HFC Plant Capacity Modeling

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Introduction

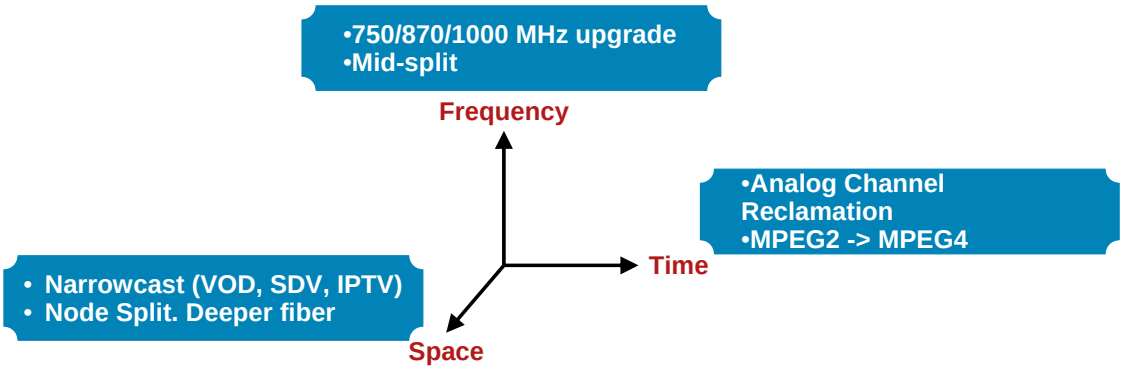
- This presentation will focus on the bandwidth potential of the HFC Plant, and how best to realize that potential.
- This presentation uses a detailed HFC Plant bandwidth model which will be available soon through the Cisco web site.

- Acknowledgements:
  - The model and the data contained within it would not have been possible without the tireless efforts or Marty Mattingly and Robert Loveless of Cisco.

The HFC Plant

- The HFC plant is rich in bandwidth.
  - Each Fiber Node can have 154 ch * 40 Mbps/carrier ~= 6 Gbps of DS bandwidth.
  - A 40 KHHP hub with 250 HHP/FN has 1 Tbps of bandwidth, most of which is untapped today.
- That bandwidth has to be mined.
  - An investment into the HFC Plant yields more bandwidth out.
  - Its like drilling for oil.
- The question is:
  - How much bandwidth is needed and when?
  - How much investment is required?

HFC Plant Degrees of Freedom



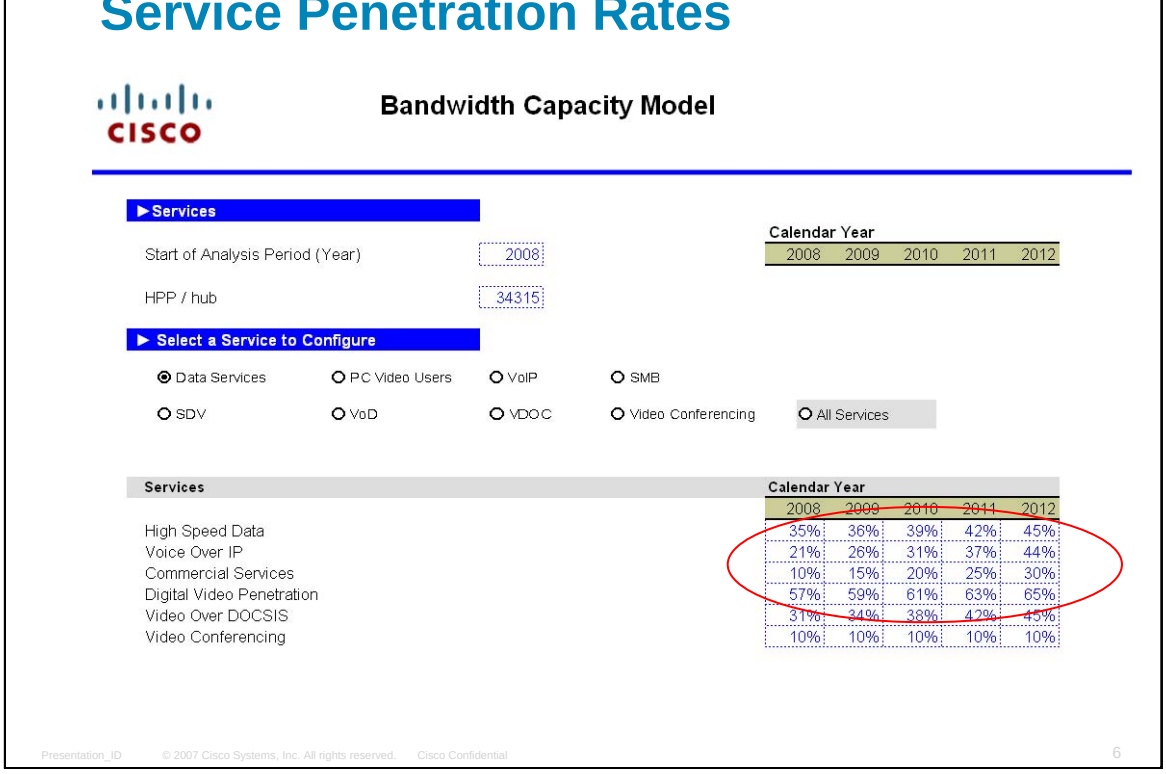
- The HFC Plant can be mined for bandwidth in three dimensions – time, frequency, and space.
  - Each dimension has at least two options.
- Thus, the HFC Plant has at least 6 degrees of freedom

