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URGENT COMMUNICATIONS

Microwave Backhaul Systems for Public Safety Get Better and Better

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Article

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Public-safety organizations—ranging from emergency response to border security—rapidly are adopting new technologies to drive improved service levels and efficiency. LTE-based communications, high-definition video-surveillance systems and critical-infrastructure sensor networks—as well as a general increase in traffic between public-safety facilities—are all triggers for new IP-optimized backhaul solutions.

Faced with the need for high capacity, reliability and security (at the lowest cost per bit), many public-safety organizations are seeking new transport technologies to replace their legacy networks and enable next-generation applications. As the cost of deploying fiber reaches new heights—often exceeding the million-dollar mark per mile of trenching—continued innovation in microwave technology has enabled these point-to-point systems to deliver fiber-like performance at a small fraction of the cost.

This article examines the latest innovations that are improving the capacity, reliability, performance, management and cost-per-bit economics of microwave backhaul radios for public-safety applications.

A patchwork of legacy backhaul systems

The underlying transport (i.e., backhaul) networks used by public-safety organizations typically are a mix of legacy licensed and unlicensed wireless technologies, as well as leased lines. These backhaul solutions can deliver throughputs ranging from several Mb/s to 20 Mb/s—with spotty reliability and high recurring costs in the case of leased lines.

In addition, the increased congestion in unlicensed bands has continued to degrade the performance of legacy wireless backhaul technologies, resulting in wireless links that only can be classified as "best effort." This patchwork of backhaul technologies being used by many public-safety organizations also poses another significant and complex challenge: where multiple networks must be managed under different platforms, fault isolation and troubleshooting becomes more time-consuming and costly.

The challenges facing public-safety organizations are being addressed by innovations in microwave backhaul technology. The first and most pressing issue is the need for significantly more capacity. In response, leading microwave vendors are responding with the following features and advances:

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 lets the system switch to lower modulation—at a reduced throughput—during a fade event such as heavy rain. Given that fade events generally impact only lower-priority traffic for a few hours per year, most operators welcome the opportunity to cost-effectively add capacity to their network.

Multi-carrier radios—Another significant development in microwave technology is the introduction of multi-carrier radios that can transmit multiple channels from a single radio and antenna. This means a

two-channel system can carry twice the traffic without adding additional hardware. This technology is most widely adopted in regions where spectrum is readily available and cost effective.

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.

Figure 1 - 4-carrier XPIC configuration on DragonWave's Horizon Quantum

Advanced compression techniques—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 30% to 40% increase in capacity, with gains up to 100% possible under certain conditions.

Wider channels—In regions where spectrum is readily available or new spectrum is being made available—particularly in bands above 24 GHz—operators have the opportunity to use channels up to 100 MHz wide. This provides double the capacity of 50 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—Multiple-input, multiple-output (MIMO) wireless technology, which is deployed widely 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. However, MIMO systems require an additional antenna and radio per link end, and they must have sufficient space diversity on the tower to achieve the desired multi-path effect.

