

Impact of Bandwidth Demand Growth on HFC Network Networks 2008



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Impact of Bandwidth Demand Growth on Hybrid Fiber Coax (HFC) Networks

- **Situation:**

- o Bandwidth demand per subscriber for video and data services is increasing very rapidly and the pattern is changing

- **Question:**

- o How well can the HFC networks evolve to meet the future demand?

- **Agenda:**

- o Today's HFC Infrastructure
- o Incremental Steps to Increase Bandwidth in HFC Plant
- o Future HFC Infrastructure
- o Conclusions

Market Trends Affecting Bandwidth Demand

- **Increasing demand for High Definition (HD) content**
 - Verizon and Dish Network offering 100+ HD channels now
- **Specialized programs with sparse viewership**
 - Driven by increasing availability of specialized content
- **Increasing popularity of Video on Demand (VOD)**
 - 25% increase in hours of use over last year*
- **Continuous increase over time in the user need for bandwidth for High Speed Internet Access (HSIA)**
 - Cable companies offering 10-15 Mbps service in response to FTTH and xDSL
- **A future step increase in the bandwidth is needed due to new user applications**
 - Peer to peer file sharing
 - Traffic from Small and Medium business customers being targeted by the MSOs
 - New interactive applications
 - ...

* Heavy Reading report

Bandwidth Needs for Current and Future Services

Service	Bandwidth		Comments
	Now	Future	
VOIP	100 Kbps	100 Kbps	Without compression, total bandwidth need is small
HSIA Downstream	2 Mbps	14 Mbps	Consensus number from multiple marketing reports
HSIA Upstream	200 Kbps	1 Mbps	
Standard Definition TV	3.75 Mbps	2 Mbps	Bandwidth need will decrease if more efficient coding is employed
High Definition TV	19.8 Mbps	10 Mbps	

- Future demand estimated using a composite of projections from market research reports
- Represents our estimate of the demand in five years.

