Attachment C

Broadband Considerations for Tennessee

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Presentation Overview

- Broadband Benefits
- Broadband…
  Definition, Technologies and Capacities
- Broadband Throughput Comparisons
- Tennessee Broadband Considerations

Broadband…

JICS

Broadband Benefits

- Economic growth
- Job creation
- Job and skills training
- Education: K-12, Higher Ed, Continuing Education; DIY
- Health care delivery, outreach and improvement
- Government and public safety service access
- Industrial and commercial competitiveness
- Knowledge dissemination
- Use of Internet of Things (IoT); Access to applications

Broadband Definition and Factors

- Broadband is high-speed internet service that is always on and ~~faster than dial up service~~ at least 4/1 Mbps[1] (New value of 25/3Mbps by FCC announced Jan 2015[2])
- Important factors for broadband service:

  Network Bandwidth – capacity in bits per second (bps) across all network links between the end user and the application (end-to-end). Consider a highway; capacity is the number of lanes and the data packets are the cars on the highway

  Network Latency - time it takes for a data packet to get from one network point to another usually measured in round trip time (RTT). Affected by distance & congestion

  Throughput – completed end-to-end data transfer

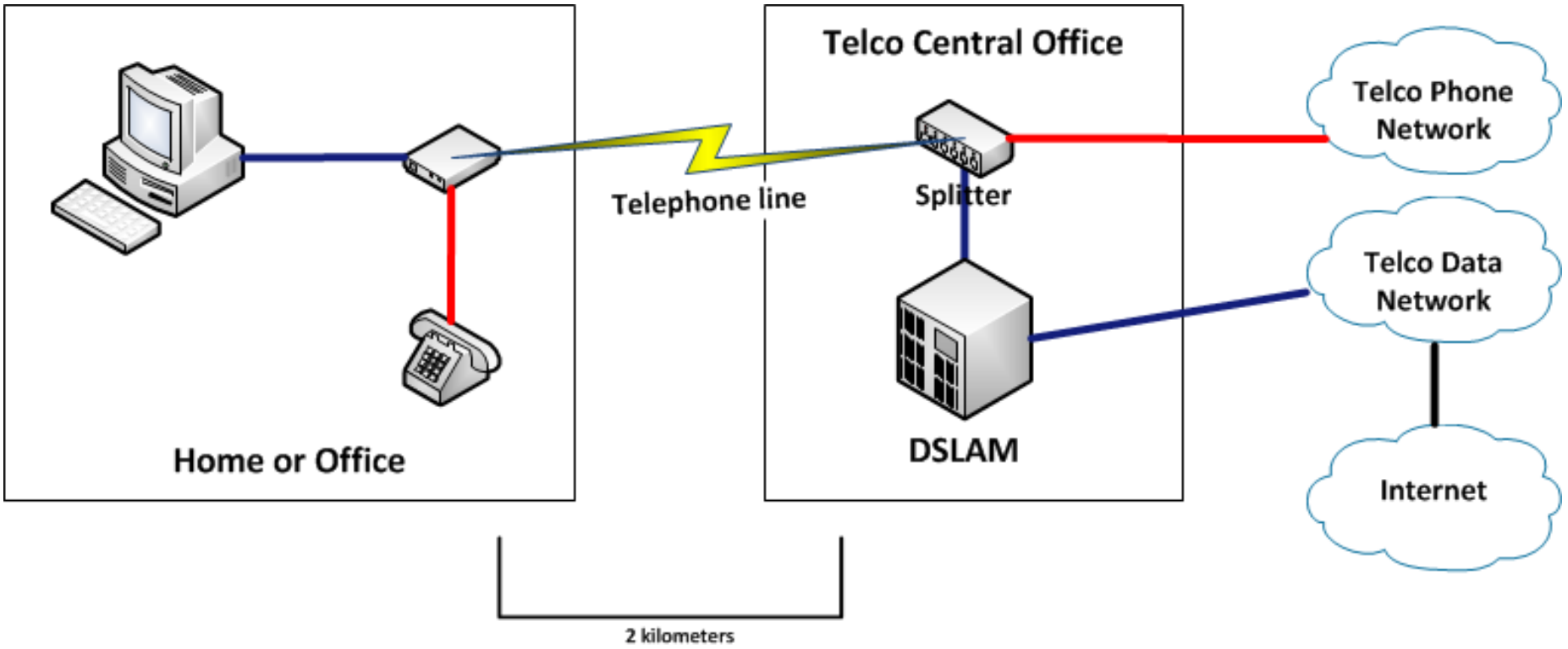
Broadband Capacities (Bandwidth)

