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# **Cable Technologies**

## **DOCSIS, PacketCable, CableHome**

Craig Owens

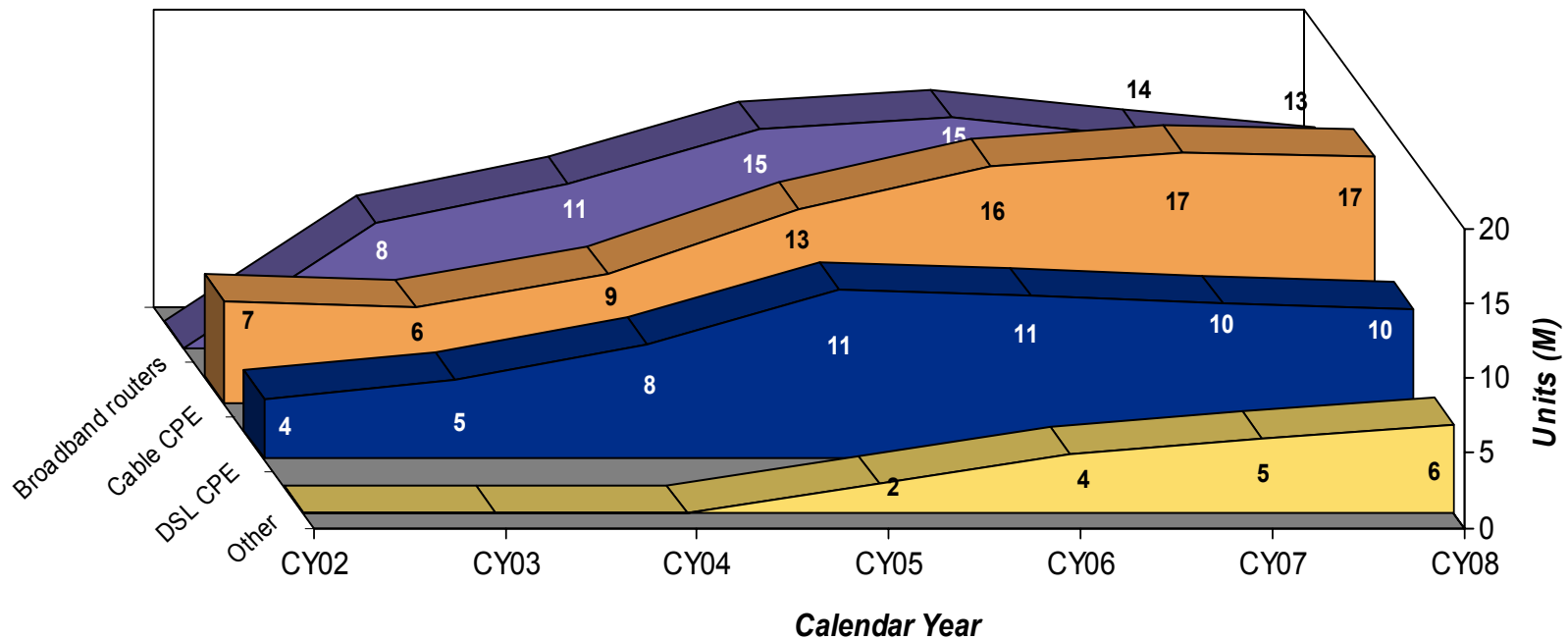
[craig.owens@netgear.com](mailto:craig.owens@netgear.com)

408-907-8066

- » **Market Data**
- » **Cable system architecture**
- » **DOCSIS**
- » **PacketCable**
- » **CableHome**
- » **CableLabs**

