

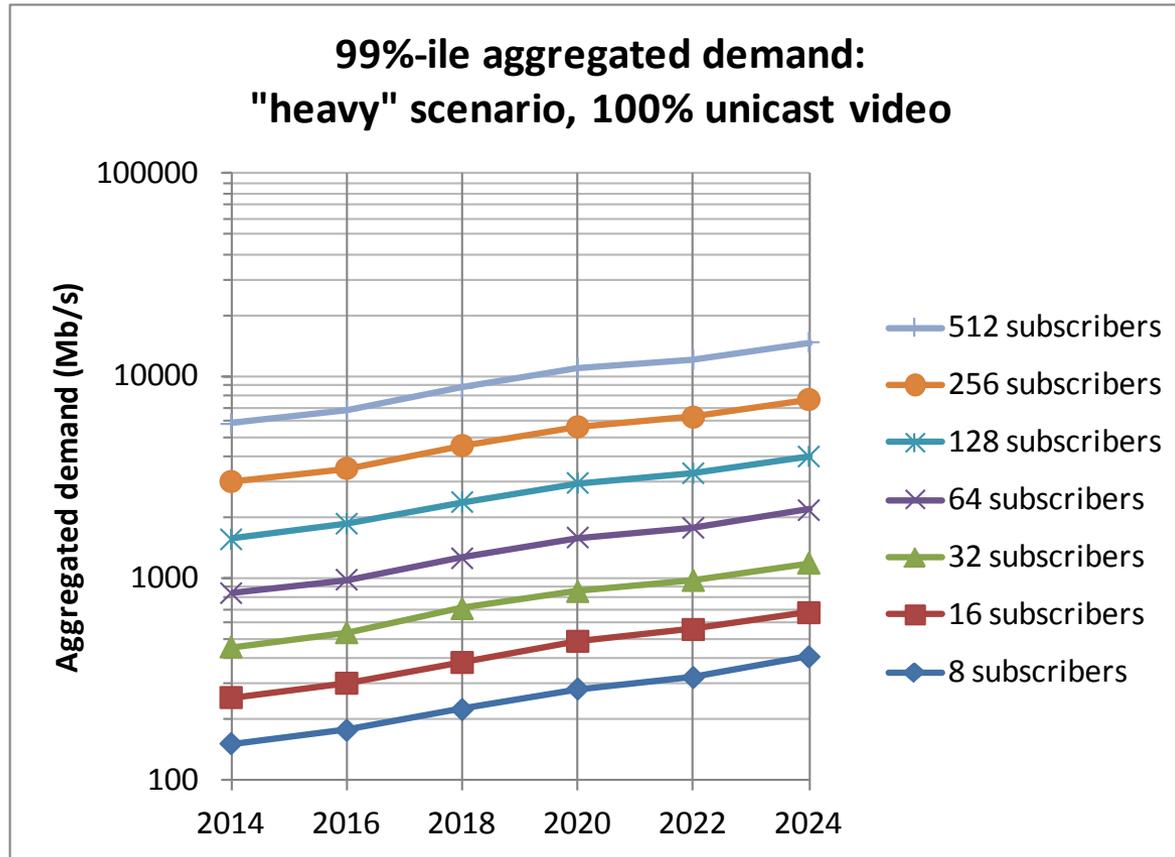


## **Bandwidth demand forecasting (for TR section 4.2.2)**

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Ottawa IEEE 802.3 NGEPON Interim meeting  
8 September 2014

