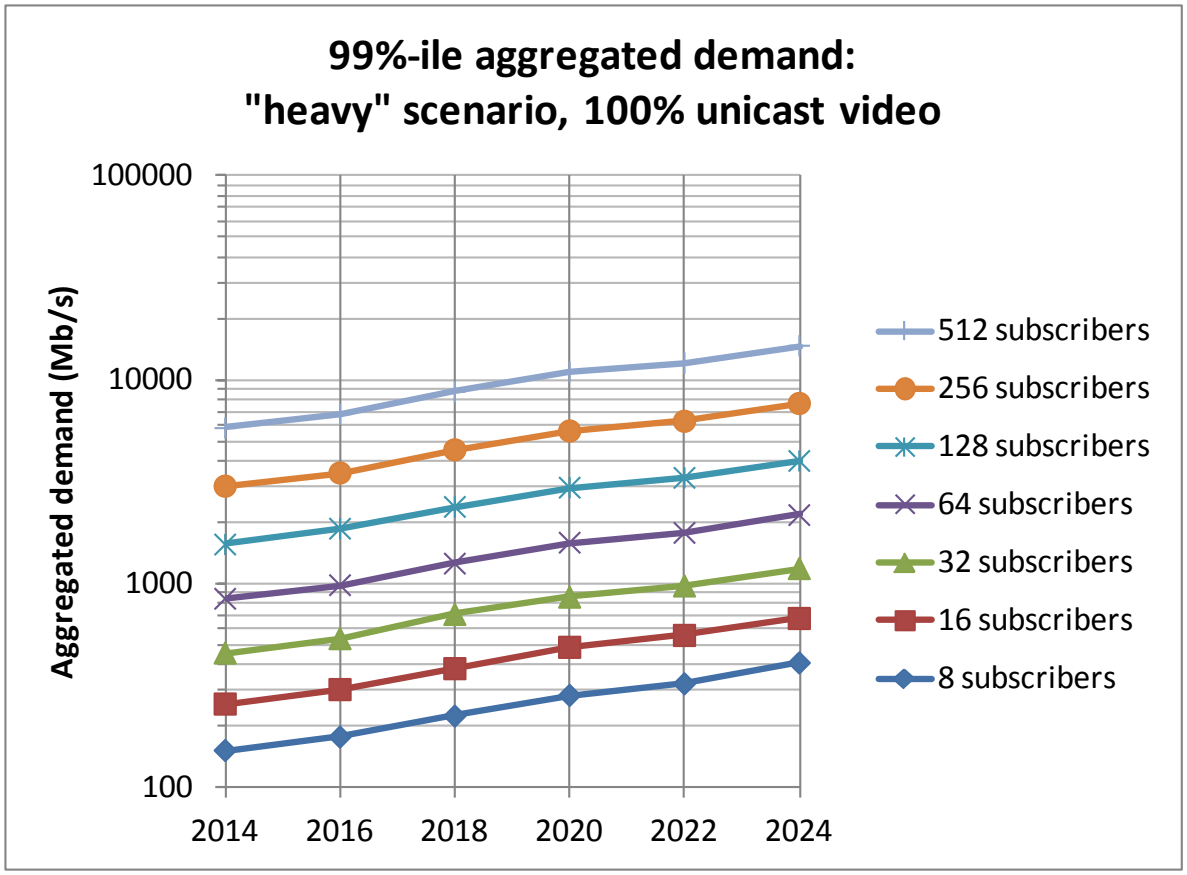
Bandwidth demand forecasting (for TR section 4.2.2)

