license is issued, frequency coordination must occur to verify the proposed link will not cause interference to an existing system. Generally, one can contract this out to a "frequency house". This however adds to the time and additional cost required to obtain a license.

In the United States, the cost of a 10 year license in the 18-38 GHz bands is on the order of $2,000. In other countries, license costs may exceed the overall cost of the link. For example, in the U.K. Ofcom license fee for a 23 GHz link using two 56 MHz channels is £2,217 (US$3,990) per year; over the lifetime of a link, licensing costs can easily exceed link hardware costs.

By comparison, registering an 80 GHz link in most countries is a relatively simple process referred to as "lightweight licensing". The spectrum allocation at 80 GHz provides a unique set of benefits including narrow beam antennas that provide excellent frequency reuse and interference protection, and an on-line licensing process that almost instantly confirms the registration of the link. In the United States the cost to license an 80 GHz link can be as low as $75 – significantly lower than the per-link license fee in the 18-23 GHz frequency range. In the U.K., the cost of an 80 GHz link license is only £50 per year.

Price

A survey of typical retail prices of the leading suppliers of short-haul, high capacity licensed frequency band radios shows that price depends primarily on the capacity of the link. Figure 8 shows the average list price for a short-haul high 18-23 GHz radio system in configurations ranging from 50 Mbps to +1000 Mbps.

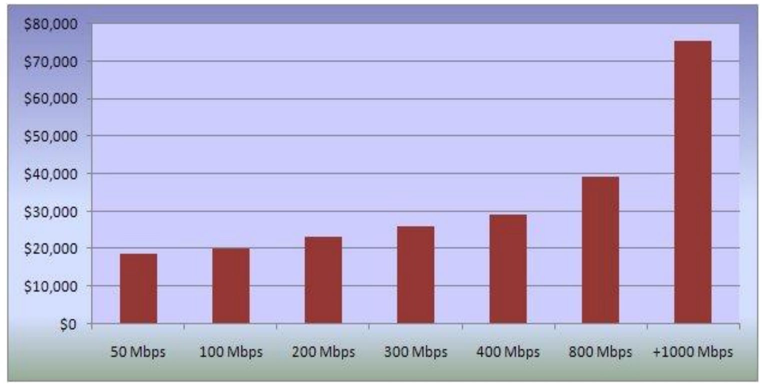

Figure 8 - Average Price for Short Haul Licensed Radios

Total Cost of Ownership

When comparing the costs of a short-haul high capacity licensed frequency link versus an 80 GHz GigE single-carrier link, one should consider not only the capital expenditures (CAPEX) such as equipment and installation charges for each solution, but also the operating expenses (OPEX) such as licensing, warranty, and maintenance. Table 1 lists the CAPEX and OPEX costs, in the United States, for single RF channel (<400 Mbps), dual RF channel (<800 Mbps), and quad channel (1600 Mbps) configurations and compares the total cost of ownership and value of the solution (in dollars per megabit per second) versus 80 GHz gigabit wireless links.

	Single Carrier <400 Mbps 18 – 23 GHz	Dual Carrier <800 Mbps 18 - 23 GHz	Quad Carrier 1600 Mbps 18 – 23 GHz	Single Carrier 1250 Mbps 80 GHz
Radio + Antenna	$29,300	$37,100	$69,200	$31,900
Surge Protectors	$250	$250	$500	$100
Cabling	$1,200	$1,200	$2,400	$500
ODU Combiner	$0	$0	$2,000	$0
Licensing	$2,000	$4,000	$8,000	$75
Installation	$4,500	$4,500	$4,500	$4,500
5 yr Warranty	$3,516	$4,452	$8,304	$4,785
5 yr Maintenance	$1,465	$1,855	$3,460	$1,375
Total Cost of Ownership	**$42,231**	**$53,357**	**$98,364**	**$43,235**
$ per Mb/sec	$106	$67	$61	$43

Table 1 - Total Costs of Ownership – U.S. Example

In other countries, where licenses fees are renewed annually such as the United Kingdom, the license fees make a more compelling argument for the use of 80 GHz links for short haul applications. Table 2 compares 23 GHz solutions utilizing a 56 MHz channel bandwidth with 80 GHz links.

	Single Carrier <400 Mbps 18 – 23 GHz	Dual Carrier <800 Mbps 18 - 23 GHz	Quad Carrier 1600 Mbps 18 – 23 GHz	Single Carrier 1250 Mbps 80 GHz
Radio + Antenna	£16,278	£20,611	£38,444	£17,722
Surge Protectors	£139	£139	£278	£56
Cabling	£667	£667	£1,333	£278
ODU Combiner	£0	£0	£1,111	£0
5 yr Licensing	£7,392	£11,088	£18,480	£250
Installation	£2,500	£2,500	£2,500	£2,500
5 yr Warranty	£1,953	£2,473	£4,613	£2,127
5 yr Maintenance	£814	£1,031	£1,922	£886
Total Cost of Ownership	**£29,743**	**£38,509**	**£68,681**	**£23,819**
£ per Mb/sec	£74	£48	£43	£19

Table 2 – Total Costs of Ownership – U.K. Example

In the U.S., the total costs of 80 GHz and single carrier 18-38 GHz solutions are almost equal, however the 80 GHz gigabit wireless solution provides three times the data rate throughput. In the U.K., there is significant cost advantage to using 80 GHz links due to the per-year license fees.

Adding a second RF carrier link doubles the throughput, however at a significant increase in total cost of ownership, and still does not reach the speeds afforded by the 80 GHz link.

As service providers and private network operators focus on the total cost of ownership, the advantages utilizing 80 GHz gigabit wireless links are compelling.

Summary

80 GHz wireless links deliver multi-gigabit data rates over multi-kilometer distances, with the interference protection of licensed band operation. The key benefits provided by these systems include:

- highest available throughput
- simple, all-outdoor design
- lowest spectrum licensing costs
- lowest dollar-per-megabit total cost of ownership

As application needs grow into the hundreds of megabits to multi-gigabit per second range, 80 GHz links offer a natural, future-proof growth path beyond the performance limits of traditional 18–38 GHz links.

About BridgeWave Communications

Founded in 1999, BridgeWave Communications is the leading supplier of outdoor Gigabit wireless connectivity solutions. The company's exclusive AdaptRate™ and AdaptPath™ technologies combined with its advanced Forward Error Correction capability deliver the highest availability at the longest distances for full-rate gigabit links. BridgeWave's point-to-point, wireless solutions are widely deployed in mainstream enterprise and service provider network applications and are poised to play a key role in the migration to 4G mobile network backhaul. With the largest installed base of GigE radios worldwide, BridgeWave delivers the highest levels of product quality and reliability. For more information, visit www.bridgewave.com.

BridgeWave Communications, Inc.
3350 Thomas Rd.
Santa Clara, CA. 95054 USA
Ph: +1 (866) 577-6908; +1 (408) 567-6908
info@bridgewave.com