Today's Cable Plant Parameters

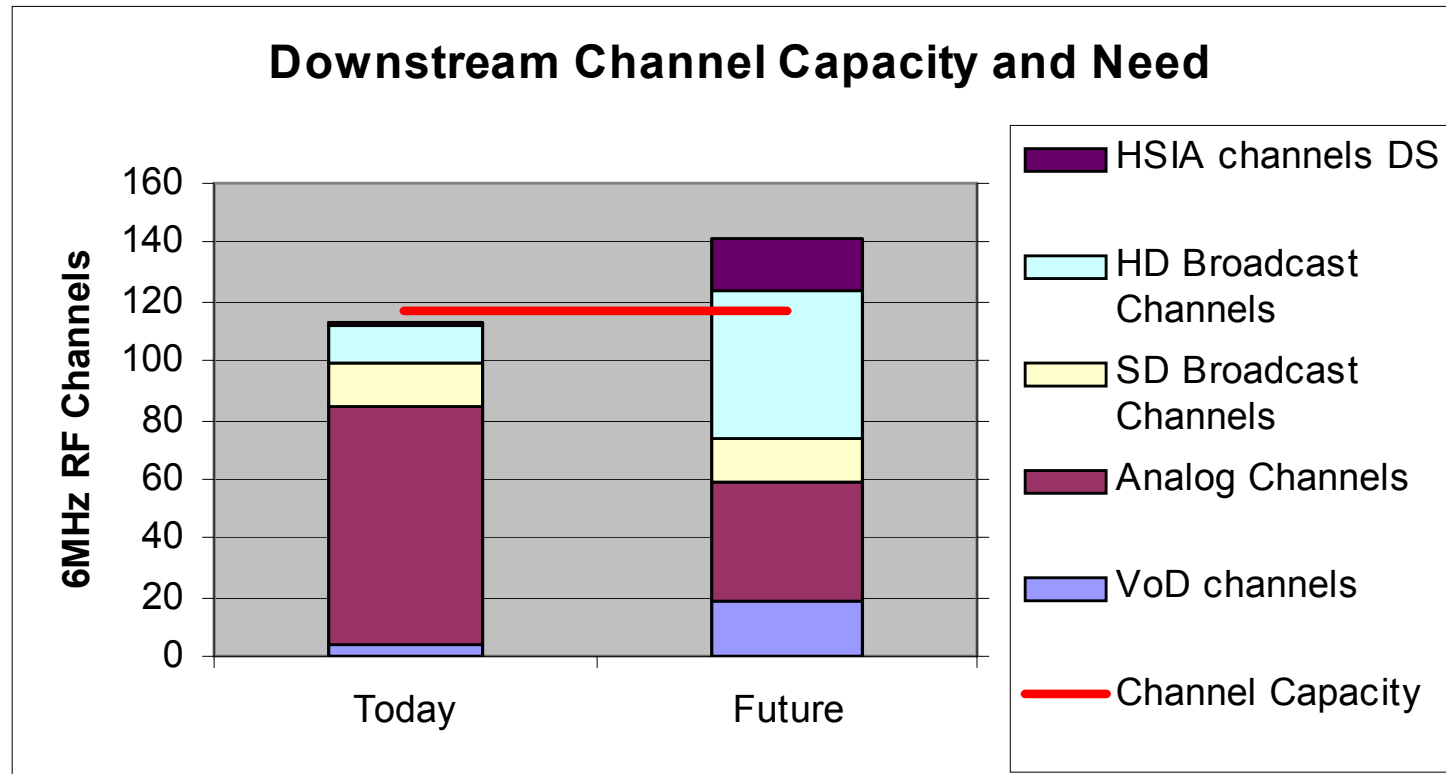
Parameter	Value	Comments
Homes passed per Fiber Node	500	Node sizes in North America range from 125 to greater than 1000, the average node size is around 500 homes.
Cable Bandwidth	760 MHz	Most HFC systems are at 760 MHz, 860 MHz and 1GHz systems also exist
Upstream/Downstream Bandwidth	45 MHz/ 705 MHz	Most common split
RF Channel Size (Downstream)/Capacity	6 MHz/ 38 Mbps	Europe uses 8 MHz/ 51 Mbps channels (capacity with 64 QAM)
RF Channel Size (Upstream)/Capacity	1.6 MHz/2.5 Mbps	Using QPSK. 6.4 MHz channel with 64 QAM can go up to 30 Mbps
Number of HD Programs/ RF Channel	2	Using 19.8 Mbps per program, some programs are encoded at lower rates
Number of SD Programs/ RF Channel	10	Using 3.5 Mbps per program, some programs are encoded at lower rates

Today's and Future Service Parameters

Parameter	Today	Future	Comments
Number of Analog Channels	80	40	Could drop to 20 for basic channels only, dropping to zero requires converter box for every TV
Number of SD Programs	150	150	Growth assumed to be in HD
Number of HD Programs	25	100	May be higher, requiring SDV
Video/HSIA Take Rate	0.65	0.65	Equal to current cable take rate, all subscribers assumed to take both cable and data
HSIA Peak Usage Factor	0.05	0.15	Number of users actively uploading/downloading data simultaneously. Increase expected due to internet TV
VoD Peak Usage Factor	0.1	0.2	Growth with increasing usage
Percent of VoD in HD	0	0.5	Growth from none today to half in five years

Note: Although analog broadcast in USA will end in 2009, cable operators may keep the analog channels on their networks for some time

