Bandwidth Trends on the Internet… A Cable Data Vendor's Perspective

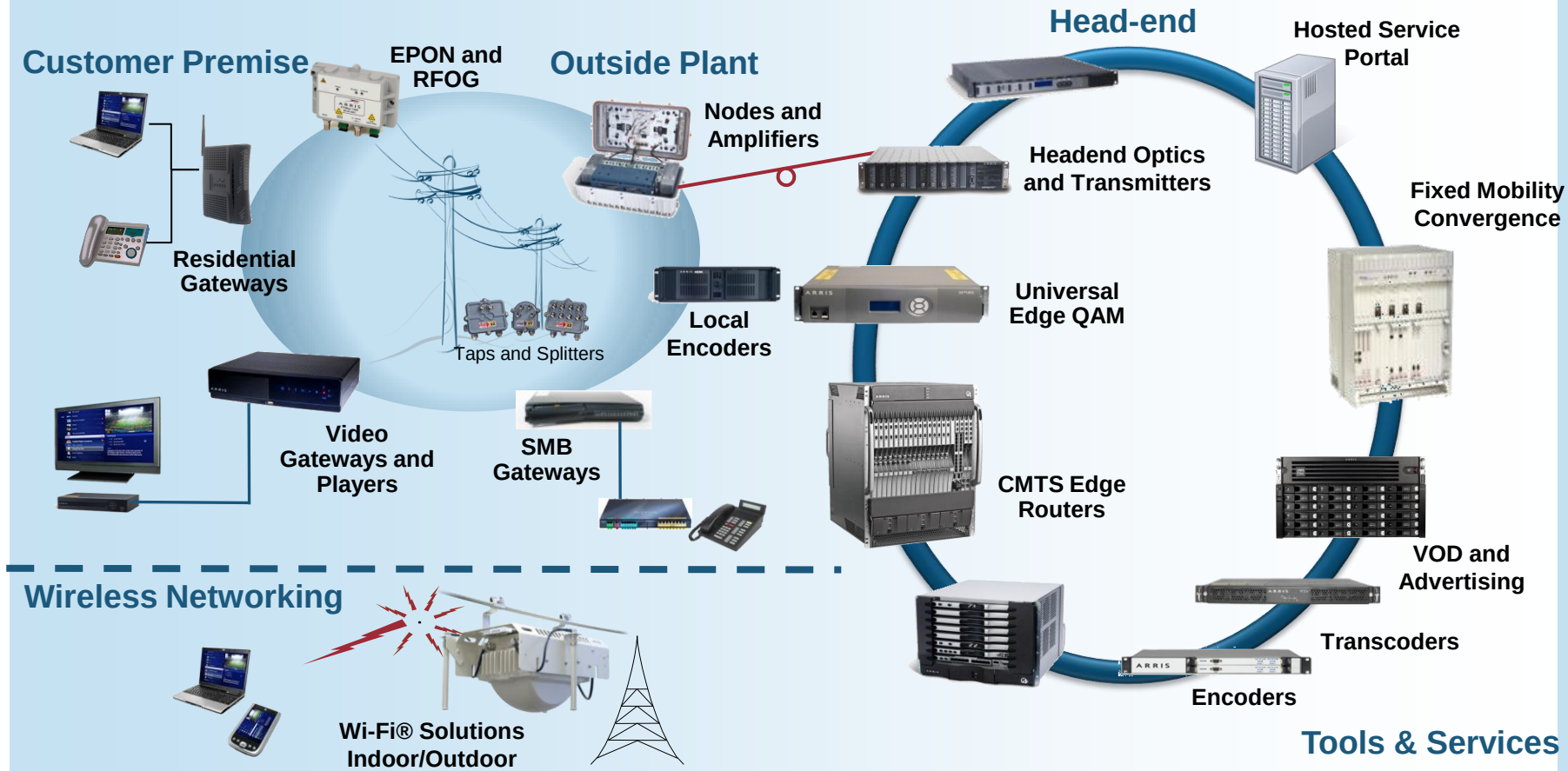
Tom Cloonan, Chief Strategy Officer, ARRIS

Agenda

- **Introduction**
- Observed Bandwidth Trends (& Predictions for the Future)
- Networking Equipment Trends
- Conclusions

Monitoring Bandwidth Trends for the Cable Industry

We need to predict the capacities for these products in the future…



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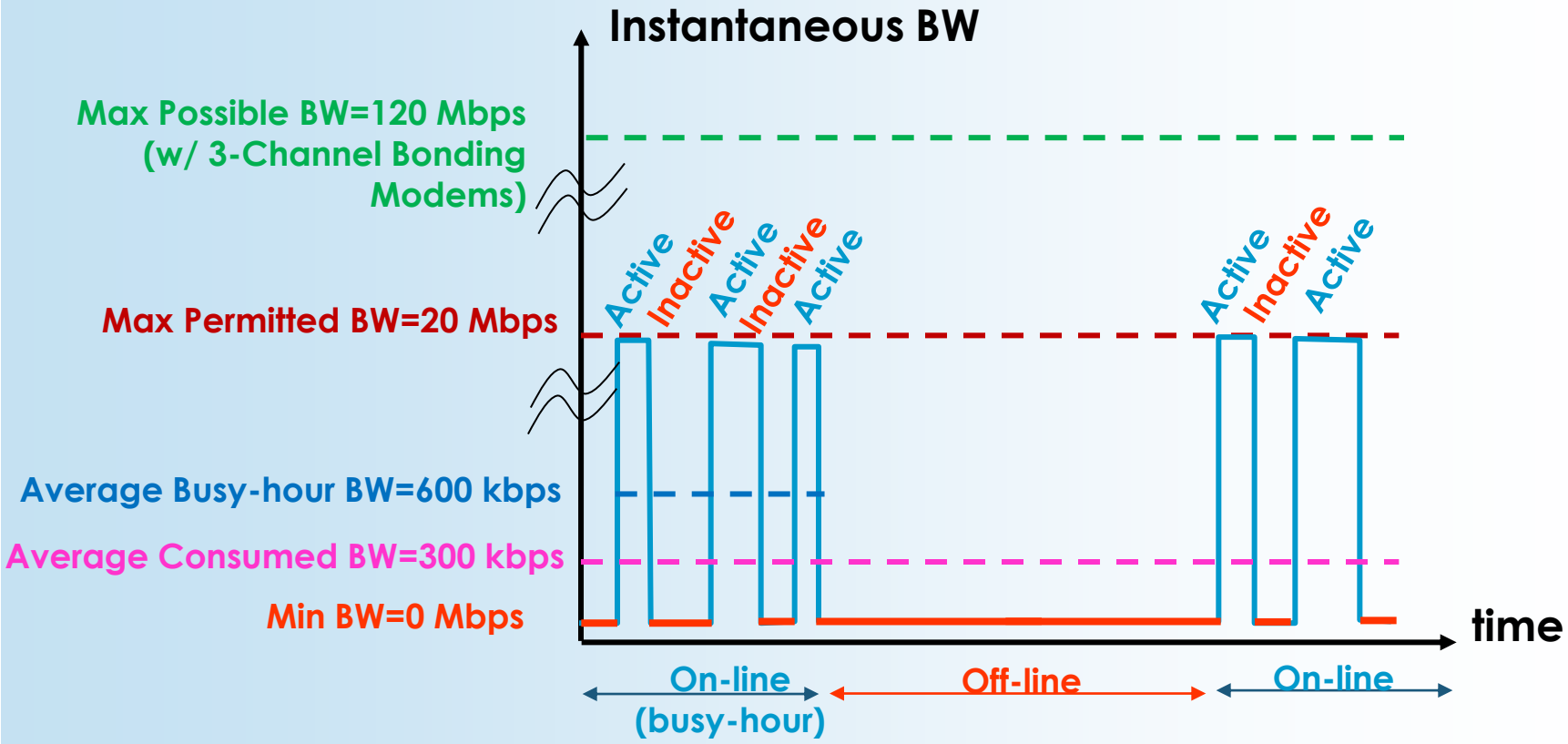
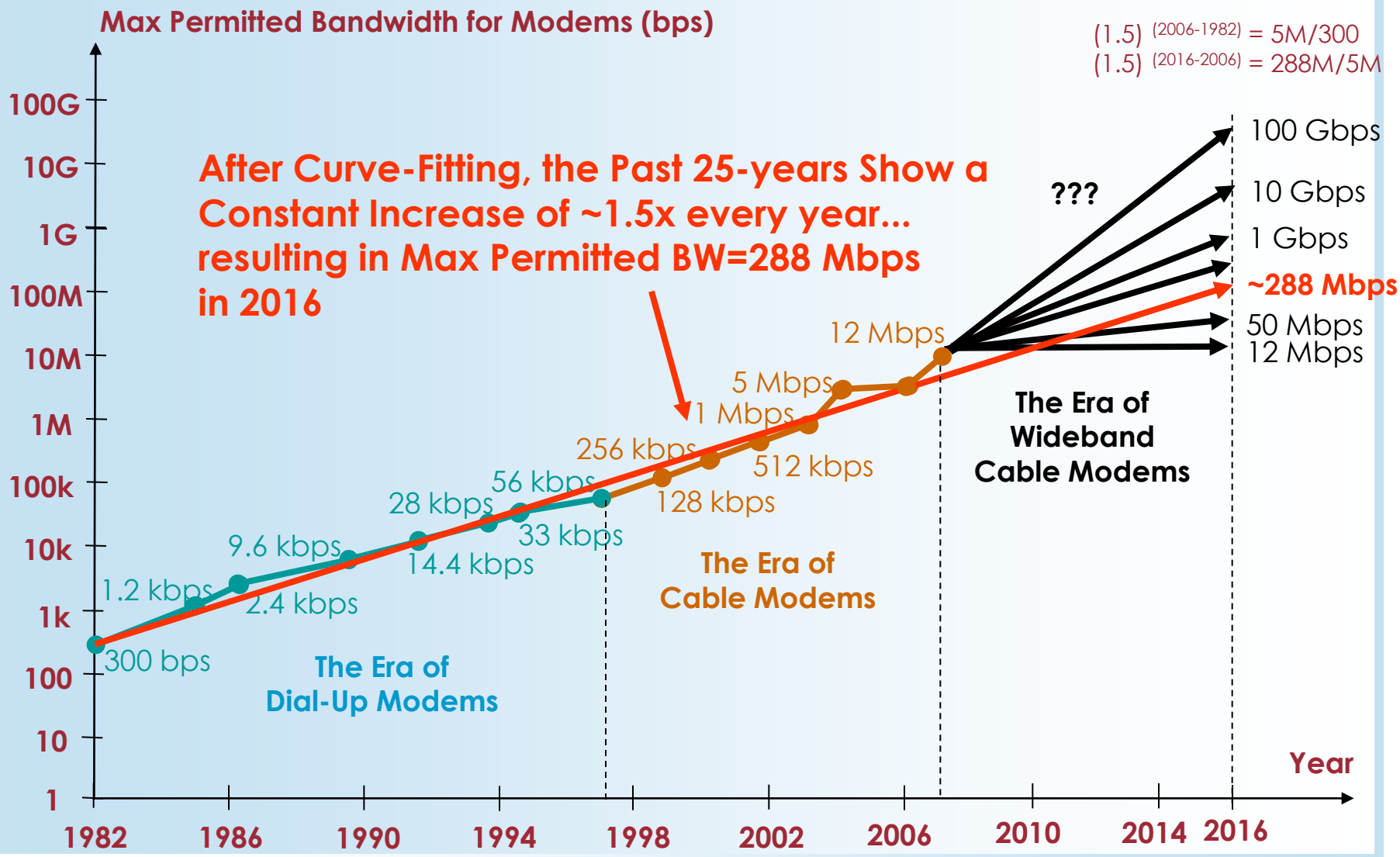
Some Basic Terms Used In This Talk