# Cable vs. DSL: North America

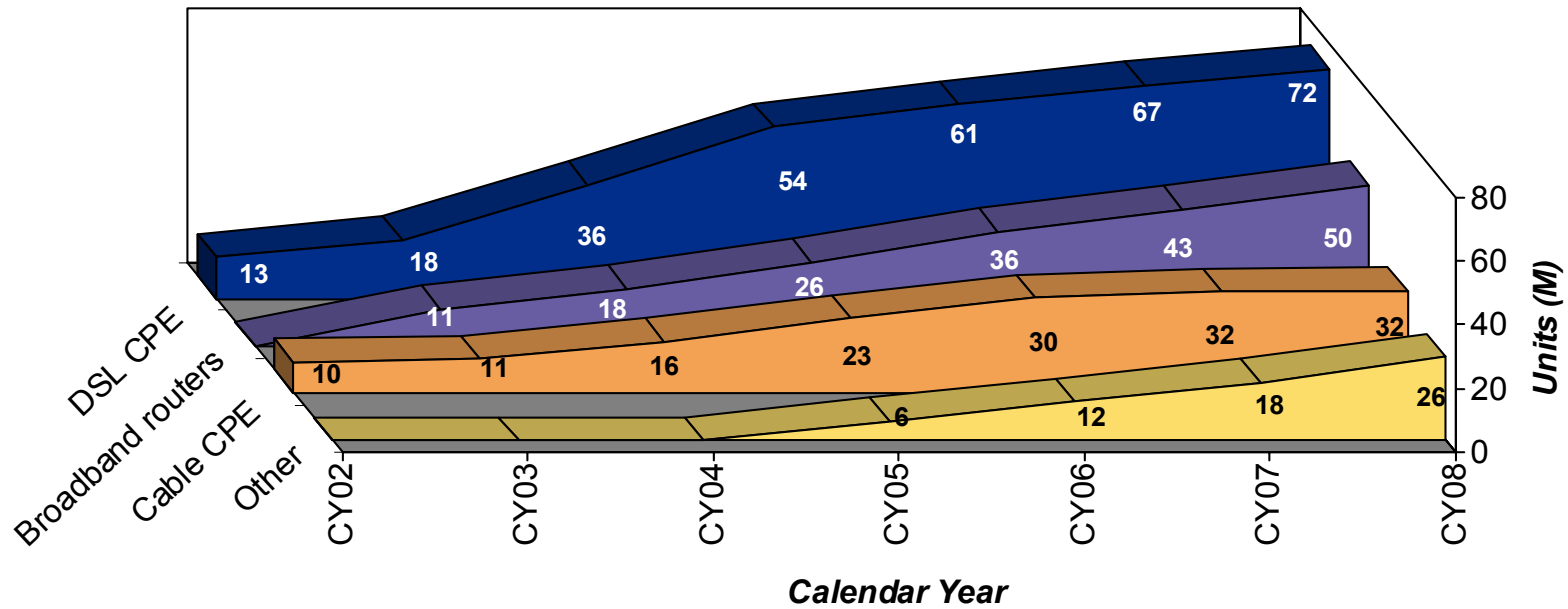
**North America Total Broadband CPE Unit Shipments**



Source: Infonetics, September, 2005

# Cable vs. DSL: Worldwide

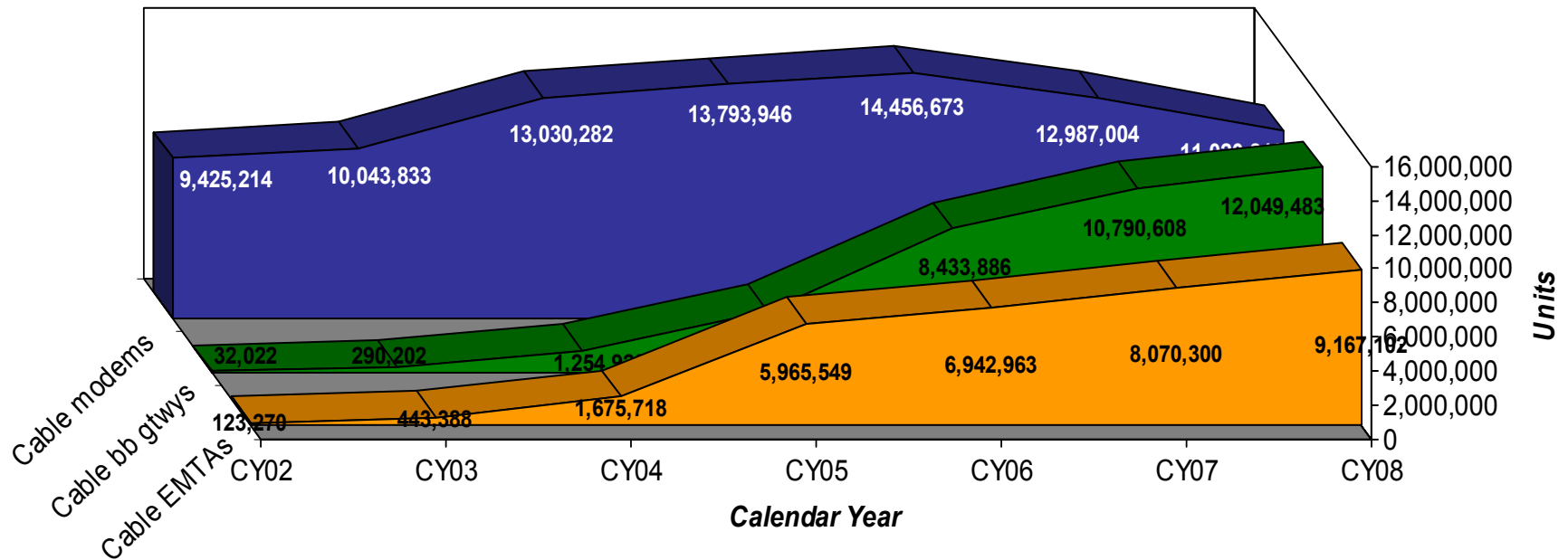
### Worldwide Total Broadband CPE Unit Shipments