# Residential aggregate bandwidth demand forecast

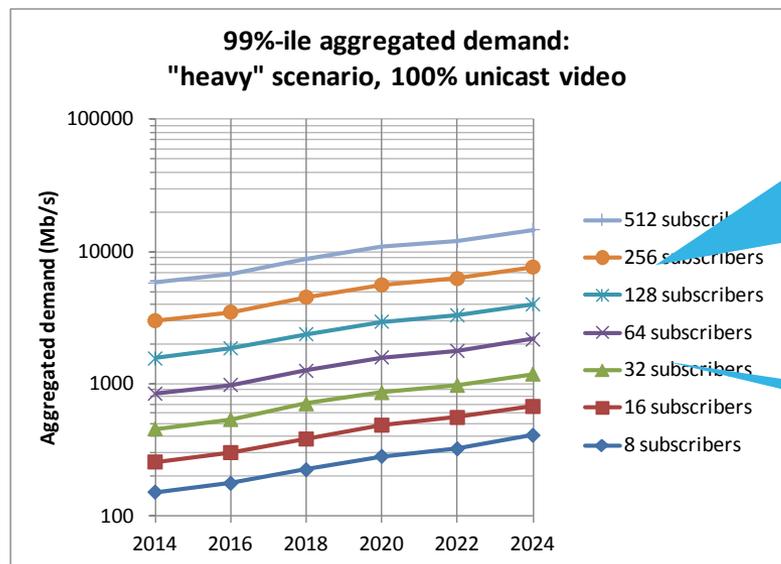


For PON network dimensioning, add bandwidth headroom above these numbers, equivalent to the maximum service level offered

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 unicast 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

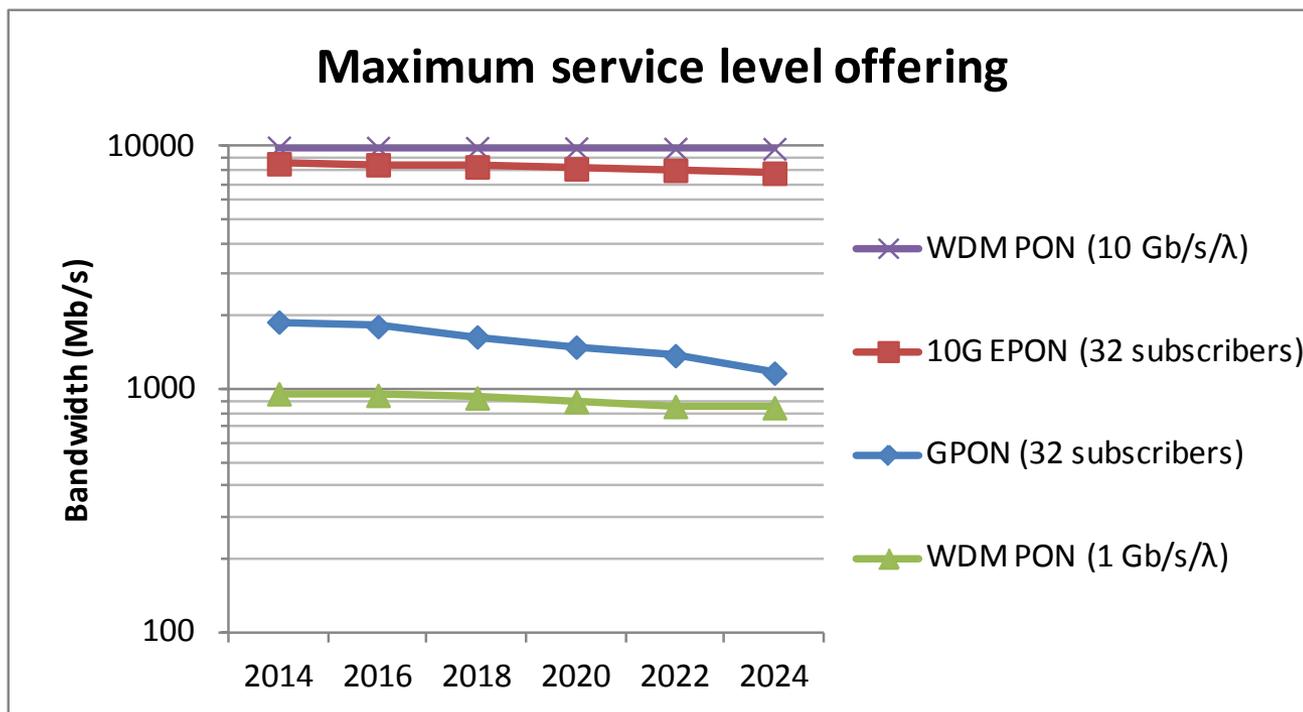
• Manuscript has recently been submitted to IEEE Communications Magazine

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# 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.

