Deploying Cable Access Infrastructures

Daniel Etman
Agenda

- Overview
- References and Specifications
- Cable Access Infrastructure Design Goals
- Characterization of the Cable Plant
- EuroDOCSIS Equipment and Offerings
- Deployment of a EuroDOCSIS Design
- Case Studies
- Questions
Overview
Design Success Questions

• Is the RF network DOCSIS Compliant?
• Is the network designed for added services?
• Do data rates support usage?
• Is the architecture easily scalable?
• Did we design for the future?
Driving Factors for Design Success

• A Design that meets our goals will include:

  Demographics Input
  Appropriate QoS Settings
  Enough BW in the IP *and* RF Domain to meet Penetration
  Sane Address Management
Design Elements of Successful Deployments

Strive for:

- Functionality
- Scalability
- Adaptability
- Manageability
- Cost Effectiveness
Elements of Successful Design

Terms and Specifications

Deployment Goals

Existing Cable Infrastructure

DOCSIS Equipment

Successful
DOCSIS
Deployment
You have the KEY!

PLANNING is the KEY to a successful Data over Cable Deployment!
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References and Specifications
White Paper Resources

- Multimedia Traffic Engineering for HFC Networks

- Combined Wisdom on the Upstream

- Successfully Deploying Data Over Cable Networks: An Overview

- Business Case for Two-Way Service Deployment over HFC Network
Measurement Units

- **dB** - Decibel. A measure of the relative strength of two signals. Multiplication becomes addition and division becomes subtraction.

- **dBm** - Decibels with respect to one milliwatt. A unit of RF signal strength used in satellite work and other communications applications.

- **dBmV** - Decibels with respect to 1 millivolt in a 75-ohm system. The unit of RF power used in CATV industry. Based on $10 \log X$ functions.

- **dBµV** - Decibels with respect to 1 microvolt in a 75-ohm system. The unit of RF power used in CATV industry. Based on $10 \log X$ functions.

- **0 dBmV = 1** millivolt measured across an impedance of 75 ohms
Terms

- **CATV** - Community Antenna TV
- **HFC** - Hybrid Fiber Coaxial. The dominant physical layer CATV design for 2-way systems
- **NTSC** - National Television Systems Committee: U.S. TV technical standard, named after the organization that created it in 1941. Uses a 6 MHz wide modulated signal.
- **PAL** - Phase Alternating Line. The TV system used in most of Europe and many other places, in which the color carrier phase definition changes in alternate scan lines. Utilizes an 8 MHz wide modulated signal.
- **SECAM** - Sequential Couleur Avec Memoir. TV system used in France and some former Soviet bloc countries. Utilizes an 8 MHz wide modulated Signal.
Terms

- **Carrier-to-Noise - C/N** (also CNR): The difference in amplitude between the desired RF carrier and the noise in that portion of the spectrum.
- **Signal-to-Noise - S/N** (also SNR): Similar to C/N but relates to a Baseband signal.
- **Ingress Noise**: Over-the-air signals that are inadvertently coupled into the nominally closed coaxial cable distribution system. Difficult to track down and intermittent in nature.
- **QPSK** - Quadrature Phase Shift Keying. A digital modulation method in which there are 2 data bits represented with each baud symbol.
Terms

- **QAM** - *Quadrature Amplitude Modulation*. A digital modulation method in which the value of a symbol consisting of multiple bits is represented by amplitude and phase states of a carrier. Typical QAM types are 16-QAM (4 bits per symbol), 64-QAM (6 bits per symbol), and 256-QAM (8 bits per symbol).

- **Downstream(DS)** - Signal flow from headend toward subscribers. Also called *Forward Path*.

- **Upstream(US)** - Signal flow from the subscribers to the Headend. Also called the *Return or Reverse Path*.

- **SID** - *Service ID*: a number that defines (at the MAC sublayer) a particular mapping between a cable modem and the CMTS.
Terms

- **FDM - Frequency Division Multiplexing.** A data transmission method in which a number of transmitters share a transmission medium, each occupying a different frequency.

- **Headend** - The location where the Cable company aggregates, combines, mixes, and modulates all signals in order to send them downstream and receive upstream signals.