Broadband Technologies

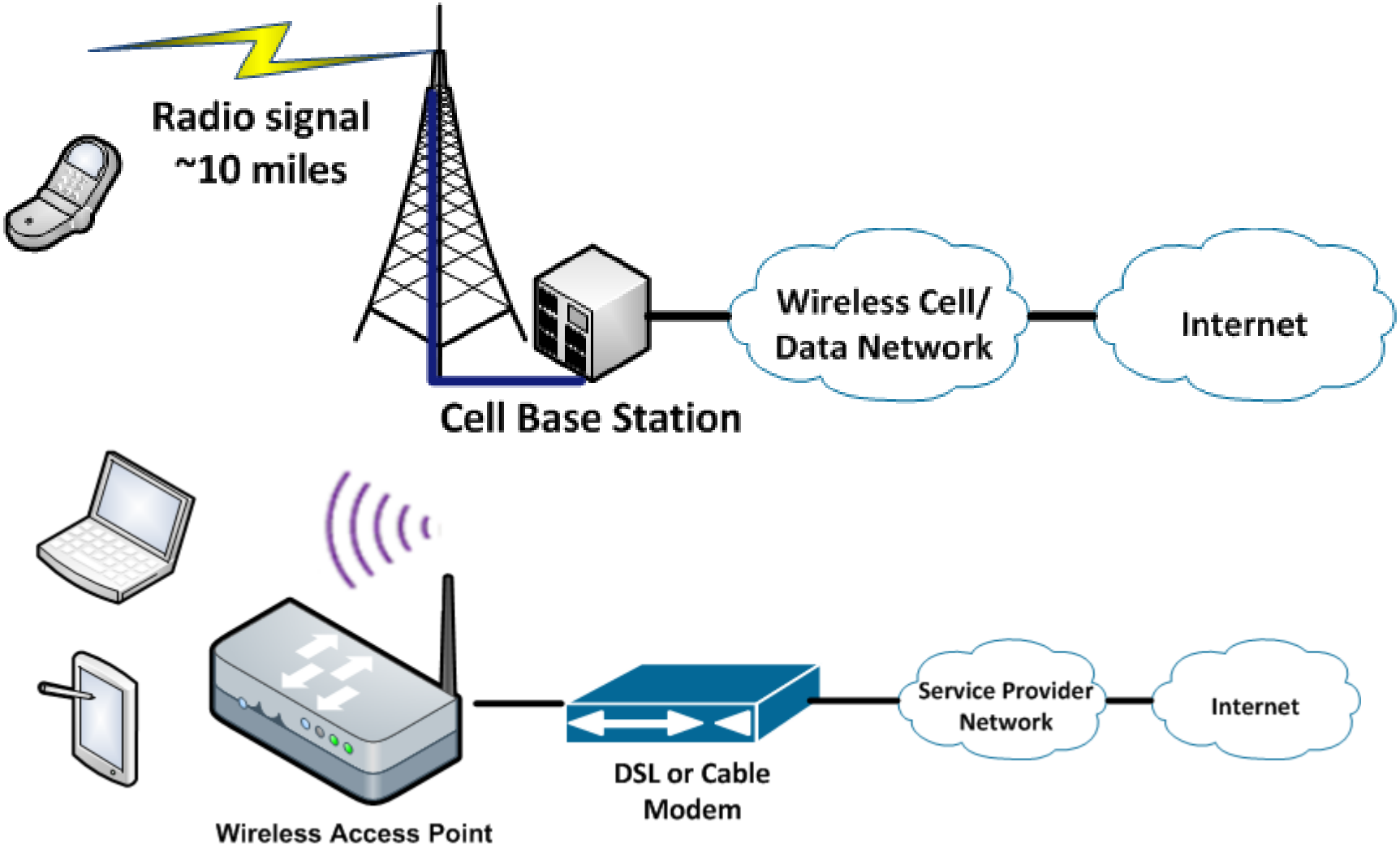
- Types of technologies that provide broadband internet service:

Technology	Bandwidth	Pros	Cons	Example providers
DSL (ADSL)	<=8Mbps (1Gbps '18)[3]	Uses phone lines	2km max	AT&T, Verizon, CenturyLink
Cable Modem	4-250Mbps (1Gbps w/ D3)	DOCSIS 1-3 standard	Must be in service area	Comcast, Charter, Wow!
Fiber	<=1Gbps, 10Gbps++	Highest capacity; 50-240km[4]	Cost of fiber deployment	Google, Level3, EPB
Wireless	4-30+Mbps	Wide area coverage	Dead zones; data fees; Lower capacity	Verizon, T-Mobile
Satellite	5-15Mbps	Wide area coverage	Latency; interruptions	HughesNet