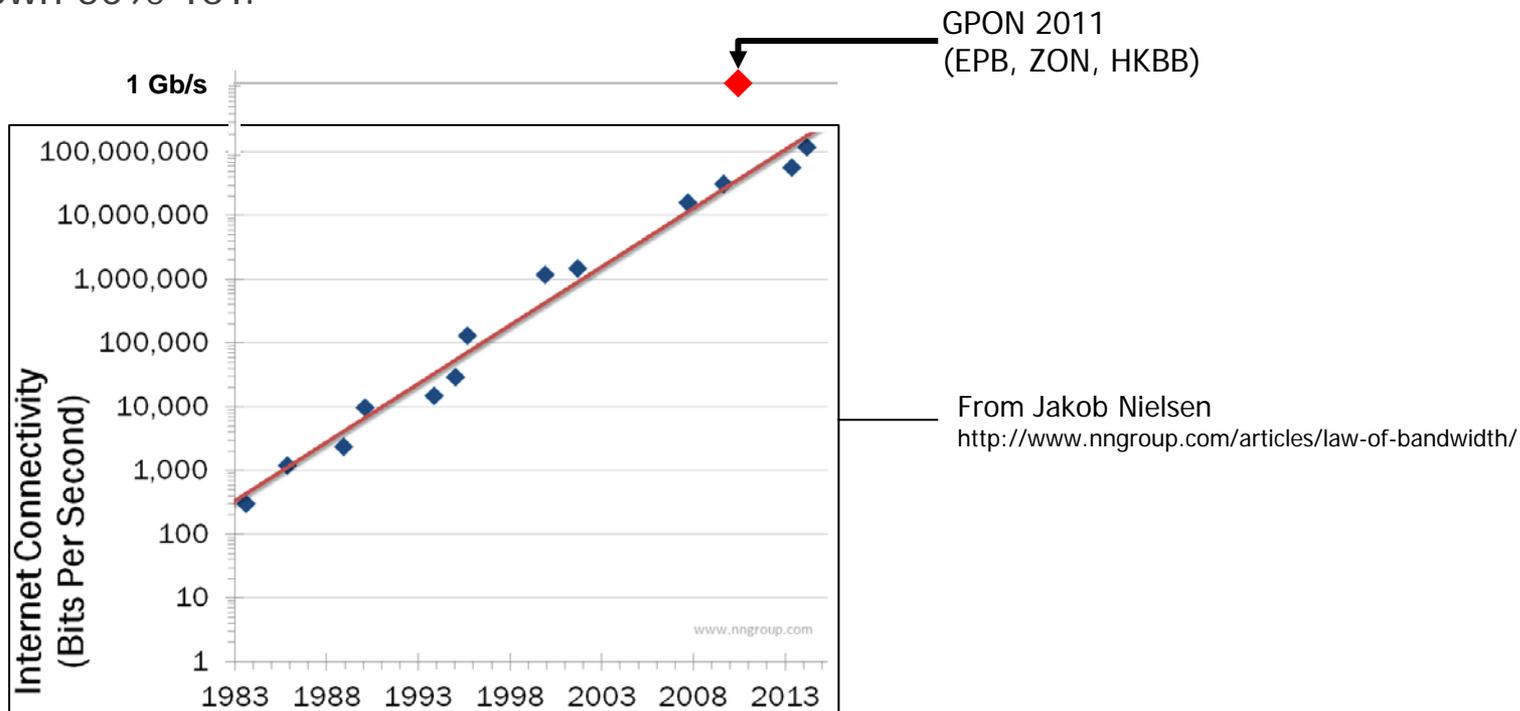
Notes on WDM PON:

- 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.



