AGENDA

- CURRENT STATUS
- DOCSIS 2.0
- M-CMTS
- DOCSIS 3.0
- Q&A
CURRENT STATUS

• Majority of MSOs in Caribbean and Latin America have deployed DOCSIS services in some form.
• If you are still on DOCSIS 1.0 you are in **SEVERE** risk of theft of service.
• DOCSIS 1.1 is widely deployed but not all advantages used.
  – QoS not being used for other application than voice.
  – Main driver were the security features of Docsis 1.1

• Major MSOs on the region and new deployments already using DOCSIS 2.0.
  – Smaller node sizes
  – High bandwidth services.
• DOCSIS 3.0 services expected to blossom on 2010.
## DOCSIS VERSIONS

<table>
<thead>
<tr>
<th></th>
<th>Spec</th>
<th>Interop</th>
<th>Certification</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOCSIS 1.0</td>
<td>1997</td>
<td>1998</td>
<td>1999</td>
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<tr>
<td>DOCSIS 1.1</td>
<td>1999</td>
<td>Q3, 2000</td>
<td>Q3, 2001</td>
</tr>
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<td>DOCSIS 2.0</td>
<td>Q4, 2001</td>
<td>Q2, 2002</td>
<td>Q4, 2002</td>
</tr>
</tbody>
</table>
BENEFITS IN A NUTSHELL

• Increased return channel capacity
• New modulation techniques
• Better performance on noisy environments

Downstream not changed nor improved
MAC layer not changed, only PHY layer.
**DOCSIS 2.0**

- Higher return path RF Bandwidth

<table>
<thead>
<tr>
<th>DOCSIS</th>
<th>1.0</th>
<th>1.1</th>
<th>2.0</th>
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<tbody>
<tr>
<td>200 Khz</td>
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<td>X</td>
<td>X</td>
</tr>
<tr>
<td>400 Khz</td>
<td>X</td>
<td>X</td>
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</tr>
<tr>
<td>800 Khz</td>
<td>X</td>
<td>X</td>
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</tr>
<tr>
<td>1600 Khz</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3200 Khz</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>6400 Khz</td>
<td></td>
<td></td>
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# DOCSIS 2.0

## IMPROVEMENTS ON SPECTRAL EFFICIENCY

<table>
<thead>
<tr>
<th></th>
<th>Bits per symbol</th>
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</thead>
<tbody>
<tr>
<td>1.X</td>
<td>3.2 bits / Hertz QAM16</td>
</tr>
<tr>
<td>2.0</td>
<td>4.8 bits /Hertz 64QAM</td>
</tr>
</tbody>
</table>
DOCSIS 2.0

NEW MODULATIONS

• A-TDMA: Evolution from DOCSIS 1.X TDMA
  – 8 QAM
  – 32 QAM
  – 64 QAM
• S-CDMA: New modulation format
## DOCSIS 2.0 ATDMA

<table>
<thead>
<tr>
<th>Hertz</th>
<th>QPSK</th>
<th>8 QAM</th>
<th>16 QAM</th>
<th>32 QAM</th>
<th>64 QAM</th>
<th>Ksym/Sec</th>
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<tr>
<td>200</td>
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<td>640</td>
<td>800</td>
<td>960</td>
<td>160</td>
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<td>400</td>
<td>640</td>
<td>960</td>
<td>1280</td>
<td>1600</td>
<td>1920</td>
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<td>1280</td>
<td>1920</td>
<td>2560</td>
<td>3200</td>
<td>3840</td>
<td>640</td>
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<td>2560</td>
<td>3840</td>
<td>5120</td>
<td>6400</td>
<td>7680</td>
<td>1280</td>
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<tr>
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<td>7680</td>
<td>10240</td>
<td>12800</td>
<td>15360</td>
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<td>6400</td>
<td>10240</td>
<td>15360</td>
<td>20480</td>
<td>25600</td>
<td>30720</td>
<td>5120</td>
</tr>
</tbody>
</table>
DOCSIS 2.0 ATDMA

IMPROVED PERFORMANCE UNDER INTERFERENCE
• Enhanced Pre-Ecualizer from 8 to 24 taps
DOCSIS 2.0 S-CDMA

SYNCHRONOUS CODE DIVISION MULTIPLE ACCESS

- Same throughput than ATDMA
- Better impulse noise performance under 20 Mhz
- Less latency
- Only useful on channels > 1 Mhz
- Requires 10X better synchronization than ATDMA
DOCSIS 2.0 MIXED MODE

Logical Channels

ATDMA & TDMA
S-CMDA

There’s a loss of performance close to 25% when mixing ATDMA and SCDMA on the same RF Channel.
There’s no loss by mixing ATDMA and TDMA
S-CDMA vs. A-TDMA Capacity Analysis

