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Importance of Spectral Efficiency in Microwave Backhaul Systems

Technological Advancements to Decrease Cost and Increase

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Microwave backhaul networks continue to scale with increased capacity to meet the data demands mobile users are placing on networks. Advancements in technology, higher capacity configuration, such as 2+0, and increased spectrum have all played a roll in this mobile network expansion. Yet, at the same time, the cost of annual backhaul spectrum has gone up as well, with most countries outside of the United States seeing prices between $1000-$4000 per year for a 28MHz channel that is, in most practical applications, limited to about 200Mbps. What's more, in many countries backhaul spectrum is so congested even acquiring a channel can often be difficult. As a baseline, 28 MHz channel spectrum lease charges account for between 50-75 percent in a 7-year total cost of ownership equation.

Clearly, there are spectrum challenges with current 200Mbps links, and scaling to 400Mbps or higher utilizing traditional technology is problematic and costly. When additional spectrum is available, the options are to use a wider 56 MHz channel or deploy a 2+0 system that consumes 2X28MHz channels. However, both of these options result in a doubling of already very expensive spectrum lease charges.

The question operators are asking is: What advances in the spectral efficiency of microwave backhaul systems can enable greater scalability? In the past, the most common technological improvement for spectral efficiency has been modulation. Most systems today offer 256QAM, which can deliver up to

200Mbps in the 28 MHz channel. Newer systems on the market are now offering 2048QAM, which provide about a 35 percent improvement over 256QAM. While there is some link budget reduction, it can typically be managed through the use of adaptive modulation, which will switch back down to 256QAM or lower during a link fade event. Recent advancements in microwave backhaul spectral efficiency are also being considered.

Some microwave systems now offer compression techniques that further improve spectral efficiency. Utilizing header optimization, which removes common fields from headers, can provide a 10-20 percent throughput improvement. More significantly, more advanced systems are incorporating bulk payload compression. This technological advancement analyzes the traffic, looks for bit patterns, and replaces them with shorter symbols, and has been found to offer 50-150 percent throughput improvement. When both these technologies are deployed, speeds greater than 500Mbps are achievable in a single 28 MHz channel. In comparison, traditional microwave systems would require 3X28 MHz channel and 3 separate microwave systems that would require 2 antennas. As a result, an operator would incur 3 times the annual spectrum costs, double the tower lease costs, and increase the CAPEX costs by 50-75 percent.

These same spectral efficiency techniques can also improve total cost of ownership on existing, lower capacity links. For example, with these new features in play, 200-250Mbps can be delivered in a single 14 MHz channel rather than a 28-56MHz channel that would currently be used. This provides a 50-75 percent decrease in the recurring annual spectrum costs.

Another emerging technique that improves microwave spectral efficiency is Multiple Input, Multiple Output (MIMO). MIMO can double the capacity in a single channel through spatial separation and by transmitting two signals over separate antennas. MIMO can be used in combination with 2048QAM and acceleration to provide further spectral efficiency improvement.

MIMO's challenge is that the separation of the antennas is very dependent on the link details, including frequency band link length. The antenna separation for many links often needs to be 5-10 meters. This is a difficulty for operators, as it requires them to fin two exact mounting locations on what is typically rented tower space. Each mounting location will incur monthly lease charges. Equipment cost and installation costs are also doubled versus a 1:0, because MIMO requires twice

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the radios and antennas. These factors and deployment challenges make it unlikely that MIMO will be deployed on a network wide scale. However, it may be used in combination with 2048QAM and compression on unique problem links to provide very high capacity, such as 1Gbps in a 28MHz deployment or in locations where only a 14 MHz channel is available to deliver up greater than 500Mbps.

Another spectral efficiency technique often discussed is XPIC. XPIC allows microwave systems to use both the vertical and horizontal polarization of the same channel on the same link. However, once the polarizations are used on a link, they cannot be used on adjacent links where they would normally be deployed, so that the adjacent links would require different channels. As a result, XPIC does not provide any network-wide spectral efficiency benefits. And, because the telecom regulator typically bills each polarization of a frequency channel separately, there is no spectrum cost savings. That said, XPIC can be useful in a network in select single link cases where only a single dual-polarized channel is available. These cases are fairly rare and deployment of XPIC has typically been limited to a small percentage of links in networks.

Spectrum costs represent a significant portion of total backhaul network costs, and it is clear that more spectrally efficient technologies are crucial to cost effectively scale networks to meet capacity demands. While the cases above all assume more spectrum would be available, in reality many operators are restricted by the amount of available spectrum. In that case, improving spectral efficiency becomes paramount in order to avoid negative impacts on service revenue. High order modulation and compression will be key technologies in enabling this much-needed spectral efficiency. MIMO and XPIC can also be useful on special network scenarios, although they are much more difficult to be deployed on a network wide basis.

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