SCTE Conference on
emerging technologies Jan 11-13. 2005

The Wideband Protocol for a DOCSIS® Network

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EDCS-416795

SCTE Society of Cable Telecommunications Engineers

Bit Capacity of the HFC Plant

HFC Downstream is ~131 channels. At 256QAM: 131 channels * 38 Mbps =	~ 5 Gbps per FN
At one optical transmitter per 500 HHP FN: 5 Gbps / 500 HHP =	~ 10 Mbps per HHP
# of HDTV streams per HHP with H.264 (AVC): 10 Mbps / 7 Mbps =	~ 1.4 HD streams per HHP
Data Capacity in a 100K HHP plant: 5 Gbps per FN * (100K HHP/500 HHP per FN)= 5 Gbps per FN * 200 FN =	~ 1 Tbps per small plant

Capacity of a 100K HHP Plant

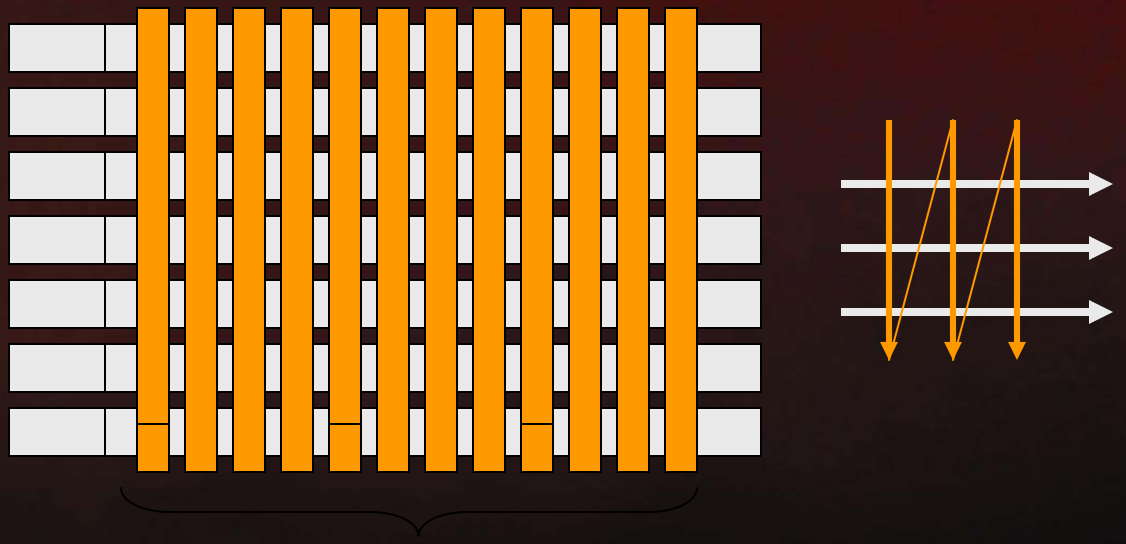
Service	Channels		Density Today	Capacity	
Analog	79	60%	x1 SG x3.75 Mbps	0.3 Gbps	3%
Digital	43	33%	x1 SG x38 Mbps	1.7 Gbps	15%
VOD & DOCSIS	9	7%	x50 SG x38 Mbps	17 Gbps	82%
Total	131		(SG=Service Group)	19 Gbps	

Capacity	131	X200 SG x38Mbps	1 Tbps

- Today's HFC Plant is running far less than 2% of capacity
  - 19 Gbps / 1 Tbps = 1.9%
- The challenge is to mine this bandwidth by re-organizing the bits on the HFC plant and the connectivity to the backbone.