Average Busy-hour BW & Average Consumed BW tend to be used quite extensively for Traffic Engineering calculations (determining how much Bandwidth Capacity is required to satisfy a given Service Group (pool) of subscribers)

Max Permitted Bandwidth Trends for Modems (First Charted in 2008)



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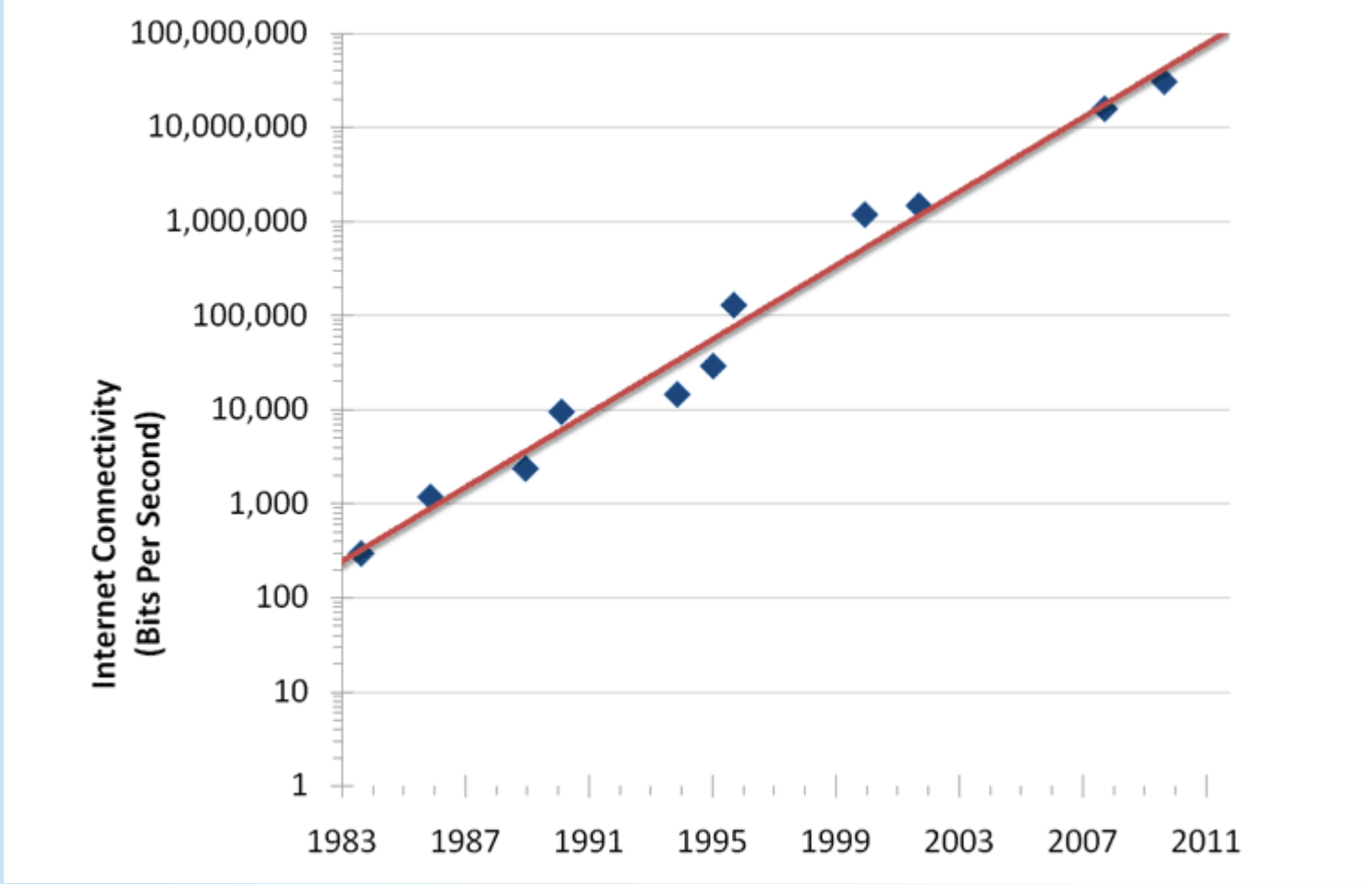
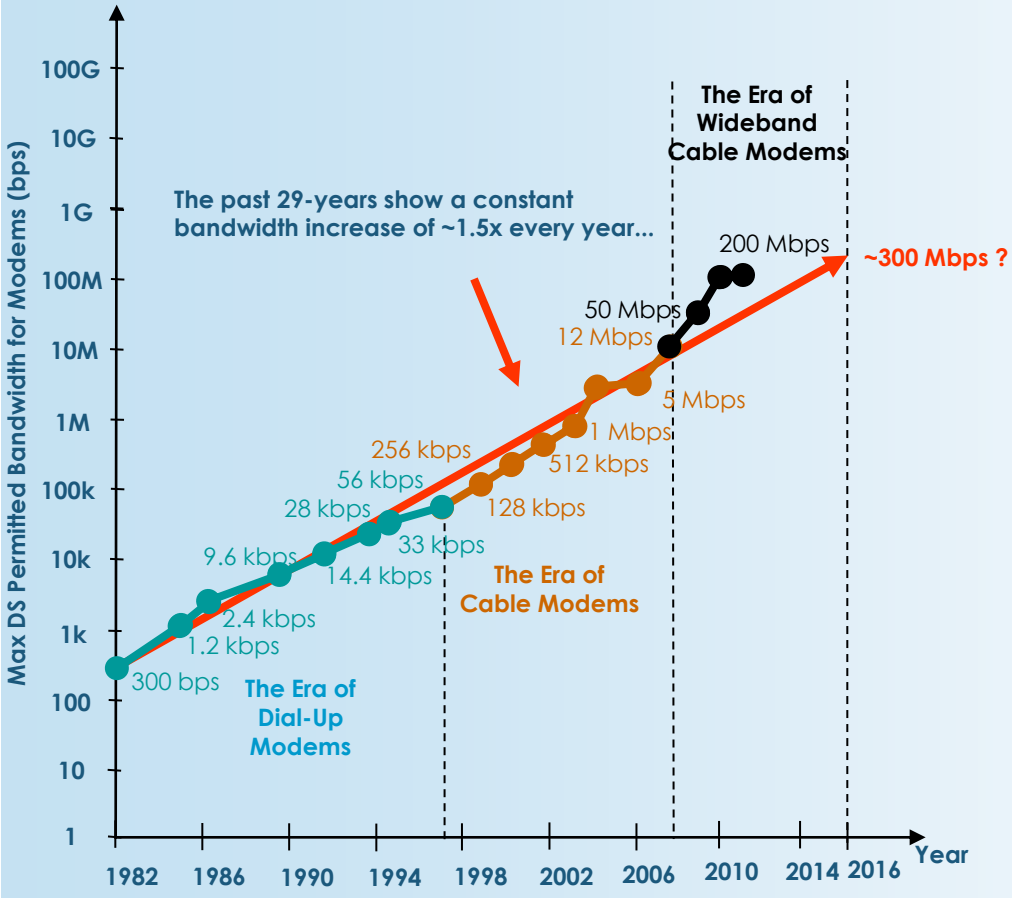
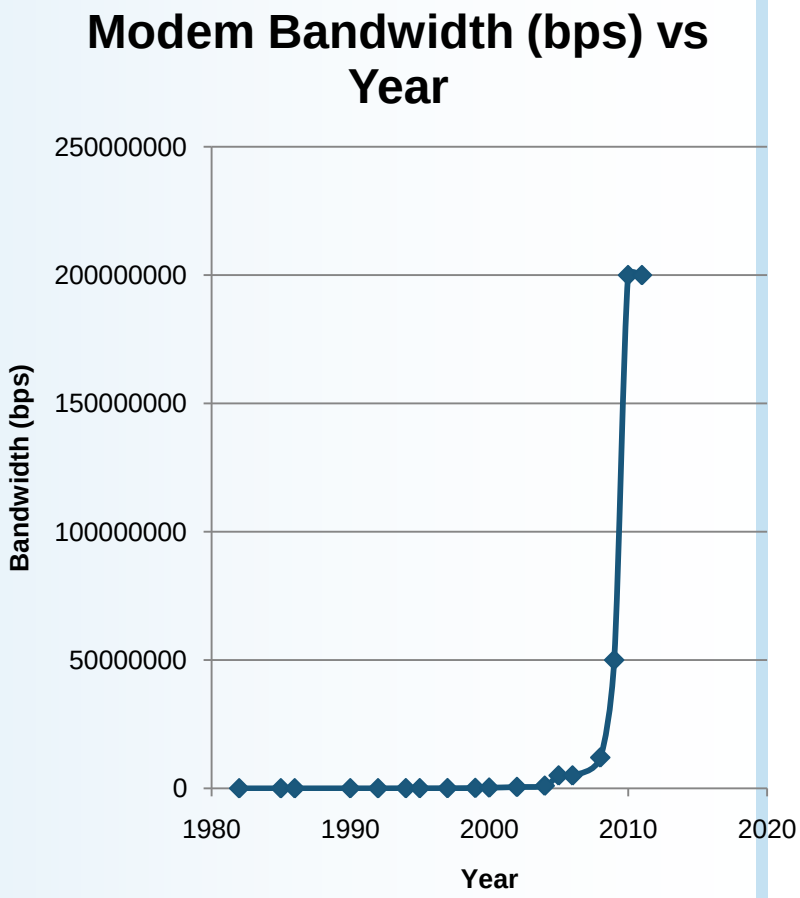
Giving Credit Where Credit Is Due: Nielsen's Law of Internet Bandwidth (1998)