DSL Network


Telco Central Office
Telco Phone Network
Telco Data Network
Internet
Telephone line
Splitter
DSLAM
Home or Office
2 kilometers

Wireless Networks



Note!! Cellular (data) wireless is not the same as WiFi wireless

Cable Network

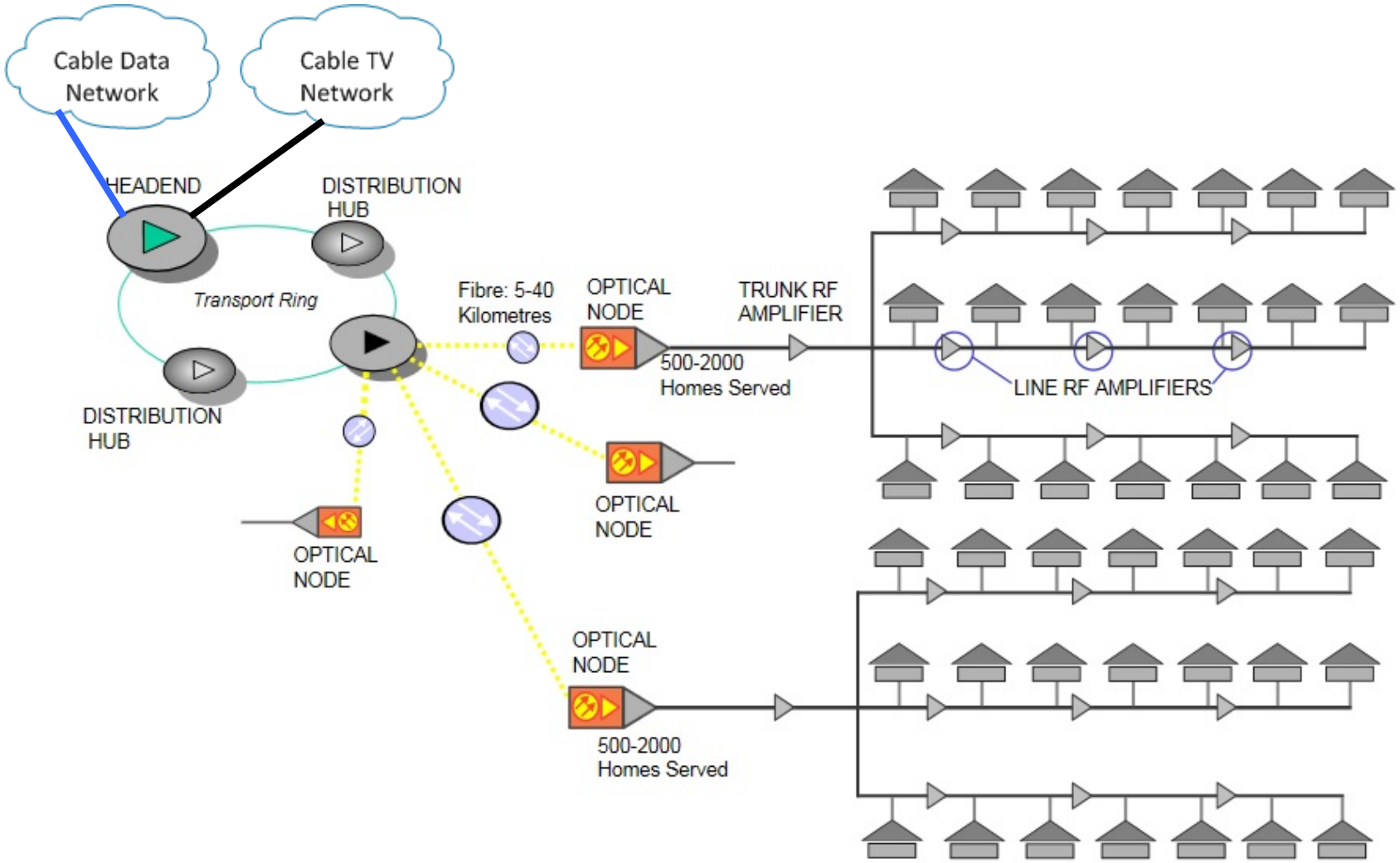
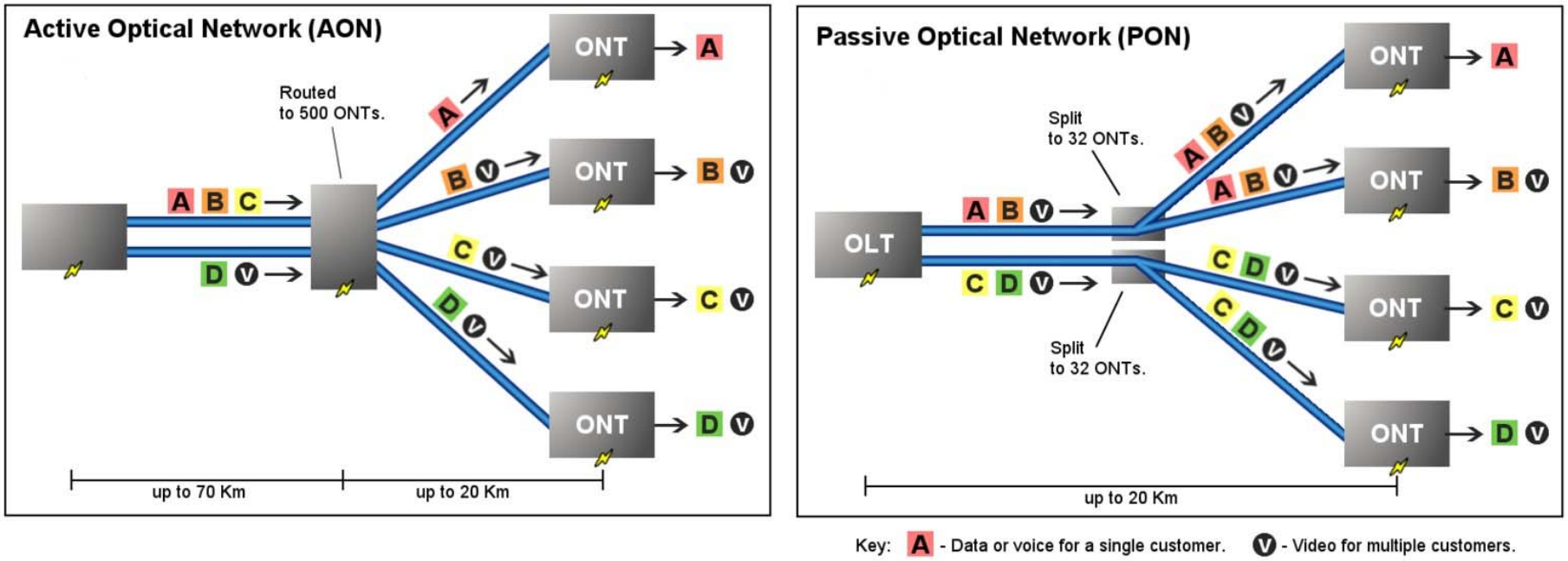