Source: Infonetics, September, 2005

# Cable CPE Shipments

*Worldwide Cable CPE Unit Shipments*



Source: Infonetics, September, 2005

VoIP Subscribers, in 000's

<b>Service Provider</b>	<b>Q4 2004</b>	<b>Q1 2005</b>	<b>Q-Q Growth</b>
<b>Vonage</b>	<b>388</b>	<b>535</b>	<b>38%</b>
<b>Cox</b>	<b>380</b>	<b>413</b>	<b>9%</b>
<b>Time Warner</b>	<b>219</b>	<b>372</b>	<b>59%</b>
<b>Cablevision</b>	<b>273</b>	<b>364</b>	<b>33%</b>
<b>Insight</b>	<b>64</b>	<b>70.4</b>	<b>10%</b>
<b>Charter</b>	<b>45</b>	<b>49.5</b>	<b>10%</b>
<b>Covad</b>	<b>20.5</b>	<b>23.4</b>	<b>14%</b>

Source: Point Topic, July, 2005

## » **Cable Modem.**

- Subscriber device, connects customer's PC or LAN to the cable TV plant (HFC)

## » **Cable Modem Termination System (CMTS).**

- Head-end equipment that concentrates communication to/from all subscribers' cable modems

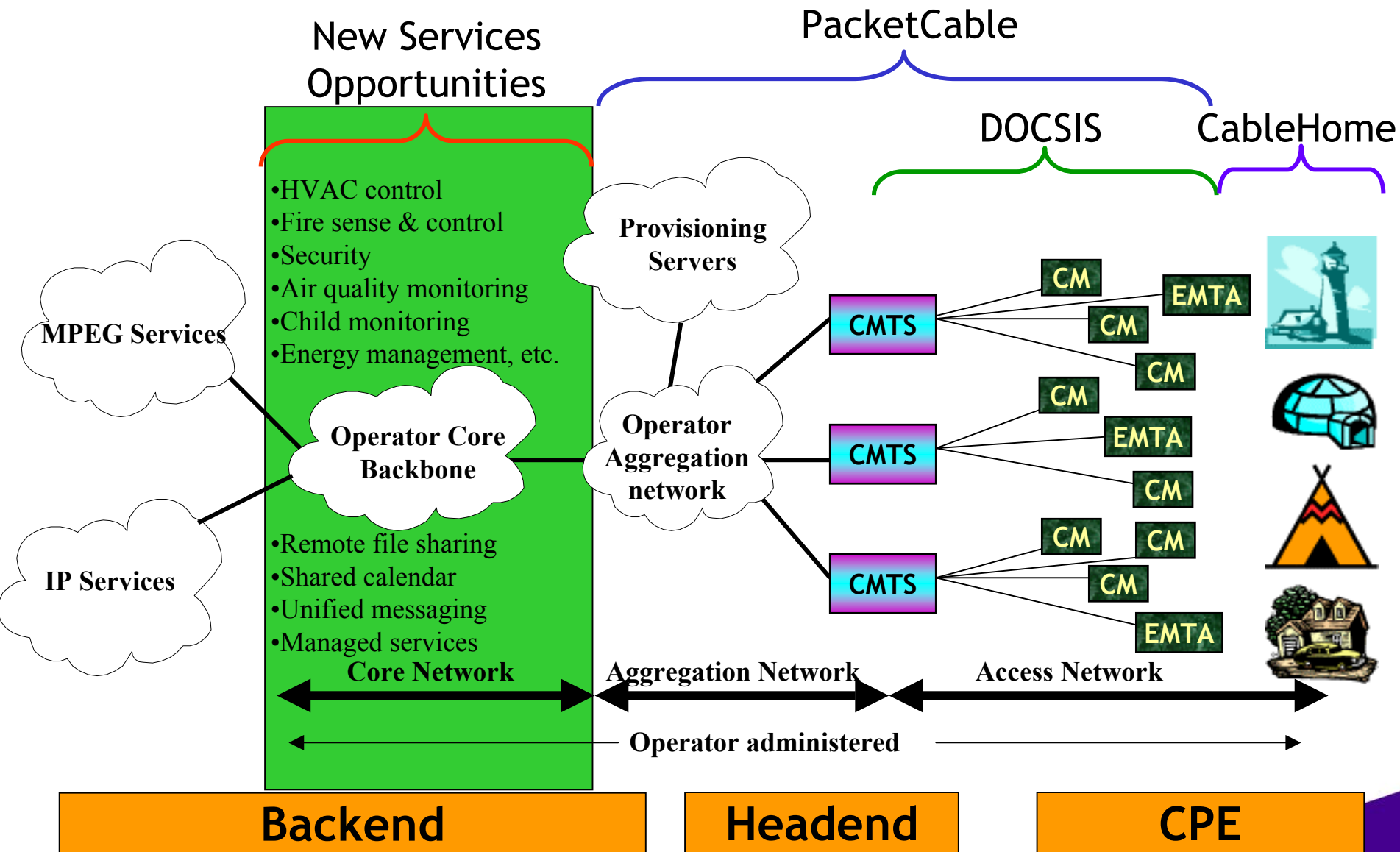
## » **DOCSIS Provisioning Server**

- Provides network configuration (IP address, etc), date and time and cable modem configuration
- Provides also downloadable code image (software) for cable modems, for software upgrade
- Support the following network services:
  - » DHCP (Dynamic Host Configuration Protocol)
  - » TOD (Time and Date Service)
  - » TFTP (Trivial File Transfer Protocol)

## » **Embedded Multimedia Terminal Adapter (EMTA)**

- Cable Modem with voice ports for VoIP service
  - » Allows connection of a plain analog telephone