Bandwidth Trends and Predictions





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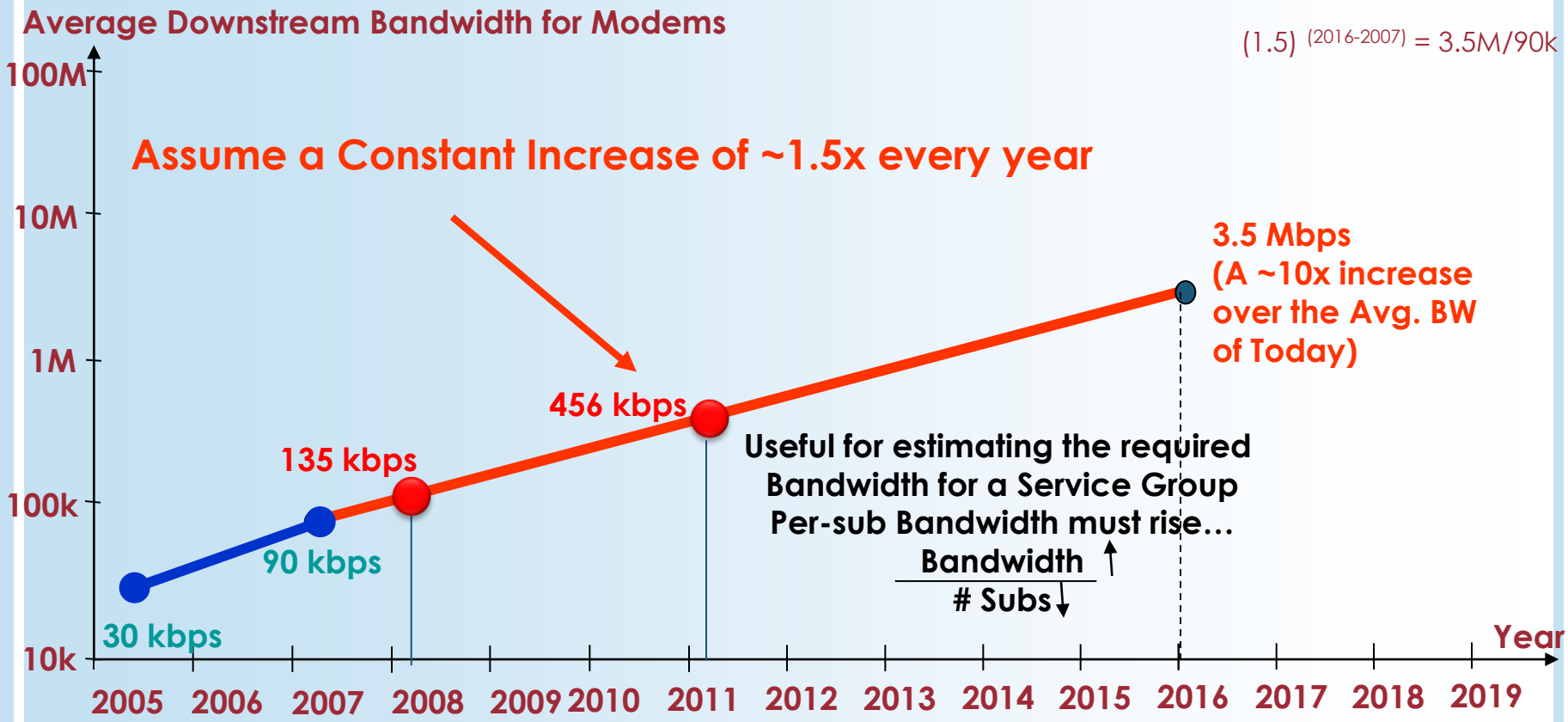
Average Bandwidth Trends for Modems (First Charted in 2008)



2016 Sanity Check: Predicted Concurrency=(Avg BW)/(Max Permitted BW)=3.5/288= ~1.2%...
This roughly matches the predictions from a Comcast conference paper:
Saifur Rahman, "DOCSIS® Migration Methodology: From A to B to 3", *Communication Technology* (SCTE, Vol. 24, No. 11, November 2007), pp. 34-40.

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Example Of How Some MSOs Might Choose To Manage Their BW/Subscriber Metric

2008

CMTS

40 Mbps

30 Mbps

Fiber Node

800 Home Service Group (320 subs)

Avg DS BW per sub = 40 Mbps/320 subs = 125 kbps/sub

As more Bandwidth per Subscriber is Needed...

2011

CMTS

80 Mbps Bonding Group

40 Mbps

40 Mbps

30 Mbps

30 Mbps

60 Mbps Bonding Group

Fiber Node

400 Home Service Group (160 subs)

Avg DS BW per sub = 80 Mbps/160 subs = 500 kbps/sub

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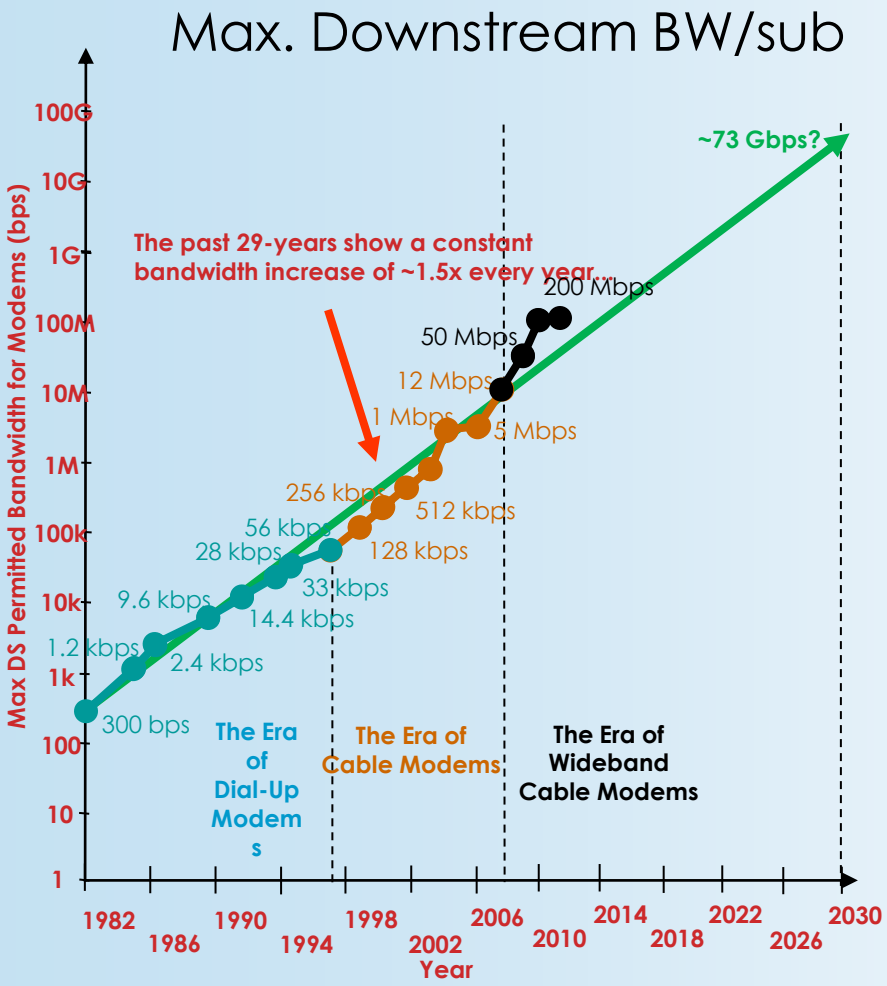
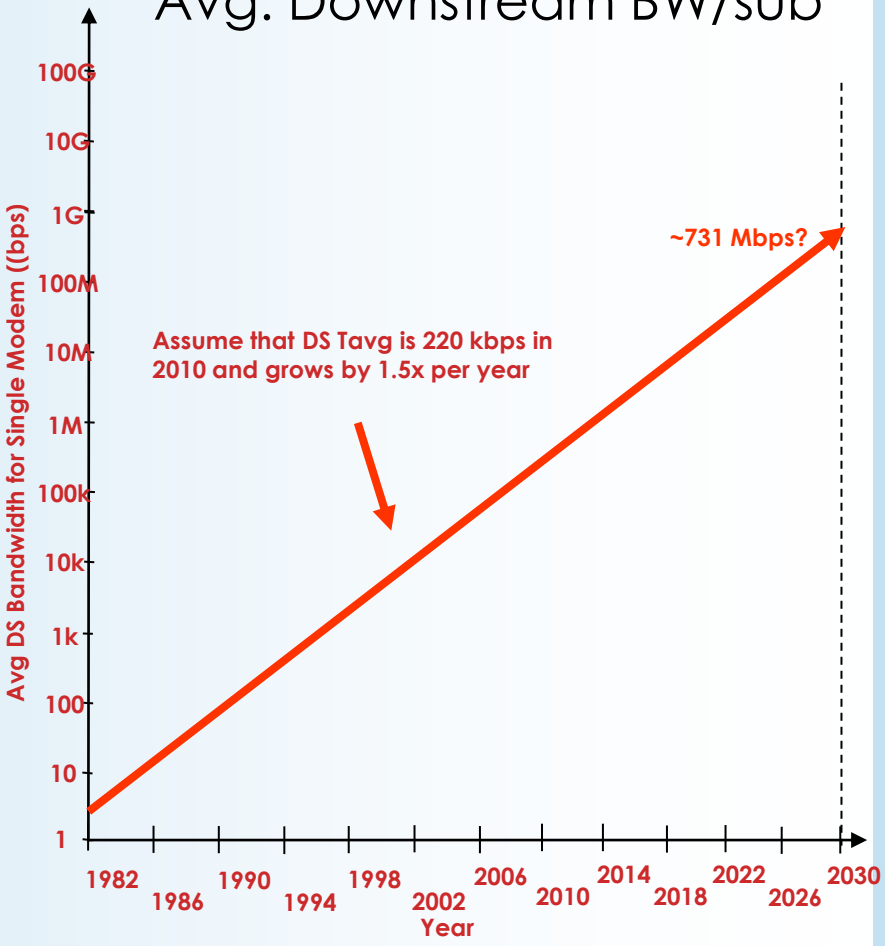
Extended View of HSD Downstream Bandwidth Trends (Per Subscriber)





