The Wireless Data Demand: Technology and Spectrum Implications

Edward G. Tiedemann, Jr.
Senior Vice-President, Engineering
Qualcomm Fellow
Qualcomm Technologies Incorporated

Silicon Flatirons Conference
Looking Back to Look Forward: The Next Ten Years of Spectrum Policy
November 13, 2012

As a result of peak network data rates that are now in the megabits, low transaction delays, user interfaces that are easy and fun to use, good high level operating systems, tablet and ereader devices, large application community ecosystems, and the overall maturing of content for mobile devices, data usage has been skyrocketing. The general population now finds mobile data to be an integral part of their lives.

The most recent CTIA semi-annual data survey shows more than 100% year-over-year growth in the amount of mobile data traffic (bytes) handled. The current domestic traffic is more than 633 billion Mbytes over a six month period ending in June 2012. To put it into a slightly different perspective, every person in the US is receiving more than 11 Mbytes/day. The well respected Cisco Global Mobile Traffic Data Forecast, 2011-2016, is predicting a 75% compound annual growth rate for North America. Their forecast would lead to every person in the US receiving more than 200 Mbytes/day in 2016, almost a 20 times increase in just four years. Based upon traffic growth rates in wired systems, there is no indication that this rate would slow down past 2016.

As a result of this massive growth, Qualcomm embarked on the "1000x challenge" to increase the practical capacity of wireless networks by 1000 times. To succeed, efforts will have to be made in multiple dimensions including basic technology enhancements, further network buildouts, and making additional spectrum resources available. These efforts will take a considerable amount of time and money, and will require significant amounts of research and development. Qualcomm alone spent more than $3.5 billion on R&D in the last year.

Since the mid 2000's, the basic communications capacity of an air interface per antenna has not increased substantially. Techniques such as good power control, adaptive scheduling, and multipath mitigation, which previously brought us enormous strides in capacity, are close to the limit. Qualcomm has demonstrated some capacity enhancements by assigning users to a more lightly loaded adjacent cell from a heavily loaded cell. The use of additional antennas through techniques such as MIMO can increase capacity; however, the number of antennas that can be put on a small portable device is limited. Space limitations and zoning restrictions cause significant problems in adding antennas for macro cellular base stations, the traditional cells where antennas are on towers or on the sides of buildings. Furthermore, the capacity gains from MIMO are limited when cells are dense, due to the low signal-to-noise ratio in much of the cell.

Zoning restrictions, the cost and time to obtain permits, and the cost of physical space for housing equipment and antennas make large increases in the number of these macro cells impractical. Advanced ASICs, integrated RF, and low transmit power allows us to build really compact cells, which have volumes of only a few cubic inches. These small cells can be placed almost anywhere that very high speed connectivity to the network can be provided. The first generation of these small cells were femto cells which were deployed in homes and enterprises to enhance coverage and provide greater capacity. These femto cells were generally not closely integrated into the overall cellular network, which made handoff between them and the regular cellular network challenging. Small cells are evolving so that they will be well integrated into the cellular network. Our vision is that small cells should be able to plugged into a 110 volt power receptacle and connected into a high speed network, such as EPON (Ethernet Passive Optical Network). The device and network will be able to self-configure as in a plug-and-play peripheral for a computer.

While small cells can be used in any frequency band, they are particularly suited for high frequency bands such as 3.5 GHz where the antennas can be both compact and efficient (a ½ wavelength antenna is about 1.6" long). Since the propagation loss of going through a wall at 3.5 GHz is high, this band is well suited for deploying a large number of small, self-configurable, indoor cells.

In addition, these low-power small-cell deployments can co-exist well with incumbents in the 3.5 GHz band, such as radars along our coasts. For this reason, it is a very positive step that the FCC will be moving forward with a proposal to reallocate 3550 to 3650 MHz as a dedicated band for small cells.

For a number of years, Qualcomm and some of its industry partners have been developing a concept called Authorized Shared Access (ASA) which allows spectrum to be shared with licensed users. The first choice for new spectrum is to clear it of incumbents and allocate (auction) the spectrum by a certain date. However, there are many bands where incumbents cannot be moved. Furthermore, these bands may be underutilized in certain regions, at certain times, or on certain frequencies. ASA creates exclusive rights in a shared band, subject to the rights of the incumbents. By providing exclusive rights to the ASA user, this provides predictability so that operators and users can plan their investments and have a level of assurance that they will be able to maintain a desired quality of experience. Depending upon the rights maintained by the incumbents, they can manage access in geographic sub regions, manage time of usage, and can quickly reclaim use of the spectrum in emergency situations.

Since the spectrum used by the current cellular operators is fragmented (some operators have four different allocations), the data rate from any allocation is limited. The standards bodies have developed carrier aggregation, a concept which allows a handset to simultaneously operate on multiple bands. While providing the potential for significantly high data rates, there are practical limits in the amount of aggregation due to intermodulation issues in receivers and transmitters, power consumption, the cell coverage being different between bands, and the additional components that are required. Thus, allocations of large contiguous blocks of spectrum should be a future objective. Until the advent of 4G, there were essentially five bands used for cellular worldwide. The lack of spectrum harmonization has now significantly increased the number of bands (3GPP has defined 37 bands in which LTE can operate). All major worldwide cellular bands cannot be practically supported in a handset. As a result, more models are required, thus increasing the complexity and the time to design and test handsets, which results in higher costs. Thus, attempts should be made to identify spectrum on a worldwide basis, even if the allocation can only be used in some geographic areas or through ASA techniques.

In addition to clearing and allocating spectrum in the traditional manner and allocating the 3.5 GHz band, releasing 195 MHz of spectrum in the 5 GHz band, which was identified by the Payroll Tax Cut legislation, will allow the latest generation WiFi air interface, 802.11ac, to reach its full potential. The 802.11ac specification supports bandwidths of up to 160 MHz and supports multiple antenna techniques for increased rates and range. In spite of the potential for increased range, coverage at 5 GHz is quite limited.

There is insufficient bandwidth in our existing bands to support the envisioned peak data rates for many services, such as streaming video and video download, which are becoming common on cellular networks. With larger screen sizes on devices, such as tablets, there is demand for higher resolution video. While the HEVC/H.265 video codec will be a significant step forward by being able to reduce the bit rates for streaming data by somewhat more than a factor of two compared to the AVC/H.264 codec, this needs to kept in perspective to the expected 25 fold increase (2011 to 2016) in video traffic predicted by Cisco.

In summary, to meet this tremendous traffic growth, all of our capacity enhancing tools will be required: new technologies, denser deployments, and rational allocation of additional spectrum.