FierceWireless

The high and wide future of radio

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Untethered is better. We love our smartphones, tablets, Bluetooth headsets, wireless keyboards and mice, wireless speakers, and ever more gadgets that connect us to work, family, friends, entertainment, and emerging applications in areas such as health, education, and energy consumption. With 4G offering fantastic performance, many users are cutting the cord to their wired broadband connection, electing for one monthly broadband bill instead of two.

The reality, however, is that today's wireless broadband networks have a small fraction of the capacity that wired broadband can deliver and this can and will suppress consumer usage and demand unless wireless providers can resolve their capacity constraints. Engineers expect that wireless capacity will expand greatly in the years ahead as Washington pumps more spectrum into the pipeline and the industry deploys LTE-Advanced, develops and eventually deploys 5G cellular, and takes full advantage of the huge capacity gains offered at higher frequencies. By next decade, wireless capacity should be inching up on wireline capacity.

The vision of all broadband over wireless is still somewhat foggy but not theoretically impossible. We can imagine the likely architectures and how spectrum will be used in order for this vision to become real. According to Mobile World Congress announcements in Barcelona last week, we don't know exactly what 5G is, but given the stated objectives of increasing capacity by a 1000 times and supporting throughputs of more than 10 Gbps, we can envision how we might arrive at this network of the all-wireless future.

Let's review a few basics. Network capacity in a coverage area is determined by the number of cells, the spectrum available in each cell, and the spectral efficiency of the technology being deployed. The network of the future will be much denser with far more cells, but as important, it will exploit much wider swaths of spectrum. In particular, mmWave frequencies of 30 GHz and higher are likely to play a crucial role—for three reasons. First, technology advances are allowing practical implementation of radios at these frequencies. Second, the higher frequencies, due to their short wavelengths, permit much higher order MIMO, resulting in higher spectral efficiency. Third and most significant, there's simply much more spectrum available.

Various 5G groups are researching next generation wireless architecture and requirements, including the European Union's 5G Infrastructure Public-Private-Partnership, the METIS Consortium (Mobile and wireless communications Enablers for the Twenty-twenty Information Society, and Next Generation Mobile Networks (NGMN). NGMN plans a detailed paper by the end of 2014 outlining requirements for technology that could potentially be deployed by 2020.

These groups have not announced any particular technical approach, but a good place to look at technology directions, particularly for high frequencies, is IEEE Wi-Fi standardization, since Wi-Fi technologies have consistently implemented advances ahead of cellular. For example, the recently completed IEEE 802.11ad , "Amendment 3: Enhancements for Very High Throughput in the 60 GHz Band," adapts 802.11 to operate in unlicensed frequencies at 60 GHz. Problems at 60 GHz are not trivial: high free space loss, higher losses through materials including human bodies, and at 60 GHz in particular, oxygen absorption of radio energy, complicating longer-range transmissions.

The reward, however, is much more spectrum to work with: 7 GHz of spectrum at 60 GHz, which is reasonably well harmonized globally and more than ten times all of allocated cellular spectrum. IEEE 802.11ad uses 2.16 GHz channel spacing to deliver 7 Gbps of throughput in a simple antenna configuration and a whopping 28 Gbps with 4X4 MIMO. LTE-Advanced, in comparison, uses 20 MHz radio channels, which the network can aggregate up to 100 MHz. 5G radios operating in mmWave frequencies will likely use bandwidths of at least 1 GHz.

In the U.S., other mmW bands include 71-76 GHz and 81-86 GHz for license-light operation based on FCC Part 101 regulations and 92-95 GHz for unlicensed indoor applications based on FCC Part 15.257 regulations. As industry expands into mmWave, additional bands may become available, such as 102-109.5 GHz.

High frequencies will not displace lower frequencies, which still provide great propagation; however, high frequencies will provide the capacity overlay. Using maturing HetNet and carrier-aggregation approaches, as well as emerging virtualization architectures, future networks will use a blend of frequencies, with high frequencies employed wherever there are high concentrations of people or demand, and lower frequencies deployed where there are not.

Specifically, UHF (600 and 700 MHz) and cellular (850 MHz) frequencies provide lower-density coverage, augmented by smaller-cells providing greater capacity built on: AWS (1.7 GH), PCS (1.9 GHz), and BRS (2.5 GHz). Beyond those bands, the forthcoming small-cell band at 3.5 GHz based on spectrum sharing, which is still in the FCC Notice of Proposed Rulemaking stage, will also play an important role in the second half of this decade. And let's not forget about unlicensed bands in which Wi-Fi offload will continue to play an important role for offload. Or if 3GPP develops a proposed unlicensed version of LTE, LTE itself will expand into unlicensed bands.

Eventually though, mmWave bands are the most likely frontier to deliver the next huge leap in capacity and throughput, and certainly the best candidates for the 10 Gbps and higher throughputs that our applications will inevitably demand.

See this Rysavy Research infographic for an overview of the role different frequencies will play.

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