- **HHP - Households Passed**

- **DPT - Dynamic Packet Transport**

- **SRP - Spatial Reuse Protocol.** (Technical name for DPT)
# International Split Plans

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### Channelization Plans
- **EIA Standard**
- **HRC** (Harmonically Related Carrier)
- **IRC** (Incrementally Related Carrier)
Symbol Legend

- Head End
- Laser/Fiber
- Satellite Antenna
- Hub
- RF Amplifier
- Bi-Directional Amplifier
- Splitter
- 8-Way Tap
- Fiber Transmitter
- Fiber Receiver
IP over Cable TV Network

Cable Network with IP Access

Feed Types:
- Off-Air
- Coax
- SatCom

RDC

Hub

Node

Node

Node

Node

Node

Node

Node

Node

Node

Node

Hub

Hub

Hub

Hub

Hub

Hub

PSTN

Internet

Cable Modem PC

COAX

Tap

Drop

Cable Network with IP Access

uBR7246vxn

Broadband Router

< 100 Channels

CNN

HBO

A&E

ESPN

TBS

Feed Types:
- Off-Air
- Coax
- SatCom

Internet

PSTN

Satellite

Coax Tap

Drop

Tap

Cable Modem PC
# Specs for Success

## Docsis and EuroDOCSIS Main Differences

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<th>EuroDOCSIS</th>
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<td>IF Output</td>
<td>44 MHz</td>
<td>36.125 MHz</td>
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<tr>
<td>Frame Format</td>
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<td>Annex A</td>
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<tr>
<td>DS Channel Width</td>
<td>6 MHz</td>
<td>8 MHz</td>
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<tr>
<td>US Frequency Range</td>
<td>5–42 MHz</td>
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</table>
## Specs for Success

### Typical EuroDOCSIS Per Downstream Bandwidth*

<table>
<thead>
<tr>
<th>Downstream Bandwidth</th>
<th>64-QAM Throughput</th>
<th>256-QAM Throughput</th>
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</thead>
<tbody>
<tr>
<td>8 MHz</td>
<td>36 Mbps</td>
<td>51 Mbps</td>
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</table>

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<table>
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<th>256-QAM Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 MHz</td>
<td>27 Mbps</td>
<td>38 Mbps</td>
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</table>

* Actual usable rates minus the EuroDOCSIS Phy and MAC overhead
## Specs for Success

**Typical EuroDOCSIS Per Upstream Bandwidth**

<table>
<thead>
<tr>
<th>Upstream Bandwidth</th>
<th>QPSK Throughput</th>
<th>16-QAM Throughput</th>
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</thead>
<tbody>
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<td>200 kHz</td>
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<td>0.546 Mbps</td>
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<tr>
<td>400 kHz</td>
<td>0.546 Mbps</td>
<td>1.108 Mbps</td>
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<tr>
<td>800 kHz</td>
<td>1.108 Mbps</td>
<td>2.176 Mbps</td>
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<tr>
<td>1600 kHz</td>
<td>2.176 Mbps</td>
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<tr>
<td>3200 kHz</td>
<td>4.352 Mbps</td>
<td>9.704 Mbps</td>
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</table>

*Actual usable rates minus the EuroDOCSIS Phy and MAC overhead*
References

Web References

• http://www.cisco.com/cable
• http://www.cablemodem.com
• http://www.tcomlabs.com
• http://www.cablelabs.com
• http://www.scte.org
• http://cable.doit.wisc.edu
• http://www.catv.org

Text References

• Modern Cable Television Technology-Video, Voice, and Data Communications
  by Walter Ciciora/James Farmer/David Large
  ISBN # 1-55860-416-2

• Broadband Return Systems for Hybrid Fiber/Coax Cable TV Networks
  by Donald Raskin and Dean Stoneback
  ISBN # 0-13-636515-9

• Cable Television Proof-Of-Performance
  by Jeff Thomas ISBN # 0-13-306382-8
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Cable Access Infrastructure
Design Goals
Types of Differentiated Services

Differentiated Services can mean substantial increases in revenue and subscriber base.

- Data (web, e-mail, etc.)
- Voice over IP (VoIP)
- Managed Access and VPNs
- Webcast Video
- Others

Each has unique design needs
Planning for New Services

- Determine customer requirements
- Know business and practical constraints
- Understand requirements of new services
- Build a reference model/metrics
- Engineer for existing design
- Deploy
- Measure results
- Refine/re-plan/re-engineer
- Repeat
Know Your Customers!

