Attachment D

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State of Tennessee
Considerations and Best Practices for Statewide Broadband Initiatives

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Introduction: Solving the Digital Divide for our Communities

Our world is changing, and it is doing so rapidly. Technology is impacting every part and parcel of our lives -- from where and how we conduct work, to whether or not we thrive economically and socially. It has impacted the way we live, our entertainment, our culture, the way government services are provided and accessed, the way healthcare is being delivered, and the way we educate our children and provide education to better improve our workforce. With the introduction and accelerated advancement of technologies, having access to affordable and abundant broadband is quickly becoming the most critical infrastructure of our time, just like electricity and transportation were in the early 1900's. Advanced broadband infrastructure has the potential to create more jobs, increase a community's competitive ability globally, create new technologies, increase opportunities for a region's companies, enhance public safety, provide better and less expensive healthcare, and provide greater educational opportunities throughout the State. In a recent report produced by the Brookings Institute in May 2014, fiber was added as a critical infrastructure.[1]

Advanced broadband networks are creating seismic changes in local, state, national and global societies, as well as markets, business and in institutions around the world. Access to social media and the Internet has shifted governments, threatened national and local boundaries, inspired revolutions, and has changed us culturally. The Internet and its associated technologies have impacted wealth, work, education, government, health, public safety, and education. Having equal access to advanced broadband networks bridges the digital divide and creates better equality between the haves and the have-nots.

Like the introduction of electricity, advanced broadband networks are fundamentally changing our world in ways that were not expected or anticipated. Much like electricity, advanced broadband networks are the enabling technology in which all things are impacted. Electricity was invented to turn on the lights, but empowered, literally, the transformation to an industrial society. Advanced broadband networks are now the enabling technology to transform us yet again, to a global technology and information society: the new Knowledge Economy. The term "Knowledge Economy" refers to an interconnected, globalized economy where knowledge, trade secrets, expertise, and sharing ideas are as critical as other economic resource

Just as it was impossible to know in advance the impact that electrification would have on the critical infrastructure to power all of our modern appliances, computers, health monitoring systems, manufacturing facilities, computers, radio and television, and financial markets; so too, it is impossible to predict the impact and reach of advanced broadband networks. We do not yet know the far-reaching impacts that the Internet will have on our lives and on generations to come.

[1] *Beyond Shovel Ready: The Extent and Impact of U.S. Infrastructure Jobs*, Brookings Institution, May 2014, http://www.brookings.edu/research/interactives/2014/infrastructure-jobs#/M10420

Speed Matters.

Bandwidth refers to the capacity, or speed of the networks to carry traffic. The question is often presented, "How fast is fast enough?" and "What should be the definition of broadband?" In February of 2015, the FCC increased the definition of broadband by raising the minimum download speeds needed from 4 Mbps to 25 Mbps and the minimum upload speed from 1 Mbps to 3 Mbps[2]. Meanwhile, the FCC's Connect America Fund[3] is eligible for areas that do not currently have 10/1 services AND does not require build outs of more than 10/1 service. In essence, while the FCC is saying broadband is defined as 25/3, they are funding "broadband build" projects at 10/1. Given the growth trends in bandwidth needs and network traffic, questions exist about whether this newest definition will be sustainable in meeting future bandwidth needs.

Global network traffic has quadrupled from 2009 to 2014. Both commercial and residential Internet bandwidth consumption are doubling every year.

In the early days of the Internet, driven largely by non-bandwidth intensive text messaging, email and websites, the average consumer did not need extensive bandwidth. Universities, financial institutions and business enterprises drove the applications that required higher amounts of bandwidth.

Early Internet Days….Universities, Finance, Enterprise

Application	Rate
Personal communications	300 to 9,600 bits/second or higher
E-mail transmissions	2,400 to 9,600 bits/second or higher
Remote control programs	9,600 bits/second to 56 kbits/second
Digitized voice phone calls	64,000 bits/second
Database text query	Up to 1 Mbps
Digial audio	1 to 2 Mbps
Access images	1 to 8 Mbps
Compressed video	2 to 10 Mbps
Medical transmissions	Up to 50 Mbps
Document imaging	10 to 100 Mbps
Scientific imaging	Up to 1 Gbps
Full-motion video	1 to 2 Gbps

[2] *FCC's 2015 Broadband Progress Report* https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-10A1.pdf
[3] Connect America Fund, https://www.fcc.gov/general/connect-america-fund-caf

When YouTube burst upon the scene in 2005, this dramatically changed things. Consumers, small businesses and residential users started to also drive Internet bandwidth demand. One video download was the equivalent of downloading 30,000 web pages. Since that time, videos and picture-rich content have been downloaded and uploaded on a regular basis by the masses. The applications we use on the Internet are becoming much more feature-rich and bandwidth intensive, and our existing networks cannot keep up with the demand for networks that support these applications.