Network Modeling Scenarios

Organic Growth	▪ Baseline reference model. ▪ Service penetration rate increases while video and data content remain constant.
1 GHz On-Demand	▪ On Demand and broadcast spectrum is gradually increased. ▪ HD content is progressively increased.
750 MHz SDV	▪ Analog and broadcast spectrum is gradually reduced and reutilized for SDV. ▪ Switched HD content is progressively increased.
750 MHz Broadcast Migration	▪ Analog spectrum is rapidly reclaimed and initially reused for HD broadcast spectrum. ▪ HD broadcast content is migrated to the Switched Digital Video tier in later years.

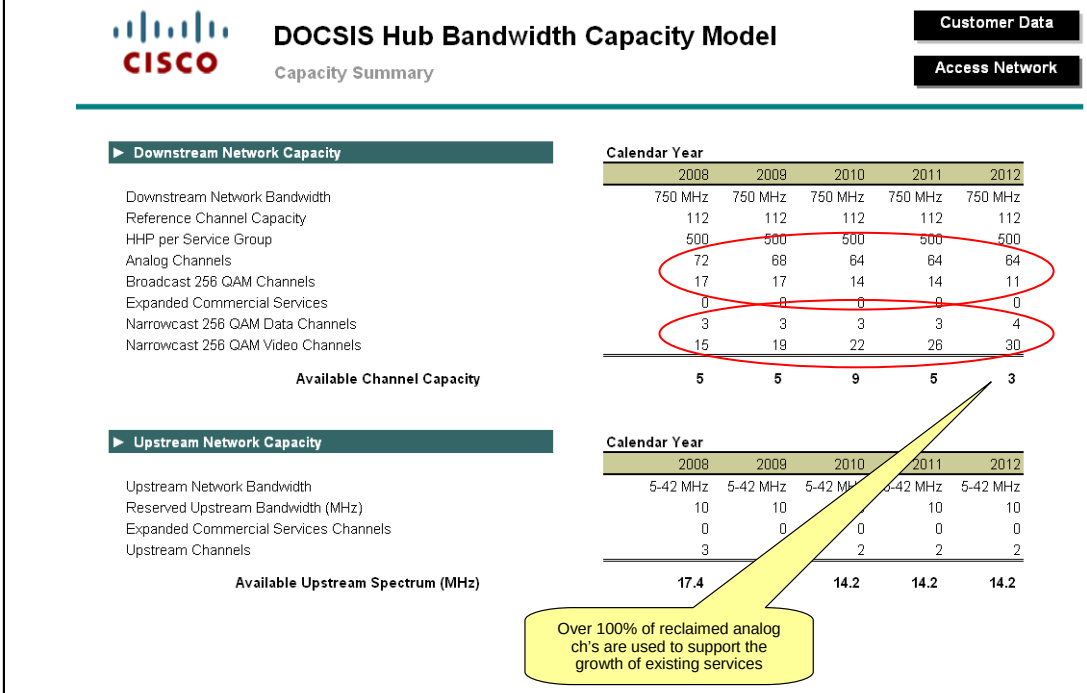
- The organic growth model uses the same service penetration as models 2,3 and 4 but holds the data and video content constant. This model isolates the effect of organic growth on the network vs. the introduction of new content (ex: HD content and higher bit rate data COS)
- All bandwidth models (2,3 and 4) are primarily HFC capacity models.
- Each capacity model also drives a CAPEX model (Hub electronics and HFC plant)
- All bandwidth models use an assumed 112 ch. loading with the exception of the 1 GHz model (154 ch's)