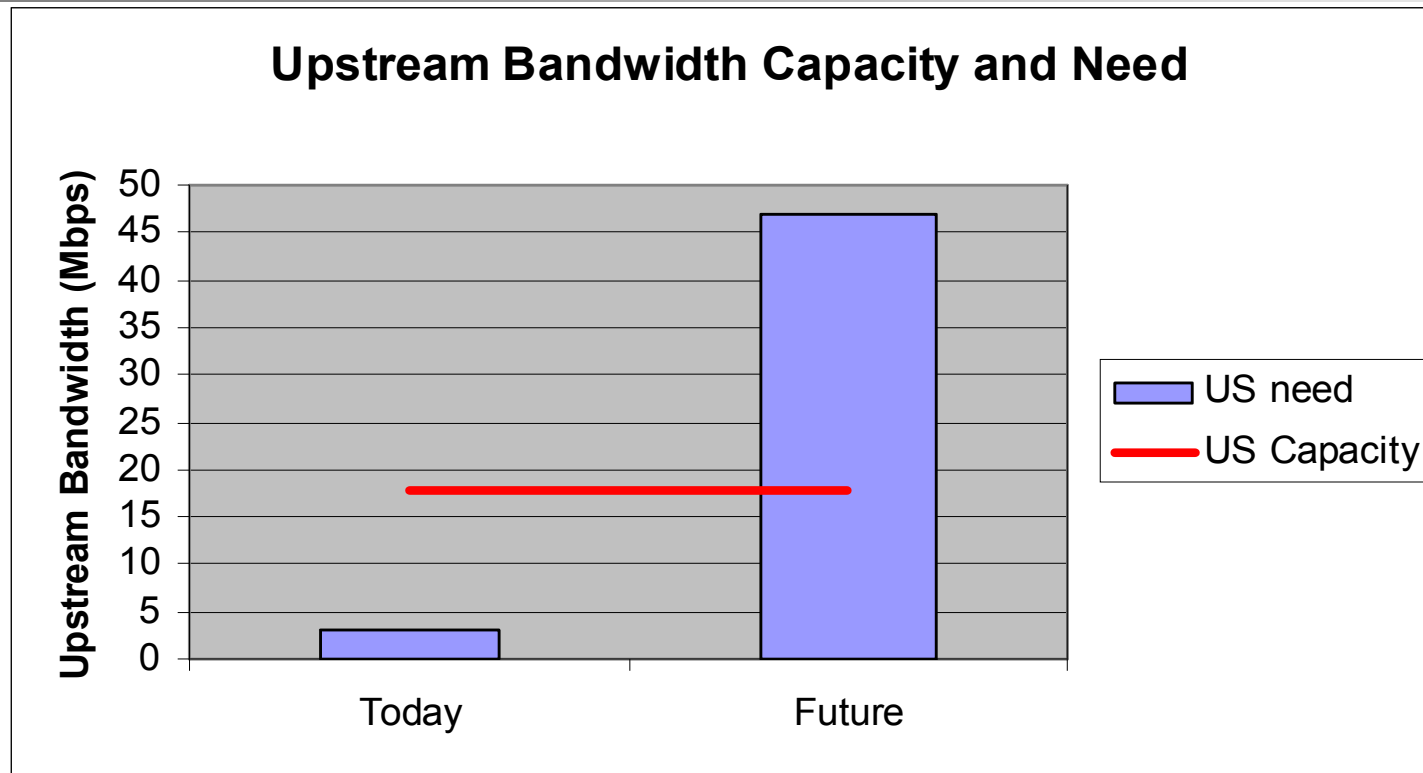
Bandwidth Capacity of Today's Cable Plant



* With 500 homes/node

- Expectation: Current cable plant will not be able to support the downstream bandwidth needs over 5 years
- Incremental steps are needed to meet the demand