Demographics
Penetration rates
Homes passed
Real usage patterns
Customer needs/desires
Types of applications in use

Understand your customers!
Business and Practical Constraints

- EuroDOCSIS specifications for bandwidth
- Penetration rate and service pricing
- Deployment speed
- Plant status and design
- Real usage patterns

Business Case for Two-Way Service Deployment over HFC Network
Data Service Offerings

- Basic data access—email, web, etc.
- Different service levels—variable subscription rates
- User self registration—avoid provisioning expenses
- On-demand service upgrades—user self provisioning
Data Service Requirements

- Symmetric vs. Asymmetric traffic patterns
- Reliability/availability
- Delay and jitter tolerant
- Speed and QoS
- Provisioning and other challenges
Delivering Voice Services

- Several voice protocols -- H.323, MGCP, etc.
- Typically use large numbers of small packets
- Extremely sensitive delay, jitter
- Heavy use of upstream bandwidth
- Overlap with data usage

EuroDOCSIS 1.1 mitigates many of the cable-based QoS issues associated with voice.

(Voice QoS also available in Cisco’s EuroDOCSIS 1.0+)
Delivering Managed Access

- Can also support corporate VPN (telecommuter) services
- DOCSIS traffic must be differentiated
- QoS on DOCSIS network & backhaul
- Traffic monitoring and billing integration

MPLS-VPNs are one very elegant solution
Don’t Forget the Backhaul

The backhaul network (the part of the network between the CMTS and the ISP) must support:

- Service bandwidth needs
- QoS requirements
- Service excellence (stability, availability, etc.)
Determining Traffic Metrics
Traffic Engineering

- **Average bandwidth**: perceived traffic rates over time. Useful for long-duration measures.
- **Peak bandwidth**: determined by numbers of users simultaneously accessing media.
- **Max bandwidth**: highest speed experienced by users. Typically used for rate limiting.
- **Media bandwidth**: theoretical maximum bandwidth of the media.
Voice Traffic

To determine voice bandwidth needed:

- Market penetration
- Lines per home
- Traffic per home

Tests estimate an approximate maximum of 70 simultaneous calls per upstream at 16 QAM.

Bandwidth will vary based on Codec and services
Traffic Engineering

- Bandwidth characteristics
  - DS channel bandwidth = 6 MHz
  - DSDR = DS QAM-64 data rate = 27 Mbps
  - US (Up Stream) channel bandwidth = 1.6 MHz
  - USDR = US QPSK data rate = 2 Mbps
Traffic Engineering

- Design assumptions

  All users will be Web surfing (none Web serving)
  Expected Penetration (10%) = 12,000
  Expected users per node = 100
  Users/Node = max. active users/node (25%) = 25
  DSAT = max. DS active time/active user = 25%
  USAT = max. US active time/active user = 25%
  MDSDR = min. DS data rate/user = 270 Kbps
  MUSDR = min. US data rate/user = 40 Kbps
Traffic Engineering

- Design calculations

Possible users/DS = DSDR/(DSAT * MDSDR) = 400
Possible users/US = USDR/(USAT * MUSDR) = 200
Possible users/DS (using 1x4 LC) = 200 x 4 = 800

Limitation is DS data rate in this example
Active users/DS = 400

Nodes/DS = (users/DS)/(users/node) = 400/25 = 16

Required DS channels = nodes/(nodes/DS) = 120/16 = 8

Required uBR 7246 Chassis with 8 1x4 LCs = 8/4 = TWO
Per Customer BW Offering

- **Offer Data Rates you can meet**
  - Oversubscription is NOT a design goal
  - Technical and Marketing need to be in sync
  - Types of Applications in Use (HTTP, VoD, SMTP)

Example:

  Subscribers want 3 Mbps DS and 512 Kbps US for 2,500 users

  Problem: Single CMTS and BW available is single DS @ 27Mbps and 3 US at 1.28 Mbps

  Conclusion: This won’t work!
QoS Settings

- Calculate QoS based on:

  Average BW = (Active Subs * BW per Sub * (1 + MAC/PHY Overhead)
  Peak BW = (Peak Subs * BW per Sub) * (1 + MAC/PHY Overhead)
  Media BW = Symbol Rate * Bits per Symbol
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Characterization of the Cable Plant
HFC Architectural Examples

- Architectural Elements
- Tree-and-Branch
- HFC Rollout
- Double Star
- Ring
- Cascading Hubs
- Cascading Headends
- Classic HFC Model
5 Major Parts to a Cable TV Network