Diagram from Wikipedia “Hybrid Fibre-Coaxial”

Fiber Network



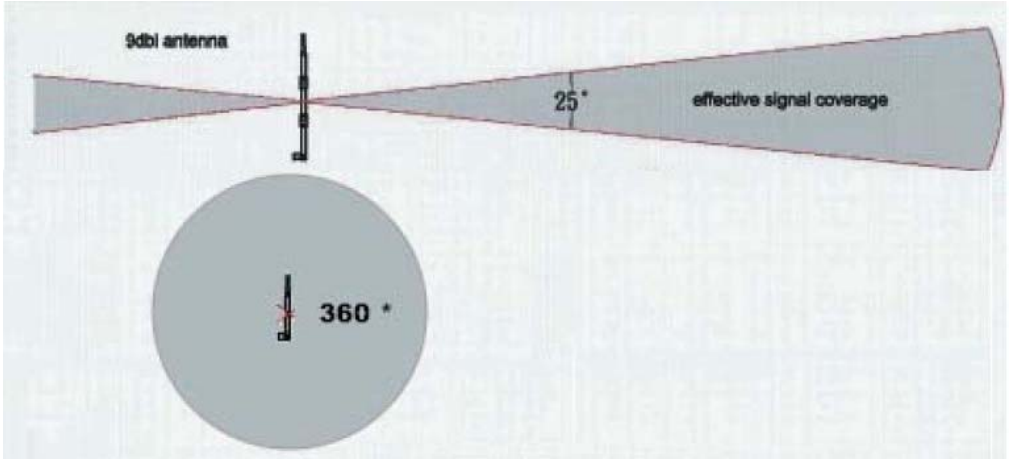
OLT – Optical Line Terminal
ONT – Optical Network Terminal
20 Km = ~12 miles