Ed Harstead & Randy Sharpe, Fixed Networks CTO, Alcatel-Lucent

Ottawa IEEE 802.3 NG EPON Meeting
8 September 2014

Residential aggregate bandwidth demand forecast

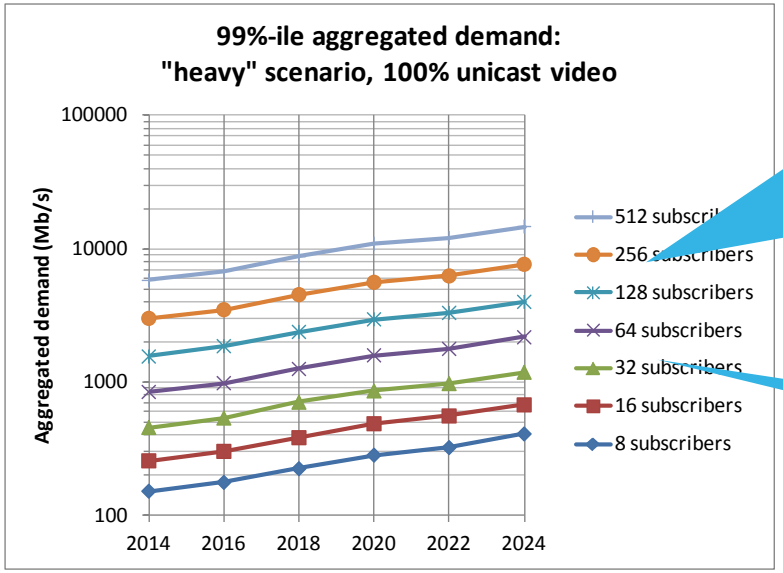


For PON network dimensioning, add bandwidth headroom above these numbers, equivalent to the maximum service level offered

Why: subscribers will need to pass a speed test at peak hour traffic

Aggregate bandwidth demand model

Peak hour sustained and burst bandwidth demands are modeled independently.



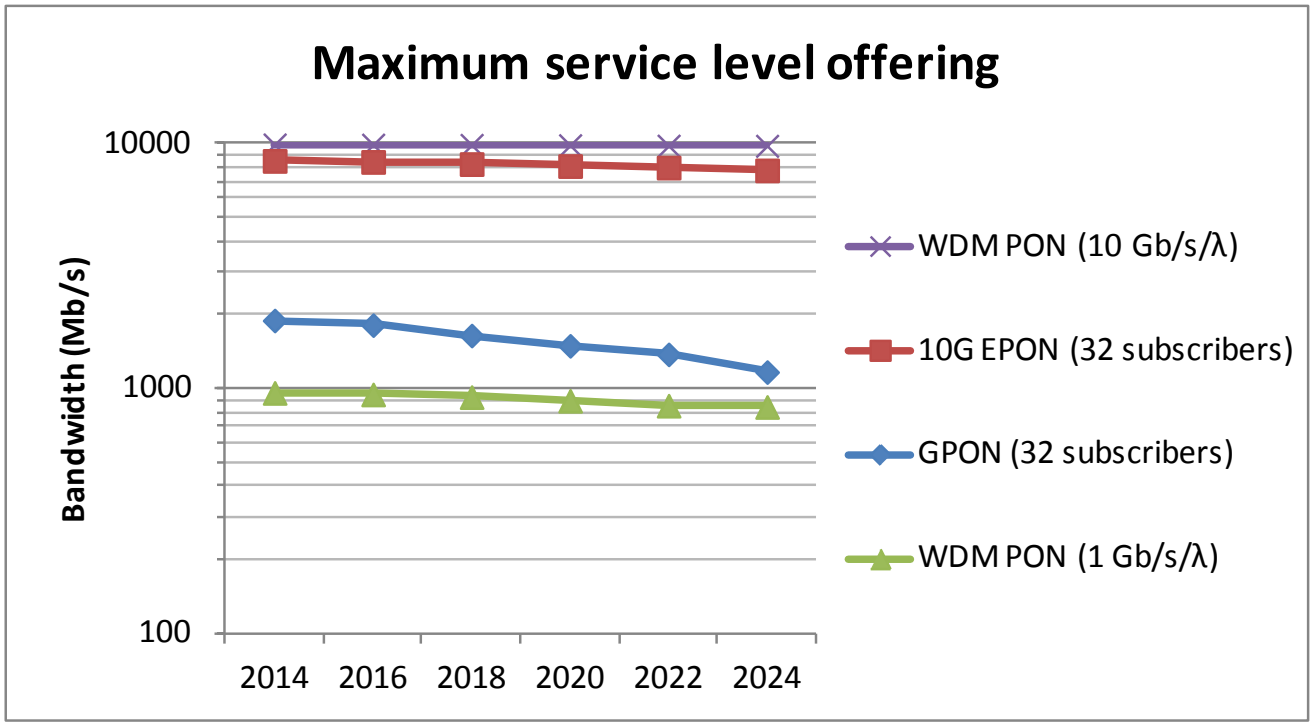
1. Sustained bandwidth demand component:
   - Video traffic is modeling using Monte Carlo techniques. Other sustained demand (e.g. voice) is neglected
   - All of managed linear pay-TV, managed VoD and OTT Internet video (e.g. Netflix, YouTube) are included
   - No multicasting all video (managed and OTT) is unicasted in-band: worst case scenario

