



# Broadband Access Over Cable

Rolf Minder, SE CCIE #5972  
SP Broadband Solutions  
[rminder@cisco.com](mailto:rminder@cisco.com)



September 19, 2001

# Agenda

- **DOCSIS Overview**
- **Cable Plant**
- **Cable Modem Provisioning**
- **DOCSIS 1.1 Key Features**



# DOCSIS Overview

What you really need to know



# Introduction

## The Underlying Technologies

- **DOCSIS**  
Data Over Cable Service Interface Specification
- **DVB-RC**  
Digital Video Broadcast, European answer to DOCSIS
- **EuroDOCSIS**  
Modified for the European 8MHz, AnnexA, 5-65MHz upstream channel

# DOCSIS Overview

(What & Why)

- **What is DOCSIS**

**DOCSIS (Data Over Cable System Interface Specification) is a standard developed under the guidance of MCNS (Multimedia Cable Network System) for the rapid deployment of Data over Cable.**

# DOCSIS Overview

(What & Why)

- **Why DOCSIS?**

- **Standards based**

**Standards based products bring more competition to the environment. Competition usually brings down the cost of products**

- **Feature rich**

**DOCSIS brings along with it the ability to add features to your network and differentiate service. The first example of this will be the Voice over IP on the CM**

- **Future Proof**

**With Standards brings in more avenues for others to get in the game. On demand video, IP video and a host of other possibilities**

# DOCSIS Overview

(Components of DOCSIS)

- **Components of DOCSIS**
  - **Cable System**
  - **CMTS (Cable Modem Termination System)**
  - **CM (Cable Modem)**
  - **“Back Office” Services**
    - **DHCP**
    - **TFTP**
    - **ToD**

# DOCSIS Overview

(Components of DOCSIS)

- **CMTS (Cable Modem Termination System)**— usually in the head end. It is the device that modulates the signal to the cable modem (CM) and demodulates the CM's response.
- **Cable modem**—associated with customer premise equipment. The CM modulates and demodulates signals to and from the CMTS.





# DOCSIS Overview

(Components of DOCSIS)