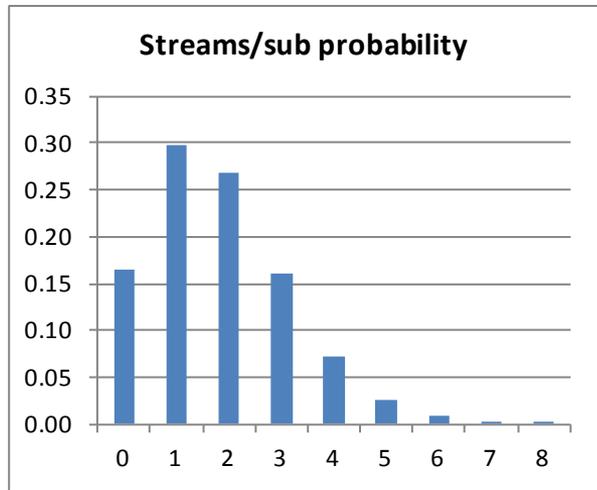
Nielsen's Law does not say anything about:

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

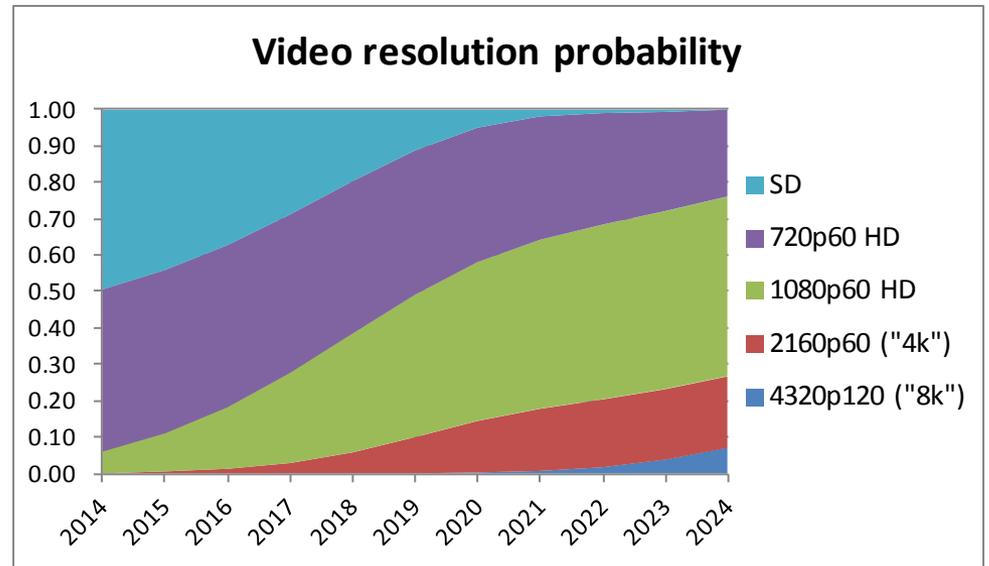
Nielsen's Law ignores the bandwidth carrying managed TV service (e.g. video QAMs)

# Backup

# Video streams transported: "heavy scenario"



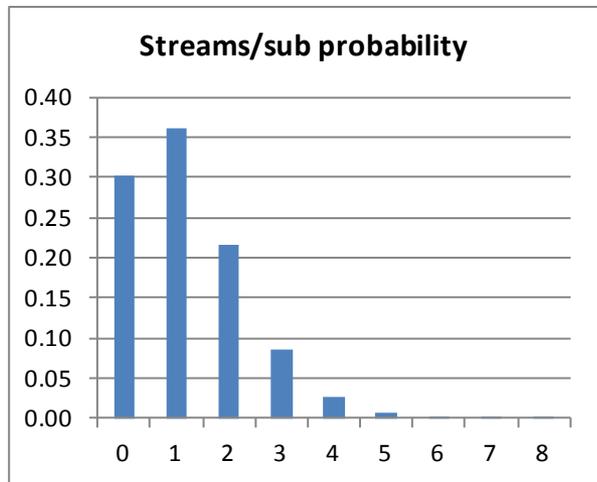
Probability distribution of number of streams per subscriber  
Average ( $\lambda$ ) = 1.8



