Take Microwave Spectral Efficiency to a New Level

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Getting the Most From Your Spectrum Investment
With Next Generation Packet Microwave

Quickly emerging 4G access technologies including LTE and WiMAX promise to deliver the first true mass-market mobile broadband experience, unlocking a host of new applications that will enhance the user experience both at work and at play. While all this new access capacity is a major step forward, everything grinds to a halt if the backhaul network does not scale accordingly. For this reason, many mobile operators are evaluating next generation packet microwave solutions for their performance, scalability, reliability, and low total cost of ownership.

Due to their high performance and attractive economics, next generation microwave backhaul solutions are set to play an important role in future mobile networks.

When selecting a microwave solution, many factors such as deployment flexibility, reach, capacity, and of course cost, come under review. Yet spectral efficiency—an equally, if not more important consideration—is often overlooked. Just as we have seen spectrum availability issues in the Radio Access Network (RAN), microwave spectrum is facing similar congestion challenges in many parts of the world. This is leading to reduced availability of larger channels and increased pricing for popular frequency bands. Spectrum is becoming an increasingly precious resource.

Spectrum scarcity is driving a need for greater spectral efficiency in microwave backhaul networks.

With capacity requirements increasing and spectrum availability decreasing, service providers will need to extract the maximum value from their spectrum investment. In the coming years, spectrum licensing costs will have the potential to make or break the backhaul business case and become a significant barrier for operators.

This paper will examine the trends in microwave spectrum as well as the impact of spectrum cost to the backhaul network business case. This will be followed by an overview of the technologies—moving from current systems to next generation microwave—that are enabling mobile operators to squeeze more capacity out of the same spectrum allocations.

SPECTRUM LICENSING TRENDS

Even though much of the business and regulatory attention tends to be on the highly valued lower frequency spectrum allocations used in the radio access network (RAN), there is now an increased focus on microwave spectrum due to concerns of congestion and future availability; this is particularly true in areas where the high cost of deploying fibre has led to a greater concentration of microwave.

In response to these concerns, many of the world's telecommunications regulators have implemented new measures to more carefully manage the available microwave spectrum. Several European countries including France and Russia have essentially eliminated larger channel bandwidths (56 MHz and above) in order to encourage greater efficiency in smaller channels[1].

The Office of Communications (Ofcom), the independent regulator in the UK, is addressing spectrum congestion with a pricing strategy that favors higher frequencies and smaller channel sizes, which is shown in Figure 1 below.

Large channel or multi-channel microwave spectrum licenses are no longer a viable option for many European mobile operators.