2. Burst bandwidth demand component
   - per subscriber averages, plus
   - maximum burst demand that a single subscriber can generate

- More detail on inputs in the backup slides
- Manuscript has recently been submitted to IEEE Communications Magazine

Maximum service level that can be offered

Equivalent to headroom left over after peak hour traffic is subtracted out:



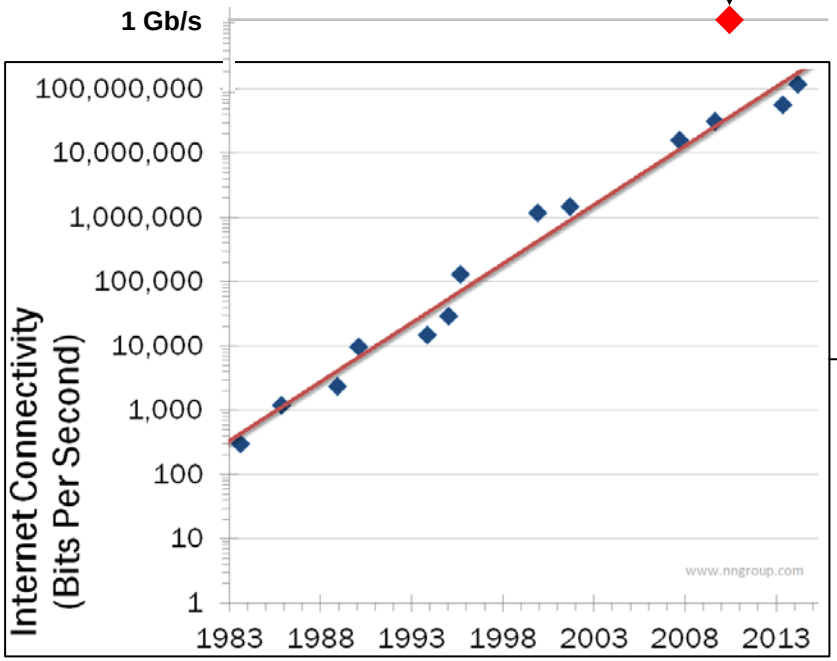
Based on methodology in:
E. Harstead, R. Sharpe, "Future Fiber-To-The-Home bandwidth demands favor Time Division Multiplexing Passive Optical Networks", *IEEE Communications Mag*., Nov. 2012.

Notes on WDM PON:
- WDM PON @1 Gb/s/λ loses to GPON over next 10 years.
- WDM PON must support 10 Gb/s/λ just to beat (barely) today's 10G EPON

Input for section 4.3: Bit Rate Trends

Question: Is this section about bandwidth offered or bandwidth demanded?