A Philosophical Side-Bar on Downstream Bandwidth Growth (Better Done Over Beers)

- Some argue that we will soon hit an asymptotic limit in Downstream Bandwidth Growth due to the limit of the human eye and mind to absorb information
- Ex: If a 20 Mbps, 3D-HD, H.264 video feed is sent to (on average) 2.3 people per home, then each home should be satiated with an average bandwidth offer of

  (20 Mbps)*(2.3)=46 Mbps…

  which we predict we will hit by ~2023 (in ~12 years).

- Maybe… BUT…
  - What about the impact of DVR pumping bandwidth?
  - What about the impact of cloud technologies (like Apples iCloud)?
  - What about machine-to-machine transfers for video search engines looking for our optimal content for each night?
  - What about holography?
  - What about the smell & touch & taste technologies that are yet-to-be invented?

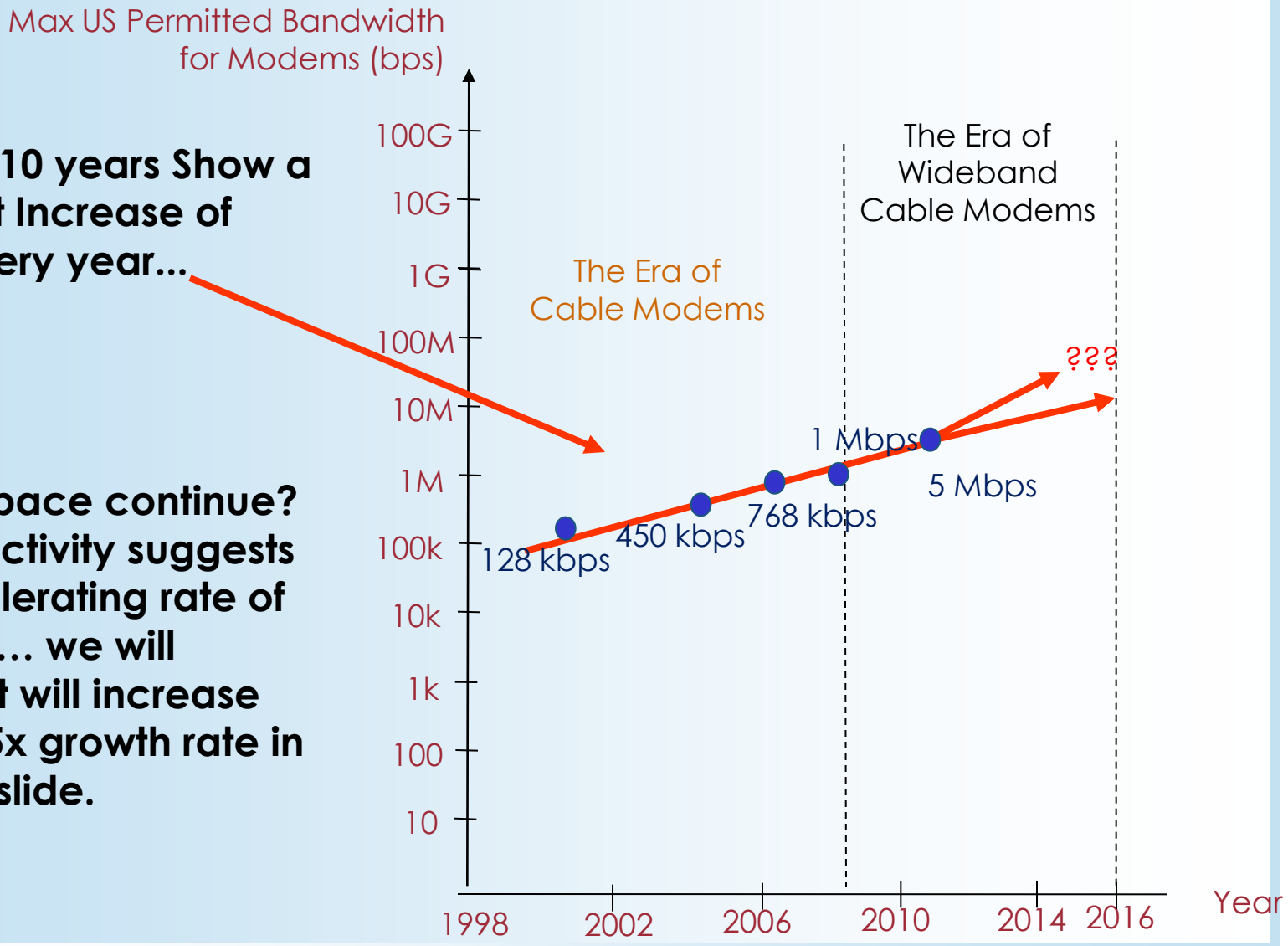
- It may be a while before we hit the asymptotic limit…

Source: ARRIS Estimates

Upstream Bandwidth Growth

The Past 10 years Show a Constant Increase of ~1.1x every year...

Will that pace continue? Recent activity suggests an accellerating rate of increase… we will assume it will increase to the 1.5x growth rate in the next slide.



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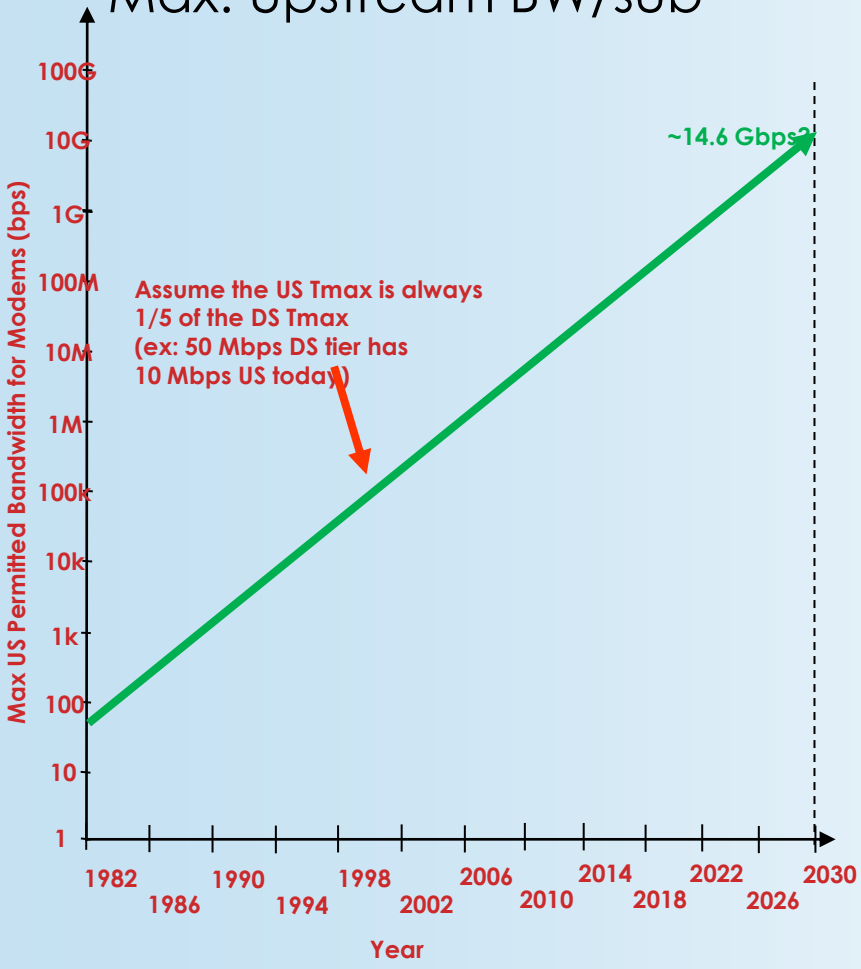
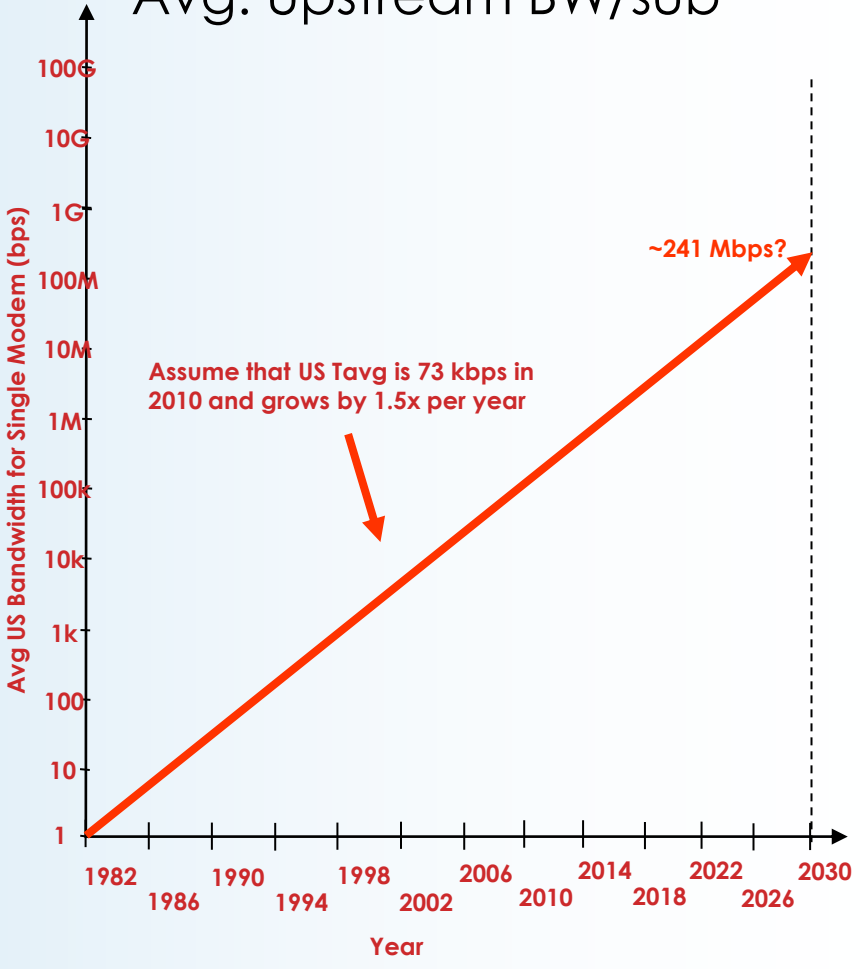
Extended View of HSD Upstream Bandwidth Trends (Per Subscriber)