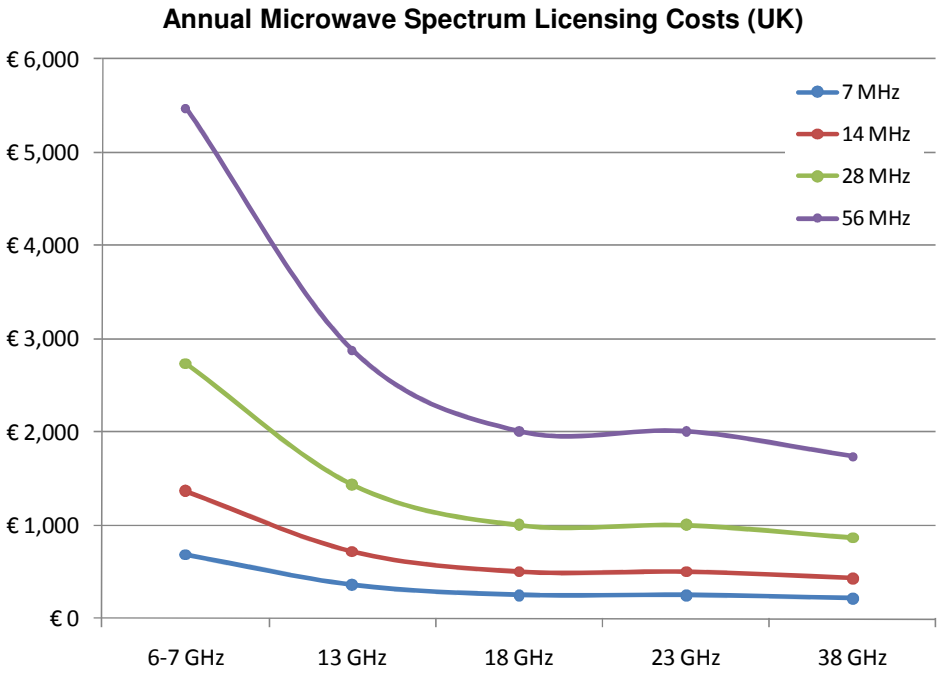

Figure 1: Annual spectrum licensing cost per link.[2]

With most regulators adopting similar pricing strategies, it is clear that larger channels and lower frequencies are cost prohibitive for most operators.

Other areas where microwave backhaul is less prevalent, such as the United States, have not been very aggressive in implementing stricter spectrum controls. There are, however, signs that additional regulation may be required in order to address congestion challenges in some of the larger urban centers.

THE BUSINESS CASE IMPACT OF SPECTRUM

For many service providers, spectrum licenses already represent one of the largest recurring costs in their backhaul network—accounting for as much as 40%[3] of a backhaul operator's 10-year total cost of ownership. Looking at future capacity requirements, where hundreds of megabits or more will be needed, careful spectrum utilization planning will be essential in order to ensure the ongoing economic viability of these backhaul networks.

Despite the significant impact to the total cost of ownership (TCO), spectral efficiency is often a secondary consideration when evaluating microwave backhaul solutions. The following chart (Figure 2) represents the backhaul business case sensitivity to various cost elements. These costs are varied according to ranges found in existing backhaul deployments, illustrating the potential impact that each can have (positive or negative) to the operator's total cost of ownership.

Spectrum costs vary widely depending on region, frequency and population density.

Efficient use of spectrum can dramatically improve the backhaul network's TCO.

Business Case Sensitivity: Impact to 10-Year Total Cost of Ownership

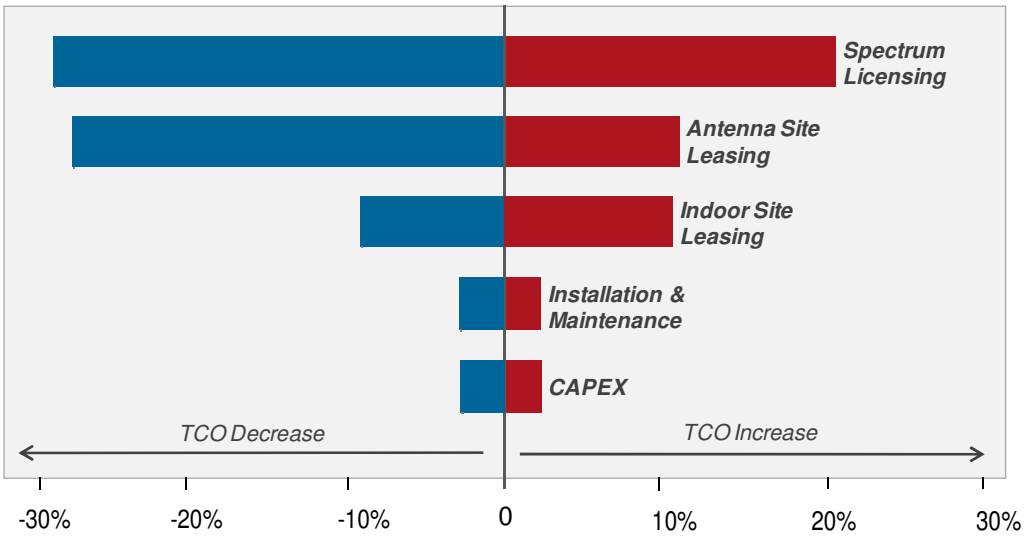

Figure 2: Backhaul business case variables and their potential range of impact to TCO.[4]

As shown, spectrum cost has a much greater impact on the operator business case when compared to items such as equipment and installation costs. The wide range of potential impact is due to a combination of pricing variation and the degree of efficiency in existing deployments. Equipment cost, while important, is often overemphasized in the buying decision as it represents a small fraction of the TCO. This highlights the importance of selecting a microwave solution that minimizes key operating expenses such as spectrum licensing.

