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Microwave Technology for Mobile Network Backhaul

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Article

March 1, 2013

New mobile devices and bandwidth intensive applications, supported by 3G and 4G networks, resulted in a 2.3-times increase in mobile traffic in 2011 and demand is on pace to double once again in 2012. Given this rapid growth, the need for high capacity backhaul has never been greater. Many operators are currently targeting 100 to 300 Mbps of capacity per cell site – a relatively modest backhaul requirement on a per site basis. However, since backhaul networks frequently aggregate multiple sites in ring/mesh architectures, for improved economics and carrier-grade availability, operators actually need a backhaul solution that can scale to several Gbps of capacity, as illustrated in *Figure 1* below.

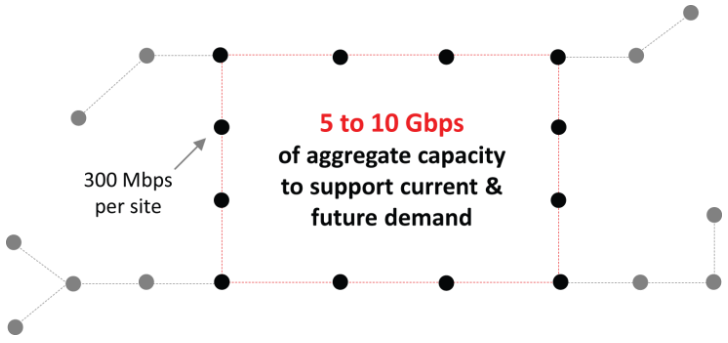

Figure 1 – Capacity requirement for sample backhaul network

In order to evolve their backhaul networks operators are seeking technologies that can provide the right combination of scale, reliability and cost. Fiber-based networks deliver the needed capacity but are often cost prohibitive when new builds are required. Wireless backhaul technologies can deliver the requisite performance, while offering rapid installation, flexible deployment options and much lower cost points than wired alternatives. Additionally, accelerated innovation in microwave backhaul technology is leading to much higher capacity and improved cost per bit economics.

This article examines the latest innovations that are improving the capacity of microwave radios. These include: higher order modulations, advanced signal processing and compression technologies, multi-channel radios and new transmission and antenna technologies.

Higher Order Modulation

There is currently a lot of activity among vendors to extend the capacity and spectral efficiency of microwave systems by moving to higher order modulations including 1024, 2048 and even 4096 QAM. A recent trial demonstrating 2048 QAM technology produced a 37% capacity increase over existing 256 QAM systems with no incremental hardware or spectrum allocation. As with most technology enhancements, higher modulations come with performance trade-offs in the form of reduced link budgets. This is mitigated with intelligent adaptive modulation technology which allows the system to switch to lower modulation, at a reduce throughput, during a fade event such as heavy rain. Given that fade events generally only impact lower priority traffic for a few hours per year, most operators welcome the opportunity to cost effectively add capacity to their network.

XPIC

Cross Polarization Interference Cancellation (XPIC) technology allows for vertical and horizontal transmission over the same channel, thereby doubling the link's capacity without adding new spectrum. While XPIC does require additional hardware, it is particularly useful in regions with high spectrum costs and limited channel availability.

Multi-Carrier Radios

Another significant development in microwave technology is the introduction of multi-carrier radios, which can transmit multiple channels from a single radio and antenna. A two-channel system can therefore carry twice the traffic without adding additional hardware. This technology is most widely adopted in regions where spectrum is readily available and cost effective.

Data Optimization

Some microwave backhaul systems can employ a combination of white space suppression, wire-speed bulk compression, and header optimization technology to significantly enhance transmission efficiency. Compression algorithms used in these networks function much like those found in today's file compression tools, substituting patterns in the payload and header data with shorter symbols. Depending on the compressibility of the traffic mix, data optimization technologies typically result in a 40% increase in capacity with gains up to 100% possible under certain conditions.

Wider Channels

In regions like the US, where spectrum availability is good and new spectrum is being made available – particularly in bands above 24 GHz – operators have the opportunity to use wider channels up to 112 MHz. This provides double the capacity of 56 MHz channels without the need for additional hardware investment and with no impact on link budget. In the case of millimeter-wave technologies (60 – 80 GHz), much wider channels (up to 1 GHz) are possible, allowing for high-capacity, albeit shorter-range, links that are well suited to fiber extension and certain small cell backhaul applications.

MIMO

MIMO (multiple-input multiple-output) wireless technology, which is widely deployed in access networks, holds promise in point-to-point microwave systems. By using multiple transmitters and receivers, MIMO leverages multi-path transmission to increase overall throughput by combining multiple signals. This is accomplished without the need for new spectrum. MIMO systems do, however, require an additional antenna and radio per link end and must have sufficient space diversity on the tower to achieve the desired multi-path effect.