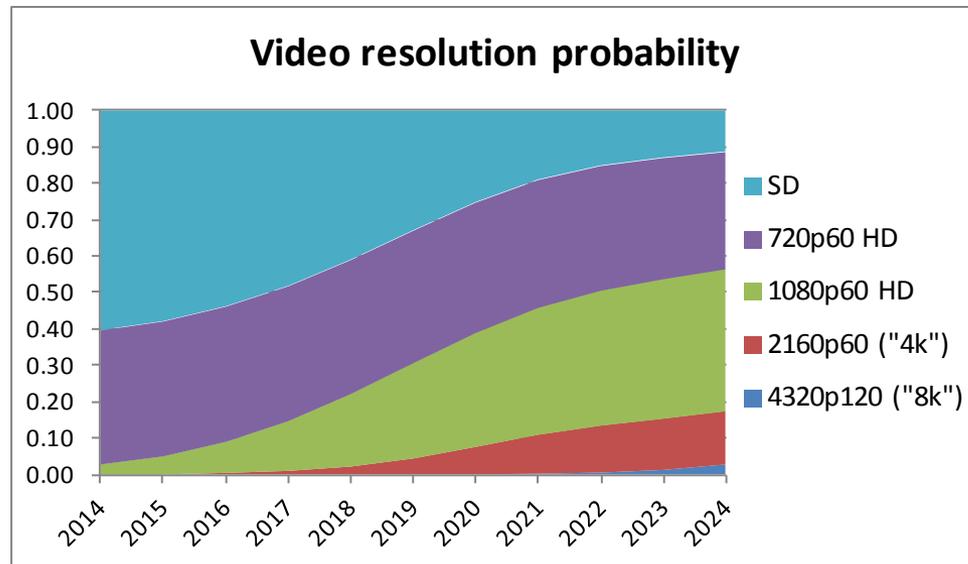
Stream resolution probability distribution forecast

3D content: 7.5% of HD streams

# Video streams transported: "moderate scenario"



Probability distribution of number of streams per subscriber  
Average ( $\lambda$ ) = 1.2

