The folly of attempting to future-proof broadband

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Policy makers are advocating a new broadband definition with symmetrical down/up speeds of 100 Mbit/s, as advanced in a March letter from the U.S. Senate to the FCC. As part of the American Rescue Plan to address broadband for underserved areas, the U.S. Department of the Treasury echoed this definition, additionally stating that recipients of federal funding for broadband are "encouraged to pursue fiber optic investments." This broadband definition with a fiber emphasis, while sounding sensible on the surface, is misguided, and will perversely result in fewer Americans receiving the broadband connection they need.

To begin with, the 100/100Mbit/s definition does not match market needs. Broadband usage today is completely asymmetrical, with more than ten to one greater downlink than uplink consumption, which might become five to one (but not until 2025) with increased use of applications such as video conferencing, telelearning and telemedicine.

Most applications need a lower uplink speed than downlink speed. Streaming applications, which account for most broadband usage, require 5 Mbit/s to 25 Mbit/s on the downlink with almost no uplink consumption. Games require 3 Mbit/s to 10 Mbit/s on the downlink but just 1 Mbit/s on the uplink. Video conferencing applications, such as Zoom, need a similar amount of speed for both downlink (3.8 Mbit/s) and uplink (3.0 Mbit/s), but the uplink amount is a small fraction of the proposed 100Mbit/s definition. Moreover, conferencing applications consume less than 5% of total consumer traffic. The pandemic did increase broadband consumption but did not change this fundamental downlink versus uplink relationship. In fact, regardless of pandemics, typical *consumers* (noting that we don't call users producers) are likely to consume more data than they generate for the rest of the decade, and perhaps forever.

Demanding symmetrical speeds will result in massive over-engineering of many networks, hugely increasing their cost with no resulting benefit. This is especially true with 5G. In most wireless networks, 5G included, uplink spectral efficiency (bits per second relative to amount of spectrum used) is about half of downlink spectral efficiency. This is due in part to subscriber devices, whether modems or phones, transmitting at much lower power than base stations. Additionally, the multiple subscriber devices in a coverage area have to negotiate with the base station for uplink transmissions, resulting in unavoidable communications overhead.

All other things being equal, greater speed requires more spectrum. For wireless networks, in which spectrum is already a scarce and precious commodity, more spectrum for uplink translates to less spectrum for downlink. This is especially true in 5G networks operating in mid-band or mmWave frequencies, the bands best positioned for addressing the digital divide. In these bands, the downlink and uplink use the same radio channel, but transmissions are divided in time using an approach called time division duplex (TDD). For example, a typical network operator might use a time division TDD ratio of 3 to 1 for downlink versus uplink. With a 100 MHz radio channel, 75 MHz would effectively be available for the downlink, with 25 MHz for the uplink.

If forced to provide symmetrical service, the operator would need to consider a TDD ratio of 1 to 1, resulting in effective downlink capacity of 50 MHz and uplink capacity of 50 MHz. This configuration would have the adverse consequence of a 33% loss in downlink capacity. Since the much higher downlink demand drives network scaling, an operator would need 33% more spectrum to accommodate the change. If such spectrum is not available, the operator would have to build 33% more cell sites to augment capacity.

In reality, the situation is even worse than this due to the aforementioned lower spectral efficiency for the uplink. A symmetrical speed requirement could absurdly mean more spectrum would be needed for the uplink than downlink, demanding even more spectrum or significantly more sites, along with procurement, zoning, backhaul, power and other cost factors. The symmetrical broadband definition thus undermines 5G as a solution to address the digital divide. This overdesign is completely unnecessary; operators will be building networks with full downlink pipes and empty uplink pipes.

This situation is not unique to wireless. In most cable broadband systems, coaxial cable spectrum is also divided between downstream and upstream traffic, and all of the same issues and higher cost consequences apply.

A more realistic solution is to set a broadband standard in which the uplink speed relative to downlink speed is representative of what the market needs based on prevailing and expected future applications. Perhaps this standard will change every three years, but at least under this model, networks can address the exact market demand. Even better, operators can easily adjust the TDD ratio in 5G networks, meaning these networks can adapt to market demand.

Only with fiber-optic connections are symmetrical connections practical, but that doesn't make fiber the best choice for every connection. All networks are based on fiber, and all broadband improvements necessitate deploying fiber ever closer to the end user. The huge cost of fiber, $20,000 per mile by some estimates, means that having fiber reach every end point would be astronomically expensive. The proper engineering approach is to establish the maximum practical reach of fiber for different scenarios, which in some cases is to the end point, but in many other cases is near the end point. An alternate technology, such as coax or wireless, can then span the last 10 km, 1 km or 0.1 km.

In contrast, mandating fiber to every location in the United States is like demanding that every house have direct access from its driveway to a freeway. According to the Wireless ISP Association (WISPA), in rural environments, a wireless connection costs a small percentage of a fiber connection.

The Senate letter states, "There is no reason federal funding to rural areas should not support the type of speeds used by households in typical well-served urban and suburban areas." This ignores the reality that providing almost any infrastructure to low population densities is more expensive than higher densities, a reason why cities exist in the first place.

Policy makers should not be advocating specific technologies over others. Yes, the government should promote and facilitate expansion of fiber, which is essential to every broadband technology, but they should leave it to local broadband expertise to decide which technology is most cost effective to actually connect a given farmhouse.

Finally, the notion that a specific broadband approach will provide futureproofing is simply wrong. A 100/100Mbit/s requirement may meet every application requirement commonly used today, but technologies in their infant states, such as fully-realized virtual reality, able to consume 5 Gbit/s, will already be able to consume fifty times more data than the 100Mbit/s capability. Down the road, full-size holographic communication, at more than 1 Tbps, could exceed the 100Mbit/s capability by a factor of 10,000. Communication technology and application capability will keep expanding rapidly in ways nobody can predict. And as much bandwidth as a fiber optic cable has, it lacks the mobility of a wireless connection. What we need is a realistic and flexible approach, embracing all possibilities.

At a time when providing broadband everywhere is a huge priority, the government should not mandate unneeded requirements and rigid technology approaches that make it both more difficult and much more expensive to achieve this goal.

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