Wideband Downstream

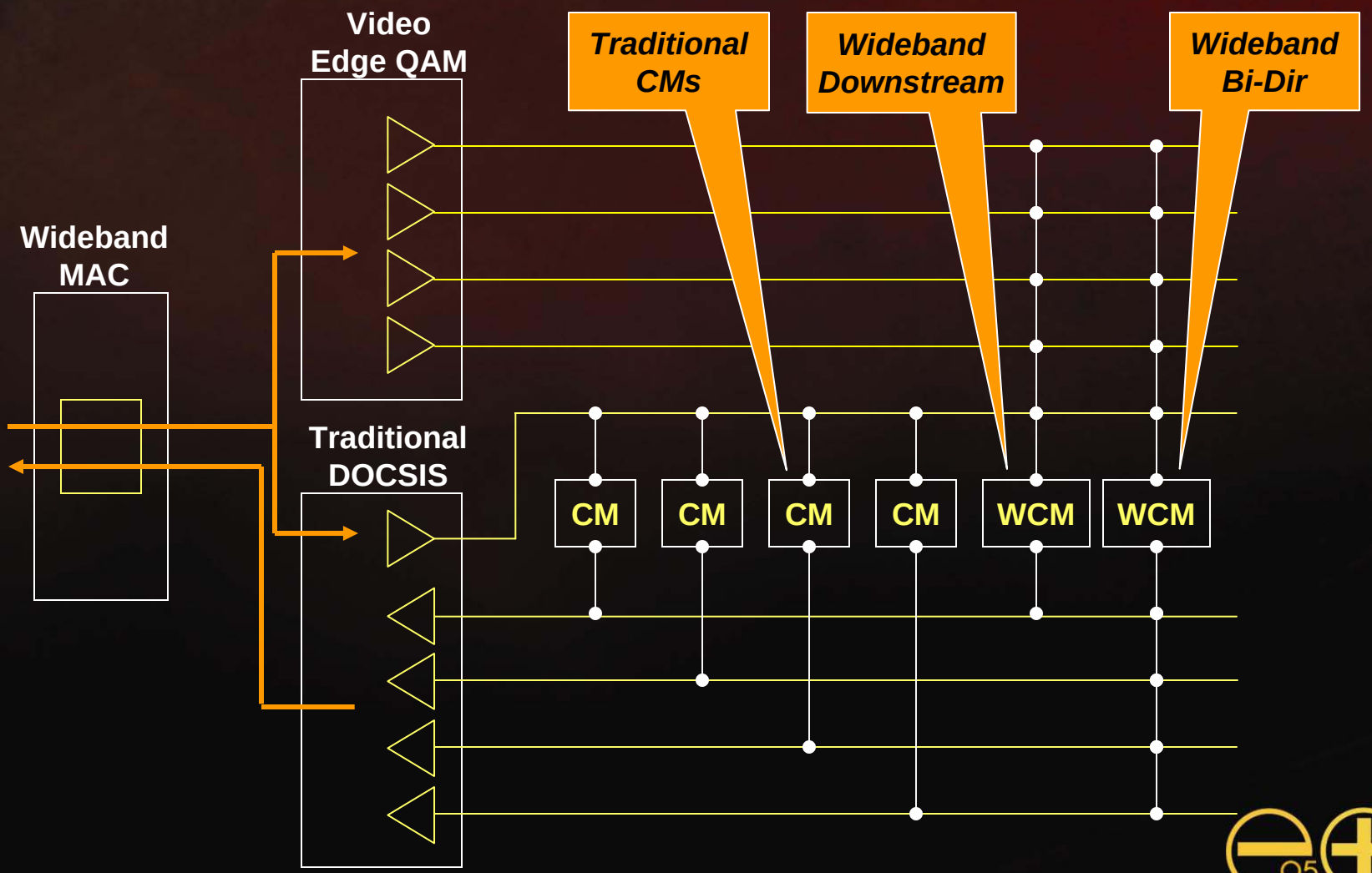
Multiple QAM Channels



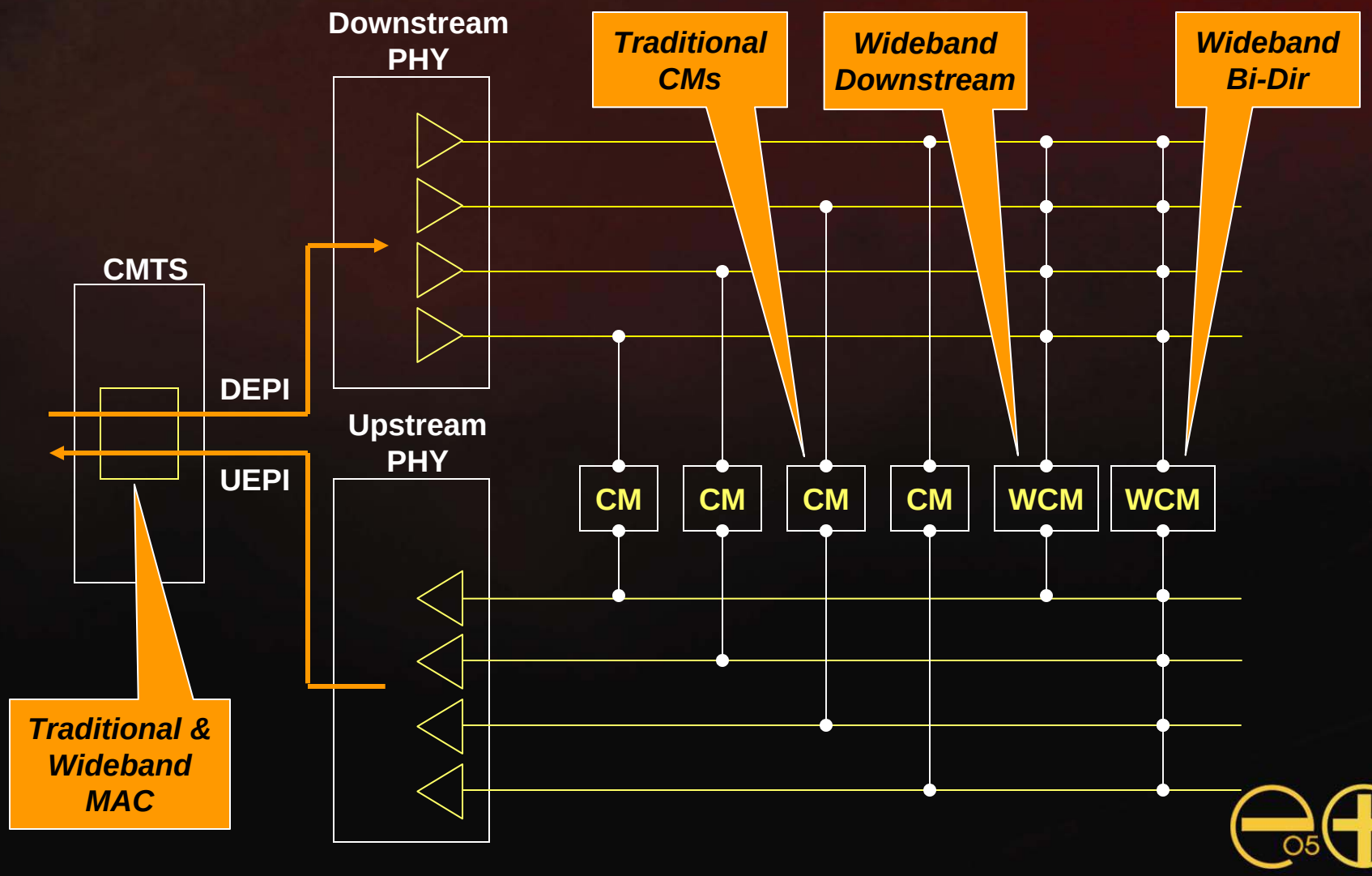
Single Wideband Channel

- DOCSIS frames are stripped “vertically” across “horizontal” MPEG-TS QAMs.
- Striping is done at the MPEG-TS packet layer.
- Each MPEG-TS packet contains a sequence number.
- A Wideband channel is assigned a PID.