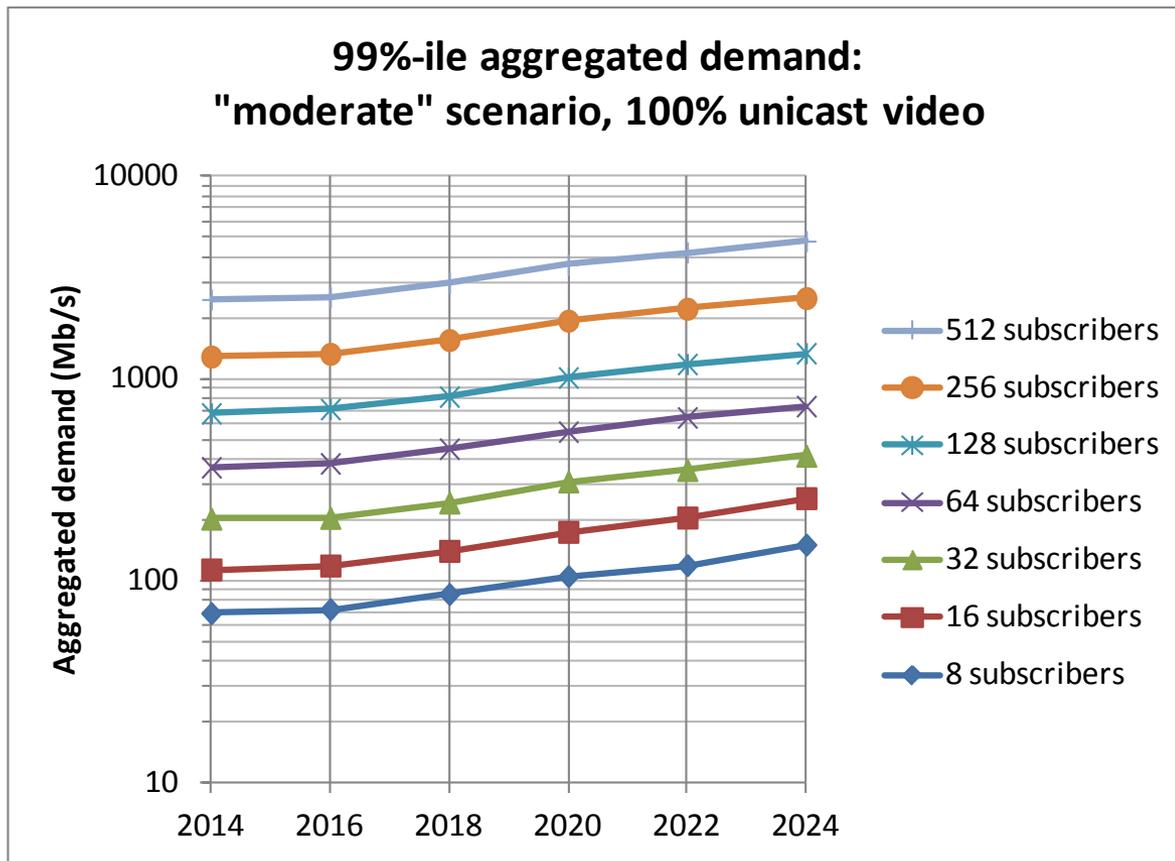


Stream resolution probability distribution forecast

3D content: 5% of HD streams

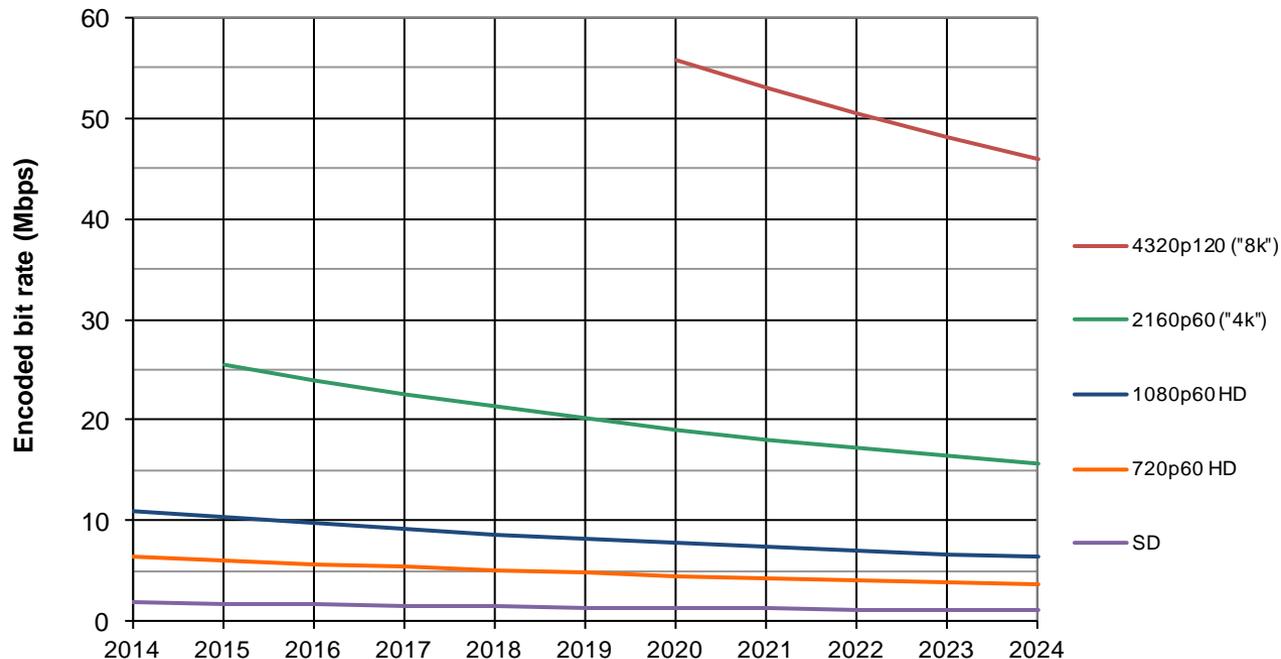
# Residential aggregate bandwidth demand forecast