- Headend
- The Trunk Cable
- The Distribution (or feeder) Cable in neighborhoods
- The Drop Cable to the home
- The Terminal Equipment (TV, Cable Modem, Set-Top Box, etc)
Tree-and-Branch System

Headend

Trunk Cable

Express Cable

Drop Cable
HFC Rollout

Headend

Fiber Cable

Fiber Node
Cable System Topology
(Optical Node)

Typically fewer than five amplifiers in cascade

Typically 200 to 2000 homes supported by one node
Double Star

Headend

Fiber Cable

Fiber Node
Ring Architecture

Ring Architecture

Satellite
Off Air
Local Studio

Primary Head End

Ring

PT - PT

Node

200 - 2000 Homes

Hub

10 - 50 K Homes

Standby Head End (Optional)
Cascading Hubs
Cascading Headends

Super Headend

Headend

Headend

Headend

Hub

Hub

Hub

Fiber Node

Fiber Node

Fiber Node
Design Advantages

- Star or Ring Provides Reliability
- NarrowCast Capability
- Headend/Hub limits Outages
- SDH RING overlay for reliability of advanced services
HFC Scalability

- Smaller, robust serving areas:
  - HFC to the node
  - Alternate feed to the node
  - Target nodes of 500 homes
  - Fewer amplifiers

Reliability and Increased Access Bandwidth
Classic HFC Network

Headend

100K HHP

20K HHP Hub

20K HHP Hub

Hub

40 Fiber Nodes Per Hub

Fiber Node

Fiber Node

Fiber Node

500 HHP

500 HHP

500 HHP
Reality is that CATV systems have variable numbers of homes passed per node. Effective design requires multiple approaches.

Older implementations usually have nodes supporting more subscribers.
Togetherness

- In a Cable Modem Network RF and IP *MUST* co-exist
- RF and IP are interdependent
- Success relies on both RF and IP excellence
Return Path Characterization

• An absolute MUST
• Should be ongoing
• Key to easily finding problems
• Use CMTS tools to assist, (Cisco’s cable flap list)
• Characterize over extended periods!
• The deployment relies on careful Return Path characterization and design
Making the Return Work

- Use the Right Tools
- Plan your combining and test points carefully
- Ensure you have done a thorough Return Path Characterization
- Ensure your Nodes are not overloaded and clipping
- Attenuate in the proper places
- Design for Ingress Reduction!
Is Your Upstream EuroDOCSIS Compliant?

<table>
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<th>Variable</th>
<th>EuroDOCSIS Specification</th>
<th>Your Plant Settings</th>
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<tbody>
<tr>
<td>Frequency Range</td>
<td>5-65 MHz Edge to Edge</td>
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<td>Carrier to Noise (upstream)</td>
<td>Not less than 22 dB</td>
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<td>Transit Delay (Map Advance)</td>
<td>&lt;= 0.800 msec</td>
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<td>Carrier to hum Amplitude Ripple</td>
<td>Not greater than -23 dBc (7.0%)</td>
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<td>Group Delay Ripple</td>
<td>5-65 MHz: 300 ns in 2 MHz</td>
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<td>Digital Signal Levels</td>
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<td>From cable modem (upstream)</td>
<td>+68 to +115 dBμV (16QAM)</td>
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<td>+68 to +118 dBμV (QPSK)</td>
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Use the Right Tools

- Tools
  - Spectrum analyzers
  - Sweep Gear
  - Network Analyzers
Return Path Characterization

- Single Sweep
- Upstream Channel 20.00 MHz
- Low Band Noise
- Peak Over Time
Spectrum Management

- Useable gaps dictate:
  - Upstream channel selection and bandwidth
  - Spectrum management options
  - Upstream data throughput
## Useable Spectrum Gaps

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</table>
Avoid Overloading and Clipping

UNITY GAIN CONCEPT

AMPLIFIER (FORWARD)

AMPLIFIER (TWO WAY)

ONE WAY TRANSMISSION

INPUT + 12 dBmV

OUTPUT + 34 dBmV

GAIN + 22 dB

CABLE LOSS - 22 dB

INPUT + 12 dBmV

OUTPUT + 34 dBmV

GAIN + 22 dB

TWO WAY TRANSMISSION

DOWN STREAM

CABLE LOSS - 22 dB

UP STREAM
Noise Funneling

- Each House is an Antenna
- Ingress will destroy packets
- Equalize path loss to Reduce Ingress Noise

