Fiber Insight, LLC

Full Speed Ahead
FTTx Technological Advances Accelerate Broadband Growth
About the speaker

Tim Yount, CFCE
Co-founder Fiber Insight, LLC
Principal Trainer & Consultant

- 25+ years in fiber industry
- Offers technology education, training, & fiber infrastructure test consulting
- Work with new and existing operators, developers, builders & maintainers of fiber networks
- Family company based in Maine

Fiber Insight, LLC is a Woman-Owned Small Business
Agenda

- What is driving networks today?
- Growth trends & gaps
- What is FTTx?
- Comparing each x-variant of FTTx
- Latest Technology trends driving bandwidth needs higher
  - 4K video, live streaming, OTT services/devices, IoT, smart devices
  - Projections for 2020 and beyond
- The answer - Next generation evolving standards
- Summary – The role of Fiber
Introduction

- Our lives irrevocably impacted by daily use of wired & wireless communications
  - Smart devices
  - Apps
  - Social media
  - Advances in use of video

By end of 2016
10,000,000 x 1Gb/s connections
70 percent residential

&
Networks capable of
1 Gigabit connections
250,000,000 subscribers globally

Source: Deloitte Global
Mixed coverage today (#s per household)

- Large urban areas w/ typically 100Mb/s +
- Small urban & rural areas – varies but many
  - <10 Mb/s downstream
  - < 2 Mb/s upstream

- Current federal broadband definition (min)
  - 25Mb/s down-stream
  - 10Mb/s up-stream

Use a graphic for this Big Gap!
Putting Bandwidth Speeds into Perspective …with Service Offerings

<table>
<thead>
<tr>
<th>Typical Service Equivalent</th>
<th>Download / Upload Speeds</th>
<th>1 GB Photo Album</th>
<th>4.7 GB Std Video</th>
<th>25 GB HD Video</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTTH</td>
<td>1 Gb/s Download</td>
<td>9 sec</td>
<td>40 sec</td>
<td>3.5 min</td>
</tr>
<tr>
<td></td>
<td>1 Gb/s Upload</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable (Coax)</td>
<td>100 Mb/s Download</td>
<td>1.5 min</td>
<td>6.5 min</td>
<td>35 min</td>
</tr>
<tr>
<td></td>
<td>100 Mb/s Upload</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4G Fixed Wireless</td>
<td>50 Mb/s Download</td>
<td>3 min</td>
<td>13 min</td>
<td>1 hr 10 min</td>
</tr>
<tr>
<td>Copper (DSL)</td>
<td>10 Mb/s Upload</td>
<td>14 min</td>
<td>1 hr 5 min</td>
<td>5 hr 45 min</td>
</tr>
<tr>
<td></td>
<td>8 Mb/s Download</td>
<td>19 min</td>
<td>1 hr 30 min</td>
<td>8 hr</td>
</tr>
<tr>
<td></td>
<td>1 Mb/s Upload</td>
<td>2 hr 30 min</td>
<td>12 hr</td>
<td>64 hr</td>
</tr>
</tbody>
</table>

Source: FTTH Council
In rural America, it’s now about survival in a high speed connected world

- Many communities will die without globally competitive broadband
  - Inability to attract or retain businesses
  - Schools can’t be competitive without HS broadband
  - Families move away
  - Kids leave as soon as they can
- Some Municipalities are going GPON today (~100 / 50 Mb/s up/down/prem)

**2016 Broadband Definitions**

<table>
<thead>
<tr>
<th>State of Maine</th>
<th>US Gov’t</th>
<th>When they need to be aiming over here to be competitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Down Mb/s</td>
<td>Up Mb/s</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>10</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>25</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>25</td>
<td>10</td>
<td>50</td>
</tr>
</tbody>
</table>

Some in planning stages today are targeting to hit US Gov’t minimums Assuming turn-up by end 2018

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We’ve come a long way...

- From copper & coax networks to hybrid fiber networks
- From basic towers supporting cell phones & pagers to smart devices
- Let’s first take a look at FTTx networks that enable our user experience today
What is FTTx?