Service Penetration Rates



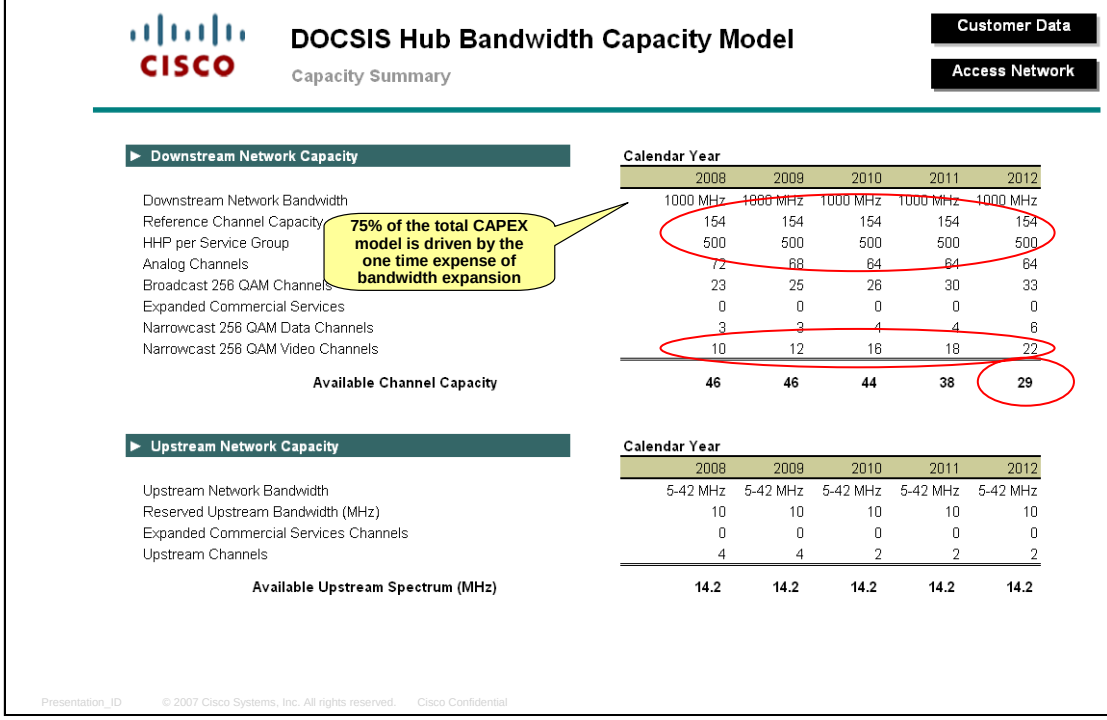
- This is an example of the actual model input
- The growth of HSD and Video based services trend from 35% - 45% and 57% - 65% respectively over a five year period
- All models are primarily sensitive to the growth of MPEG based video content and the introduction of High Definition content