Nielsen's Law of Internet Bandwidth states that offered premium connection speeds to U.S. users has grown 50% YoY.



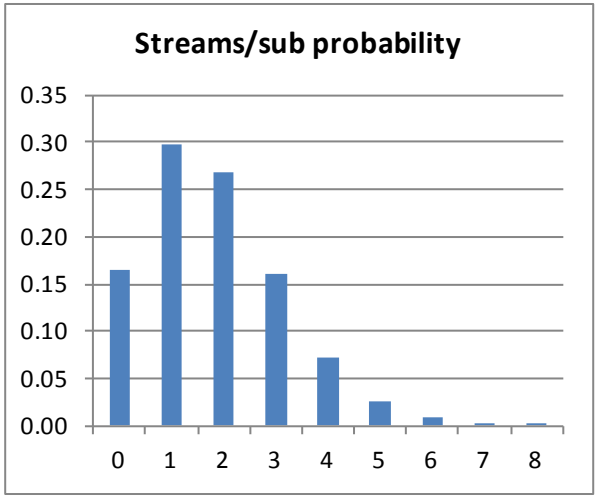
Nielsen's Law does not say anything about:

- bandwidth demand
- offered speeds on fiber networks (off by one order of magnitude)

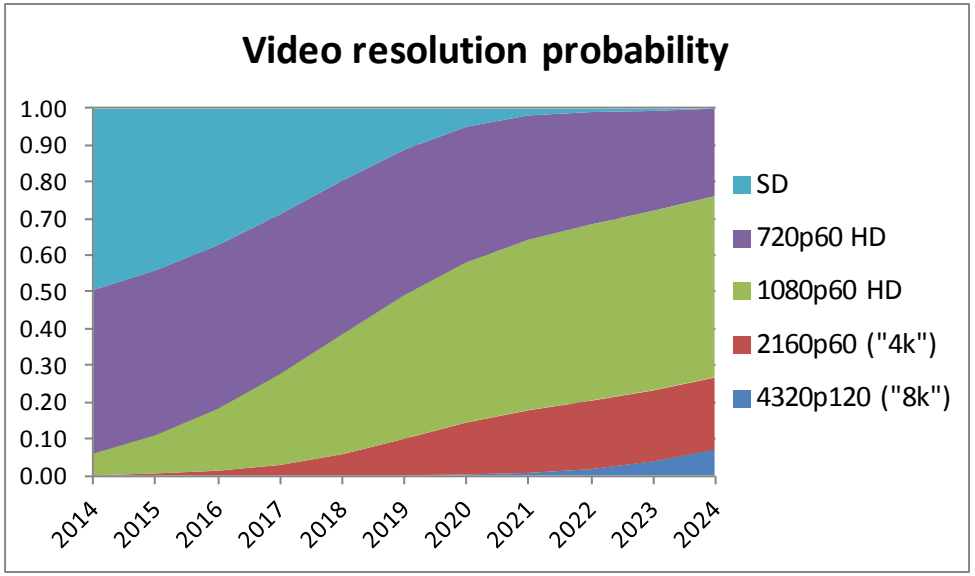
Nielsen's Law ignores the bandwidth carrying managed TV service (e.g. video QAMs)