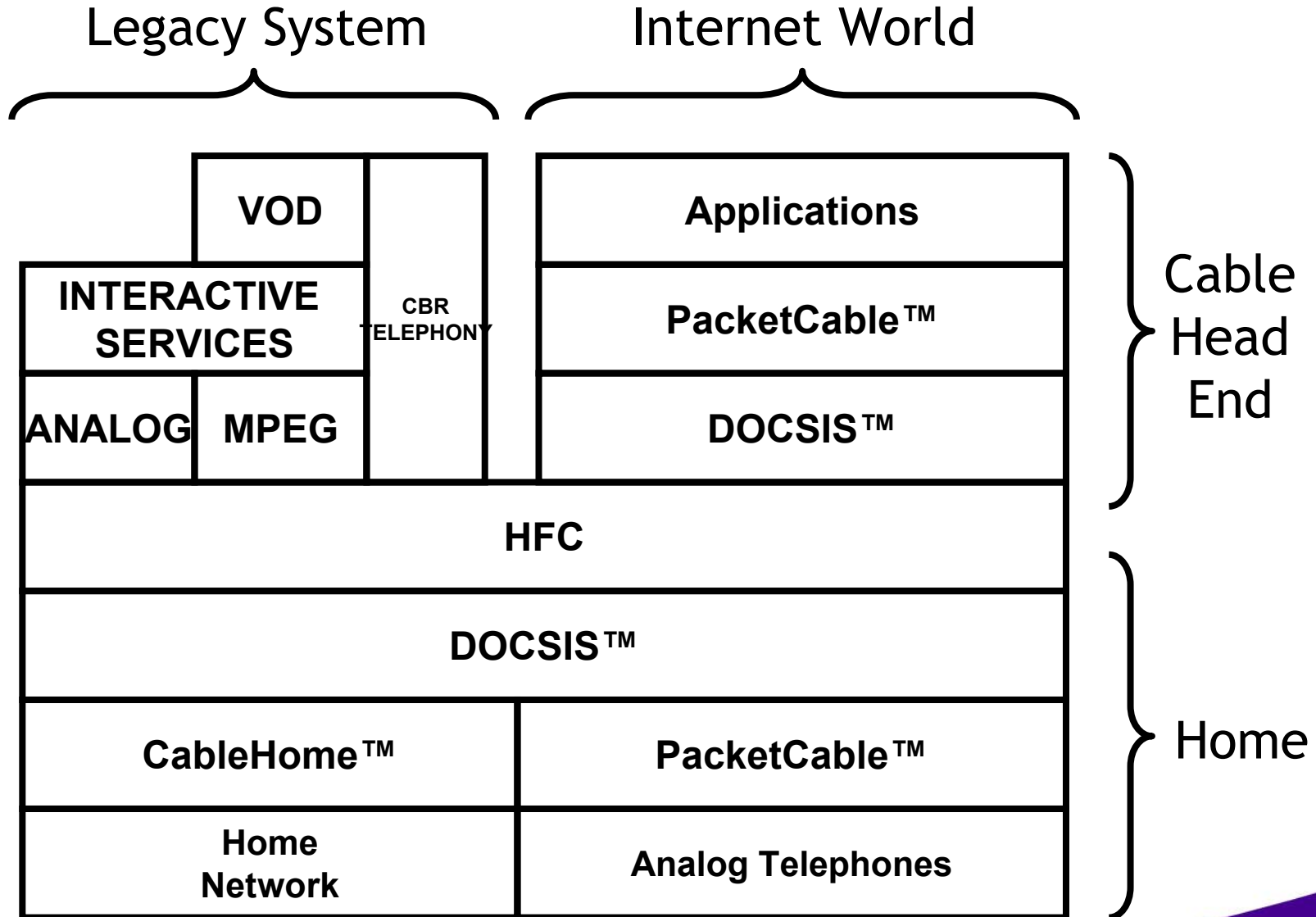
# Cable Architecture





- » **Data Over Cable Systems Interface Specification (DOCSIS)**
  - Industry effort, led by CableLabs<sup>®</sup> to create an open standard for data (internet) over cable TV
  - Specified in 1997, first products certified in March 1999
  - DOCSIS allows MSO's to achieve higher levels of penetration via retail, auto-provisioning, external cable modems, and self-installs.
- » **DOCSIS only deals with the communication between the CM and the CMTS.**
- » **DOCSIS utilizes 1 downstream channel from the channel lineup and 1 or more channels from the return path to achieve bi-directional connection.**
- » **Maximum raw data throughput**
  - 43 Mbps downstream
  - 10 Mbps upstream

# Cable Services Protocol Stack



- » **Backward compatible with DOCSIS 1.0**
- » **Enhanced Quality of Service (QoS) Allows cable operators to deploy new services such as:**
  - Tiered data services with guaranteed bandwidth
  - Voice over IP
  - IP Multicasting
- » **Improved security (Baseline Privacy +) based on SNMPv3**
  - Reduces possibility of theft of service
  - Provides secure software downloading
- » **Concatenation and Fragmentation**
  - Allow more efficient use of available bandwidth
  - Guarantee real-time traffic for voice over IP.
- » **Specification released in 1999**

- » **Backward compatible with DOCSIS 1.0, 1.1**
- » **Advanced Upstream PHY enables symmetrical services**
  - Higher order modulation formats and increased symbol rates
    - » 8QAM, 32QAM, 64QAM
    - » 5.12 Msps
    - » Maximum raw upstream data rate: 30.72 Mbps
  - Synchronous-Code Division Multiple Access (CDMA)
    - » Multiple modems can transmit simultaneously on the same RF channel, separated by different orthogonal codes.
    - » Robust upstream for noise environments