- Access Network fiber to a defined point
- Fiber deployed to a point near or to premises
  - Hybrids
  - All-Fiber
- Defines medium to premise (not inside)
Fiber to the Curb/Cabinet (FTTC)

- **Telco – xDSL**
  - DSL = Digital Subscriber Line
  - Fiber fed to DSLAM in neighborhood
  - DSLAM transitions fiber to copper twisted pair (TWP)
  - DSLAM to premise via TWP
  - Multiple TWP can be combined to increase bandwidth (bonded twp)
  - Speed limited by distance from DSLAM (or CO)
Fiber to the Node (FTTN)

- Cable / MSOs – HFC (hybrid fiber/coax)
  - Fiber fed to node in neighborhood
  - Converts to Coax @ node
  - Each coax from node feed multiple premises w/ amplifiers
  - Speed impacted by how many homes share each coax & usage by homes closest to node
Fiber to the Home (FTTH)

- Fiber “GPON or EPON”
  - Home or MDU
  - Dedicated fiber to each premise
  - “Home run” or split-based PON
  - Bandwidth shared in PON based on split ratio (1:32 typical)
  - Often wireless/WiFi extensions make the final connection

GPON = Gigabit Passive Optical Network
EPON = Ethernet Passive Optical Network
Fiber to the Business - FTTB

- Multiple delivery options
  - Dedicated fiber
  - CWDM “Wavelength”
  - FTTH split-based PON
- Dedicated 1-10Gb/s typical to each business
- PON variants slower speeds for smaller businesses
Fiber to the Antenna (FTTA)

Mobile Wireless
Tower, rooftop, DAS, Small Cell
(e.g., Verizon Wireless, ATT Mobility, T-Mobile)

Fiber

4G Fixed Wireless Internet
Premise connectivity from line-of-sight antennas
(e.g., Red Zone Wireless)

Fiber
Brownfield vs. Greenfield

- **Existing neighborhoods = Brown-field**
  - Generally FTTC or FTTN
  - ILECs/MSOs resist going FTTH unless Biz case proves out

- **New expansion areas + Greenfield**
  - FTTH logical choice since build-out has to happen

- **FTTA** – possible extension or augmentation to both
## Comparing the X’s

<table>
<thead>
<tr>
<th>Service Provider</th>
<th>Technology</th>
<th>Topology Category</th>
<th>Max Speed Gb/s</th>
<th>Standard or Reference Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telco</td>
<td>VDSL</td>
<td>FTTC</td>
<td>0.055</td>
<td>0.019</td>
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<tr>
<td></td>
<td>VDSL2</td>
<td></td>
<td>0.013</td>
<td>0.0016</td>
</tr>
<tr>
<td></td>
<td>G-PON²</td>
<td>FTTH / FTTB</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>MSO Cable</td>
<td>HFC DOCSIS 3.0</td>
<td>FTTN</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>(G)EPON</td>
<td>FTTH / FTTB</td>
<td>1.25</td>
<td>1.25</td>
</tr>
<tr>
<td>Wireless</td>
<td>4G Advanced Wireless Internet</td>
<td>FTTA</td>
<td>1 / 0.1</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Notes:

1. Reported aggregate maximum speeds and distances. Actual speeds may also vary based on distances and other factors.
2. Represents predominant service provider type deployments. Some exceptions may occur.
But... technology trends are already pushing beyond even today’s FTTH capacities

- 4K Video & Live Streaming
- Over the Top Content & Devices (OTT)
- Internet of Things (IoT)
- 5G Wireless
Emergence of Next Gen Bandwidth-Rich Requirements

- **4K Super HD Video Technology**

Source: http://4k.com/resolution/
Bandwidth Drivers:
4K Live Streaming

- 4 million unique viewers tuned in to SuperBowl50 (1.4mil/min) via live streaming apps

Examples:
Periscope
Streaming Netflix Edition
Bandwidth Drivers: Over the Top Content (OTT)

<table>
<thead>
<tr>
<th>Over The Top Content Services</th>
<th>SVOD</th>
<th>AVOD</th>
<th>TVOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subscription-based</td>
<td>Free &amp; Ad-Supported</td>
<td>Transactional-based</td>
<td></td>
</tr>
<tr>
<td>Hulu</td>
<td>Hulu</td>
<td>I-Tunes</td>
<td></td>
</tr>
<tr>
<td>Netflix</td>
<td>Sony Crackle</td>
<td>Instant Video</td>
<td></td>
</tr>
<tr>
<td>Fullscreen</td>
<td>Vimeo OnDemand</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Home Delivery Devices - Examples

- Apple TV
- PlayStation Vue

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Bandwidth Drivers: Internet of Things (IoT)

- “Machine to Machine” integration of connected devices and sensors
- Control, direct, collect data from devices via smart apps
The IoT—Smart Wearables

Smart Shoes  Smart Clothing  Smart Watches
A look ahead at the IoT

Sources: IEEE Spectrum, Google, General Electric, Cisco
The next major evolution in wireless

**5G – What we know today**

- Deployed by 2020?
- 1Gb/s /device minimum
- < 1ms latency
- Energy efficiency improvements
- IoT mass deployment enabler
- Many unknowns
- Key driver higher mobile bandwidth demands
What’s next in FTTx?