While all other cost elements will remain relatively fixed, spectrum cost is set to rise dramatically, becoming the dominant cost for operators (Figure 3) deploying broadband mobile networks. This is due to the fact that many existing microwave backhaul solutions will not scale sufficiently within existing spectrum allocations, resulting in additional spectrum investment for operators.

Most existing microwave backhaul networks will not scale to handle 4G data rates without additional spectrum investments.

Backhaul Total Cost of Ownership: Traditional Microwave Solutions

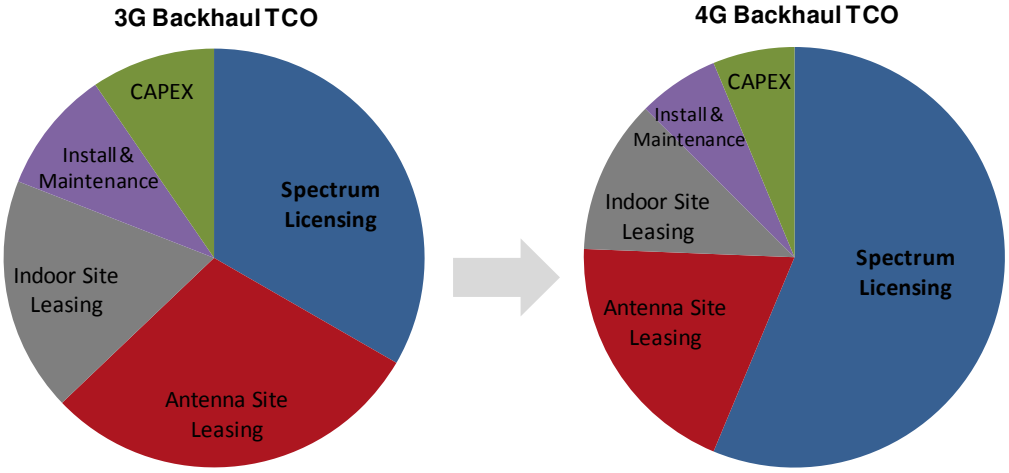

Figure 3: 10-Year TCO for European backhaul networks.

Fortunately, next generation packet microwave systems address many of these elements with capabilities such as all-outdoor deployment, reduced antenna sizes, and most importantly a suite of technologies which deliver a dramatic improvement in spectral efficiency relative to previous microwave systems.

In the next section, we will identify some of the key advancements that have driven massive improvements in the spectral efficiency of microwave systems; looking at technology deployed today as well as the latest advances in next generation packet microwave.

SPECTRAL EFFICIENCY GAINS: CURRENT MICROWAVE SOLUTIONS

HIGHER ORDER MODULATION

Increasing modulation depth boosts spectral efficiency but other techniques will be required to make significant gains in the future.

The introduction of higher modulation rates has provided a dramatic boost to spectral efficiency for each generation of microwave system; moving from QPSK to 256QAM has driven a 4-fold increase in throughput. The additional complexity associated with these higher modulations does however translate into a reduction in system gain, which can affect performance during periods of heavy rain. Fortunately, techniques such as adaptive modulation—which automatically shift to higher or lower modulation rates depending on weather conditions—greatly enhance the utility of higher order modulations by optimizing throughput for different classes of service. As an example, a service provider could offer 99.999% availability for high priority traffic and 99.9% availability for lower priority activities such peer-to-peer traffic or YouTube video streaming.

When comparing microwave solutions, it is important to note that many of the systems available today do not support higher modulation levels in small channel sizes. This is a very important consideration for operators looking for maximum efficiency across all available channel options.

Future advances in modulation depth are possible but this is a case of diminishing returns. For example, going from 256QAM to 512QAM adds significant cost and complexity, yet provides only a 12% increase in throughput. In addition, higher modulations entail greater export controls which will complicate the procurement of these systems. Consequently, higher modulations alone will not deliver the capacity and spectral efficiency needed to support advanced 4G services.