Backup

Video streams transported



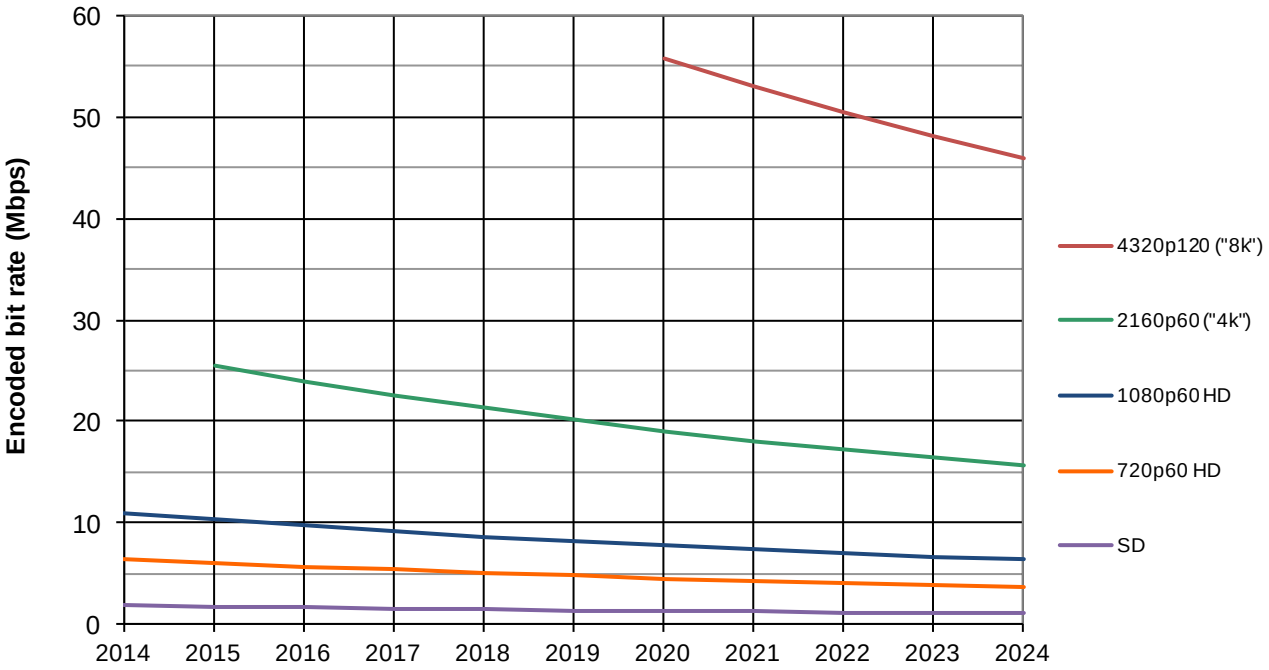
Probability distribution of number of streams per subscriber
Average (λ) =1.8



Stream resolution probability distribution forecast

3D content: 7.5% of HD streams

Encoded video bit rate forecasts



- Chart forecasts nominal bit rates for good quality video
- HD and UHD bit rates are multiplied by 1.275 quality factor for higher quality
- 3D content: 1.4x higher bit rate than 2D