Max. Upstream BW/sub



Avg. Upstream BW/sub



Some Notes On Upstream Bandwidth

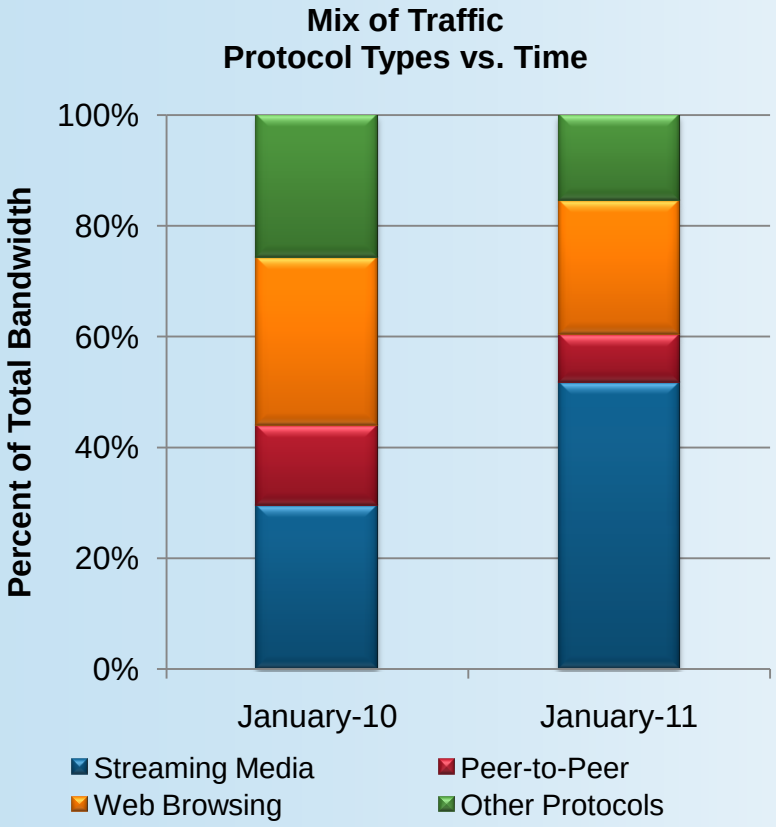
- Upstream Bandwidth is comprised of two types of traffic:
  - Protocol Messages (ex: HTTP GETs, TCP ACKs, etc.)
  - Uploads (ex: P2P torrents, Web-Page inputs, FTP transfers)
- The Protocol Message Bandwidth is predictable and almost calculable (if you know the Downstream Bandwidth & assume typical TCP ACK behavior):

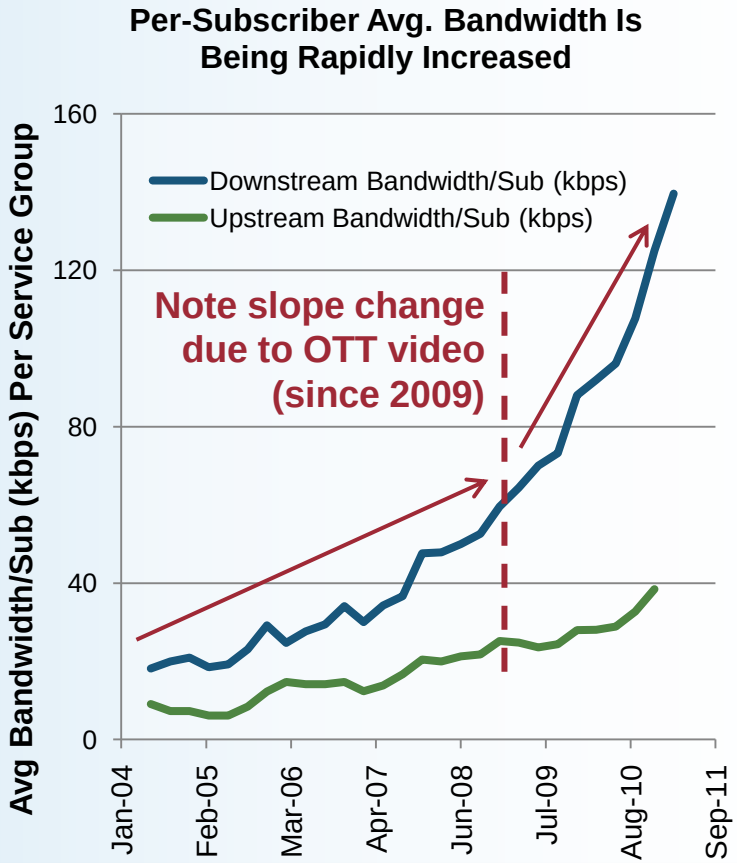
US Protocol Message BW = ~DS BW * (64 bytes/ACK pkt)/(2*1500 bytes/TCP pkt)
= ~DS BW * (0.0213)
= ~2% * DS BW

- The Upload Bandwidth is harder to predict… it is highly dependent on the popularity of apps at any given time
  - Ex: When P2P was big in 2008, US BW was ~41% of DS BW
  - Ex: When OTT IP Video became big in 2010, US BW dropped to ~28% of DS BW

Source: ARRIS Estimates

Over-The-Top (OTT) Streaming Media Is Dominating the DOCSIS HSD Growth





Source for both graphs: Top 5 US MSO

- **The traffic mix is changing fast… Service Providers must respond quickly**
- **The ratio of Downstream-to-Upstream bandwidth is growing as IP Video increases… ~2.4 in 2008 and ~3.5 in 2010**