- » **Improved noise immunity**
  - FEC correction for 16 bytes per Reed-Solomon block (vs. 10 for DOCSIS 1.1)
  - Adaptive equalizer structure with 24 taps (vs. 8 for DOCSIS 1.1)
  - Improved ingress cancellation
- » **Specification released in 2001, but most plants are still running 1.1**

## » DOCSIS 3.0

- 100 Mbps downstream, 50 Mbps upstream
- Video services (broadcast and video on demand)
- Additional bonded downstream and upstream channels (4 or more)
  - » Existing CMs work on 1 channel, D3.0 works on multiple channels
- Specs: 2006, products: early 2007???

## » Commercial Services over DOCSIS (CSoD)

- VPN service
- T1 replacement

## » eDOCSIS

- Allows integration of DOCSIS modems into non-traditional devices, such as TVs, Set Top Boxes, etc.

## » Modular CMTS (M-CMTS)

- Allows easier integration of data service and other services, such as video

- » **Cable Plant must be “clean” and upgraded to 2-way capable**
- » **100 mile maximum distance**
- » **Downstream**
  - A DOCSIS channel takes the place of a single analog television channel
  - 88 – 860 MHz (108 – 862 MHz Europe)
  - Channel spacing: 6 MHz (8 MHz Europe)
  - Modulation: 64QAM, 256 QAM
- » **Upstream**
  - Upstream channels use spectrum previously reserved for STB communication
  - 5 – 42 MHz (5 – 65 MHz Europe)
  - Noisy portion of spectrum requires flexible channels
    - » Amateur radios, home intercoms, impulse ingress due to switching transients, household appliances, etc.
  - Multiple upstream channels can be associated with each downstream channel
  - Modulation: QPSK, 8QAM, 16QAM, 32QAM, 64QAM, 128QAM (CDMA only)

## Downstream Data Rates

Modulation	Symbol Rate	Raw Throughput
64 QAM (6 bits/symbol)	5.056941 Msp/s	30.34 Mbps
256 QAM (8 bits/symbol)	5.360537 Msp/s	42.88 Mbps