Organic Growth Model



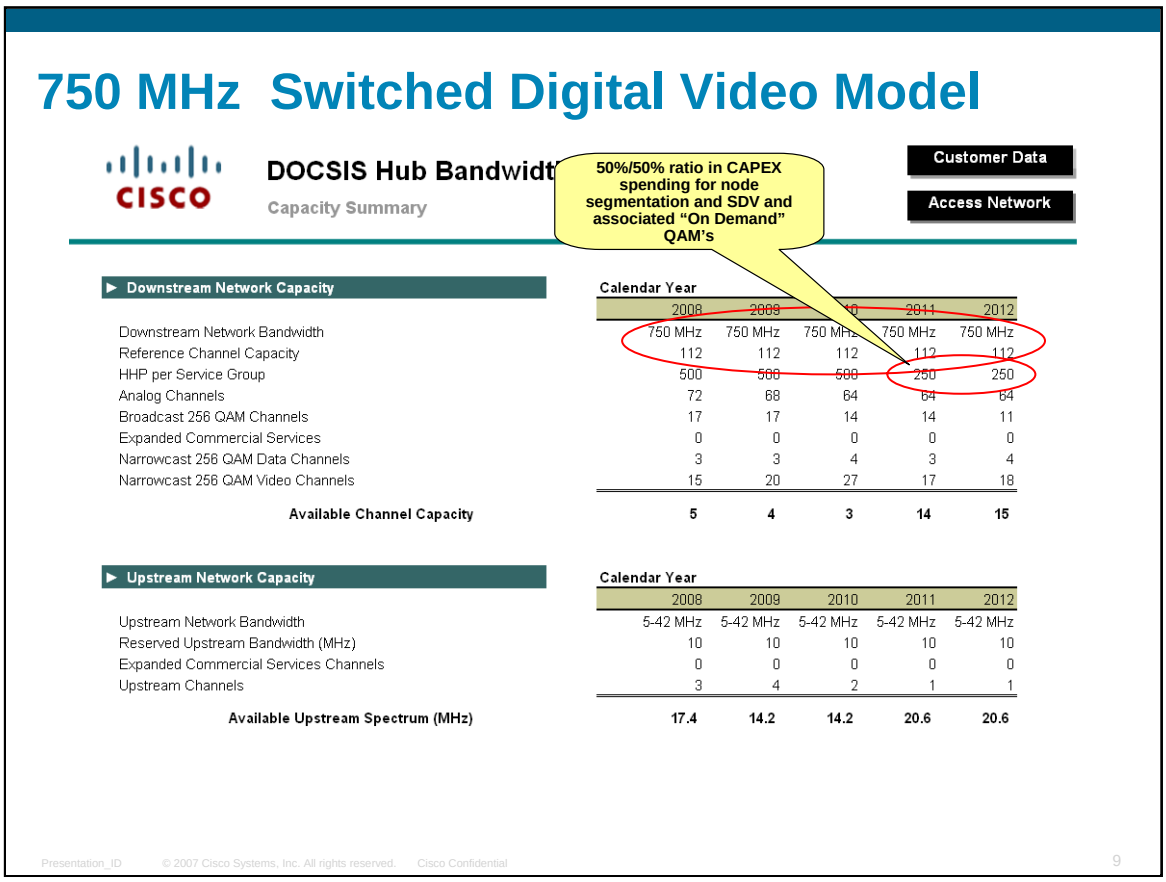
- The organic growth model assumes a 500 hhp service group and targets the growth of narrowcast QAM's
- In this example the quantity of narrowcast QAM'S grew from 18 in 2008 to 34 in 2012 (47% difference)
- Although 14 channels are incrementally reclaimed throughout the 5 year modeling period (8 analog and 6 broadcast), it can be seen that there are 2 fewer channels available at the conclusion of the model (5 ch's vs.3 ch's)
- This would indicate that very aggressive analog reclamation needs to occur to offset the organic growth of existing voice, video and data services