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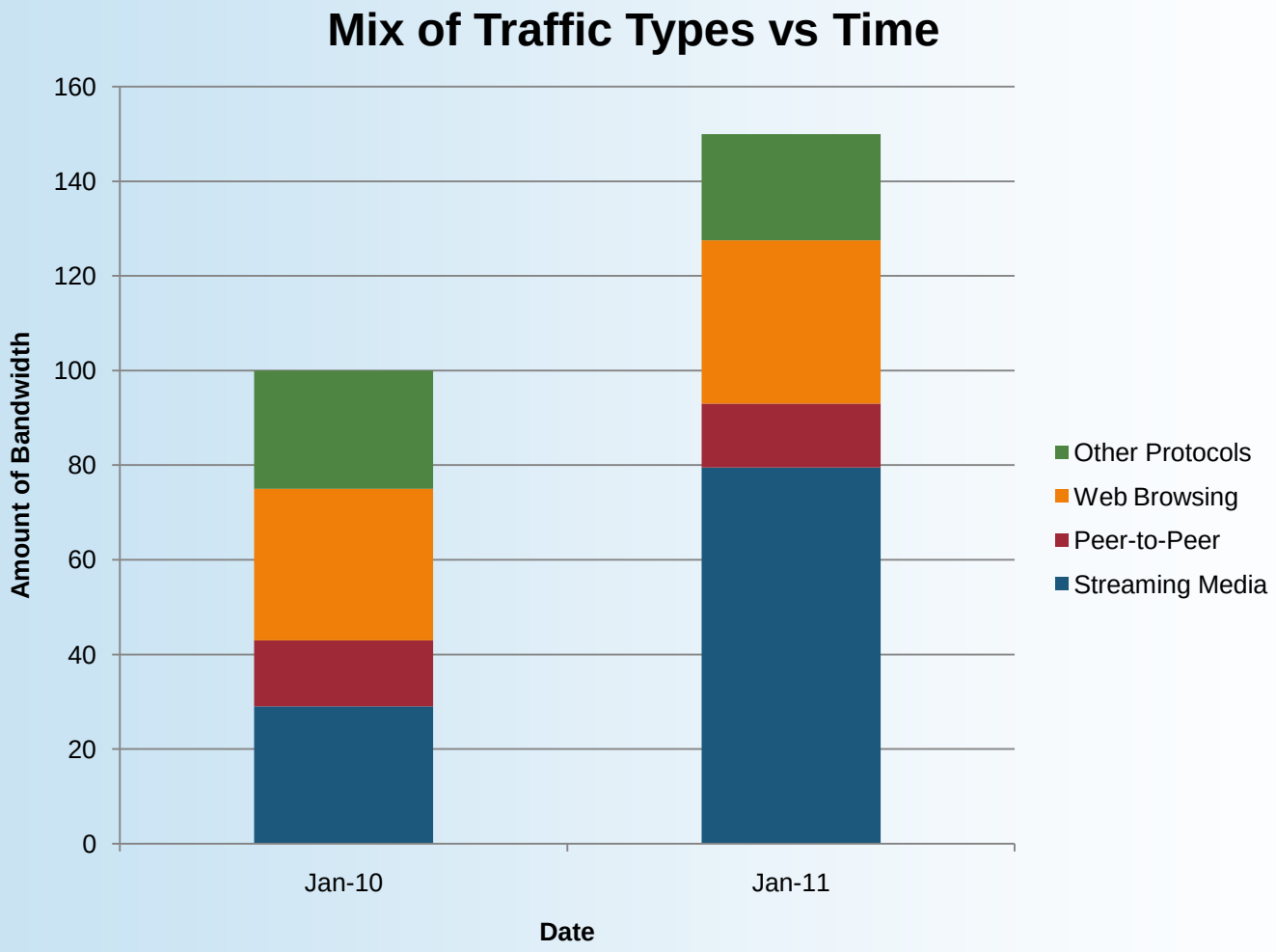
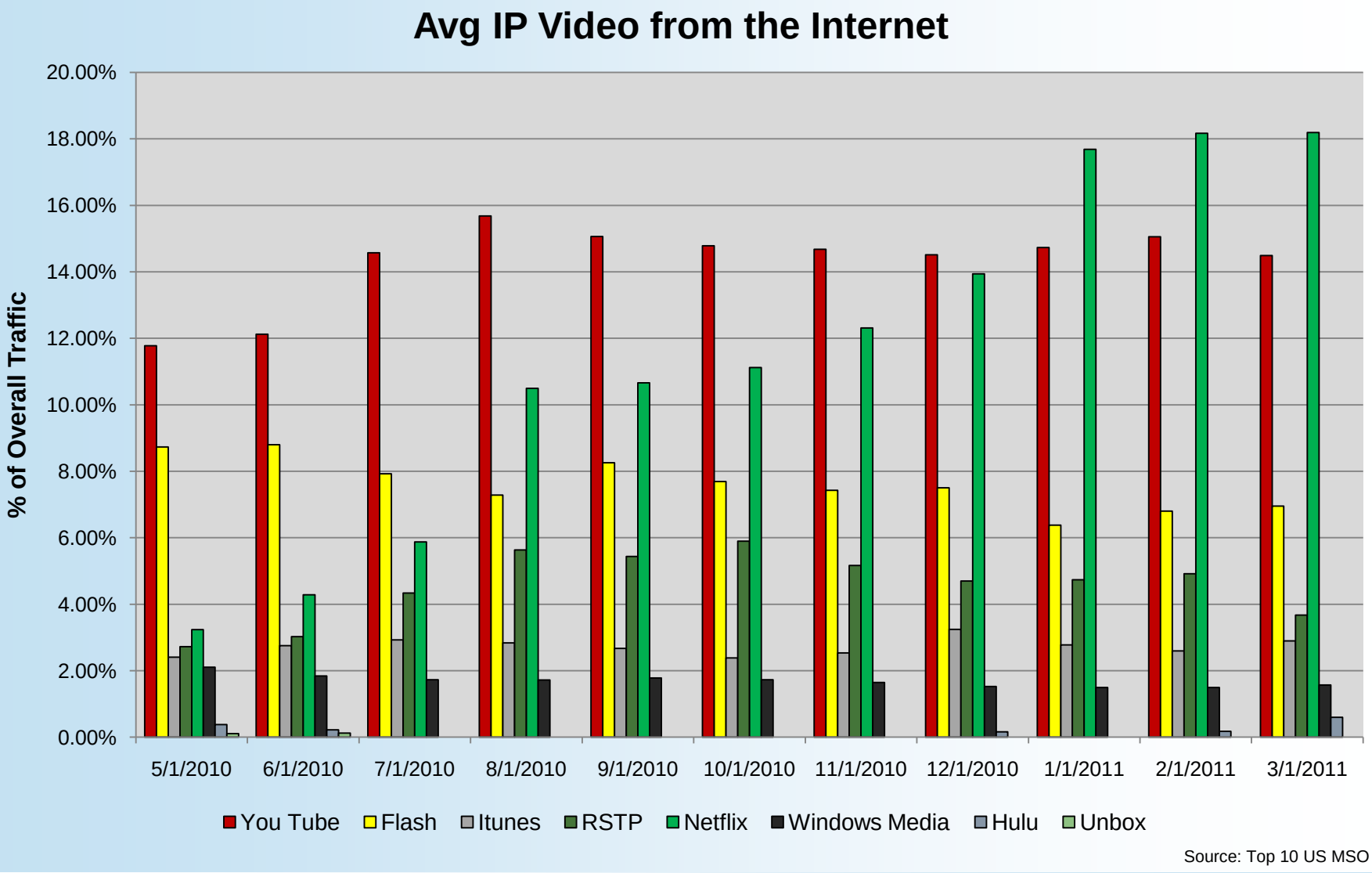
Bandwidth Trends for Different Traffic Mixes



IP Video Trends Over Time

May 2010 – March 2011



Source: Top 10 US MSO

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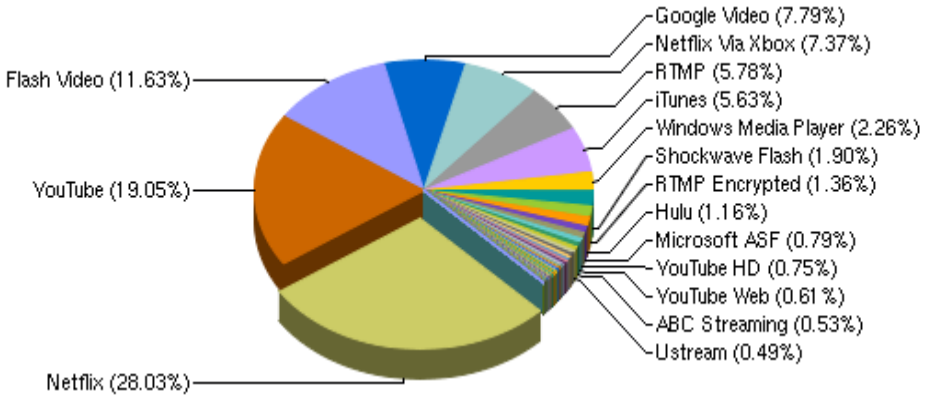
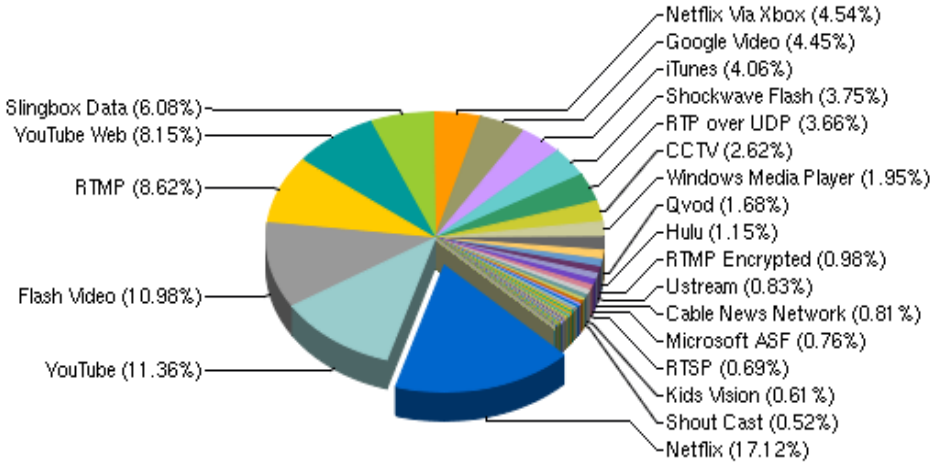
Overall IP Video Traffic Details (March 2011)

Internet to Subscribers



Subscribers to Internet



Max Downstream Bandwidth Consumption (Gb/s)

Overall IP Video Downstream	185.67	Percentage of Overall Traffic
Netflix (Add all Netflix Values)	65.73	18.19%
You Tube (Add all You tubes and Google Video)	52.36	14.49%
Flash (Add Flash and Shockwave)	25.12	6.95%
RSTP (RTSP, RTMP and RTSP over UDP)	13.26	3.67%
Itunes	10.45	2.89%
Windows Media (WMP and MS ASF)	5.66	1.57%
Hulu	2.15	0.60%

Max Upstream Bandwidth Consumption (Gb/s)

Overall IP Video Upstream	6.64	Percentage of Overall Traffic
You Tube (Add all You Tube and Google Video)	1.59	1.52%
Netflix (Add all Netflix Values)	1.44	1.38%
Flash (Add Flash and Shockwave)	0.98	0.94%
RSTP (RTSP, RTMP and RTSP over UDP)	0.93	0.89%
Slingbox	0.40	0.39%
Itunes	0.27	0.26%
Windows Media (WMP and MS ASF)	0.18	0.17%
CCTV	0.17	0.17%
Qvod	0.11	0.11%
Hulu	0.08	0.07%