- **“Back Office” Services**

- **DHCP (Dynamic Host Configuration Protocol) Server**

- RFC 2131—provides dynamically assigned IP addresses for modems and PC's

- Allows re-use of assigned IP addresses

- **TOD (Time Of Day) Server**

- RFC 868—provides timestamps for logged events

- **TFTP (Trivial File Transfer Protocol) Server**

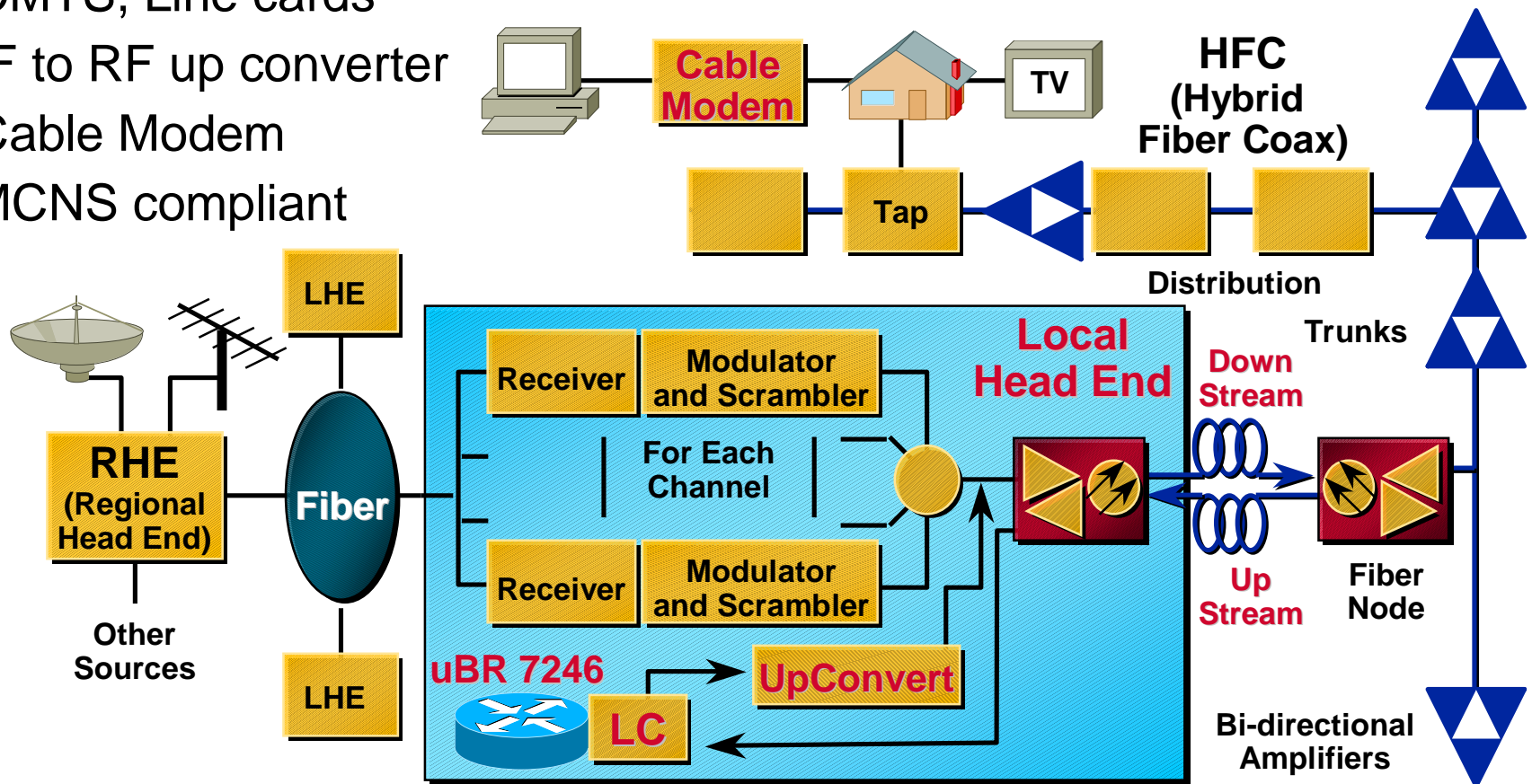
- RFC 1350—provides modem configuration files