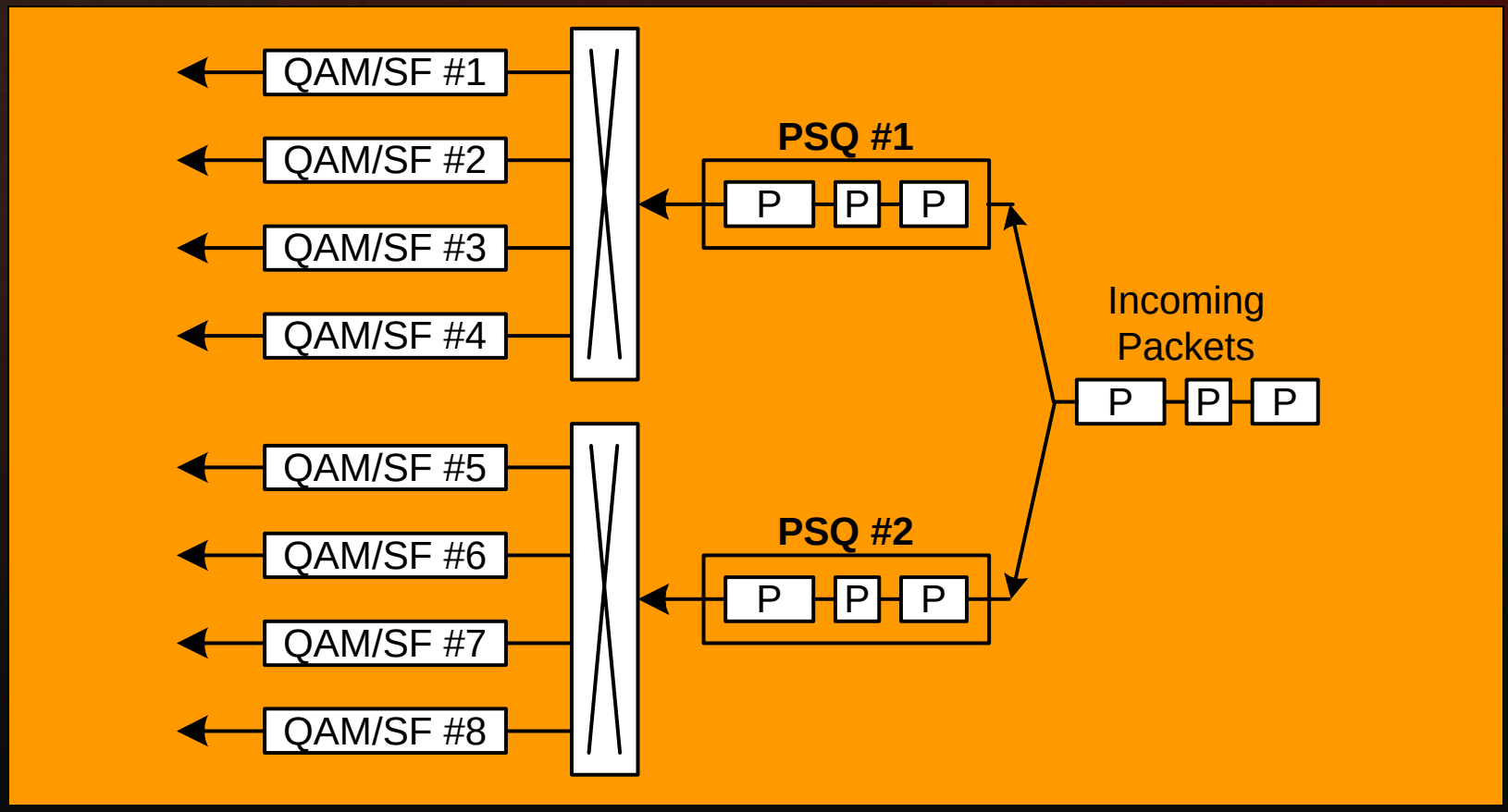
Legacy CMTS Connectivity



Modular CMTS Connectivity

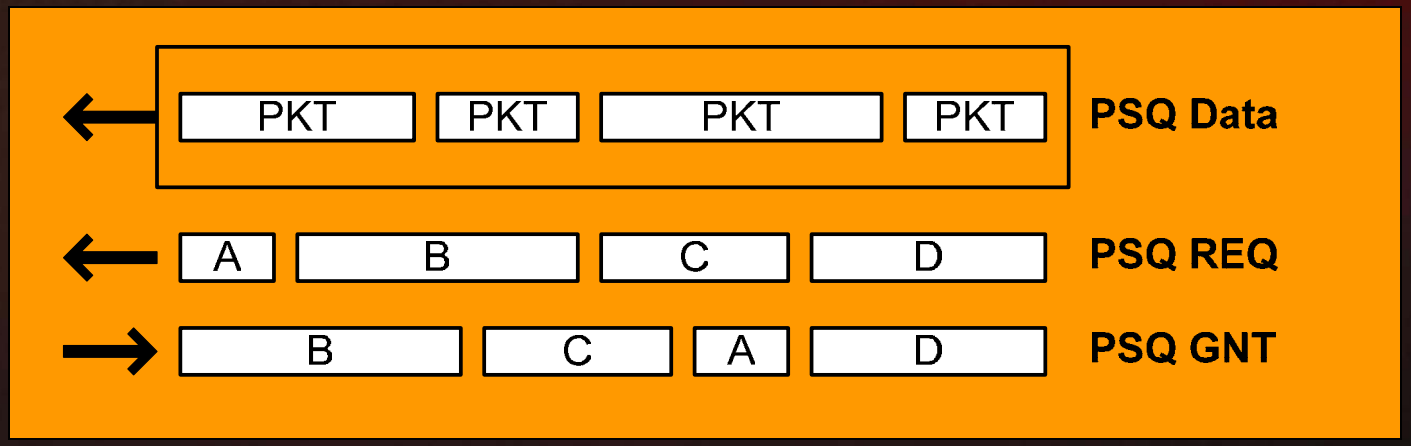


Wideband Upstream



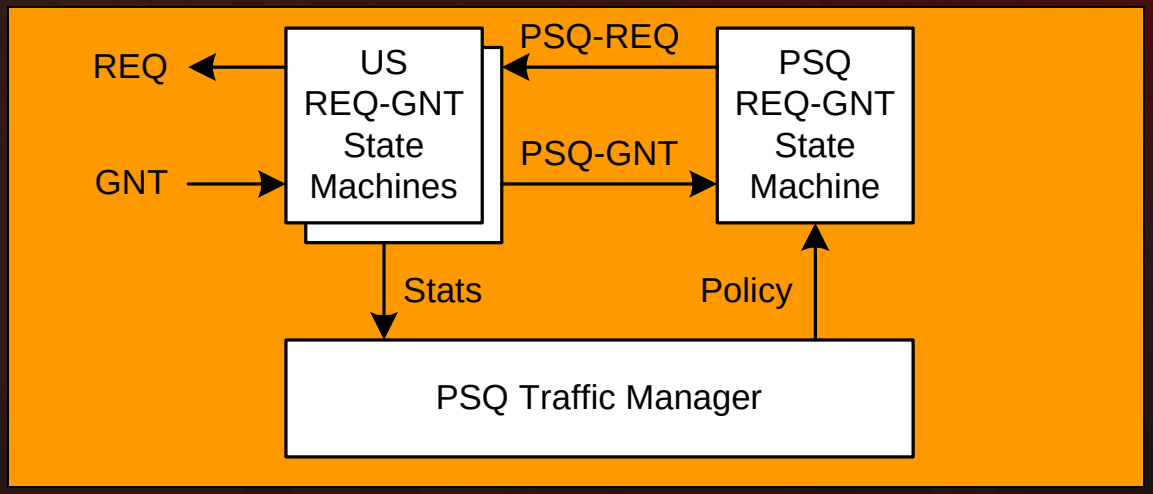
- Upstream data is transported with a Packet Streaming Protocol and striped across multiple QAM/Service Flows.

Wideband Upstream



- Packets are gathered into a Packet Streaming Queue and sent out with a Packet Streaming Protocol.
- REQs are sent to different QAM/SFs pairs. Multiple REQs may be outstanding. (SF = Service Flow)
- Bytes are committed from the PSQ to the WCM output queue when the GNT is returned.
- The protocol allows for dropped REQs and out of order GNTs.