## Upstream Data Rates

DOCSIS 2.0

Modulation	160 ksp/s	320 ksp/s	640 ksp/s	1.28 Msp/s	2.56 Msp/s	5.12 Msp/s
QPSK 2 bits/symbol	320 kbps	640 kbps	1.28 Mbps	2.56 Mbps	5.12 Mbps	10.24 Mbps
8QAM 3 bits/symbol	480 kbps	960 kbps	1.92 Mbps	3.84 Mbps	7.68 Mbps	15.36 Mbps
16QAM 4 bits/symbol	640 kbps	1.28 Mbps	2.56 Mbps	5.12 Mbps	10.24 Mbps	20.48 Mbps
32QAM 5 bits/symbol	800 kbps	1.6 Mbps	3.2 Mbps	6.4 Mbps	12.8 Mbps	25.6 Mbps
64QAM 6 bits/symbol	960 kbps	1.92 Mbps	3.84 Mbps	7.68 Mbps	15.36 Mbps	30.72 Mbps

- » **Downstream channel searching and synchronization**
- » **Obtain upstream parameters**
  - CM chooses a temporary upstream channel
- » **Ranging: 0 – 215 minislots (6.25 us each)**
  - CMs must adjust transmit timing to account for propagation delay of up to 100 miles of cable
  - Transmissions from all CMs must be synchronized at CMTS.
- » **Establish IP connectivity**
  - DHCP used to assign IP address
  - Additional parameters communicated through DHCP extensions
    - » IP address of TFTP Server, TOD server
    - » Time zone
    - » Name of configuration file



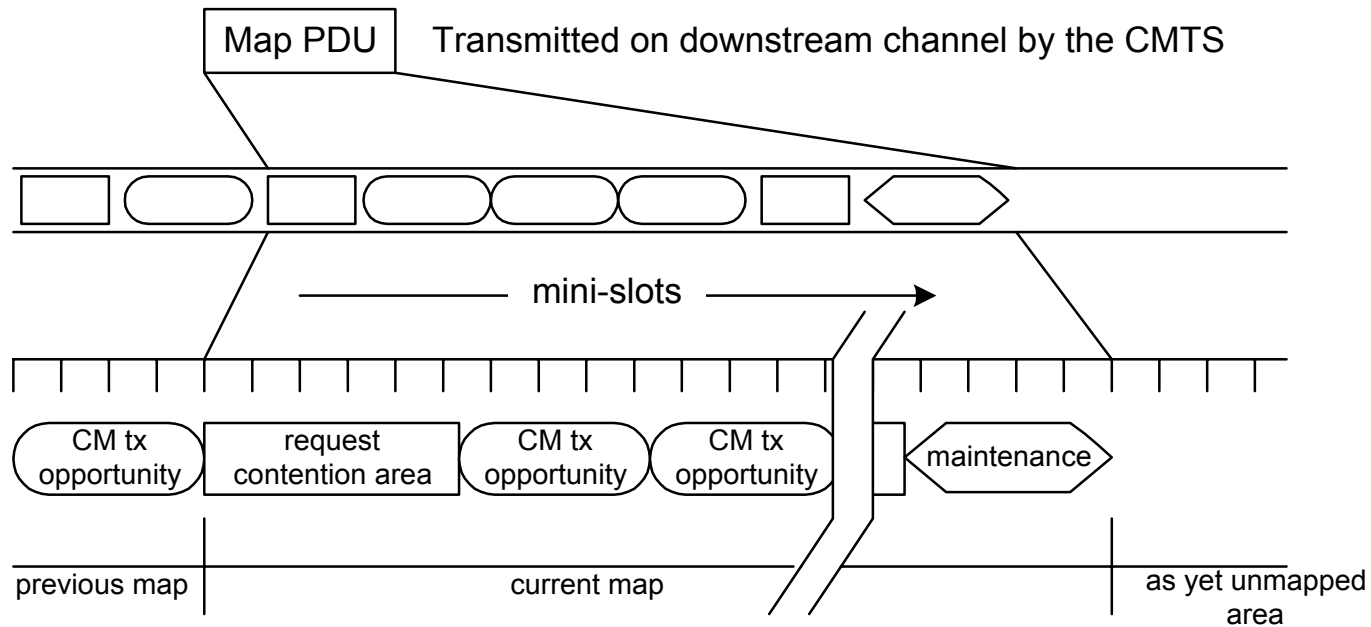
- » **Establish time of day using TOD server**
- » **Transfer operational parameters**
  - Configuration file downloaded using TFTP
  - CMTS assigns new upstream channel, in which case repeat ranging
- » **Firmware upgrade (optional)**
  - Automatic upgrade if current firmware version is different than version indicated in configuration file
  - Dual images protects against power outages during upgrade
- » **Registration: CM authorized to use the network based on MAC address**
- » **Baseline Privacy initialization, if CM is provisioned to run Baseline Privacy**