Upstream Bandwidth Capacity of Today's Cable



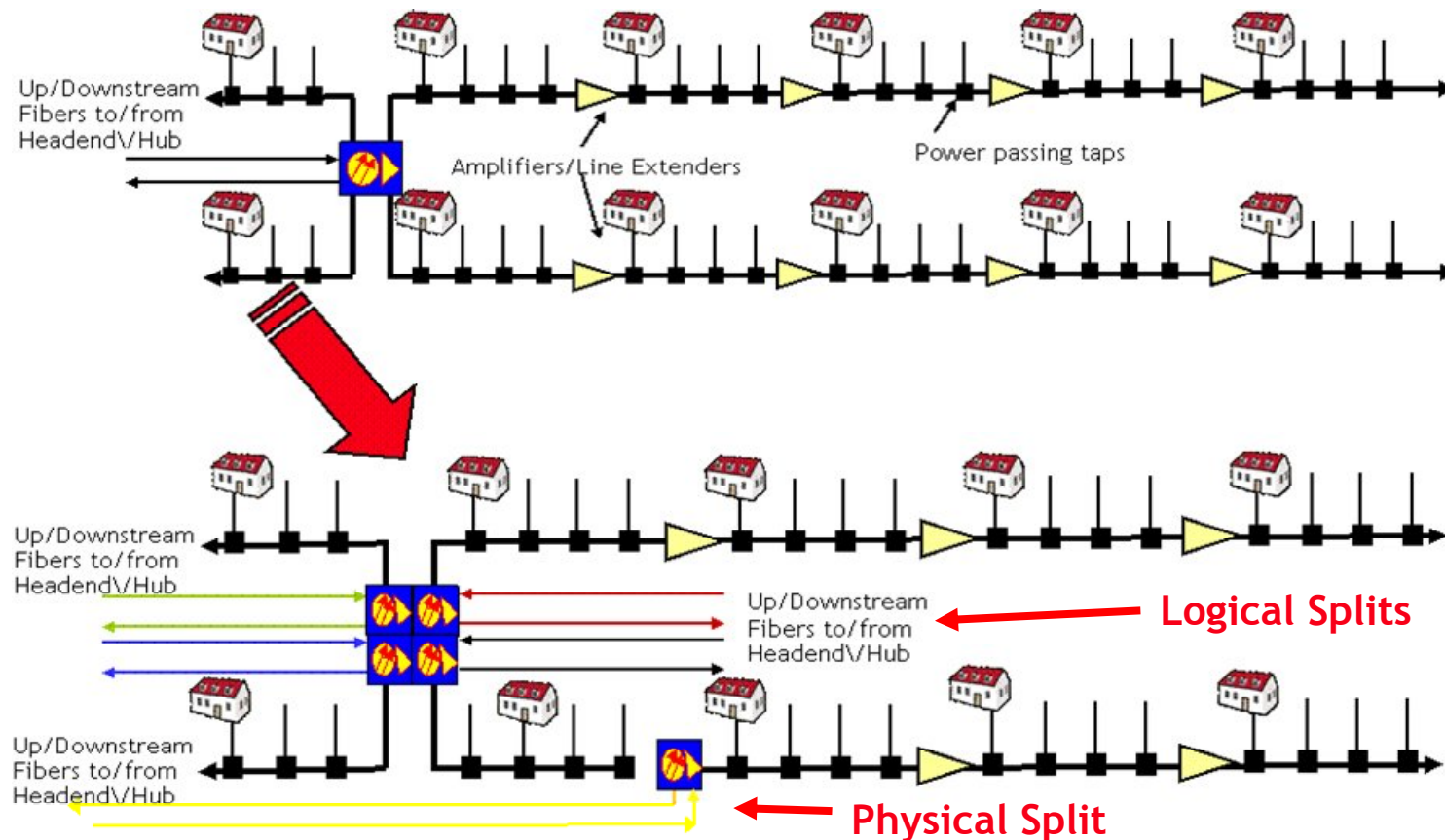
- Upstream capacity of the HFC plant is 45 MHz
- Channel width of 1.6 MHz carrying 2.5 Mbps bandwidth
- Typically up to 7 usable channels (given the noisy environment).