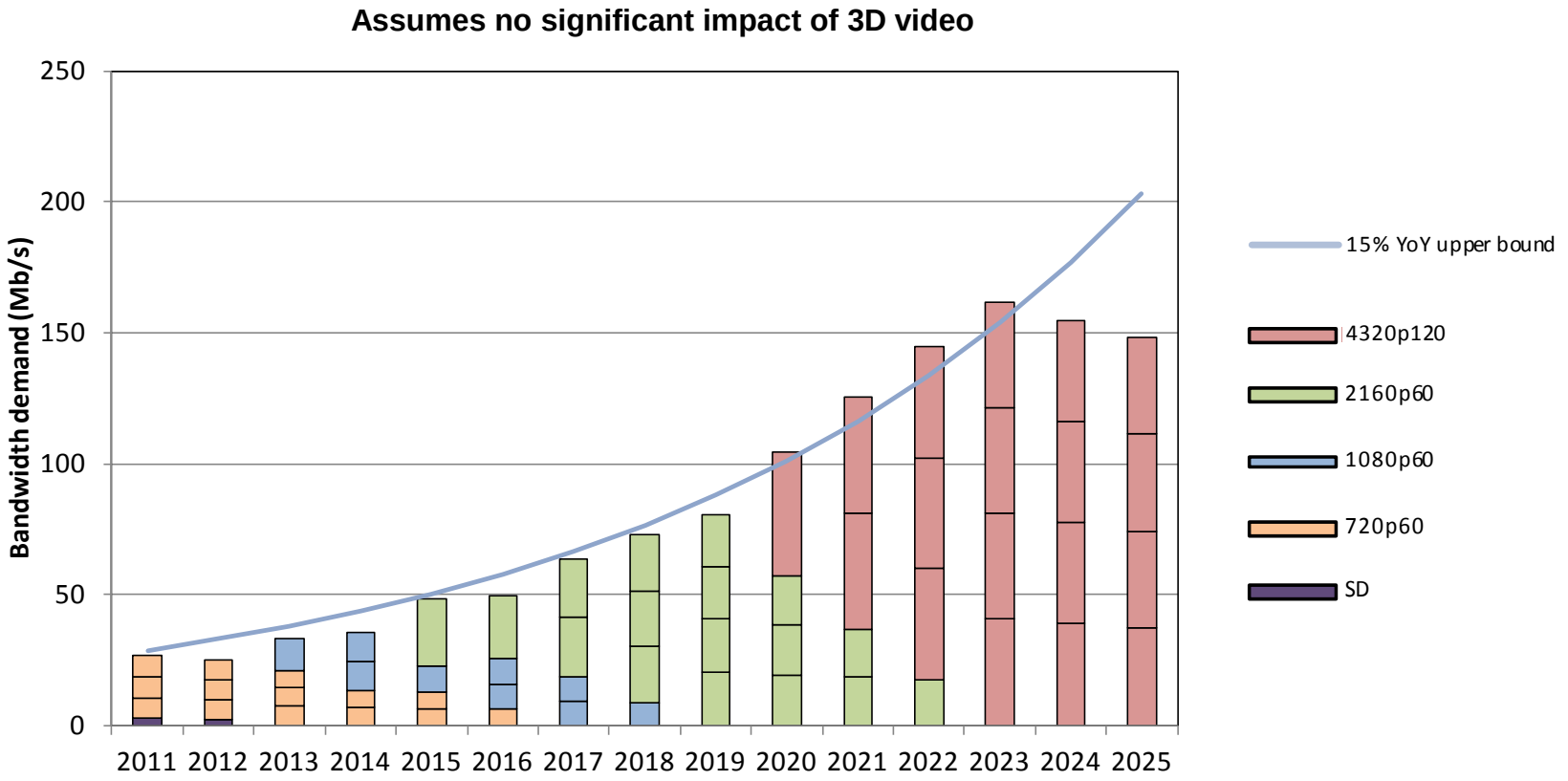
Burst traffic demand component

Cox reported an average of 400 kb/s of downstream DOCSIS traffic per subscriber during peak hour in 2014[1]. This is consistent with private data from other operators.

- Assume that to first order it is all Internet traffic (neglect managed VoD)
- Based on Sandvine measurements[2] 36% of that traffic is bursty: 144 kb/s average peak hour bursty traffic per subscriber on a DOCSIS network.
- Traffic could be higher on fiber networks: multiply by 1.5x: 216 kb/s per subscriber
- We grow this number by 21% YoY based on inputs from the Cisco VNI[3] and Pyramid[4] and multiplying by 1.5x