- » **188-byte MPEG-2 packets (4-byte header, 184 bytes payload)**
- » **ITU Recommendation defines:**
  - Framing structure (MPEG-2)
  - Channel coding (RS FEC, Interleaving, Randomization and Trellis)
  - Channel modulation (64/256 QAM)
- » **DOCSIS frames can be mixed in with frames for other services (digital video, for example)**
- » **DOCSIS frames can span multiple MPEG packets**

MPEG Header DOC	Pointer_field (=0)	Stuff-bytes (0 or more)	Start of MAC Frame #1 (up to 183 bytes)	
MPEG Header Video	Digital Video Payload			
MPEG Header DOC	Continuation of MAC Frame #1 (184 bytes)			
MPEG Header Video	Digital Video Payload			
MPEG Header DOC	Pointer_field (=M)	Tail of MAC Frame #1 (M bytes)	Stuff_bytes (0 or more)	Start of MAC Frame #2 (M bytes)

- » **Upstream bandwidth is allocated by the CMTS**
- » **Dynamic mix of contention- and reservation-based transmit opportunities**
- » **The upstream channel is modeled as a stream of “mini-slots”**
- » **The upstream transmission time-line is divided into Information Elements (IEs)**
  - Each interval is an integral number of mini-slots.
  - Each interval is labeled with a usage code
    - » What type of traffic can be transmitted during that interval
    - » What physical-layer modulation is allowed
- » **Types of Information Elements**
  - Request: Contention interval where CMs may request bandwidth
  - Request/Data: Contention interval where CMs may request bandwidth or transmit short data packets
  - Long and Short Data Grant: Provides opportunity for a CM to transmit upstream packets without contention
  - Data Acknowledge: Acknowledges that a data PDU was received, if requested by CM
- » **Scheduling algorithm is not specified by DOCSIS**
  - Many different scheduling algorithms may be implemented by different CMTS vendors

- » **The CMTS controls the upstream channel through the Allocation MAP**
  - Defines transmission opportunities on the upstream channel
  - Includes a variable number of information elements (IEs). Each information element defines the allowed usage for a range of mini-slots.
- » **The set of all maps describes every mini-slot in the upstream channel**



## » **MAC-layer security services for DOCSIS CMTS - CM communications**

### » **Security goals**

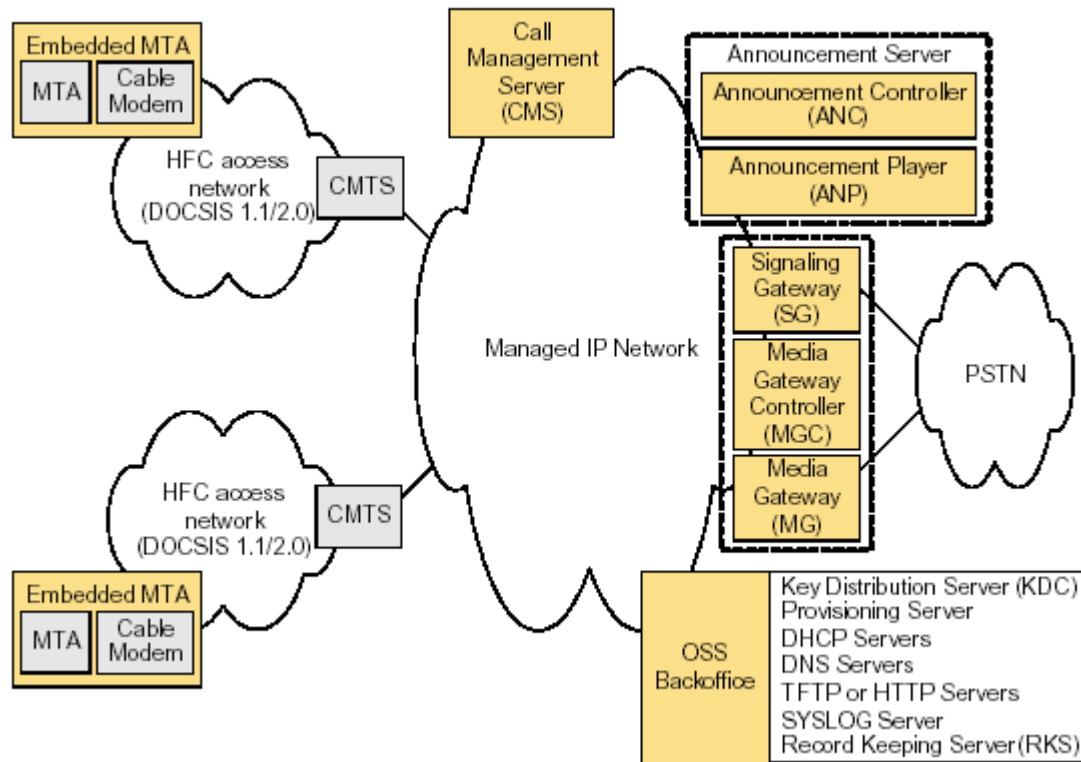
- Provides data privacy equal to or better than that provided by analog modems or DSL
- Provide MSOs with service protection; i.e., prevent unauthorized users from gaining access to the network