* With 500 homes/node

Upstream bandwidth need in the future far exceeds today's capacity

Incremental Steps to Increase Bandwidth in HFC Plant

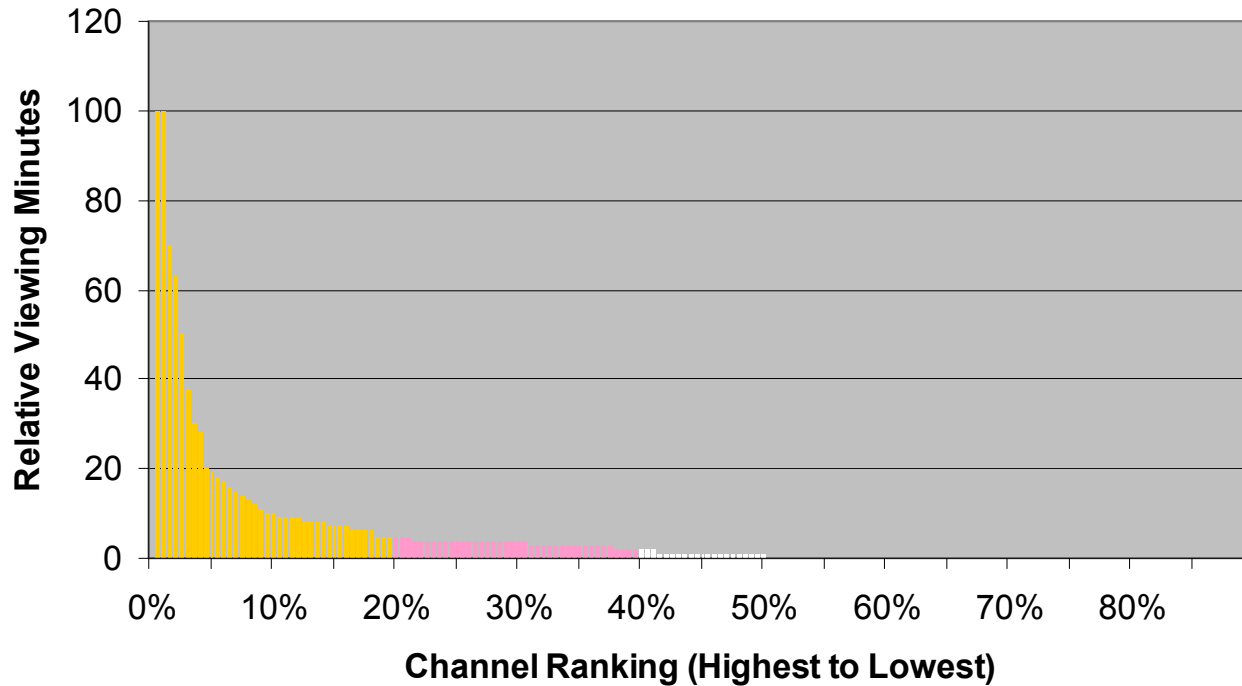
Node Splits



- First logical node split, 500 to 250 homes costs ~ **\$6 per home passed** (Only new laser Tx/Rx needed at ~ \$ 3K for two ends)
- Physical node splits require new fiber and are much more expensive at about **\$65 per home passed** to go from 125 home node to 64 home node