Source: Top 10 US MSO

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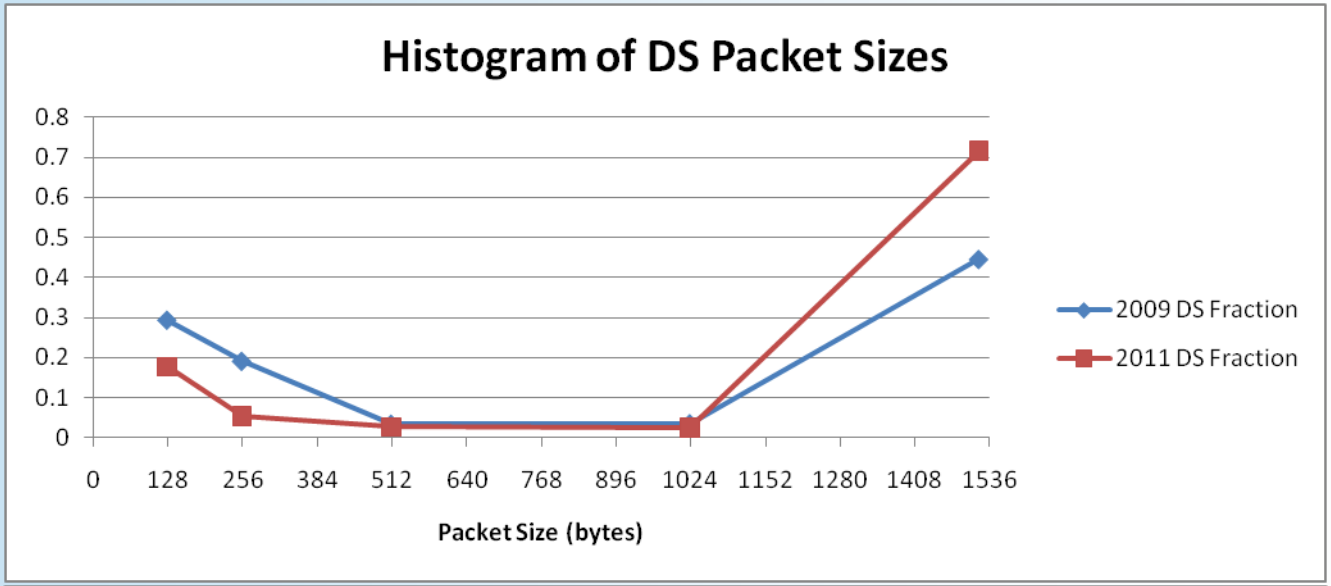
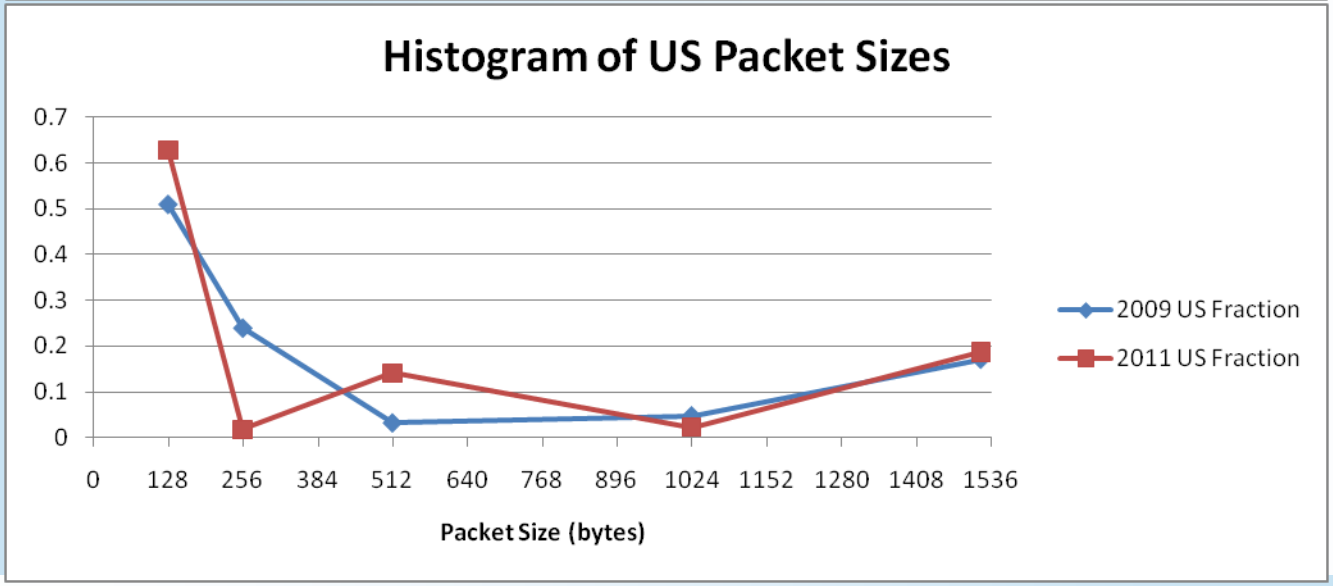
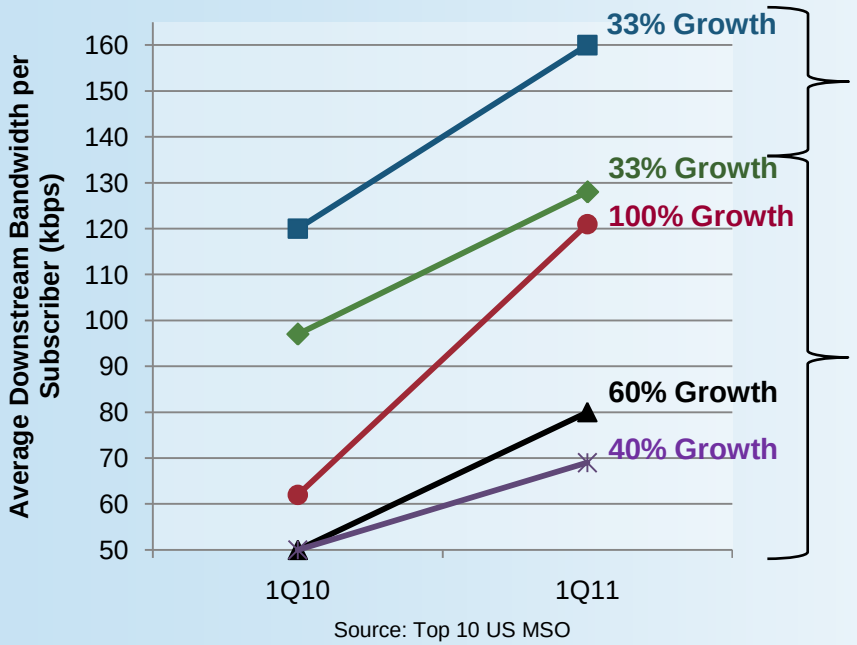
Snapshot of Packet Size Trends





Bandwidth Trend Differences Between Different Service Providers

Bandwidth Trends at Five Service Providers in 2010



Source: Top 10 US MSO

This may represent an **"un-congested"** subscriber's bandwidth level in 2011

These may represent **"congested"** subscriber bandwidth levels in 2011

Subscriber Satisfaction Issues Will Drive Service Providers to Increase Investment to Retain and Attract Customers

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Why Discuss Equipment In A Talk On Bandwidth Trends?

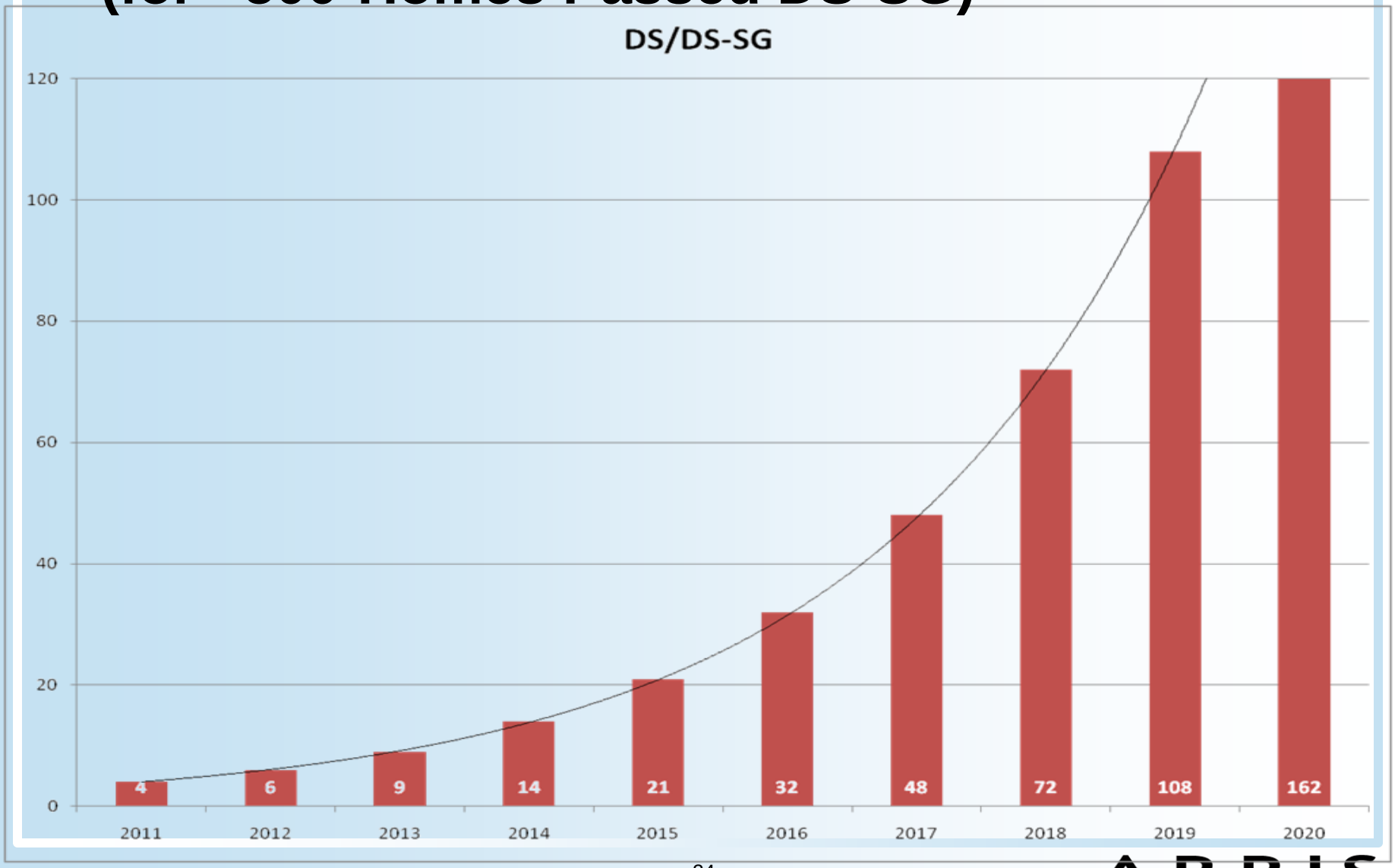
- In order for the Bandwidth Trends to materialize, the available Equipment MUST be able to support the predicted Bandwidths at acceptable cost levels

