BridgeWave
COMMUNICATIONS

THE ECONOMICS OF GIGABIT 4G MOBILE BACKHAUL

How "wireless fiber" 80 GHz links provide an economical alternative to operator-owned fiber

Gregg Levin
Vice President, Infrastructure Solutions
BridgeWave Communications

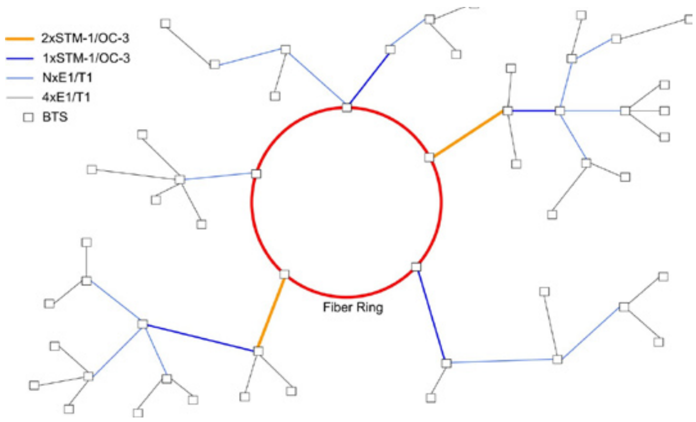
BridgeWave COMMUNICATIONS

Executive Summary

Today, copper-based T1/E1 circuits dominate mobile base station site backhaul, complemented by the use of 6-38 GHz microwave links when copper circuits are either unavailable, too costly, or take too long to deploy. As 4G capabilities are added to today's urban 2G/3G networks or are rolled out as green-field deployments, cell site backhaul and aggregation network requirements will rise from the tens and hundreds of megabits/second into the gigabits/second of capacity range. Low cell-site fiber penetration rates, coupled with often prohibitive costs of new fiber lateral deployment, will drive the adoption of "wireless fiber" 80 GHz backhaul solutions, as a technology upgrade for both copper and microwave backhaul solutions. Unlike copper circuits and leased fiber services, 80 GHz solutions scale in performance up to the multi-gigabit performance range, without incurring a corresponding increase in operator costs. 80 GHz solutions provide highly-available connectivity at typical urban backhaul distances and feature sufficient capacity to simultaneously support legacy TDM and rapidly-growing IP packet traffic. With worldwide adoption of the 80 GHz spectrum band underway, 80 GHz links are well-positioned to fulfill a critical enabling role for emerging 4G mobile deployments.

Backhaul Today

Over 85% of the quarter-million North American cell sites are connected using T1 circuits, with fiber connections serving less than 10% and microwave radio links only about 5%. This is in contrast to Europe where microwave links provide two-thirds of the backhaul connections, followed by copper E1 connections at around 25% and fiber at below 10%. In Asia, almost 50% of connections are fiber with microwave around 40% and copper at 10%. Backhaul contributes 30-40% of mobile operators' total network operation costs; as such, the choice of backhaul technology is heavily driven by cost considerations, with the relatively low-cost of North American T1 lines driving the much higher use of copper backhaul in this region. The low cost of labor in developing Asian countries and the very high population densities of large Asian cities make fiber installation a much more economical choice than in North America and Europe. Typical cell-site backhaul capacities are 1-8 * T1/E1 (1.5-16 Mbps) and are implemented as multiple T1/E1 copper circuits or single microwave or fiber connections. Microwave links are typically deployed in branching tree structures, typically with approximately five hops between the most distant cell sites and the core fiber network. Microwave backhaul traffic is aggregated as it moves towards the core, often reaching OC-3/STM-1 rates in dense, high-traffic areas.



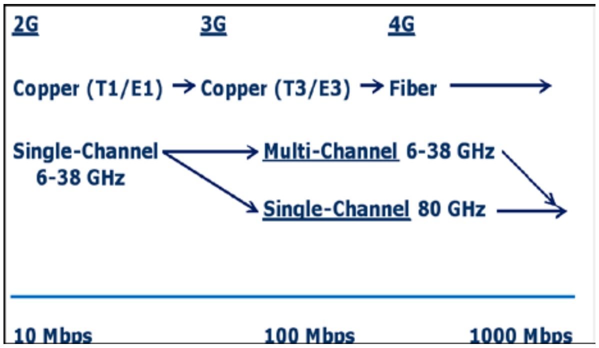
Exponential Capacity Growth

Capacity growth is being driven by the deployment of data services, especially laptop data connections with flat-rate pricing in line with DSL offerings. Data traffic surpassed voice traffic in mid 2007, and traditional TDM voice traffic is expected to level out in 2009 as both new data and new voice service deployments move from TDM to IP packet data transport in the coming years. Peak user data rates are doubling on the order of once per year, based on the deployment of new radio access technologies and additional cell sites and spectrum. Operators who have been aggressively rolling out 3G services have reported seeing a quarterly (or faster) doubling of their total network data traffic.