## "Moderate" scenario



No headroom included

# 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 (heavy scenario)
  - 0.85 quality factor for higher bandwidth efficiency (moderate scenario)
- 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.

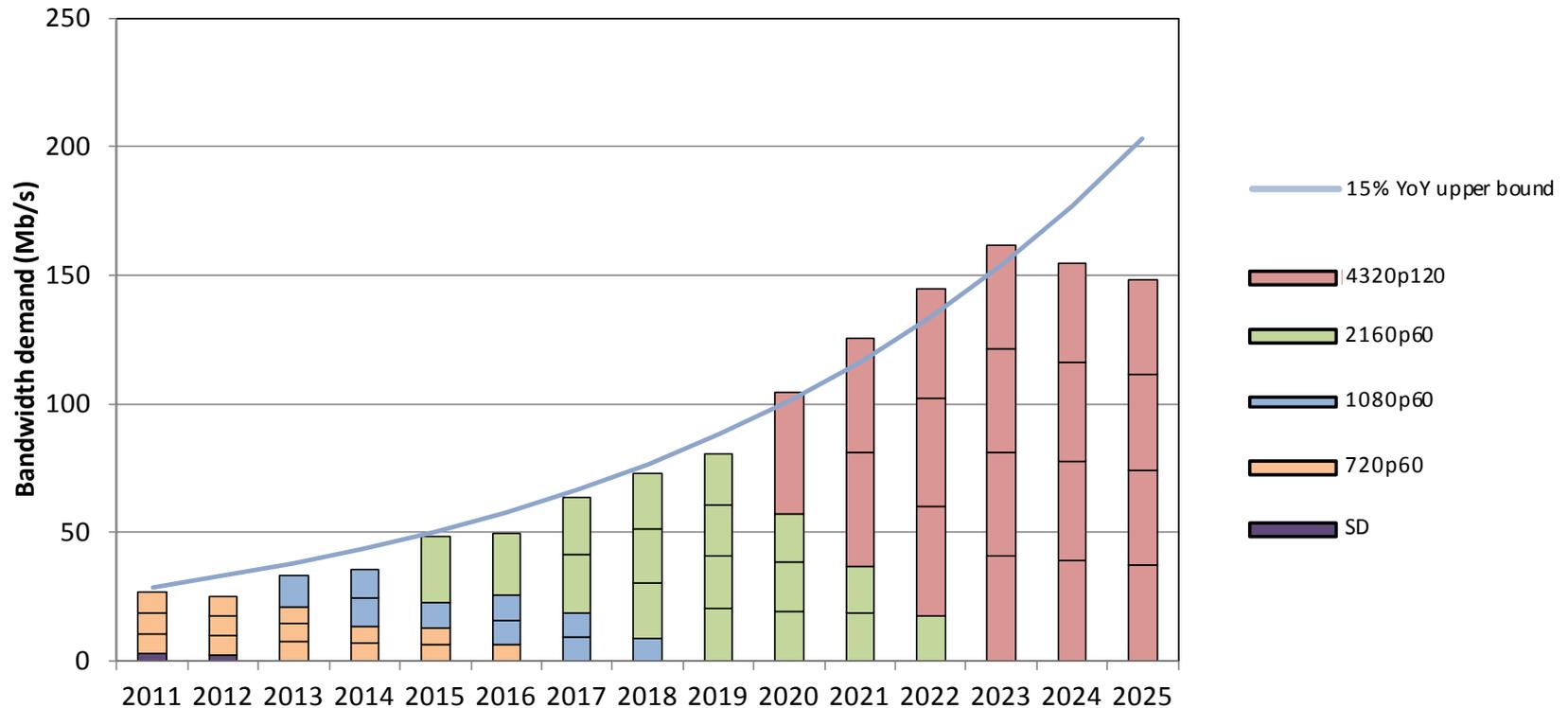
[2] Sandvine, “Global Internet Phenomena Report: 1H 2014”, <https://www.sandvine.com/trends/global-internet-phenomena/>

