Tech Insights - The Case for Boosting User Equipment Performance

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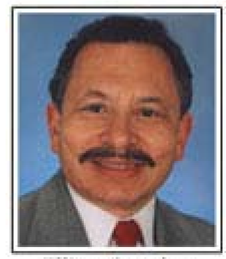
Common wisdom says carriers need to bump up network capacity to improve data services, but another cost-effective move they can make right now involves increasing the radio performance of user equipment.

According to conventional wisdom, the largest challenge facing wireless network operators in coming years will be expanding the capacity of 3G and 4G data networks to meet anticipated explosive growth in traffic volumes.



Elliott Drucker

I often take a contrarian view when it comes to industry CW, but in this case I believe it's dead on, even though carriers appear to be moving toward usage-based service pricing. Readers who expect a bit of controversy in these columns need not fear, however, because I part ways with the consensus when it comes to the priorities carriers are applying to address the pending capacity crunch.

It's not that current capacity enhancement initiatives aren't important. Network upgrades, though costly, are an ever-present necessity. Deployment of 4G promises a more efficient air interface, at least for data. Developments of technologies like MIMO and smart antennas offer additional hope for improved spectrum efficiency. And in the longer term, we look for more spectrum being made available for broadband. These are all prudent and necessary measures, but in my opinion the most cost-effective, lowest risk effort carriers could undertake right now to improve their data services would be to increase the radio performance of user equipment (UE). That performance is generally defined by published industry standards, which most carriers rely upon for their specifications to UE suppliers. But there is nothing that prevents carriers from specifying better UE radio performance, and there are ample reasons for them to consider doing so.

What I am talking about here are two specific types of UE: smartphones that run Web browsers and data applications; and "air card" modems that provide wireless Internet access to portable computers. Together, these types of UE account for the vast majority of traffic on wireless data networks. Their radio performance – both receive and transmit – is crucial not only to their users' QoE but to performance of the network in which they operate.

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How can UE radio performance be so important? It all relates to the operation of wireless data networks. First of all, we must understand that the data speed (in bits/second) that can be supported on a radio channel between a serving base station and a particular UE is utterly dependent upon the quality of that channel. More specifically, throughput speed is governed by the signal-to-(noise + interference) ratio (SNR) at the receiver. It doesn't matter what the theoretical "up to" speed is for the channel – that will only be achieved when the UE and serving base station are in close proximity, and usually in line-of-sight. Under more typical circumstances, SNR will be lower and consequently so will throughput speed.

Another factor we have to consider is that the throughput capacity of a channel in the network – that is, a given RF channel in a given sector of a given base station, likewise has little to do with theoretical "up to" speeds but is instead a composite average of the speeds that can be supported for the UEs that it serves. This seems pretty obvious: If we could somehow double the average throughput for each of the UEs the channel serves at full capacity, the channel's capacity would also be doubled. Roughly speaking, such a doubling of throughput speed for each UE would require a 3 dB increase in its SNR.

So, both individual throughput speeds and channel throughput capacities are dependent on the SNR of radio channels between UEs and base stations. How can we go about increasing all those SNRs? If a network is interference limited, increasing average SNR requires lowering path loss for desired signals and/or increasing it for interfering signals. But today's 3G networks are mostly noise limited, so increasing SNR for a given path loss requires increasing either transmit power or receiver sensitivity.

On the forward (downlink) channel, we could boost maximum available base station transmit power, but doing so on a network-wide basis would be a huge and costly undertaking. Alternatively, we could improve the receiver sensitivity of UEs operating on the network. Sensitivity is inversely proportional to a receiver's noise figure (NF). Industry standards for 3G UEs allow NFs of around 7–9 dB, which is really very modest. Achieving a 2 or 3 dB reduction in NF might incur a modest per-unit cost, but it should result in a big increase in average downlink throughputs.

Base station receiver sensitivity is already pretty good, so improving uplink performance will probably require boosting maximum UE transmitter power. That maximum power is defined by 3G air interface standards, but there is a lot of "slop" in the specification. For example, HSPA smartphones and data cards are generally "Class 3" UEs, which have a nominal maximum transmit power of +24 dBm. However, there is a +1/-3 dB tolerance to that specification, and UEs are allowed to "back off" by several more dB when operating at the highest modulation levels.

Design of UE transmitters is a tricky business. To operate at the highest modulation levels defined for 3G air interfaces, power amplifiers must maintain high linearity, which generally means low efficiency. Constraints on cost and battery life push designs to the lowest allowable output power levels, so maximum UE transmit power will almost always be near the bottom of what the specifications allow.

It seems, therefore, that actual maximum UE transmit power could be increased by several dB and still remain well within specified limits. This would certainly improve uplink throughput performance, but is it technically and economically practical? Based upon laboratory and field trials, it appears that a new technology from Quantance can in fact allow UE power amps to operate with very high linearity and much improved efficiency, providing higher average uplink speeds and improved battery life. What's more, the technology resides on a single, low cost chip that can be integrated into existing designs that use common UE chipsets, without changes to protocol stack software.

Quantance claims that its technology increases average maximum UE transmit power by more than 2 dB, with a corresponding increase in average uplink data speeds, while actually reducing battery drain. It also claims that implementation on a large scale basis would have a very modest per-device cost and should actually reduce costs for some multi-band capable UEs.

So it appears that, for a modest per-unit cost, carriers could obtain UEs that would boost data performance for both individual users and their networks as a whole. My guess is that customers would gladly pay a bit more for "high performance" smartphones and data cards, but even if a carrier had to eat the added cost as part of the traditional equipment subsidy, it would most likely be worth it. The capital and operational costs of achieving comparable performance improvements through network upgrades would almost certainly be much higher.

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