BridgeWave
COMMUNICATIONS

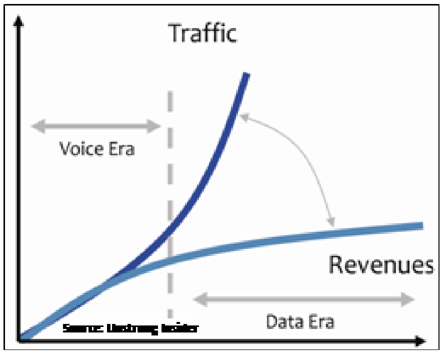
Impact of 4G on Backhaul Technology

4G mobile networks are defined by the ITU's IMT-Advanced requirements as providing at least 100 Mbps peak capacity for high-mobility applications. These requirements go far beyond the IMT-2000 3G performance definitions and will be first addressed by LTE and evolving WiMAX standards. These increases in over-the-air user access bandwidth will drive a corresponding increase in the capacity requirements of the mobile backhaul network. Current 10-30 Mbps base station site backhaul connections will grow to hundreds of megabits per second per site, and gigabits per second in the aggregation networks. The use of multiple T1/E1 (or T3/E3) copper circuits or microwave links that are sufficient for today's 3G backhaul will transition to fiber or higher-capacity wireless backhaul solutions as 4G deployments are launched. The higher-capacity wireless alternative include going to multiple radio channel 6-38 GHz links (essentially multiple radio links packaged as one) or moving to the new 80 GHz spectrum band that is capable of providing multi-gigabit-per-second data rates using only a single radio channel.



Fundamental Economic Challenge

The economic challenge facing network operators when transitioning to much higher capacity backhaul solutions is that while data traffic is dramatically increasing, revenue increases based on new higher-capacity services are more limited. Operators seeing a 10X increase in data capacity may only see a corresponding 20-30% increase in data service revenue. This decoupling of revenues from traffic capacity requires that any increases in the cost of backhaul must be in line with modest revenue growth, rather than the higher traffic growth. The technologies chosen for future backhaul deployments must deliver substantial economics of scale as backhaul capacities grow from tens-of-megabits-per-second to gigabits-per-second. Copper circuits clearly fail to deliver such economies of scale, with costs raising linearly with capacity beyond T3/E3 data rates.



Fiber as the Preferred Solution

All things being equal, most operators will choose fiber optic cabling as their preferred backhaul solution. It is perceived as a well-proven technology (it's been deployed in core networks for decades) with nearly limitless capacity scalability. Unfortunately, most of the time operators do not already happen to own fiber running directly to a base station site, and are therefore faced with either paying to install a new fiber run or paying installation and recurring costs to another operator to provide fiber-based services to the site. When the costs of installing fiber are low and the time to complete the installation is acceptable, fiber usually becomes the preferred solution. The issue is that fiber installation is an expensive proposition in most developed countries, ranging from $250K-$1000K per mile in dense urban areas, so running anything more than a short fiber lateral to a nearby ring is typically prohibitive except in extremely dense subscriber areas. Also, lengthy construction and permitting delays often make fiber installation an unacceptable alternative.

Leasing high-capacity data services from another operator is almost always unacceptable from a cost perspective. Even without up-front installation charges, the lowest-cost short-range GigE or SONET/SDH services are typically in the $5-15K per month range, and can run much higher than this based on recovery of any required fiber construction costs. These costs run far higher than operators pay to lease four T1/E1 circuits for backhaul today (typically under $1,000/month in the U.S. – higher in Europe).

BridgeWave
COMMUNICATIONS

Wireless Backhaul Alternatives

Single channel traditional 6-38 GHz microwave links top-out at around 350 Mbps due to the limited RF channel bandwidth that they are permitted to use. Maximum allowed channel bandwidths are normally no more than 56 MHz, and even using high-order modulation (256-QAM) these links are limited to transmitting around 350 Mbps per channel. In order to scale beyond this data rate in the traditional microwave bands, it is necessary to transmit multiple signals using multiple RF channels. Each channel used requires additional electronics and an additional spectrum license, so these links fails to deliver significant economies of scale beyond 350 Mbps. A more cost-effective alternative is to transition these backhaul applications to use the new 80 GHz millimeter-wave spectrum, where "wireless fiber" radios are permitted to use up to 5 GHz channels to deliver multi-gigabit data rates using cost-effective single RF channel designs. 80 GHz radios provide major cost advantages over 6-38 GHz links for data rates exceeding 350 Mbps; they also enable operators to scale their backhaul capacities far beyond the practical limits of 6-38 GHz technology. The capacity advantages also enable the use of ring and mesh topologies to increase service availability and offer the potential to simultaneously carry high capacity TDM and IP traffic to ease migration between the circuit and packet worlds.