- **Bin File created with Configuration File Editor**

# The Big Picture

## • Components

- CMTS, Line cards
- IF to RF up converter
- Cable Modem
- MCNS compliant



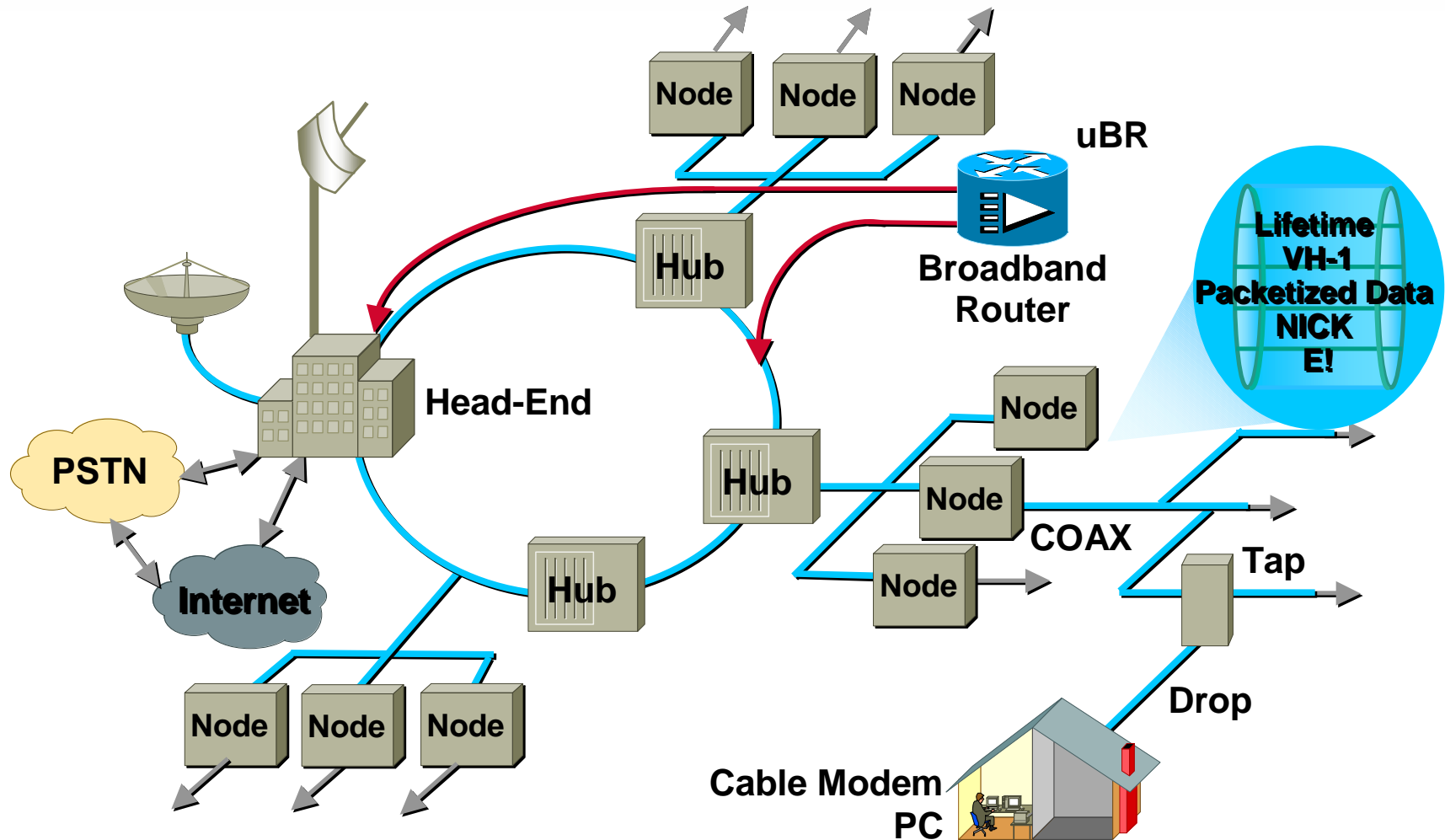


# DOCSIS

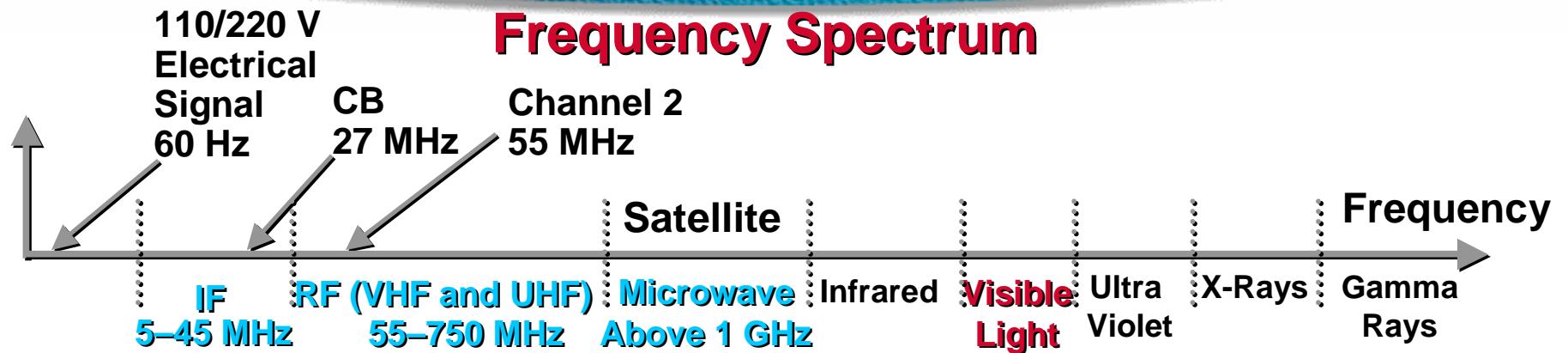
## Cable Plant



# Cable Plant Components

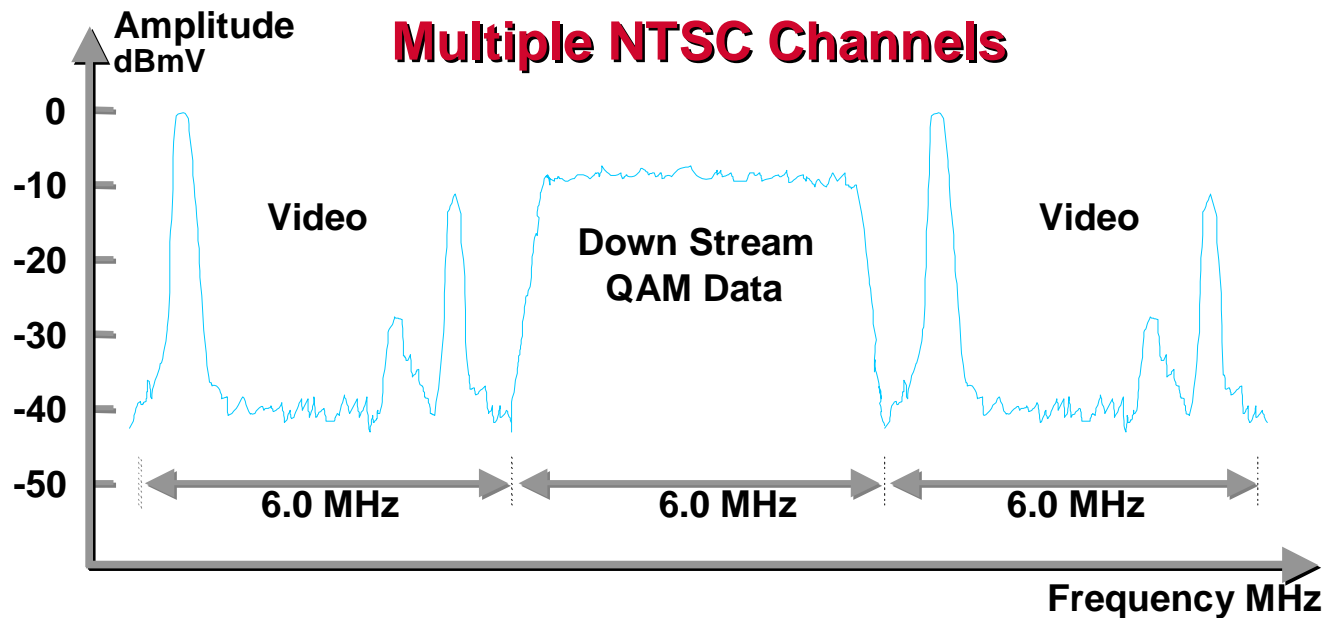


# RF Spectrum



- **Radio Freq (RF)**  
Above audio to infrared
- **Down Stream (DS)**  
Cable company to subscriber  
55–750 MHz
- **Up Stream (US)**  