Modulation Order

ATDMA-only system

15 MHz

ATDMA
3.2 MHz
16-QAM
10 Mbps

ATDMA
6.4 MHz
16-QAM
20 Mbps

ATDMA
6.4 MHz
32-QAM
25 Mbps

ATDMA
6.4 MHz
64-QAM
30 Mbps

ATDMA
3.2 MHz
64-QAM
15 Mbps

40 MHz

SCDMA-capable system

5 MHz

SCDMA
6.4 MHz
32-QAM
25 Mbps

SCDMA
6.4 MHz
64-QAM
30 Mbps

ATDMA
6.4 MHz
32-QAM
25 Mbps

ATDMA
6.4 MHz
64-QAM
30 Mbps

ATDMA
6.4 MHz
32-QAM
15 Mbps

ATDMA
6.4 MHz
32-QAM
12.5 Mbps

42 MHz
**S-CDMA vs. A-TDMA Capacity Analysis**

**S-CDMA advantages**
- S-CDMA increase capacity up to ~50%
- Enables 100 Mbps Upstream Service Rates
- Defer Node Splits
## NETWORK REQUIREMENTS

### ATDMA

<table>
<thead>
<tr>
<th>Channel SNR Required (dB)</th>
<th>Modulation Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>QPSK</td>
</tr>
<tr>
<td>18</td>
<td>8QAM</td>
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<td>21</td>
<td>16QAM</td>
</tr>
<tr>
<td>24</td>
<td>32QAM</td>
</tr>
<tr>
<td>27</td>
<td>64QAM</td>
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<tr>
<td>30</td>
<td>128QAM</td>
</tr>
<tr>
<td>33</td>
<td>256QAM</td>
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</table>

### SCDMA

<table>
<thead>
<tr>
<th>Channel SNR Required (dB)</th>
<th>Modulation Type</th>
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</thead>
<tbody>
<tr>
<td>12</td>
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<tr>
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<tr>
<td>24</td>
<td>64QAM</td>
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<tr>
<td>27</td>
<td>128QAM</td>
</tr>
<tr>
<td>30</td>
<td>256QAM</td>
</tr>
</tbody>
</table>
32QAM and 64QAM usually requires small node sizes.
• 1000 HHPP max
• N+1 or N+2 usually
M-CMTS Goals

• “Independent scalability of CMTS functions from DS PHY”
  – Means: need to add DS channels without adding US channels
• “Lower the cost to deliver video over DOCSIS service to be competitive with today’s MPEG VOD”
• 2005 Incremental DOCSIS DS channel cost: $24K ASP for 2DS+8US CMTS blade = $12,000 per DS channel
  – 2005 Incremental MPEG VOD channel cost: $12K for 24-channel MPEG EQAM = $500 per DS channel
    • But with no rate limiting, scheduling, QOS, encryption, VOIP compression, or RF switching
M-CMTS Interfaces
What’s important and not for M-CMTS

- What’s important is that the two M-CMTS goals be met:
  - De-coupling downstream and upstream capacity; and
  - Lowering the cost of downstream capacity.
- What’s important is the adoption of the DEPI specification by the EQAM industry.
  - Enables a transition to DOCSIS IPTV with DEPI EQAMs.
- What’s NOT important is the concept of separating the upstream PHY layer:
  - Separation into an “upstream shelf” and definition of an “Upstream Edge Physical Interface” (UEPI)
  - Independent vendor implementations of “CMTS Core” and “upstream shelf” MAC functions;
DOCSIS 3.0 – What’s New
DOCSIS 3.0
DOCSIS 3.0 Features

• Channel Bonding
  – Upstream Channel Bonding
  – Downstream Channel Bonding

• IP Multicast
  – Source Specific Multicast
  – QoS Support for Multicast

• Security
  – Enhanced Traffic Encryption
  – Enhanced Provisioning Security
  – Certificate Revocation

• Network Management
  – CM Diagnostic Log
  – Enhanced Signal Quality Monitoring
  – Service Statistics Reporting

• IPv6
  – IPv6 Provisioning & Management of CMs
  – Alternative Provisioning Mode & Dual-stack Management Modes for CMs
  – IPv6 Connectivity for CPEs

• Physical Layer
  – Upstream Frequency Range Extension

• Business Services over DOCSIS
  – Layer 2 Virtual Private Networks
  – Support for T1/E1 Services
DOCSIS 3.0 Channel Bonding
**Channel Bonding**

- **Feature Description**
  - Simultaneous data transmissions on multiple channels
    - Support of at least 4 upstream & 4 downstream channels is required (can support more)
    - Channels don’t have to be adjacent
  - Legacy CMs can be supported on each channel