Wideband Upstream



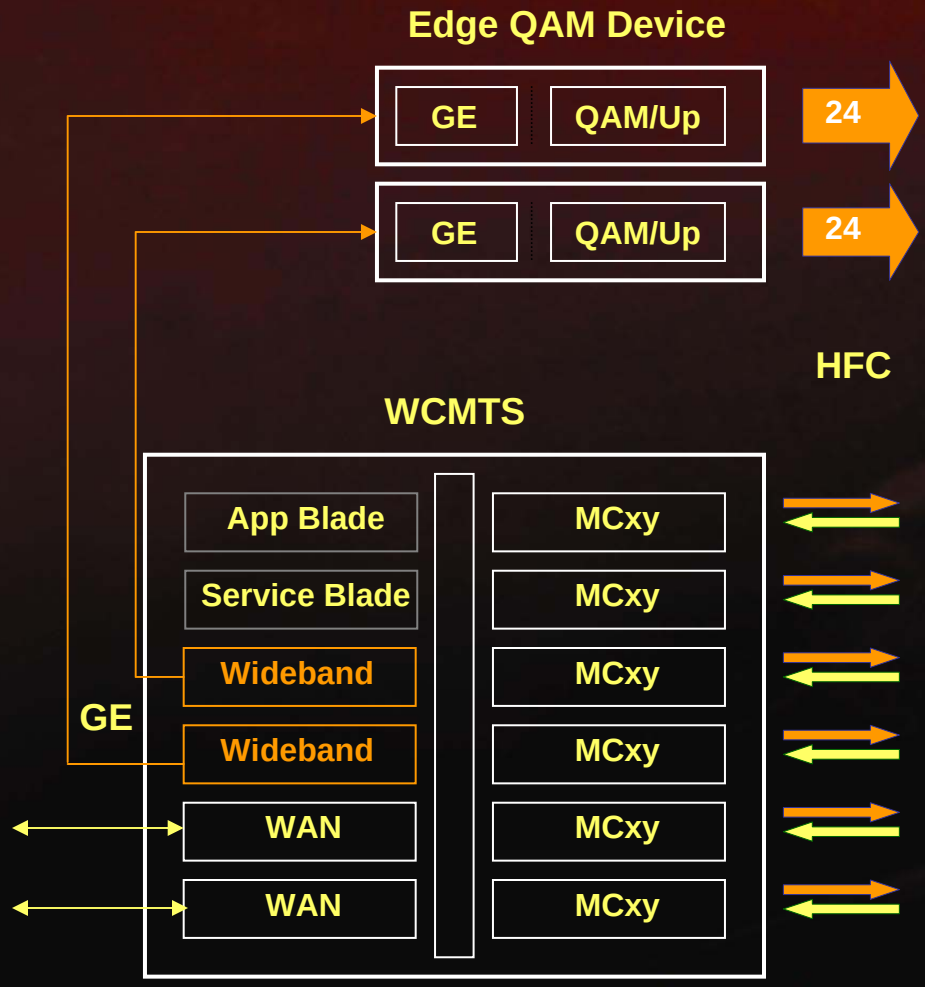
- U/S REQ-GNT State Machine (S.M.) same as today.
- PBQ S.M. is new and interfaces between packet queues and U/S REQ-GNT S.M.
- PSQ Traffic Manager picks the upstream to put the REQ on based upon criteria given to it from the WCMTS.
  - Hierarchical Service Flows; Round Robin; Least Busy, etc.