Incremental Steps to Increase Bandwidth in HFC Plant

Switched Digital Video

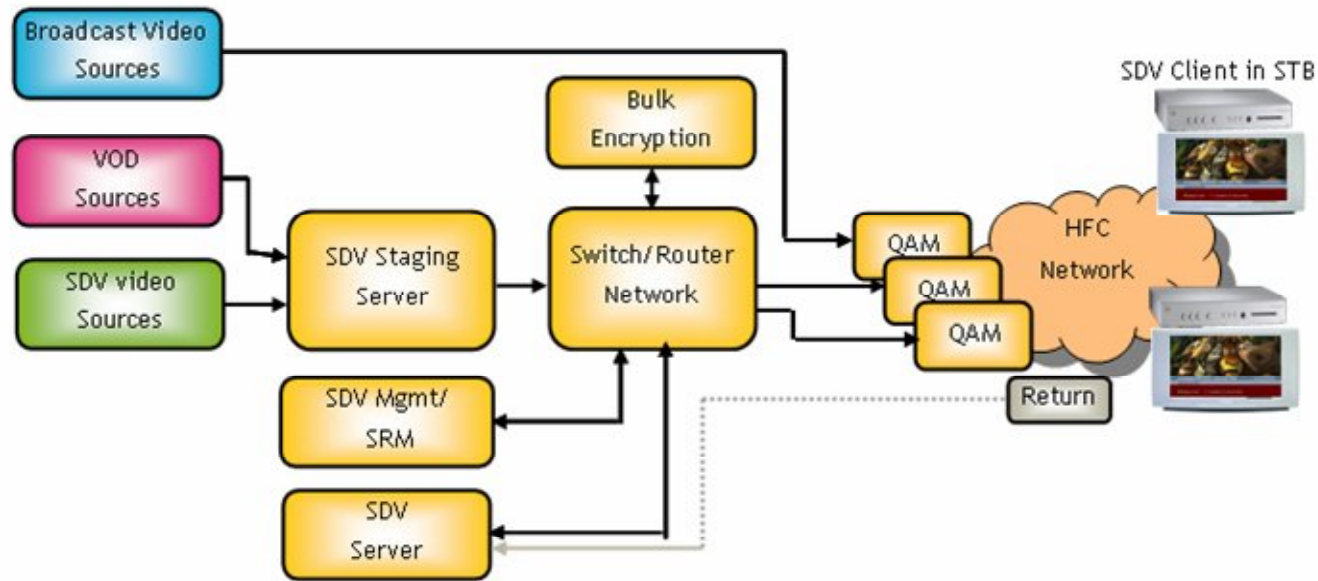


Data from Comcast

- Top 20% of the channels account for most viewing minutes
- Of the bottom 200 channels only 40 are active at any given time
- Example: 125 home node with 65% take rate, 3 video devices per home, 200 programs
 - Broadcast requires 200 program streams
 - Assuming 75% of the video devices are tuned to the top 50 programs, the remaining devices each requiring a unique stream would need additional 61 streams for a total of 111 video streams.
 - A saving of about 40% from the 200 broadcast channels

Incremental Steps to Increase Bandwidth in HFC Plant

Switched Digital Video



Generic SDV Architecture

- Staging server only sends only those programs to the fiber node that are selected by users from that fiber node
- SDV server interacts with STB client for channel changes
- Estimate: 40% to 50% of broadcast bandwidth can be freed up
- Cost per home passed ~ \$16 to \$32 (primarily in STB client, SDV servers and QAMs)

Incremental Steps to Increase Bandwidth in HFC Plant

Analog Reclaim and Bandwidth Expansion

o Analog Reclaim

- Analog over-the-air broadcast to end in the US in February 2009.
- MSOs are already reducing the number of analog channels
- Most plan to continue to carry analog on their HFC networks.
- Every analog channel removed allows 2 HD or up to 10 SD signals to be added to the lineup.
- Completely removing them requires that all TVs or video devices in a home use a converter device; this adds the expense of ~ **\$ 40 per TV**

o Cable Bandwidth Expansion

- Typical US cable plant is **760 MHz** today.
- Upgrading to **850 MHz** or **1 GHz** adds a large number of channels
- Requires **outside plant** components upgrade (amplifiers, splitters, isolators etc.)
- New **set top boxes** capable of tuning into the higher channels
- Cost of the upgrade is estimated at ~ **\$40/HHP**, primarily for STB upgrades