- **Benefits**
  - Scalable deployment
    - MSO can choose to bond any number of channels (2,3,4,etc.) to provide adequate bandwidth to their customers
  - Enables business and backhaul services
  - Subscriber gain of ~10%-25% more customers per channel due to greater statistical multiplexing
**High-DS Bandwidth via Channel Bonding**

**Channel Bonding**
- Will allow bonding between 4 and up to 16 Adjacent or Non-Adjacent (TBD) RF DS Channels Together
- Huge Bandwidth Increases: Assume bonding up to 40 Mbps per DS
- Statistical Multiplexing gain over a Single Channel equals more users and bandwidth
Channel Bonding (cont.)

• Benefits (cont.)
  – Higher Data Rates
    • Downstream Capacity with 6MHz & 256QAM
      • Four channels, 160 Mbps
      • Three channels, 120 Mbps
      • Two channels, 80 Mbps
    • Upstream Capacity with 6.4MHz & 64QAM
      • Four channels, 120 Mbps
      • Three channels, 90 Mbps
      • Two channels, 60 Mbps
  – Increased Robustness
    • CMs can survive loss of all but one channel
    • Flexibility to avoid upstream ingressors
      • Multiple smaller channels can be bonded

• Requirements and restrictions for deployment
  – Must have available spectrum
IP Multicast Features
Source Specific Multicast-SSM

• Feature Description
  – Delivery of multimedia (audio/video) services from one source to multiple subscribers’ CPEs (IPv4 & IPv6) based on customer request

• Benefits
  – Enables operators to offer broadcast-like services over DOCSIS based on subscriber demand (e.g. IPTV service)
  – Enables bandwidth efficient on-demand multimedia services as compared with unicast
  – Facilitates offering of interactive video/audio and data services

• Requirements and restrictions for deployment
  – Requires DOCSIS 3.0 CMTS & 1.1 or greater CM
QoS Support for Multicast

• Feature Description
  – Provides guaranteed bandwidth for multicast sessions
  – Provides ability to control the amount of bandwidth that can be used by multicast traffic that is not part of an MSO service offering

• Benefits
  – Enables differentiation of QoS-enabled multicast services
  – Enables service level guarantees to be offered to the end customer
  – Enables offering of QoS-enabled packages to third parties

• Requirements and restrictions for deployment
  - Requires 3.0 CMTS & 1.1 or greater CM
  - Cable operator needs to configure QoS parameters for various multicast sessions
IPv6 Features
IPv6 Provisioning & Management of CMs

• Feature Description
  – 3.0 CMs can be provisioned with an IPv6 address

• Benefits
  – Solves the MSO’s address crunch problem without creating isolated networks

• Requirements and restrictions for deployment
  – MSO Operations Support Systems need to be upgraded to support IPv6
  – CMTS must be upgraded to support IPv6 based CM provisioning
Alternative Provisioning Mode & Dual-stack Management Modes for CMs

• Feature Description
  – When enabled by MSOs, allows for:
    • CMs to failover to IPv4 provisioning when IPv6 provisioning fails & vice-versa
    • MSOs to manage CMs via IPv4 & IPv6 addresses concurrently

• Why was it incorporated?
  – Enables phased migration strategy
  – Provides an optional fall-back mode when migrating to IPv6 from IPv4

• Benefits
  – Allows MSOs to begin using IPv6 for provisioning and management without doing a hard cut-over
  – Will allow MSOs to communicate with CMs when there are IPv4 or IPv6 specific network outages

• Requirements and restrictions for deployment
  – CM consumes both an IPv4 and an IPv6 address. (Does not benefit MSOs who are running out of IPv4 address space.)
**IPv6 Connectivity for CPEs**

- **Feature Description**
  - CMTS enables IPv6 address configuration and connectivity to the customer devices

- **Why was it incorporated?**
  - Other CableLabs specified devices need to be capable of being provisioned and managed via IPv6 due to IPv4 address space constraints
  - In the future, customer devices will look for IPv6 addressing by default

- **Benefits**
  - Allows MSOs to rollout new IP based services that would not be possible because of the lack of IPv4 address space

- **Requirements and restrictions for deployment**
  - MSO CMTS and management systems need to be upgraded to support IPv6
  - CableLabs specs need to be updated with IPv6 capabilities and devices need to be procured against these specs.
Security Features
Enhanced Traffic Encryption

• Feature Description
  – Provides stronger traffic encryption, 128 bit Advanced Encryption Standard (AES) for user’s data

• Why was this incorporated?
  – National Institute of Standards and Technology (NIST) has declared single DES as not acceptable for government applications.
  – Industry was concerned about public perception.