CROSS POLARIZATION INTERFERENCE CANCELLATION (XPIC)

One approach used to effectively double capacity within existing spectrum allocations is to transmit on both the vertical and horizon polarization of the RF channel (as shown in Figure 5).

XPIC technology filters the transmission interference allowing both signals to operate in the same space. This technique does require additional hardware but this capital expenditure is typically minimal in comparison to the long term operations savings generated. XPIC is a less attractive option in countries, where wireless operators must pay for the equivalent of an additional channel to operate a cross-polarized system.

XPIC filtering of the cross-polarized signal allows two separate data streams to be transmitted over the same channel.

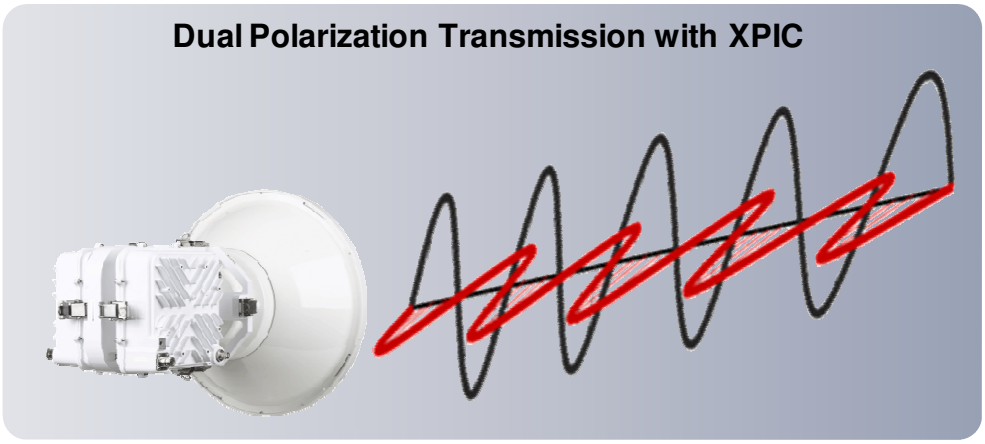

Figure 5: Dual Polarization transmission with an XPIC filter, doubling spectral efficiency.

ELIMINATING PROTOCOL CONVERSION

As mobile networks move to a much more data-centric traffic profile, traditional SONET/SHD backhaul systems introduce significant protocol conversion inefficiencies and latency. Packet-based microwave systems are designed to transport IP natively, eliminating this conversion overhead. In addition, statistical multiplexing results in improved link utilization, enabling mobile network operators to deliver emerging services much more efficiently.

4G-optimized packet based backhaul networks not only allow for greater efficiency but they also enable advanced signal processing and bandwidth optimization designed to further augment the efficiency of backhaul networks.

NEXT GENERATION MICROWAVE: BANDWIDTH OPTIMIZATION

One of the most significant advances in microwave systems, and perhaps the most effective means of cost effectively increasing spectral efficiency, is to implement bandwidth optimization technology.

These base band techniques leverage white space suppression, header and bulk optimization, and lossless compression to eliminate the transmission of redundant information. This leading edge capability drives a 2 times or greater throughput improvement.

When contrasted to alternative approaches, such as moving to higher modulations, the advantages of bandwidth optimization are clear: going beyond 256QAM introduces additional complexity, increased interference sensitivity and a further reduction in dynamic range—all for small incremental increases in spectral efficiency. Bandwidth optimization techniques on the other hand can yield well over a 100% improvement in spectral efficiency with no impact to system gain and little impact to system delay.

By augmenting existing microwave solutions with bandwidth optimization technologies, next generation packet microwave systems deliver a new level of spectral efficiency. For example: these advanced systems could allow an operator to backhaul over 200 Mbps of capacity in a cost effective 7 MHz channel—an ideal solution for 4G base stations. The following chart depicts the spectral efficiency improvements in Mbps/MHz spanning multiple generations of microwave.

New technologies can more than double the spectral efficiency of previous generation microwave systems.

