Growing Importance of Spectral Efficiency in MicroWave Backhaul Systems

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As mobile networks have scaled with increasing capacity, so too have the supporting microwave backhaul networks, which serve 70-80 of all mobile sites. Backhaul links have scaled through advancements in technology, higher capacity configuration, such as 2+0, and increased spectrum. However, the cost of annual backhaul spectrum has also increased, currently running between $1000-$4000 per year for a 28MHz channel in most countries outside of the United States. This 28MHz channel is limited to about 200Mbps with most traditional microwave systems as the use of wider spectrum channels. Already today, costly annual spectrum lease charges for a 28 MHz channel represent between 50-75 percent of the 7-year total cost of ownership. Compounding this problem is the fact that, in many countries, backhaul spectrum is so congested even acquiring a channel can often be difficult.

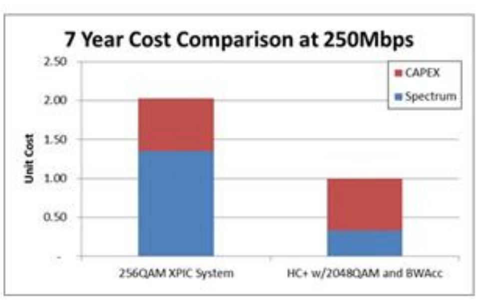
Given the spectrum challenges with a current 200Mbps link, scaling with traditional technology to 400Mbps or higher is extremely problematic. If more spectrum is available, the options are to use a wider 56 MHz channel or deploy a 2+0 system that consumes 2X28MHz channels. Yes, both of these options double the already very expensive spectrum lease charges.

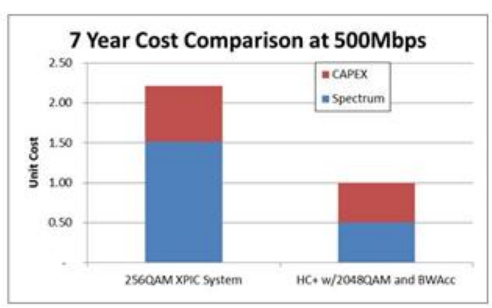
To enable greater scalability, operators are exploring any advances in spectral efficiency of microwave backhaul systems. In the past, the most common technological improvement for spectral efficiency has been modulation. Most systems today offer 256QAM, which can deliver up to 200Mbps in the 28

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. Other advancements in microwave backhaul spectral efficiency are also being made.

Recently, some microwave systems are offering compression techniques to further improve spectral efficiency. Many systems offer header optimization, which removes common fields from headers and provides a 10-20 percent throughput improvement. More significantly, advanced systems are beginning to offer bulk payload compression. Bulk payload compression analyzes the traffic, looks for bit patterns, and replaces them with shorter symbols. This technology has been found to offer 50-150 percent throughput improvement. Each of these technologies can be used together to provide overall improved throughput. By combining these features, 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, which would, in turn, incur 3 times the annual spectrum costs, double the tower lease costs, and 2-3 times the CAPEX costs.

The above spectral efficiency techniques can also improve total cost of ownership on existing and lower capacity links. For example, 200-250Mbps can be delivered in a single 14 MHz channel with these new features versus a 28-56MHz channel that would currently be used. This can provide a 50-75 percent decrease in the recurring annual spectrum costs. The two figures below show the total cost of ownership benefits of the 14 MHz scenario and 28 MHz scenario, assuming a spectrum cost of $1500/year. As shown, the 14 MHz case provides a 50 percent total cost benefit for improved spectral efficiency and, in the 28 MHz case, there is close to a 60 percent total cost benefit through increased spectral efficiency.





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

The challenge with MIMO 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 provides a very difficult challenge 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 the radios and antennas. This combination of factors and deployment challenges make it very 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.

A fourth spectral efficiency technique that is often discussed is XPIC. XPIC allows the microwave system 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. In addition, each polarization of a frequency channel is typically billed separately by the telecom regulator, so there is no spectrum cost savings. Where XPIC can be useful in a network is 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.

With spectrum costs representing a large portion of total backhaul network costs, it is clear more spectrally efficient technologies are crucial to scaling network cost effectively. The cases above all assume that for existing technologies more spectrum could be available to scale. In reality, many operators are restricted by the amount of spectrum available. So, without improved spectral efficiency, and with limited scalability, they may instead see negative impacts on service revenue. High order modulation and compression will be key technologies to delivering this spectral efficiency. Although MIMO and XPIC can also be useful on special network scenarios, they are much more difficult to be deployed on a network wide basis.

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