Wideband Signaling

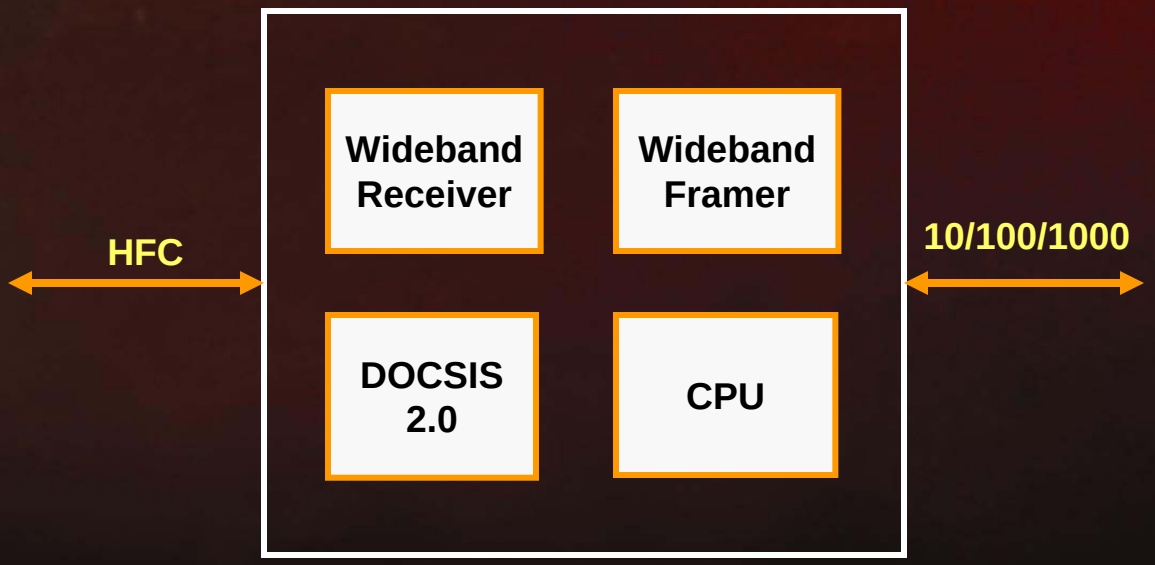
- Wideband Channel Descriptor (WCD)
  - Describes WB channel (Freq, PID, status)
- Registration
  - Uses DOCSIS registration.
- Addressing
  - Can be the same or different subnet.
- Security
  - Uses BPI+. Can share same key as traditional DOCSIS.

Wideband CMTS

- WB MAC fits into CMTS
- Interfaces to external Edge QAM devices for downstream
- Interfaces to traditional DOCSIS cards for upstream.



Wideband CM



- New Design
  - WB Receiver is a multi-channel tuner
  - WB Framer does packet reconstruction
- Overlays existing DOCSIS chip designs
- With integration, it will be less than 2x today's CM prices.

5 Year Goal

Downstream: 1 Gbps per FN
Upstream: 100 Mbps per FN

- Downstream
  - ~ 24 QAMs. 20% of downstreams for IP.
  - Lines up nicely with GE backhauls.
- Upstream
  - 4 to 8 QAMs.
  - Expansion of RF BW to 65 MHz or 85 MHz helps.
- Asymmetrical BW is okay.
  - HFC Plant bandwidth is 22:1
  - Revenue generating BW is downstream BW.

Scaling to 100x

CMTS to Plant Connectivity	Relative Capacity	
1 DOCSIS DS across 24 FN	--	1x
1 DOCSIS DS across 4 FN	1 x	6x
4 DOCSIS DS across 4 FN	4 x	24x
4 DOCSIS DS across 1 FN	16 x	100x
24 DOCSIS DS across 1 FN	100 x	600x

- A 100 times increase in downstream data capacity from today can be achieved without any impact to the outside plant and with only 20% of the downstream RF BW.
- A 100 times increase in downstream data capacity from 1998 (1x6 card, 4 FN per US) could be achieved with 4 DOCSIS DS per FN. If done by 2008, that would be a factor of 100x over a period of 10 years!

Competitive Threats

Bonded ADSL2+	44 Mbps up to 5,000 ft and 8 Mbps at 12,000 ft.
UDSL	180 Mbps aggregate at 1,000 feet, and 50 Mbps aggregate at 4,000 feet
Korea	13 Mbps VDSL is routinely deployed – and winning – against DOCSIS. Korean Telecom plans to deliver FTTH with 50 Mbps to 100 Mbps to ~73% of Korean households by 2010.
Japan	FTTP is an official government program where a number of operators have announced 1 Gbps residential services.
Europe	French Telecom has announced an 18 Mbps Service, and Italy has ETTH (FastWeb) at 10-100 Mbps.
USA	SBC announced a $6+ billion dollar initiative for 20 Mbps FTTH to 18+ million households by 2007.

Summary

- The goal of the Wideband Protocol for a DOCSIS Network is to provide 10x the throughput at 1/10th the cost.
- There is an incredible amount of bandwidth on today's HFC plant. The challenge is to mine this bandwidth by re-organizing the bits on the HFC plant.
- Downstream Wideband is first priority
- Round 1 was dial-up: telcos won the transport
- Round 2 is broadband: Cable initially won.
- Round 3 will be wideband: Who is going to win?