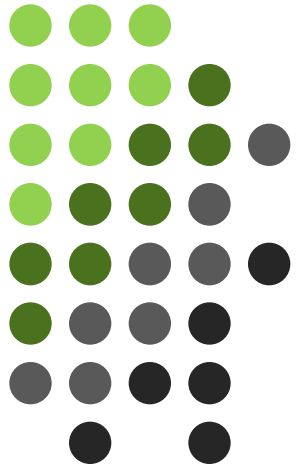
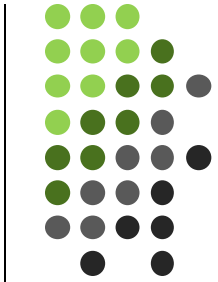
Burlington Telecom

Broadband Technology Clinic

Burlington Telecom Advisory Board



What are the Defining Characteristics of a Broadband Service?



- Speed
  - Throughput capability both down and upstream
- Performance
  - Latency and packet loss
- Reliability
  - Downtime and congestion
- Abundance
  - Unlimited vs. metered access

Common Broadband Technologies

- DSL

- HFC

  (DOCSIS)

- WiFi

- Mobile Wireless

- Fiber

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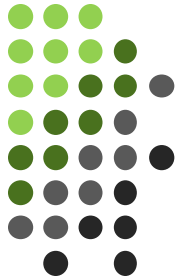
DSL – Digital Subscriber Line

- DSL uses copper telephone wire.
- Cable plant challenges
  - Special conditioning often required to service – labor intensive
- Service quality easily impacted by environmental factors..
  - Line noise, corrosion, water, shorts
- Highest speeds only achieved in close range to DSLAM
  - DSLAM's typically must be fiber fed
  - Long loops (circuits) = low bandwidth and low performance

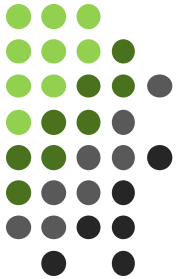
DSL – Types and Traits



- ADSL – Most commonly deployed.
  - ADSL2 and ADSL2+ are the latest ADSL
  - Asymmetrical - Maximum speed of 24/1.4Mbps
  - Maximum range of 5km – speed capability falls sharply after 1km

- VDSL2 – The Best DSL can do
  - Symmetrical – 200/200Mbps
  - High Performance distance limitation
    - 200M at 150meters – 100M at 500 meters – 50M at 1km
    - Equal to ADSL2 at 1.5km
  - Fiber optics and powered electronics cabinets into each neighborhood – FTTC (fiber to the curb)

DSL – Who's It Appeals to



- Customers with no broadband alternatives
- Customers who seek out the lowest cost service with little regard to quality or performance of service
- Those who like traditional land line phone service and receive bundled DSL internet at a steep discount

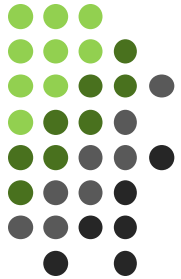
DSL – Limited Future

- No new advances since 2010 and none on the horizon.
- Total collapse of market share wherever there is wire line competition.
- Low cost to consumers + High cost to maintain

  =

  Many DSL Providers looking for an exit and alternative technologies to sell

DOCSIS (cable broadband)

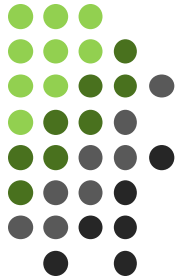


- DOCSIS: Data Over Cable Service Interface Specification --- A Cable Company's answer to Broadband
- Modern Cable systems primarily use HFC (Hybrid Fiber-Coaxial)
- HFC systems use fiber to transport video/data signals to an optical node located in defined geographic area. Node converts fiber to coax.
- Technology is driven using RF (radio frequency)

DOCSIS - How it Works

- A cable system's capacity for TV and Data depends on how much RF spectrum the plant supports. Older systems can be as low as 500mhz. Newer plants are upto1Ghz.
- Currently, all content is delivered over 6mhz carriers in the US. A 1Gz plant can typically use 150 - 6mhz channels (some are reserved)
- Analog TV – each analog channel uses 6mhz
- QAM (quadrature amplitude modulation) – How channels get "digitized" and transmitted over HFC. Each "QAM" is a 6mz channel. Each QAM can transmit 38Mbps of data/video.