### » **Two component protocols:**

- Encapsulation protocol for encrypting packet data across the network
  - » 3-DES Cipher Block Chaining (CBC) encryption
  - » MAC headers are not encrypted
  - » The payloads and headers of MAC management messages are sent in the clear to facilitate normal operation of the MAC sublayer.
- Key management protocol providing the secure distribution of keying data from CMTS to CMs
  - » CMs must have factory-installed RSA private/public key pairs

- » **Provides packet-based voice, video and other high-speed multimedia services over hybrid fiber coax (HFC) cable systems**
- » **Allows connection of a plain analog telephone using an Embedded Multimedia Terminal Adapter (EMTA)**
- » **Goals**
  - Enable voice quality capabilities comparable to or better than PSTN
  - Provide a network architecture that is scalable and capable of supporting millions of subscribers
  - Support primary and secondary line residential voice communications capabilities
    - » Battery backup capability
    - » Electronic surveillance possible
- » **Leverages QOS capabilities of DOCSIS 1.1/2.0**
- » **Based on NCS variation of MGCP**
- » **PacketCable 1.0 specification released in 2000**
- » **PacketCable 2.0 will be based on SIP**
  - Specification date, TBD

# PacketCable Architecture



- » **Standardizes residential gateway (home router) functionality**
  - NAT, Firewall, DHCP
  - No subscriber configuration needed (“works out of the box”)
  - Common consumer applications are not broken by NAT
- » **Allows cable company to control home networks and offer managed services**
  - Parental controls, firewalls, email virus scanning
  - All centrally configured and controlled
  - Remote diagnostic tools for MSO customer care
  - Ability to drive new services for consumers (data, voice, video)
- » **QOS integration with DOCSIS 1.1**
- » **UPnP Discovery allows remote visibility and control of devices in the home**



# CableHome Technical Value

Functionality	Existing Product Features	CableHome Features	Value
Network Management	Console, Telnet, Web-based, UPnP	SNMPv3	<ul style="list-style-type: none"> <li>» Remote configuration and management</li> <li>» Proactive event reporting</li> </ul>
Device Provisioning	Unmanaged DHCP	SNMPv3, Managed DHCP	<ul style="list-style-type: none"> <li>» Zero config for residential gateway</li> </ul>
Address Translation	Unmanaged NAPT	SNMPv3, Managed NAPT & NAT	<ul style="list-style-type: none"> <li>» MSO manageability and visibility</li> <li>» Support for popular apps</li> <li>» Eliminate unnecessary traffic on HFC</li> </ul>
Secure Software Download	None or Firmware	Secure Software Download (DOCSIS 2.0 and 1.1)	<ul style="list-style-type: none"> <li>» Remote device functionality upgrade</li> <li>» Upgrade to firewall policies</li> </ul>
Security/Firewall	None or weak/No Firewall	Medium Security/Policy file Download	<ul style="list-style-type: none"> <li>» Secure Management &amp; Firewall</li> </ul>
QoS	None	Supports PacketCable Telephony and UPnP QoS	<ul style="list-style-type: none"> <li>» Enables a higher quality user experience for multi-media</li> </ul>

## » **CableLabs serves the cable television industry by:**

- Researching and identifying new broadband technologies
- Authoring specifications
- Certifying products
- Disseminating information.

## » **Certification**

- Cable companies will NOT purchase cable modems or other cable products without certification
- Certification Waves, typically 9 weeks
- Cost of \$60k to \$110k, depending upon product
- Very difficult to pass. Any failures during testing result in no certification. You must resubmit in next cert wave and pay again (\$\$\$).

## » **EuroDOCSIS and EuroPacketCable certified by tComLabs in Belgium**