- We will explore this topic from the point-of-view of DOCSIS CMTS Equipment, which serve 20-50 “Service Groups”

- For an Typical Single High-Speed Data “Service Group” with ~500 Homes Passed, MSOs predict:
  - 2008: 1 DOCSIS Downstream (~40 Mbps)
  - 2011: 4 DOCSIS Downstreams (~160 Mbps)
  - 2015: ~20 DOCSIS Downstreams (~800 Mbps)

Source: ARRIS Estimates

Downstreams Per DS-SG Bandwidth Trends (for ~500-Homes Passed DS-SG)



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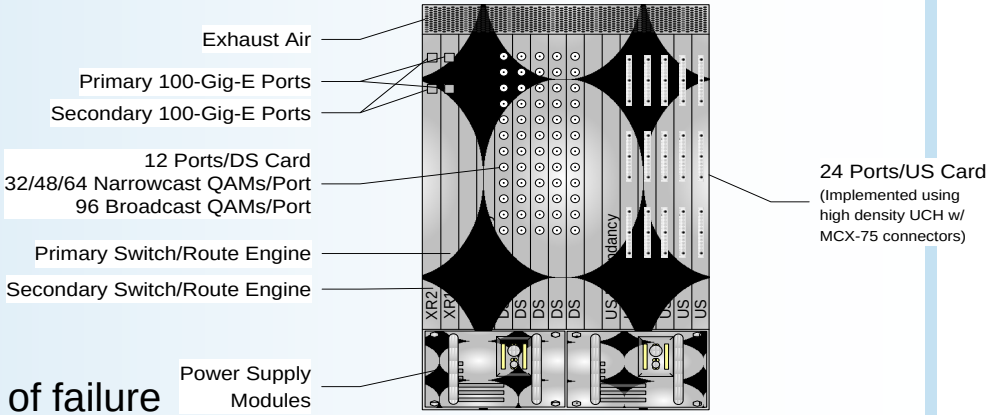
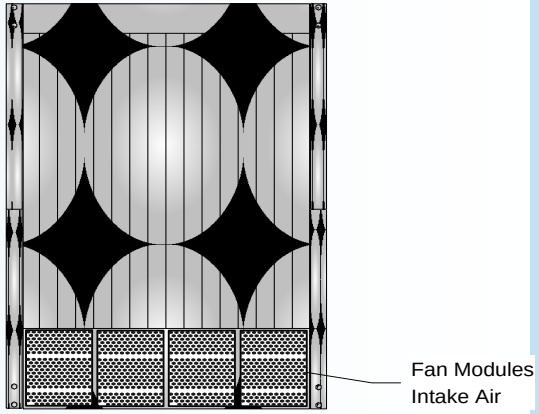
CCAP… The Cable Industry Response to Rapid Bandwidth Growth

- Converged Cable Access Platform
  - CMTS (HSD, VoIP)
  - UEQ (VoD, SDV, M-CMTS)
  - IP Video
  - EPON
- Highly Available
  - Fully redundant design, no single point of failure
  - Separate upstream and downstream modules supporting dynamic mix of services
- Future Proof
  - Terabit-plus capacity in backplane
- **Extreme Density**
  - **20x-80x increase in capacity**
  - **14x-60x power reduction**
  - **20x-80x space reduction**
- **Support for up to ~6.3 Gbps of Downstream Bandwidth to each Service Group**

Rear View
16U Chassis



Front View
16U Chassis



The CCAP Architecture Has Been Designed to Carry the Cable Industry Deep Into the Next Decade and Beyond...

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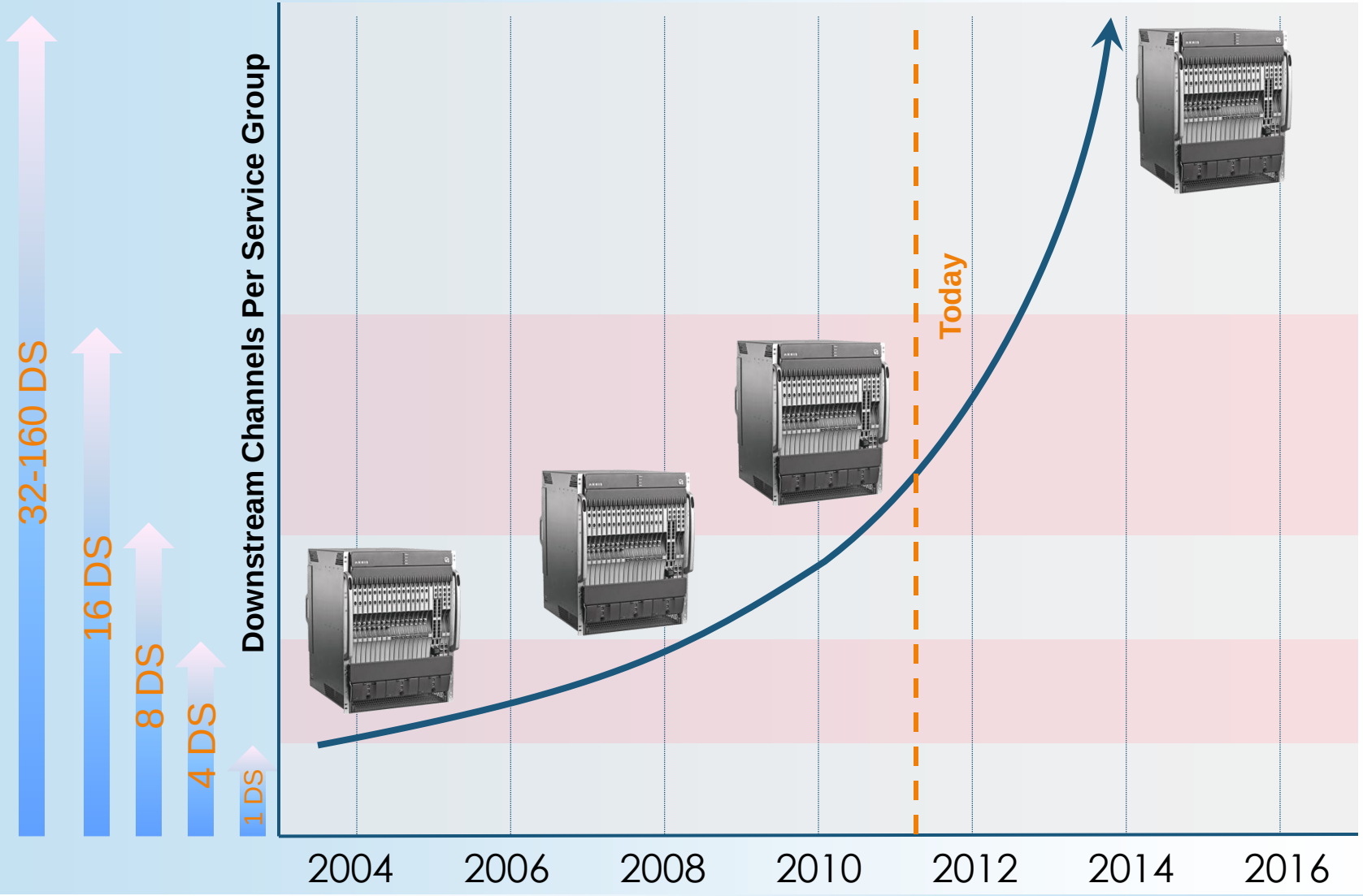
CMTS Edge Router Evolution

Ongoing Capacity Expansion based on Moore's Law



Moore's Law & a Perfect Storm of New Technologies Will Enable Required Features for this Decade

Building Blocks	2007 Capabilities	2011 Capabilities	Increase
L2/L3 Switch Chips	60 Gbps	640 Gbps	10x
High-Speed Digital-to-Analog Converters	1 Downstream Channel per DAC	100+ Downstream Channels per DAC	100x
Burst Receivers	2 Upstream Channels per Receiver	12 Upstream Channels per Receiver	6x
Processor Chips	2 Cores per Chip	32 Cores per Chip	16x

- Allows higher capacities within a given chassis size
- Allows increased densities
- Allows for a single chassis that supports all services
- ***Allows Lower Cost/Channel***
- ***Allows Next-Gen Networking Equipment to support the Need***

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Conclusions

- Bandwidth growth on Service Provider networks has been growing exponentially for ~30 years
- The Downstream growth rate has been roughly 1.5x per year… Web-Surfing was the driver of growth in 2000… P2P was the driver of growth in 2008… IP Video is the driver of growth today
- The growth is expected to continue for many years into the future as new “yet-to-be-invented” applications are created
- Network equipment providers are capitalizing on Moore’s Law to provide the capacities that will support this growth
- The Internet will continue to grow to support the newly-evolving Applications & the higher Bandwidth Goals (ex: “1 Gbps to every home”) that will dominate the markets of the future

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Convergence Enabled.

THANK YOU