Incremental Steps to Increase Bandwidth in HFC Plant

Improved Encoding and DOCSIS 3.0

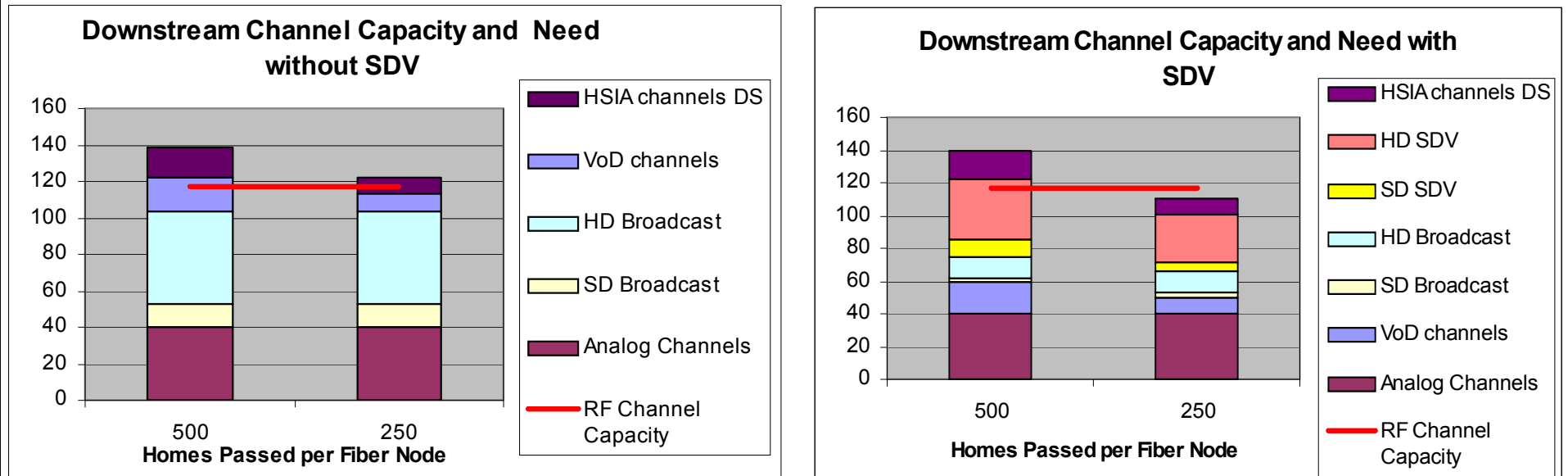
o Better Encoding

- MPEG4 encoding doubles the number of SD or HD programs that can be carried in a 6 MHz channel
- Most of the embedded set top boxes are not MPEG-4 ready
- Changing out all the set-top boxes can be expensive (~ **\$150 per home passed**)
- Cutover to MPEG4 can be complex and expensive