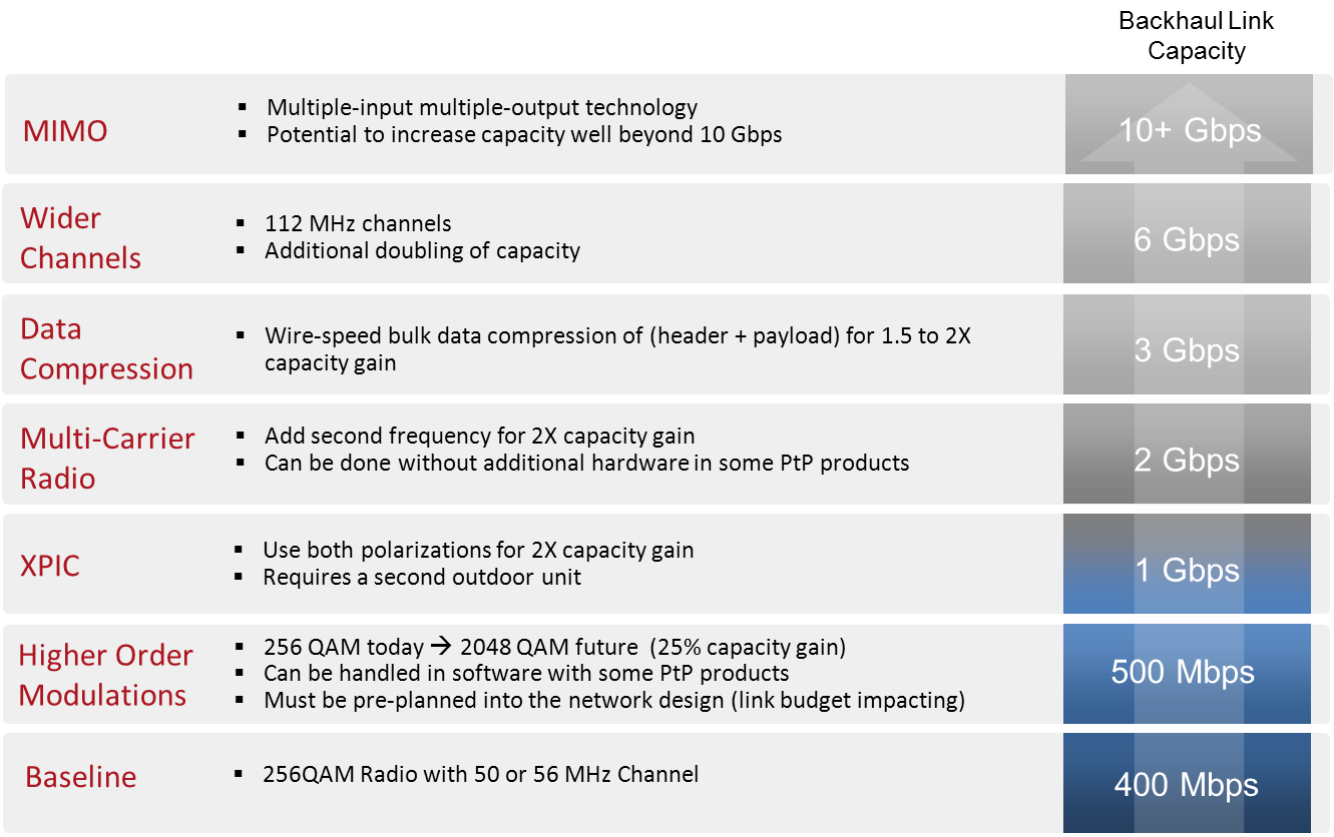

Figure 2 – Microwave capacity improvements

We can see from *Figure 2* that a combination of new radio features, wider channels and higher order modulations will be implemented to deliver backhaul capacities up to 10 Gbps and beyond; a 25-fold increase from the baseline scenario. Cisco's latest Visual Networking Index for mobile traffic has forecasted an 18-fold increase in mobile traffic over the next 5 years – a good indication that the technology is in fact keeping pace with end user demand.

While spectral efficiency improvements are driving much of the capacity gains, there is also a need for increased backhaul spectrum. Therefore frequencies bands over 24 GHz, which tend to have greater availability, will likely play a larger role in mobile backhaul moving forward. Fortunately, the smaller antennas and shorter reach restrictions of these bands make them ideal backhaul frequencies for the small cell networks that are expected to account for a large portion of future mobile network capacity.

Taking into account the cost and complexity of alternative backhaul solutions, it appears that microwave technology innovation, along with new backhaul spectrum being made available, should allow wireless backhaul to remain the predominant global backhaul technology for the foreseeable future.

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