- Hybrid Solutions
  - DOCSIS 3.1
  - G.FAST
  - “Wireless Fiber” – New Gb/s wireless

- Next Generation – FTTH/B
  - X-GPON
  - NGPON
Comparing emerging technologies

<table>
<thead>
<tr>
<th>Service Provider</th>
<th>Technology</th>
<th>Topology Category</th>
<th>Speed Gb/s ¹</th>
<th>Standard or Reference Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telco</td>
<td>XG-PON1</td>
<td>FTTH / FTTB</td>
<td>10</td>
<td>2.5</td>
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<tr>
<td></td>
<td>NGPON2 (WDM-PON)</td>
<td></td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(10 x 4 λs)</td>
<td></td>
</tr>
<tr>
<td>MSO Cable</td>
<td>HFC DOCSIS 3.1</td>
<td>FTTN</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>10G-EPON</td>
<td>FTTH / FTTB</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>NG-EPON</td>
<td></td>
<td>25-40 ?</td>
<td>10 - 25?</td>
</tr>
</tbody>
</table>

Notes: ¹ Reported aggregate maximum speeds and distances. Actual speeds may also vary based on distances and other factors.

G.Fast is a Telco solution for Gigabit speeds over copper, however distance range is limited to ~100 ft, so I considered the applications to be outside the scope of this discussion.
The latest chatter - “Wireless Fiber”?

“Wireless Fiber” – in reference to Gb/s speeds via wireless over short distances

- Verizon reported 1Gb/s trial speeds up to ~500 yards (actual practical range might be a bit shorter)
- Can cover last bit of distance from pole or street
- Could extend broadband coverage to those just beyond fiber reach
- It’s still FTTA - Fiber still has to feed the antennas
- Late 2017 or 2018 before 5G deployments begin

"I think of 5G initially as, in effect, wireless fiber, which is wireless technology that can provide an enhanced broadband experience that could only previously be delivered with physical fiber to the customer,” Quote from Verizon CEO Lowell McAdam

Source: http://www.fiercetelecom.com/installer/verizon-ceo-details-wireless-fiber-5g-deployment-trials
X-GPON – 10Gb/s PON

- Split-based PON
- 10Gb/s down; 2.5Gb/s up
- Uses different wavelengths
- Can operate with existing GPON on same fiber
- Ensures investments in GPON today to stay relevant
- Early deployments NOW
NGPON2 - WDM PON

- Wavelength Division Multiplexing (WDM)
  - 4 separate wavelength channels per fiber
  - Each channel carrying up to 10Gb/s
  - Aggregate 40Gb/s per fiber downstream
  - Migration from splitters to WDM

Note: Although 4 wavelengths travel downstream & 4 different upstream, this graphic illustrates only one set of four in one direction.
FTTH Network Evolution Path

Install fiber once – that fiber will support many years of advancements

GPON

X-GPON - New

NGPON - Lab (1-3 years?)

2.5 Gb/s Down
2.5 Gb/s Up
@ 32 homes
78 Mb/s per home

10 Gb/s Down
2.5 Gb/s Up
@ 32 homes
312 Mb/s per home
78 Mb/s per home

NGPON 40 Gb/s Down
10 Gb/s Up
@ 32 homes
1250 Mb/s per home
312 Mb/s per home

Newer evolutions designed to coexist with original installed systems.
– original FTTH investments are not lost as new technologies added.
Enabling a true connected world

- Wireless connectivity is becoming the dominate user network interface.
- Fiber enables it by providing the bandwidth needed to the antennas for that last short link.
- No matter what the last mile provides as connection to the user, fiber is the common denominator.
In Summary

- We are in an unprecedented era of connectivity growth & rapid technology change
- Today’s FTTx comes in many flavors / speeds
- Advances in video, OTT and IOT accelerating bandwidth demands beyond current service levels
- Available bandwidth varies greatly depending on where you live, work and play
- Communities that don’t keep up risk long term viability - maybe even survival
- Newer FTTx advances will enable us to keep up on a global scale.
References

References

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Broadband Communities - Jan/Feb 2016


“EPON and RFOG Technology Overview”,  SCTE - November 3, 2015

“5G is coming and it is the future of mobile”  Alan Carlton-  Network World, Feb 5, 2016

Zhone “VDSL2 Backgrounder”
Questions / Discussion