o DOCSIS 3.0

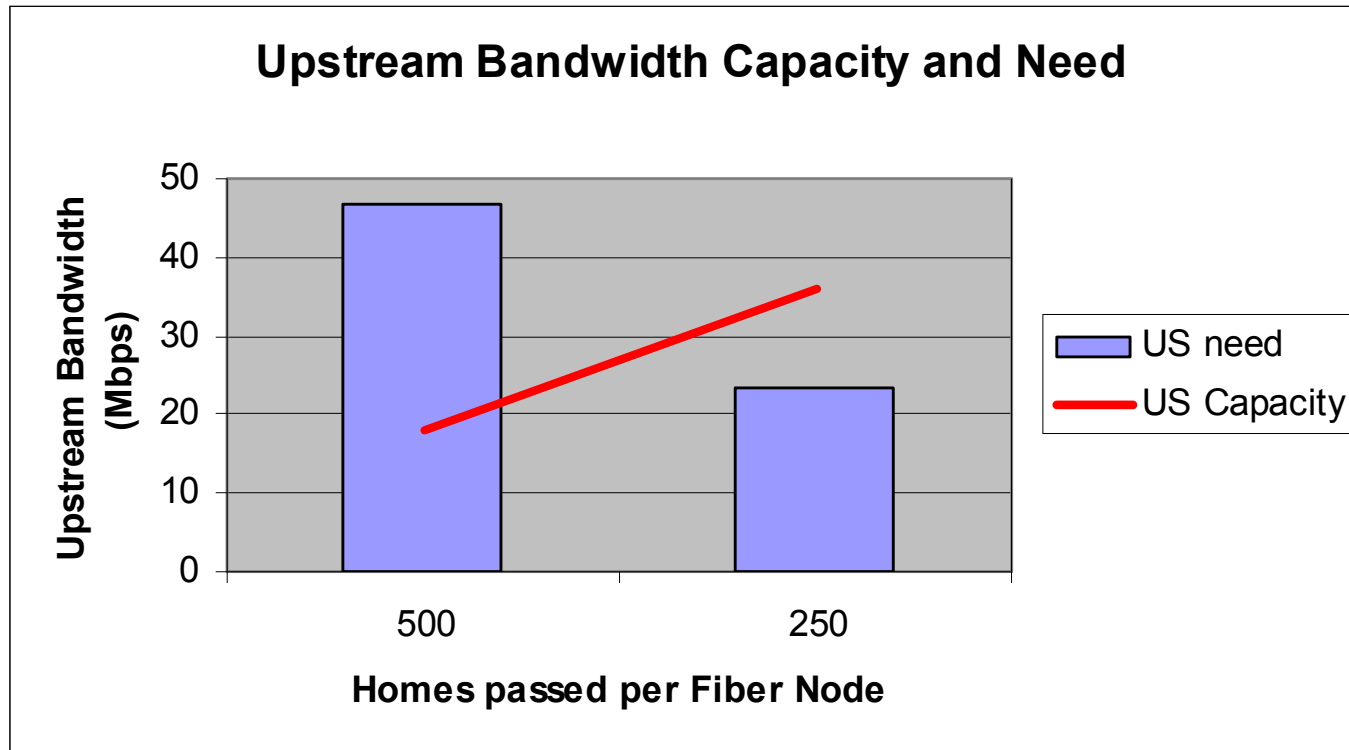
- Does not increase total bandwidth capacity, upstream or downstream
- Bonding of several 6 MHz channels allows much higher burst rates per user to match peak rates for FTTH
 - Standard supports bonding of 4 channels giving **160 Mbps** downstream
 - With 128 QAM and 6.4 MHz channels upstream data rate can be **120 Mbps**
 - Some products support bonding of up to 8 channels for even higher rates
- Estimated upgrade cost: CMTS = **~\$12/subscriber**; Modem with channel bonding = **~\$50/subscriber**

Downstream Bandwidth Capacity & Need for Future Demand



- Without SDV, the downstream BW is exceeded for both 500 and 250 home nodes.
 - o Node split reduces the BW need for HSIA and VoD but not for broadcast
- With SDV, using 25% of channels as broadcast, 3 video devices per home and 25% user watching a unique stream
 - o Downstream BW is not sufficient for a 500 home fiber node, with large number of homes, the advantage of SDV is negligible, but is sufficient for a 250 home per fiber node
- **One Node split (to 250 homes) and adding SDV are sufficient to meet the demands for downstream BW**

Upstream Bandwidth Capacity & Need for Future Demand



- Upstream BW is not sufficient with the 500 home fiber node
 - o Current plant allows for 2.5 Mbps per channel
- **Node split to 250 homes meets the upstream demand**
 - o BW need is halved by the node split
 - o Smaller plant allows use wider channels or better modulation to give 5 Mbps per channel

Conclusion

- MSO HFC networks appear to be reasonably and economically upgradeable to handle the projected future demands over the next five years.
 - One node split and introduction of SDV are sufficient to meet the future demand

- **Competition**
 - **FTTH/GPON**
 - GPON delivers 2.4 Gbps downstream shared over 32 or 64 homes.
 - For 64 homes the future service set will require about 1.8 Gbps of capacity
 - **GPON has more than enough capacity to handle the future demand**

 - **FTTN/xDSL**
 - xDSL uses a single data stream for each subscriber which must meet the individual peak demand
 - Bandwidth needed for 3 simultaneous HD programs and HSIA data at 14 Mbps is 44 mbps.
 - **To meet the future needs xDSL networks will also have to undergo incremental upgrades such as bonding of two ADSL2+ or VDSL2 channels and improved encoding for HD channels**