• Benefits
  – Maintains privacy of customer traffic.
  – Avoids negative public perception possible with continued use of existing encryption algorithm.

• Requirements and restrictions for deployment
  – Enhanced traffic encryption is only possible between a CMTS and CM that are DOCSIS 3.0 compliant.
Enhanced Provisioning Security

- **Feature Description**
  - Increases security of the CM provisioning process
    - Applies authentication before CM accesses MSO’s operation support systems
    - Configuration file transfers encrypted

- **Why was this incorporated?**
  - MSO’s have experienced:
    - Denial-of-service attacks on MSO’s operation support systems
    - Hacked modems were requesting unauthorized services

- **Benefits**
  - Reduces operational complexity while enhancing network security

- **Requirements and restrictions for deployment**
  - No special requirements or restrictions for deployment
Certificate Revocation

- Feature Description
  - A more efficient method for the CMTS to check up-to-date certificate revocation status each time a CM attempts to authenticate
- Why was this incorporated?
  - Current certificate revocation method is cumbersome
- Benefits
  - Reduces operational complexity in managing un-trusted certificates across CMTSs
  - Facilitates sharing certificate revocation data across multiple MSOs
- Requirements and restrictions for deployment
  - Requires the operator have a security policy in place that governs the distribution and storage of certificate data
Physical Layer Feature
<table>
<thead>
<tr>
<th>Feature Description</th>
<th>Why was this incorporated?</th>
<th>Benefits</th>
<th>Requirements and restrictions for deployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optional feature to extend upstream operation from 5-42 MHz to 5-85 MHz</td>
<td>Provides a mechanism to obtain more upstream bandwidth</td>
<td>Adds 200 Mbps of potential capacity</td>
<td>Have to move lower analog channels or go all digital</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Switchable feature allows MSO to enable it when plant is ready</td>
<td>Legacy conditional access has to be moved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>New downstream/upstream symmetry ratio enables business services.</td>
<td>Have to upgrade fiber nodes and amplifiers</td>
</tr>
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<td></td>
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<td></td>
<td>Have to use filters to protect customers’ legacy CPE devices</td>
</tr>
</tbody>
</table>
Network Management Features
CM Diagnostic Log

- Feature Description
  - CMTS reports CMs with connectivity problems
- Why was this incorporated?
  - Vendors implemented proprietary mechanisms
  - MSOs wanted a standardized approach
- Benefits
  - Enables adoption of common mechanisms for troubleshooting CM connectivity
  - Enables proactive maintenance
- Requirements and restrictions for deployment
  - Operation systems require updates to make use of this information
Service Statistics Reporting

- Feature Description
  - Streaming mechanism to report service statistics from CMTS. e.g. subscriber usage, CM status and traffic statistics
- Why was this incorporated?
  - Current mechanisms for collection of CMTS service statistics do not scale well
  - Current approaches do not provide sufficient information for traffic modeling
- Benefits
  - Access to more statistics while consuming less network capacity
  - Continuous and concise transmission of statistics reduces CMTS resources allocated to network management operations (do more statistics collection with less memory and processing power)
- Requirements and restrictions for deployment
  - MSOs need to interface operation support systems with streaming data systems
Business Services over DOCSIS (BSoD)
BSoD Layer 2 Virtual Private Networks (L2VPN)

- Feature Description
  - Creates transparent, private and dedicated connections between cable modems at multiple business sites
- Why was this incorporated?
  - Cable operators asked for a non-proprietary L2VPN gateway solution
- Benefits
  - More flexible alternative to Frame Relay service for business customers
  - Does not require special VPN equipment or client software at the customer’s site
- Requirements and restrictions for deployment
  - Requires enabling DOCSIS BPI+ security feature
  - Requires L2VPN-capable CM & CMTS
Support for T1/E1 Services

- Feature Description
  - Business Services over DOCSIS-TDM Emulation service (BSoD-TE) is a method for cable operators to deliver T1, E1 and NxDS0 emulation services

- Why was this incorporated?
  - MSO members in the Business Service Roundtable expressed an interest in offering T1/E1 services over DOCSIS in a standard way

- Benefits
  - MSOs can now offer a competitive service to that offered by telcos

- Requirements and restrictions for deployment
  - CMTS
    - A supporting CMTS will require a GPS, BITS, or DTI master clock
    - DOCSIS 1.1 & 2.0 CMTS - May need hardware addition to CMTSs without clock interfaces (DOCSIS 3.0 CMTS will have the needed timing interface)
  - CMs
    - Requires specialized CMs with T1/E1 interfaces (per spec).
  - Operations
    - May need to be tightened to guarantee service availability