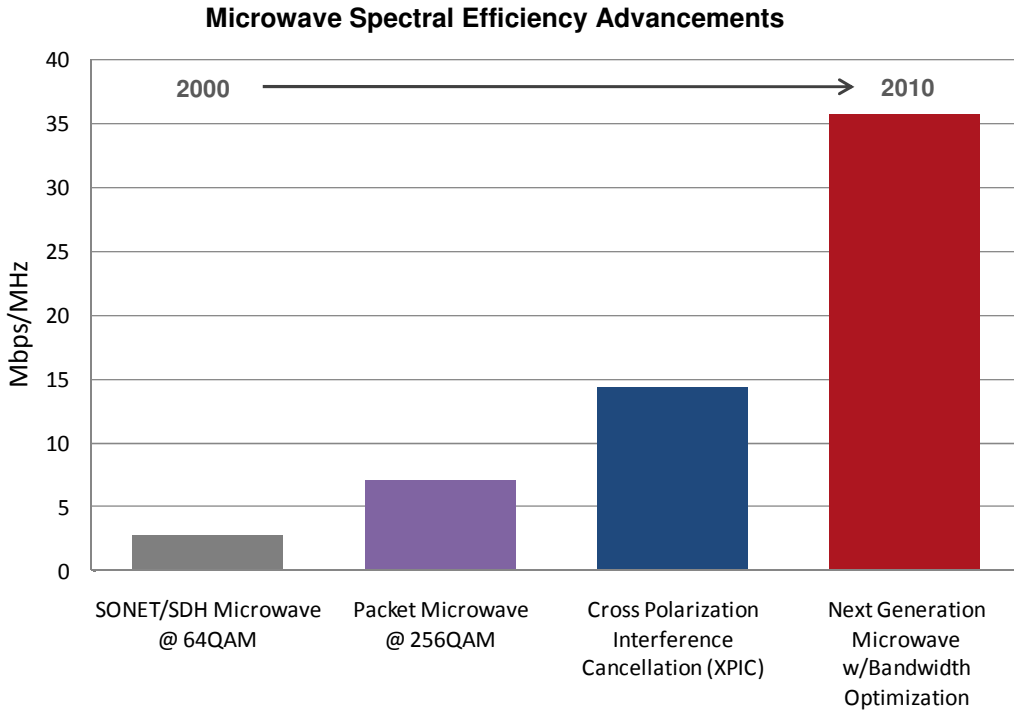

Figure 4: Spectral efficiency improvements through each generation of microwave.[5] The spectral efficiency represented in the next generation system is based on a typical traffic mix and may be higher or lower depending on the actual deployment.

CONCLUSION

Backhaul spectrum, like other highly valued finite resources, is being consumed at rapid rate. With microwave spectrum congestion becoming a real issue in many regions, decreased availability and increased cost has meant fewer options for service providers looking to expand their spectrum footprint. Furthermore, adding channels could have implications to the long term viability of their business model.

In order to address these issues, next generation microwave systems are leveraging a suite of technologies including higher order modulation, XPIC, packet-based architectures, and new bandwidth optimization techniques to boost spectral efficiency to new levels. This is enabling operators to provide much more capacity in smaller spectrum allocations, which is a key requirement for 4G networks.

Looking forward, backhaul networks will continue to evolve in order to deliver higher levels of spectral efficiency, staying ahead of bandwidth demands of future mobile networks. In addition, advances to existing techniques will be complimented by new architectures such as micro or pico-cells, as well as software defined and cognitive radios.

By deploying next generation microwave solutions, service providers gain a significant advantage; both in the performance of their network and their ability to cost effectively deliver high value services and applications without running into a spectrum barrier.

To learn about the industry's highest spectral efficiency packet microwave solutions, please visit www.dragonwaveinc.com.

[1] Autorité de régulation des communications électroniques et des postes (ARCEP)
[2] Ofcom spectrum licensing guide. Assumes 99.995% availability.
[3] Based on single 56 MHz channel license in the UK
[4] DragonWave internal analysis – various market sources
[5] Published microwave throughputs, next generation spectral efficiency based on DragonWave Horizon Quantum solution