"PON vs AON" diagram by Riick - Own work.
Licensed under CC BY-SA 3.0 via Commons - https://commons.wikimedia.org/wiki/File:PON_vs_AON.png

Home Fiber ONT

A Note About Home and Farm Networks

- Many homes and farms will want wired connectivity coupled with WiFi access to provide wireless connectivity to the average 4 devices per person, the Internet of Things devices and/or farm equipment
- Be aware that WiFi station antennas can provide long range directional WiFi access to remote devices both stationary and mobile; narrower beam = longer range



Broadband Throughput Comparison

- File size examples

Size	Bytes	Example/Use Cases
Very small	1MB	Email, Email with small attachment, picture or graphic
Small	10MB	Music file, trailer or short video, complete website, hand MRI scan
Medium	100MB	Photo or music album; OS software update; head, cardiac or abdomen PET, MRI or CT scan; streaming video
Large	1GB	1 hour movie or TV show, complete SW distribution, 200 image CT scan; Windows 10 download (3GB)
Very Large	1TB	Audio/movie collection, PC or server backup, individual CT scan collection
Research & Industrial	1PB	Research file collection, hospital or laboratory image collection

Broadband Throughput Comparison

Size	Bytes	5Mbps	20Mbps	100Mpbs	1Gbps	10Gbps	100Gbps
Very small	1MB	**1.6sec**	**<1sec**	**<1sec**	**<1sec**	**<1sec**	**<1sec**
Small	10MB	16sec	**4sec**	**<1sec**	**<1sec**	**<1sec**	**<1sec**
Medium	100MB	2min	40sec	**8sec**	**<1sec**	**<1sec**	**<1sec**
Large	1GB	27min	7min	1.3min	**8sec**	**<1sec**	**<1sec**
Very Large	1TB	18days	4.6days	22hrs	2.2hrs	13.3min	1.3min
Research & Industrial	1PB	50yrs	12.7yrs	2.5yrs	92days	9.2days	22hrs

8 bits = 1 byte
1MB = 1 Megabyte = 10^6 bytes

1GB = 1Gigabyte = 10^9 bytes
1TB = 1Terabyte = 10^{12} bytes
1PB = 1Petabyte = 10^{15} bytes

Broadband Throughput Comparison

- 5 Mbps capacity is acceptable but large files will stretch human capacity to focus/concentrate
- 20 Mbps-1 Gpbs is optimum capacity range to coincide with typical file sizes (that match use cases) with human behavior and ability to focus/concentrate on a task or topic
- 1 Gbps would be an optimum capacity for a 10 year Tennessee Broadband Vision or Plan as this capacity is not widely available and coincides with file sizes of typical use cases and human behavior timeframes for ability to concentrate/focus on a task or topic

Broadband Vision or Plan Considerations

- Implementing broadband for all Tennesseans is at the intersections of six factors: the urban and rural location, wired and wireless technologies, and private and public investment (including partnerships)
- Areas where private industry is not willing to service then government and/or non-profits should have a role to provide the infrastructure. This does not have to include the service. Provide the infrastructure and let the service providers compete to provide the service.
- A 10 year bandwidth target for a Tennessee broadband vision or plan should be at or near 1Gbps (upload and download) to keep Tennesseans competitive

Broadband Vision or Plan Considerations

- Health care, libraries and schools should be well connected and at the target capacity early in the plan
- Provide for gigabit WiFi hotspot and kiosk capability for low income and/or rural access in key locations (county hospitals, libraries, etc). New York City kiosks provide an example:

  …workers began installing the first LinkNYC access points in New York. First announced in November 2014, the hubs are designed as an update to the standard phone booth, using upgraded infrastructure to provide gigabit Wi-Fi access points. … the hubs will also include USB device charging ports, touchscreen web browsing, and two 55-inch advertising displays. The city estimates that ads served by the new hubs will generate more than $500 million in revenue over the next 12 years.[5]

Footnotes

1 – National Broadband plan, https://www.fcc.gov/general/national-broadband-plan, March 17, 2010.

2 – Brian Fung, “The FCC has set a new, faster definition for broadband”, Washington Post, Jan 29, 2015.

3 – Lowly DSL poised for gigabit speed boost. http://www.cnet.com/news/lowly-dsl-broadband-poised-for-gigabit-speed-boost/. Jan 2016.

4 – Fiber optic application distances, https://en.wikipedia.org/wiki/Fiber-optic_communication. Jan 2016.

5 – New York LinkNYC, http://www.theverge.com/2015/12/28/10674634/linknyc-new-york-public-wifi-installation-photos-gigabit. Dec 2015.