[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](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

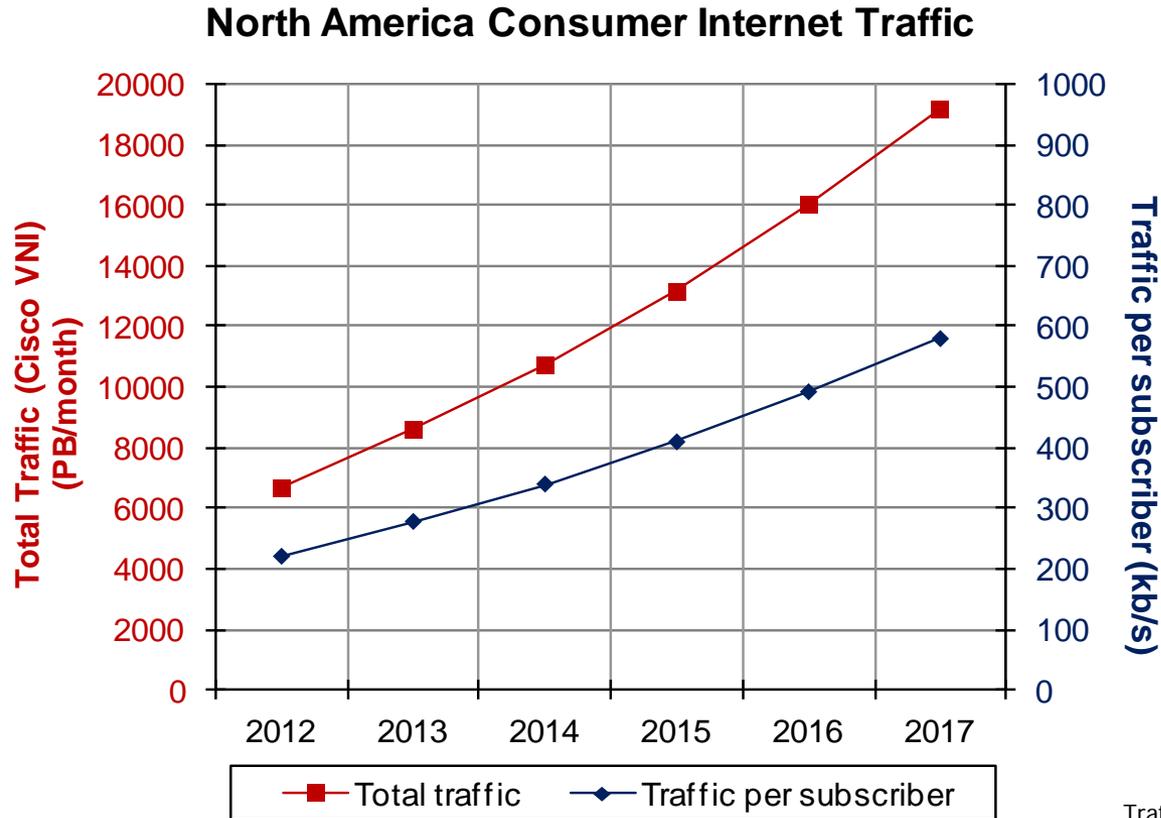
Assumes no significant impact of 3D video



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**

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