E-band Grows Up

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When E-band radios (those operating in the 80 GHz band) were first introduced they were simple, “brute force” devices that had few features, yet were the only real way to achieve Gbps speeds over a microwave link. Due to the technology limitations, these radios were also limited to very simple modulation schemes that resulted in very poor spectral efficiency. Although, at the time, spectrum in the 80 GHz range was plentiful and almost completely un-used, spectral efficiency wasn’t such an important consideration. That said, history has shown that many natural resources once thought to be effectively unlimited often prove to be quite finite as more and more people try to make use of them.

As spectrum allocation became more of an emergent issue, regulatory bodies around the world started to draft rules that encouraged better spectral efficiency, which, in turn, drove the E-band radio makers to move from analog to digital modulation schemes. This also opened up the door to add many of the packet-based features, such as forward error correction, adaptive modulation, QoS, and others that are now commonplace in lower frequency microwave radios. Meanwhile, the capacity of lower frequency radios continued to improve, with the addition of higher order modulation (up to 2048 QAM most recently), the addition of lossless packet compression, statistical multiplexing, multi carrier radios, cross polarization operation (XPIC) and multiple antennas on a single link (MIMO).

The net result of adding all these advancements is that common carrier radios (those operating in the 6 GHz to 42 GHz bands) are now capable of delivering capacities of several Gbps over a link. This increase in capacity does not come without a price, however, as many of these techniques require additional radios (XPIC) and/or antennas (MIMO) which drive up the cost per link.

So if E-band radios are starting to look more and more like the other common carrier radios one has to ask the question: Where does it make sense to use them? Well, even though the E-band spectrum is a finite resource, it is still largely un-populated. Thus, in regions where microwave has been heavily used and the lower frequencies are largely occupied, it is much easier to find an available frequency in the E-band spectrum for new links. It is only as the E-band radios have gained feature parity with the lower frequency radios that operators have begun to consider this option seriously.

Secondly, since there is more spectrum available at E-band, regulators have allocated larger channels in E-band (For example under ETSI regulations there are eighteen 250 MHz channels at E-band vs twenty 56 MHz channels at 38 GHz). This means that at the same level of modulation E-band radios can still deliver more capacity per radio than the lower frequency radios. The larger channel size is countered by the fact that it is more difficult to achieve the higher order of modulation in the E-band radios due to the low noise and linearity performance required.

Another consideration is that, the RF propagation loss increases as the frequency increases. This means that at the same level of modulation, the E-band radios have a much shorter reach than the lower frequency radios. Finally, the E-band spectrum is not available in all markets. Some significant markets, such as India, have yet to finalize the regulations for the use of this spectrum.

The use case is of course different for macrocell backhaul than for small cell backhaul. For macrocell backhaul the reach is probably the most important factor which limits the application. The cell site spacing is driven by the radius of the macrocells and is smaller in dense urban areas and larger in suburban or rural areas. Using 1500 meters as the typical reach of an E-band radio, this would cover less than 20 percent of the link distances in a typical North American metro area design such as Chicago or Atlanta.

Techniques to effectively increase the reach of E-band radios – such as higher power, adaptive modulation and/or frequency, compression – will enable a higher percentage of links to be addressed by the E-band radios. When a mobile operator runs out of available RAN spectrum at a site due to increased user demand, the only options available to further increase the capacity are to split the macro cell or to deploy small cells.

Splitting the macro cells reduces the average cell site spacing, thereby increasing the percentage of links that are addressable by the E-band radios. For outdoor small cells, however, the form factor necessary for deployment on streetlights and lampposts rules out the use of conventional, large parabolic antennas. In fact, regulators in many jurisdictions have placed limitations on the minimum antenna size allowable with E-band radios in an effort to improve the spectral re-use (narrow the beam width to minimize interference between links). This effectively precludes the use of E-band radios in most outdoor small cell deployments. Radios operating under area licensed regulatory regimes (e.g. sub 6 GHz or 24 & 28 GHz in North America) or 60 GHz license exempt radios do not have these antenna restrictions and so are currently a better fit for small cell backhaul. As regulations evolve, this picture may change.

The next generation of E-band radios soon to be available from microwave vendors won't resemble the early product offerings of yesteryear. They are much closer to feature parity with the lower frequency radios, are better integrated into the overall network management paradigm, and offer much better spectral efficiency. As a result, they are much more likely to be broadly deployed and move from being a niche product to one given greater consideration in a number of different deployment scenarios. Of course, contrary to some early predictions, E-band radios will not take over the world, but will rather take their place among the lower frequency radios in mobile operators' toolkits.

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