

**FCC Public *En Banc* Hearing at Carnegie Mellon University  
July 21, 2008**

Testimony by *Rahul Tongia, Ph.D.*  
(<http://www.cs.cmu.edu/~rtongia>)

*COVER SLIDE*

Good evening. I'm delighted to be here to talk about issues of broadband and the digital divide, an area of research specialization. I just left a place where connectivity is not the primary concern -- the hospital. They've recently started free WiFi service for patients and their families, and I observed that even though it isn't used by everyone, when it is used, it's very useful. My wife and I just had twins, and so if I'm sleepier or even less coherent than usual, I have a good excuse.

My work is global in its scope, but I've also focused on the digital divide in the US as well. One of many lessons I learned is that the digital divide is a moving target. It's not sufficient just to be online; the locations, times, applications, and, of course, the speeds matter. The US has done quite well with availability of Internet access, in part due to the near ubiquitous nature of online dial-up availability. But what about broadband?

I won't go into the challenges of measuring broadband access, the reasons for any disparities, or even contentious discussions on what is broadband? I think we will all agree that broadband increasingly important, and it is used for a number of societal functions including education, seeking a job, online commerce and banking, voter information, etc. It's also a great equalizer, being used by those who are geographically near, or those with disabilities. Pew and others have documented how those with broadband have different online habits than those using dial-up or shared access at a library, school, etc.

Intuitively, we can get a sense that as networks grow in size and value, those who are not in the network become further and further behind. However, conventional wisdom and traditional analysis indicates we are overall better off societally. But what about the *individuals* who are excluded? In some work just recently presented, done with Ernest Wilson of USC, I attempted to formalize the study of network exclusion. I will briefly summarize some high-level findings, I believe they are quite disturbing.

*SLIDE 2 – Network Effects Matter*

Metcalf's Law is one of the most famous network laws, which points out that the value of a network doesn't just depend on you, it depends on how many others are part of the network. If you have a phone, you need other people with a phone as well. For such a system, Metcalf's Law can be approximated as saying that the value of a network is proportional to the square of the number of users.

*SLIDE 3 – How do we Measure Disparity?*

There are some corrections or modified Laws based on the type of network (such as linear, for broadcast), social networks, etc. However, Metcalf's Law and all the other Network Laws not only show monotonically increasing value with size, they are all based on network inclusion. Any disparity, which I will argue actually becomes a cost, is simply calculated as the difference between those in the network and those outside, who are assigned a zero value.

Say we have a network with 19 members. Metcalf's Law would imply a value proportional to 361, or, per person,  $361/19 = 19$ . But surely the disparity for those who are excluded is different

whether just one person is excluded, for an applicable population of 20, or whether 81 people are outside the network, out of a population of 100!

*SLIDE 4 – An Exclusion-Based Framing*

We've proposed an alternative exclusion-based framing that takes into account both the growing included network, which may be an inherently superior network such as broadband (or immunized, insured, etc.) as well as the number of people who are excluded.

The included (growing) network matters not only because it gives signals to dynamic processes, (including supply and demand) but complementary networks (like content, software, etc.) will shift towards such a network. Even if you have dial-up, and nothing else changes in terms of number of dial-up subscribers, you'll find content will become increasingly larger, flashier, etc. When we examined a number of leading websites over time, their size has increased between five- and ten-fold in the last few years.

*SLIDE 5 – Exclusion Really Matters as Networks Grow*

In a traditional framing, the individual disparity between included and excluded increases, but is modest (e.g., linear in Metcalfe's Law). When we apply our exclusion based framing, we find that the cost of exclusion begins to look **exponential** as fewer and fewer people remain excluded. To our surprise, we found this is true for any underlying network structure (network law)! You'll see that as a new technology emerges, inclusion confers a competitive advantage to those few who have it. As it becomes widespread, *not having it* is what hurts.

*SLIDE 6 – Exclusion has Societal Costs as well*

Those who are excluded from the "included" network will often resort to alternative or parallel networks. These can be less efficient, more expensive, less environmentally green, etc. If I cannot, say, download a government form of the Web, I might have to write, call, go there in person etc. Going may involve long lines, taking a bus, driving etc. This has implications on time, energy, environment, etc.

One closing but major point based on this is that worrying about exclusion is more important than just for the individuals who are excluded. Because of a number of factors, including alternative and parallel networks that societally we demand be operational, exclusion imposes costs on everyone, included those who are so-called included. The classic example is health insurance, where the uninsured disproportionately end up in emergency rooms, sometimes having skipped less expensive preventative care. Not only are the costs often borne by taxpayers, such cases also delay services for other critical patients.

In telephony networks, our phone system still allows pulse dialing in parallel to touchtone, ostensibly for the very few people who might need it. It may be cheaper to just give them touchtone instruments (?). Similarly, if we consider older operating systems like Windows 98 on computers, they are no longer supported and are unlikely to be patched from a security perspective. It is precisely these machines, which are still online, that are responsible for a very large fraction of the Internet zombies, Trojans, attacks etc.

Will asymmetries and inequalities disappear in society? No, and I'm not advocating uniformity or homogenization of networks. However, broadband might be something so important to society, like roads and electricity, that we need to actively address the 4 A's of the digital divide:

*Awareness, Availability, Accessibility, and Affordability.*

Thank you.

[For further information, please see my website <http://www.cs.cmu.edu/~rtongia>

Available are [further comments](#) on the hearing, personal reactions, and in-depth presentations and publications on network exclusion].