DOCSIS - How it Works (cont.)



- CMTS (cable modem termination system) – Most newer DOCSIS 3.0 CMTS can place 16 QAM's per port. (Many still using 8) Ability for 32 channels per port will become more common in next couple years.
- 8 channels down = 304Mbps
- 16 channels down= 608Mbps (typical 1-2 Up = 75M)
- 32 channels down= 1.2 Gbps
- These channels are typically shared amongst 300+ subscribers on the same fiber node. 1 CMTS port = 1 Node
- The end result: High oversubscription per node (neighborhood/region)

DOCSIS - Summary

- DOCSIS 3.0 can deliver large amounts of bandwidth to a limited number of users per node
  - Limited scale: Current HFC designs do not accommodate for large numbers of customer using high bandwidth simultaneously
  - The fix: More nodes must be added. More fiber added into more neighborhoods and more CMTS ports used. Costly.

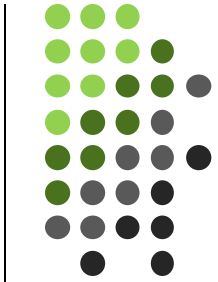
DOCSIS - Future

- DOCSIS 3.1 spec released from cable labs in 2013: Dynamic frequency ranges – No longer limited to 6mhz – 38Mbps.
- Bandwidth capacity per node could increase 5+ times.
- Technology remains highly asymmetrical. Same fundamental oversubscription issues as previous DOCSIS versions.
- Early adoption by 2016 (manufacturing lag – chips)
- Large scale deployment in Tier 1 markets in 2017
- Smaller markets in following years

Mobile Wireless

- Uses over the air radio waves (RF) to deliver service.
  - No true ability to control quality and performance
- Use of FCC licensed frequencies (spectrum)
  - WiMAX. LTE – Can achieve speeds beyond 100Mbps. Real world data on Sprint, ATT and Verizon show 8-15Mbps.
- Antennas, antennas, antennas.
- Backhaul – Supporting High Speeds require fiber to the “towers”
- High density + high usage = low performance
  - Low usage caps – high overage penalties
- Dependable coverage is difficult if not impossible in certain terrains.

Mobile Wireless - Summary



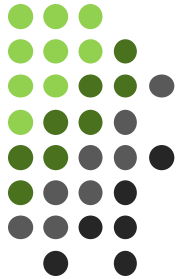
- Technology will continue evolve bringing increased speeds and larger LTE coverage areas

- Industry insiders freely acknowledge that LTE is not a true competitor to wire line based broadband.

WiFi

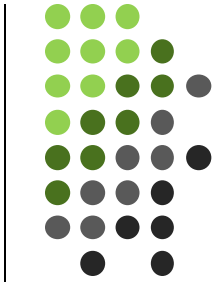
- A complementary networking technology which is intended for deployment alongside fast fixed networks
- Designed to deliver broadband to a small number of users in geographically isolated areas
- WiFi uses unlicensed frequencies which anyone can use for any purpose. Overuse of allotted frequencies in populated areas can make service unreliable.
- Low Power: Best speeds achieved when very close to access points – service level and quality quickly fades as distance increased.

WiFi – 802.11(x)



- Common deployed ieee standards:
  - 802.11 g = 54mbps max
  - 802.11 n = 150 mbps (up to 600Mbps with MIMO radios)
- Newest standard:
  - 802.11 ac = 1.3Gbps
- All data rates are in ideal situations – no interference – one connection

WiFi – Summary



- Despite constant advances in WiFi, it will continue to be a technology that inherently cannot provide a consistent, reliable service to end users.
- It does not perform well in urban and high density settings.
- A WiFi service provider cannot control bandwidth or performance.
- “For Fee” WiFi broadband service deployments typically fail where there is any broadband competition.

FTT(x) – Fiber to the….

- Fiber-To-The-Home/Premise - PON and Active
- Unmatched performance and reliability.
- Proven flexibility to accommodate rapid changes in service delivery demands.
- Unparalleled bandwidth scaling.
- Fiber is future proof. Terabits (Tbps)– Petabits (Pbps) and beyond. It eliminates the need for endless costly plant upgrades and enhancements.
- Price points are competitive with copper, reaffirming that fiber is the obvious choice for new network construction.