The Fiber to the Home Council (FTTH) stated its position clearly in a brief to the FCC. "Even today, with most users still operating on last-generation broadband technologies, the capabilities of advanced video, cloud-based services, and other bandwidth-intensive applications are growing at a pace beyond what our existing networks are capable. Cisco and other scientific companies talk about the network in terms of "terabytes" of capacity in the network center, or "core."[4] According to the Cisco 2012 Zettabyte Report, businesses today routinely require symmetrical Gigabit service between their locations."[5]

Also referenced in the Cisco 2012 Zettabyte Report, global Internet traffic grew 45 percent during 2009 alone and has doubled every year since then. Both commercial and residential Internet bandwidth consumption are doubling every year, as video, cloud computing, advanced storage solutions, telemedicine, telecommuting, video conferencing, etc., are becoming more prevalent. Applications are becoming more bandwidth intensive and as more devices—tablets, smartphones, computers, appliances—are being used both in the home and for business applications. ***Research conducted by Cisco[6] states by 2016, there will be nearly three Internet Protocol or IP-connected devices per person.*** This prediction seems to be easily met, as of 2013, the number of Internet-enabled devices outnumbered the number of people in the world.[7] The driver of this is not only smart-phones, tablets and computers, but even more so, the Internet of things—predominately wearables (clothing that has an Internet connection) and smart home applications. Additionally, with growth in Internet-connected televisions, radios, set-top boxes, Blu-ray players, Netflix, cameras and picture frames, the number of hours spent viewing entertainment applications online (i.e. movies and TV). Netflix is expected to be the "number one television network in 2016."[8]

With these bandwidth-intensive applications and the number of devices in the home using these applications, the consumer at home uses 74 Mbps to over 3.6 Gbps.

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[4] *America's Petition to the Federal Communications Commission for Rulemaking to Establish a Gigabit Communities Race-to-the-Top Program*, Fiber to the Home Council, July 2013, http://www.ftthcouncil.org/p/cm/ld/fid=47&tid=79&sid=1221

[5] *The Zettabyte Era*, Cisco, May 2012, http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/VNI_Hyperconnectivity_WP.html

[6] *Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2015–2020 White Paper*, February, 2013, http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html

[7] *Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2015–2020 White Paper*, February 2013

[8] *Netflix U.S. Viewing to Surpass ABC, CBS, Fox and NBC by 2016: Analysts*, Variety, June, 2015, http://variety.com/2015/digital/news/netflix-viewing-abc-cbs-fox-nbc-1201527442

Average Residential Bandwidth Needed, Applications 2015			
Service	**Bandwidth Need per Device**	**Number of Devices per Home**	**Internet Bandwidth Usage**
TV	2 to 20 Mbps	3.5	2 to 70 Mbps
DVR	2 to 20 Mbps	2	0
Home Theater	1 to 6 Mbps	1	0
Internet Browsing	1 to 20	1 to 5	1 to 10 Mbps
Printer	.5 to 1 Mbps	1 to 5	0
Digital imaging	1 to 20 Mbps	1 to 3	0
On-line Gamine	.5 to 1 Mbps	1 to 3	.2 to 1 Mbps
Video Capture	.1 to 1 Mbps	1 to 10	.2 to 3 Mbps
Portable Audio	1 to 20 Mbps	1 to 3	0
Video Steaming	10 to 1000 Mbps	3.5	35 to 3500 Mbps
Smart TV	35 Mbps	1	35 Mbps
Total	**54 to 1,163 Mbps**		**74 to 3,619 Mbps**

A home shares bandwidth amongst all the applications that are running at once, so if there are 10 applications running at the same time that each require 10 Mbps download, that home needs 100 Mbps connectivity. The table above illustrates this by showing the bandwidth needed for applications, how many devices are typically present, and the net impact of bandwidth usage.

While smartphones and Netflix are improving quality of life, the Internet's transformational power lies with the economic impact broadband provides a region, from opening up a world of online educational resources to providing businesses with the opportunities to expand their markets and improve efficiencies through ecommerce. Additionally, broadband connectivity is critical to communities looking to implement smart-grid[9] and smart-city[10] applications.

According to FTTH's brief to the FCC referenced above, "the average monthly traffic in 2014 on the Internet has been equivalent to 32 million people streaming Avatar in 3D, continuously for the entire month." The sum of all forms of Internet Protocol (IP) video (Internet video, video on demand, video files exchanged through file sharing, video-streamed gaming, and videoconferencing) was 64% in 2014 and is predicted to be 80 percent by 2019[11]. Applications supported by cloud-based services through multiple devices have created the need for always-on connectivity and advanced broadband network bandwidth.

[9] *Practical Applications of Smart Grid Technologies*, SEL, February 2009, http://www.energycentral.com/reference/whitepapers/103216
[10] *25 Technologies Every Smart City Should Have*, Mashable, December 2012, http://mashable.com/2012/12/26/urban-tech-wish-list/#i8dVC9NPnaqG
[11] *Online Video Will Account for 80 Percent of the World's Internet Traffic by 2019*, Digital Trends, May 2015, http://www.digitaltrends.com/home-theater/online-video-will-dominate-internet-traffic-by-2019/

Although there have been tremendous improvements in wireless communications, and in technologies that beef-up existing cable networks, industry leaders are seeing the need to extend fiber-optic network technologies further and deeper into neighborhoods, business parks and industrial centers. As more devices are connected to the Internet and applications are more bandwidth rich, there is a strong argument that favors more all-fiber connections to homes and businesses. The gold standard for bandwidth capability is quickly becoming offering Gigabit services or speeds that support 1,000 Mbps. With this being said, there is a strong need to also connect mobile and portable users through wireless or Wi-Fi technology and cellular networks also need to be upgraded. In areas where building an all-fiber-optic network is cost-prohibitive, such as rural, mountainous and geographically disperse areas, a combination of technologies, relying on wireless and fiber-optic cable may need to be considered.