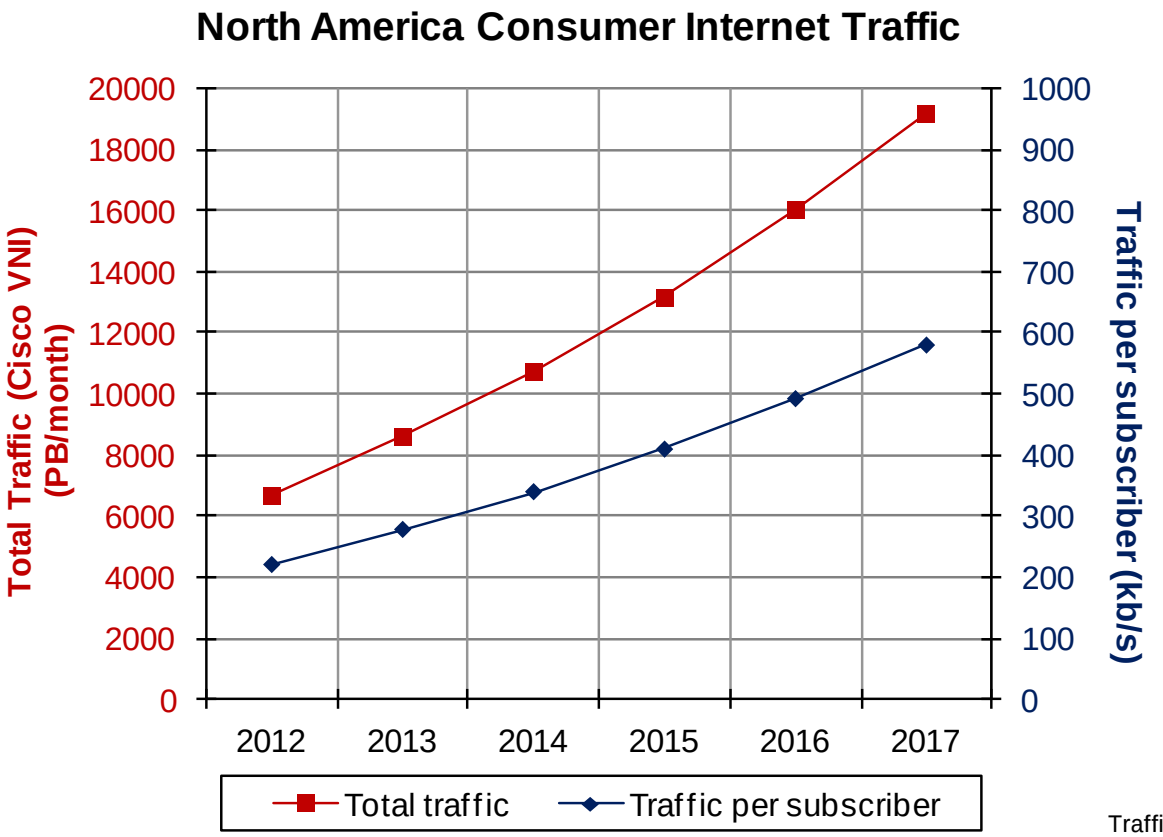
[1] J. Finkelstein, A. Bernstein, S. Parikh, “SDN and NFV for Cable Networks”, 2014 Spring Technical Forum (NCTA, SCTE and CableLabs), Los Angeles, CA.
[2] Sandvine, ”Global Internet Phenomena Report: 1H 2014”, https://www.sandvine.com/trends/global-internet-phenomena/
[3] Cisco, “Cisco Visual Networking Index: Forecast and Methodology, 2012–2017”, http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-481360.pdf, May 2013.
[4] Pyramid Research, “Western Europe Fixed Forecast Pack 2Q2013” and “North America Fixed Forecast Pack, 2Q2013”, June 2013.

Streaming video bandwidth demand, single subscriber: upper bound



Based on methodology in:
E. Harstead, R. Sharpe, "Future Fiber-To-The-Home bandwidth demands favor Time Division Multiplexing Passive Optical Networks", *IEEE Communications Mag.*, Nov. 2012.

Bandwidth demand: Internet traffic forecasts?



Traffic forecast data from Cisco Visual Networking Index, 2013

Subscriber forecast data from Pyramid Research. Fixed Forecast Pack, 2013

- Internet video is the driver for growth
- But subscriber traffic is still measured in 100s of kb/s!

Internet traffic forecasts miss IPTV, so underestimate access network demand

www.alcatel-lucent.com