1 GHz On Demand Model



- The 1 GHz model assumes 154 maximum channels and uses 500 hhp services groups
- 75% of the total CAPEX model is driven by the one time expense of bw expansion. The remaining 25% is used to support the required QAM expansion in the video and data service groups.
- A gradual amount of analog reclamation is assumed but is not required. The analog reclamation curve shown here was included to maintain parody with the other 750 MHz models (which was required)
- In this model a significant amount of new HD content is considered to be “highly viewed content” and is therefore introduced in the broadcast tier
- The QAM’s in the “On Demand” tier more than doubles and 75% of this content is assumed to be HD content in year 5
- Approximately 20% of the available 154 ch’s remains available for future services at the conclusion of the 5 year modeling period. This is the highest percentage of available channel capacity of all scenarios modeled

750 MHz Switched Digital Video Model



- In this modeling scenario 750 MHz of physical bandwidth is maintained throughout the modeling period (112 ch's)
- Even though 11 channels are reclaimed through year 3, the network model reaches capacity in year 4 and segmentation to 250 hhp service groups is required.
- It is necessary but not desirable to incur the HFC node segmentation cost that is driven primarily by the requirement for additional physical bandwidth
- Although additional analog reclamation could have been used to counter the requirement to segment the nodes, this cost of Digital Terminal Adapters more than offsets this cost as can be seen in the following model.

750 Broadcast Migration Model

DOCSIS Hub Bandwidth Capacity Model

Capacity Summary

Customer Data

Access Network

Downstream Network Capacity

	Calendar Year				
	2008	2009	2010	2011	2012
Downstream Network Bandwidth	750 MHz	750 MHz	750 MHz	750 MHz	750 MHz
Reference Channel Capacity	112	112	112	112	112
HHP per Service Group	500	500	500	500	500
Analog Channels	72	25	25	25	25
Broadcast 256 QAM Channels	34	66	58	50	32
Expanded Commercial Services	0	0	0	0	0
Narrowcast 256 QAM Data Channels	2	3	4	4	6
Narrowcast 256 QAM Video Channels	4	17	25	31	40
Available Channel Capacity	**0**	**1**	**0**	**2**	**9**

25% of the total CAPEX spend is driven by the deployment of DTA's

Upstream Network Capacity

	Calendar Year				
	2008	2009	2010	2011	2012
Upstream Network Bandwidth	5-42 MHz	5-42 MHz	5-42 MHz	5-42 MHz	5-42 MHz
Reserved Upstream Bandwidth (MHz)	10	10	10	10	10
Expanded Commercial Services Channels	0	0	0	0	0
Upstream Channels	4	4	2	2	2
Available Upstream Spectrum (MHz)	**14.2**	**14.2**	**14.2**	**14.2**	**14.2**

- In this model 750 MHz physical plant bandwidth and 500 hhp service groups are maintained
- 66% of the analog spectrum is rapidly reclaimed and reutilized in the broadcast spectrum for the introduction of HD content
- The broadcast channels are reduced by 100% throughout the modeling period and migrated to the SDV tier
- Although 500 hhp service groups are maintained, 25% of the total CAPEX model is driven by the deployment of DTA's (an industry driven average of $40/DTA and 2 DTA's per basic subscriber was assumed)

Summary and Observations

Organic Growth	▪ **Approximately 47% increase in narrowcast QAM bandwidth is due to the organic growth of video and data services.**
1 GHz On-Demand	▪ **The 1 GHz solution requires the least amount of capital and also provides 29 available channels at the conclusion of the 5 year model.**
750 MHz SDV	▪ **The 750 MHz SDV solution requires 14% additional capital and provides 15 available channels at the conclusion of the 5 year model.**
750 MHz Broadcast Migration	▪ **The Broadcast migration solution requires 17% additional capital and only provides 9 available channels at the conclusion of the 5 year model.**

- Each modeling scenario requires varying levels of operational complexity but supports each business case regardless of network bandwidth.

- A high degree of analog reclamation or increased plant capacity should be anticipated to support the organic growth of existing services
- The 1 GHz On Demand model offers the greatest degree of flexibility and plant capacity while offering the lowest capital investment of all modeling scenarios
- The SDV scenario and 1 GHz models are complimentary to one and other. When the strategies of SDV and 1 GHz expansion are combined, a 13% increase in incremental CAPEX spending is required.