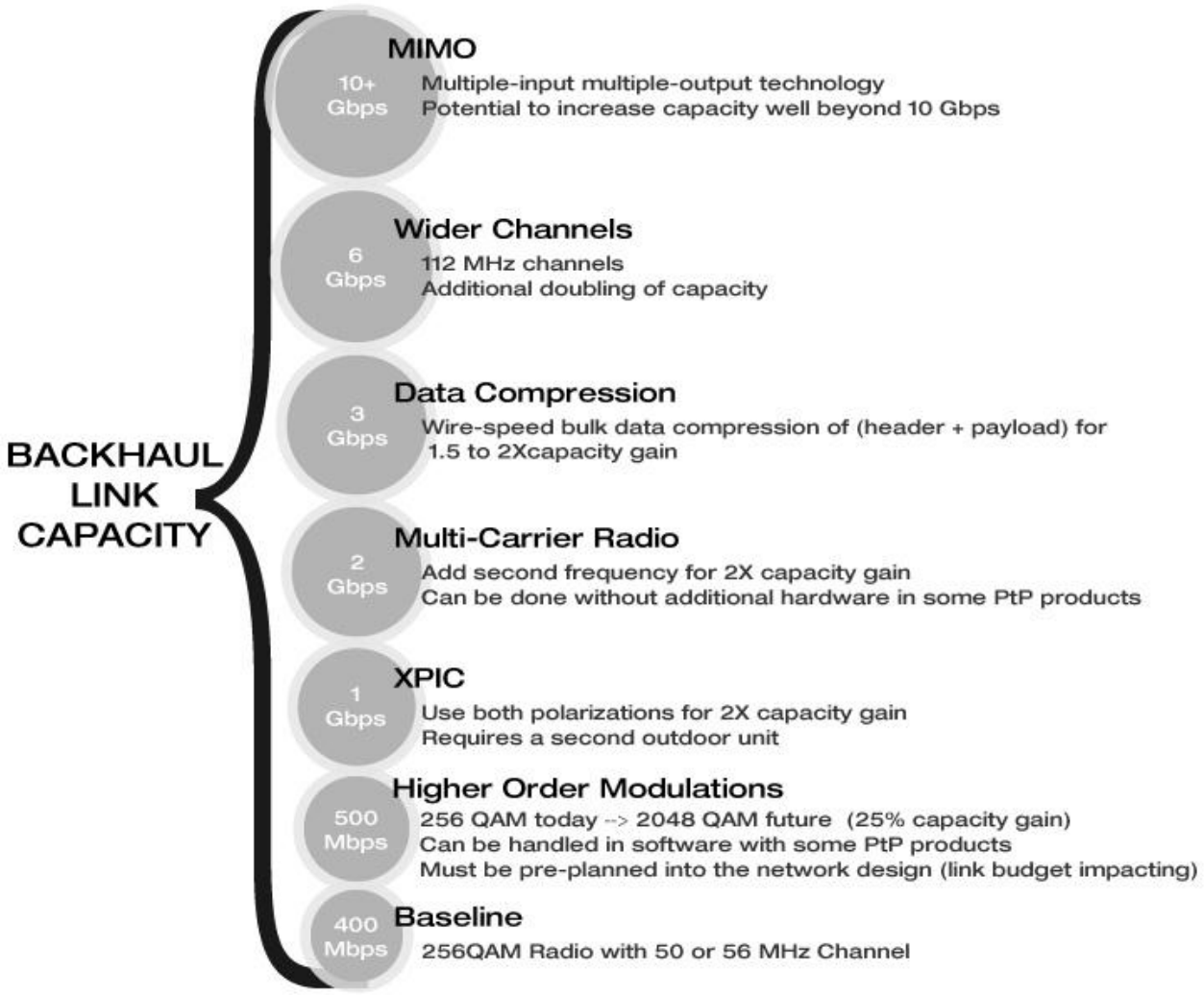

Figure 2 – Microwave capacity improvements

Figure 2 shows that a combination of new radio features, wider channels and higher-order modulations will be implemented to deliver backhaul capacities up to 10 Gb/s and beyond—a 25-fold increase from the baseline scenario. Cisco System's latest Visual Networking Index for mobile traffic forecasts an 18-fold increase in mobile traffic during the next 5 years. In other words, technology innovations are keeping up with user demand.

Delivering more security and higher QoS

To make a high-capacity backhaulnetwork useful to public-safety organizations, equal consideration must be given to the underlying technologies that shape, prioritize and secure the transmission, in order to ensure a high level of service for mission-critical applications and provide a simple means to managing it all.

Low-latency sub-6 GHz systems—Licensed and unlicensed bands below 6 GHz will continue to be important frequencies for public safety. Mission-critical applications such as real-time video not only use more bandwidth, they require significant advancements in the latency performance of sub-6 GHz systems.

Traditional sub-6 GHz radios have experienced latency in the 6-7 millisecond range. This latency is sufficient for smaller networks with few hops, but the combined latency of such systems across larger networks often results in unacceptable levels of service degradation.

Emerging sub-6 GHz systems use advanced traffic-management and radio-transmission techniques to drive latency performance down to 1-2 milliseconds. This ensures that delay-sensitive traffic can be transported effectively, even in large daisy-chained networks with many hops back to the point of presence.

Enhanced quality of service (QoS)—As public-safety agencies add new traffic types (such as video) to their networks, it is essential that different traffic streams be assigned higher or lower priority levels to ensure that mission-critical traffic always is given top priority. Current microwave systems typically offer several queues that can be assigned specific priority levels, which are handled in weighted-fair-queuing or round-robin fashion.

Some microwave solutions take this a step further by offering packet cut-through technology, which enables the data path to suspend the transmission of the current frame, send a frame from a "cut-through" queue, and then resume transmission of the suspended frame. This results in much lower latency and packet-delay variation for time-sensitive traffic.

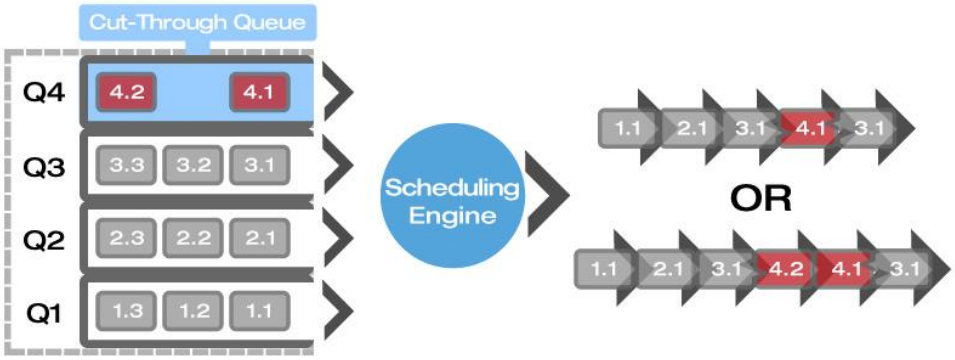

Figure 3 – Packet cut-through technology.

Encryption—Given the sensitive nature of public-safety communications, integrated encryption is an important consideration when selecting a microwave system. Some organizations also may look for systems that meet the Federal Information Processing Standard (FIPS) Publication 140-2, which is a U.S. government standard for the secure transmission of information. Microwave solutions that offer integrated 256-bit AES encryption, along with other advanced security features that protect both payload and management data, are classified as FIPS 140-2 compliant.

Single management platform—Another aspect of ensuring a higher-quality level of service is the choice of platform used to manage the day-to-day operation of the network. Organizations with multiple technologies managed by various systems have much more difficulty monitoring and isolating faults in the network, resulting in higher operational costs and increased network downtime—something few public-safety organizations can afford. Microwave solution vendors that provide a single management platform for the entire backhaul, including both licensed and unlicensed systems, offer a significant advantage to the network operator.

The many advances in microwave communications are giving public-safety organizations an attractive upgrade option for their existing backhaul networks. The capacity improvements seen in the industry

remain well ahead of the rapid pace of new network demand. Advances in the performance, reliability and security of both licensed and unlicensed systems—managed under a single platform—provides a carrier-grade transport network for mission-critical applications.

With cost savings typically exceeding 90% when compared to fiber-based alternatives, the case for microwave backhaul in public-safety networks is perhaps stronger now than ever before, and will become even more viable as technological advancements continue in the market sector.

Chris York is product marketing manager for microwave solutions vendor DragonWave (www.dragonwaveinc.com).

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