Splitter
Establishing Signal Levels

+18 dBmV  +40 dBmV  100 Ft  TAP  600 Ft  TAP  500 Ft  TAP
1 dB (2/29)  6 dB (2/20)  5 dB (2/17)

DROP LEVEL  +10 dBmV  +12.6 dBmV  +10 dBmV
100 Ft  1 dB  100 Ft  1 dB  100 Ft  1 dB
(+9 dBmV)  (+11.6 dBmV)  (+9 dBmV)
EuroDOCSIS Equipment Requirements
Functionality/Manageability

Does the Headend support:

- Necessary IP QoS functions
- Routing requirements for services
- Security feature set (DOS, TOS)
- Management interface/tools
- Debugging and troubleshooting
- Field-tested EuroDOCSIS algorithms
Scalability/Adaptability

Does the Headend support:

- EuroDOCSIS density for now and the future
- Appropriate backhaul technologies
- Large-scale provisioning
- Traffic model equal to deployment
- Future upgrades for new services/subs
Cost Effectiveness

The most cost effective design is one that supplies service excellence

- Minimal downtime or service interruption
- Strong system-wide design
- Planning for the future
Services to Support

Analog video on RF

Digital video:
- MPEG/64QAM

Voice, Web, Webcast

Video:
- IP/MCNS/64QAM
Design for Scalability - CMTS

- Scalable EuroDOCSIS density – upgrade past 2:8 without chassis modifications
- Scalable Processor speed – variety of processors available, must scale to support added services such as voice
- Scalable Egress technologies – flexible use of backhaul technologies to support users
Design for Scalability – IP network

DPT/POS allow BW migration
Web Cache Valuable

Optical Backbone Allows:
* Scalability
* Redundancy
* Investment Protection
Redundancy – CMTS

- Power redundancy—AC and DC options
- EuroDOCSIS redundancy—RF failover without modem rescan/resync
- Egress redundancy—backhaul networking
- Processor redundancy—hot failover
Redundancy – IP network

STM-4 → RDC → STM-16 → RDC → STM-4

2 RDC’s
Hierarchical Design

The Backbone is the same as any Enterprise Network

The Difference is BW truly needed at the edge
Address Management

• Plan your Address Space

  Cable Networks quickly deplete addresses
  Use 10net for Cable Modems
  NAT can be misleading for advanced services
  Route summarization key for routing overhead
Deployment of EuroDOCSIS Infrastructure
Headend Design Keys

• Key Components
  Plan Ahead
  Keep Records
  Use a Uniform Approach
  Monitor Success
Test Design before Deployment

uBR7246vxr

Up Converter

Cable Modem

Di-Plex Filter

Splitter

44Mhz (downstream)

5-65Mhz (upstream)

RF 80-750Mhz

IF
Combining Possibilities

You Can...

• Combine Multiple Rx Nodes to One Receiver
  Called: **Sparse Mode**

• Combine Multiple Rx Node to Multiple Receivers
  Called: **Dense Mode**

• Combine One Rx Node to Multiple Receivers
  Called: **WideBand Dense Mode**

(IP engineers may confuse these combining models with multicast sparse and dense modes. They are very different.)
Sparse Mode

Limited Bandwidth for Multiple Serving Areas

Over-Subscription a Concern

Collisions a possibility

Greatest Density

Be realistic about numbers of modems per linecard
Dense Mode

Each US MUST be a different Frequency

Load Balance through provisioning

Easy way to add BW to a Serving Area

Need Open Upstream Ports

U0 = 20 MHz @ 1.6 MHz
U1 = 22 MHz @ 1.6 MHz
U2 = 26 MHz @ 1.6 MHz
U3 = 28 MHz @ 1.6 MHz

BW = 10.24 Mbps for 3 Serving Areas
Extreme Dense Mode!