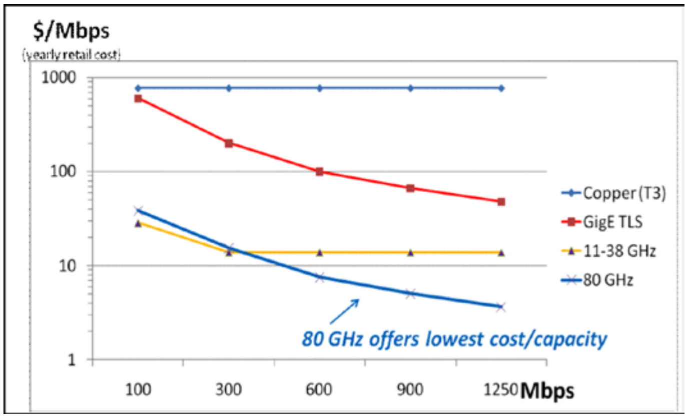
80 GHz links are most appropriate for urban backhaul scenarios, where gigabit capacities are most needed and where required backhaul distances are consistent with 80 GHz link deployments at 99.995% or better availability at up to 2 miles (3 kilometers). In Europe, where 38 GHz links are widely used, it is interesting to note that 80 GHz links operating at full gigabit data rates offer virtually identical link distances/availabilities as 38 GHz links operating at only 311 Mbps (2 * STM-1).

Another benefit that 80 GHz brings to dense urban deployment scenarios is the ability to deploy a very large numbers of high-capacity links within a given geographic area. The combination of a very large spectrum allocation (10 GHz) coupled with tightly focused antenna beamwidths provides for virtually unbounded link deployment densities. The fact that high data-rates can be realized using low-order modulation (e.g. QPSK or 16QAM) with 80 GHz links supports much shorter frequency re-use distances than is possible using high-order modulation in lower frequency bands, further improving maximum link deployment densities. Several country spectrum regulators view 80 GHz links as a means for addressing lower-frequency congestion issues that are becoming increasingly common in major urban areas as the number of cellular base station sites grows.

Beyond the costs of the radio links themselves, 80 GHz spectrum licensing costs are typically much lower than corresponding 6-38 GHz licenses. While licensing costs vary from country-to-country, many regulators are looking to follow the "light licensing" approach already adopted by the U.S. and U.K. In the U.S., a 10-year 80 GHz license costs $75 and can be obtained in real time using an on-line registration database. In the U.K., a yearly 80 GHz license costs £50. This compares to 6-38 GHz licensing costs that can run $2,000 per radio channel in the U.S. (typically higher in Europe) and can take over a month to obtain.

Technology Cost Scaling

The following chart shows how costs scale with increases in capacity for the various backhaul technology alternatives that are available to operators. The table excludes the option of mobile operator installing new fiber circuits themselves (discussed earlier), since the construction costs for this vary significantly from case to case. The chart shows U.S. retail pricing (rather than volume-discounted prices) spread over a seven-year equipment amortization period to provide a relative technology cost comparison.



BridgeWave COMMUNICATIONS

Note that copper and 6-38 GHz wireless solutions fail to effectively scale into the gigabit capacity space. Only leased fiber services (a GigE Transparent LAN Service, in this case) and 80 GHz wireless links scale with backhaul capacities that exceed 300 Mbps. While these two alternatives follow similarly-shaped curves, the 80 GHz link alternative provides over 10X better economics than leased fiber services.

Worldwide Adoption of 80 GHz Spectrum

The 80 GHz spectrum band (71-76 GHz and 81-86 GHz) was first allocated by the U.S. FCC in 2003 and then by Ofcom in the U.K. in early 2007. The 10 GHz of allocated spectrum far exceeds the allocations available at lower frequencies, making this spectrum ideal for offering multi-gigabit connectivity. Generally, these bands are not in use for other applications, making it relatively straight-forward for regulators to allocate this spectrum in a consistent manner worldwide. In Europe, CEPT has published a formal recommendation for the allocation of this spectrum and ETSI is in the process of voting on a completed draft recommendation (expected approval by 2Q09) to govern the specifications of radios that operate in this band. It is up to individual country regulators to formally make this spectrum available for use within their country, however many countries, both within and outside of the European Union, generally follow the recommendations of CEPT and ETSI.

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 Road, Santa Clara, CA 95054 USA
Ph: +1 (866)577-6908; +1 (408)567-6908
info@bridgewave.com

www.bridgewave.com