Each US MUST be a different Frequency

Provisioning Assistance Speeds Bringup

Stop Gap before Node Split

Need Open Upstream Ports

U0 = 20 MHz @ 1.6 MHz
U1 = 22 MHz @ 1.6 MHz
U2 = 26 MHz @ 1.6 MHz
U3 = 28 MHz @ 1.6 MHz

BW = 10.24 Mbps for One Serving Area!
Combining Issues – Ingress!

uBR-MC16E

- 64 QAM
- 36 Mbs
- 8 MHz BW
- 44 MHz IF
- QPSK
- 2.3 Mbs
- 1.6 MHz

RF
80-750 MHz
Frequency F 1

Upconverter

OPTICAL TRANSMITTER SPLITTER

FROM NODE # 1 (32 dB CNR)
FROM NODE # 2 (32 dB CNR)
FROM NODE # 3 (34 dB CNR)
FROM NODE # 4 (35 dB CNR)

SIGNAL FROM 4 NODES

3000 HOMES PASSED

ONE RECEIVER SUPPORTING 4 NODES (2000 HOMES PASSED)
Watch the C/N

- Determining aggregated C/N when combining nodes

Example:

- Determine aggregated C/N for upstream signals having C/N of 32 dB, 34 dB, and 35 dB

- Total C/N = 27.04 dB
Example

Consider four upstream signals having Carrier to Noise Ratios (C/N) as follows:

<table>
<thead>
<tr>
<th>Signal</th>
<th>C/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>US # 1</td>
<td>32 dB</td>
</tr>
<tr>
<td>US # 2</td>
<td>32 dB</td>
</tr>
<tr>
<td>US # 3</td>
<td>34 dB</td>
</tr>
<tr>
<td>US # 4</td>
<td>35 dB</td>
</tr>
</tbody>
</table>

Combining CNR:

1. US # 1 + US # 2:
   - dB difference = 0 dB
   - dB Subtraction = 3.0 dB
   - Total Noise$_1$ is 29.0 dB

2. Total Noise$_1$ + US # 3:
   - dB difference = 5 dB
   - dB Subtraction = 1.2 dB
   - Total Noise$_2$ is 27.8 dB

3. Total Noise$_2$ + US # 4:
   - dB difference = 7.2 dB
   - dB Subtraction = 0.76 dB
   - Total Noise$_3$ is 27.04 dB

The aggregated noise of the four upstreams results in a C/N of 27.04 dB
Combining issues – Bandwidth!

Make Sure the Reverse Combining is Well Thought Out

WOW, 3.58 MBps!

Only 2.5 Mbps Available per upstream!

Cable Modem A

Cable Modem B

512 Kbps US
Plan for Growth

Have enough Bandwidth for your users

A modem only has one tx and one rx

There is a media max and an aggregate max dictated by the protocol and the physical network

Ahhh, that’s better 10 Mbps...
Case Studies
Case Study: Return Path Noise and Planning

- Provider found that current bandwidth was over utilized and service quality was suffering.

How does the provider avoid this issue?

Case Study: Narrowband Ingress

- MSO had service interruptions every evening due to narrowband ingress. Local RF noise picked up by open taps in the plant.

**How could this have been avoided?**

**Characterization of the return path over time using cable TV analyzer to identify and avoid problem spectra.**

(advanced CMTS with spectrum agility and a spectrum analysis or monitoring tool)
Case Study: Heterogeneous Combining

- Customer had nodes varying from 2000 to 370 homes passed.

**Does this customer use sparse or dense mode?**

Customer required both forms of combining to accommodate both legacy and recently implemented fiber nodes.
Case Study A

- Customer Used Demographics for 5000 New Subs per month
- More worried about “Next Customer” than proper design
- Ignored RF importance
- Used Existing Backbone and simply added Broadband Traffic
Case Study A

Backbone Design

CMTS x 4
CMTS x 4

HFC
HFC

1 Gbps

FE links
GE links
FE links

FE links

Time of Day
DHCP
TFTP
Case Study A

Issues:

• Customer has 30,000 Customers per month coming on the network

• Customer has no central management control

• Ignored RF importance - Not Enough Frequency Available

• GigE Backbone is saturated
Case Study B

- Customer Deployed Over Large Geographic Area
- WAN Bandwidth a major issue
- No IP address Planning
- Used NAT extensively
- Each city One UBR and 2,500-3,500 users per linecard
Case Study B

Issues:

- Backhaul BW undersized - E1 for each City
- Lack of Real IP addresses - Single Class C
- NAT limits functionality - gaming, etc. broken
- Over-subscription drives customer dissatisfaction
You have the KEY!

PLANNING is the KEY to a successful Data over Cable Deployment!
Questions?
Deploying Cable Access Infrastructures

Session SPL-230
Please Complete Your Evaluation Form

Session SPL-230