Subscriber to cable company  
5–42 MHz

# Composite Downstream Spectrum



- **QAM**

**Quadrature Amplitude Modulation**

# Basic RF and Multiplexing Concepts

- **Multiplexing**

  - TDM (Time Division Multiplexing)**

  - TDMA (Time Division Multiple Access)**

  - FDM (Frequency Division Multiplexing)**

- **Modulation**

  - QPSK (Quadrature Phase Shift Keying)**

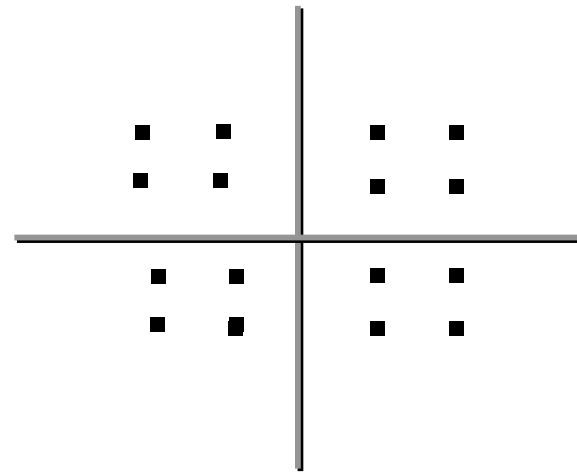
  - QAM (Quadrature Amplitude Modulation)**

- **FEC (Forward Error Correction)**

  - (Reed Solomon Coding Algorithm)**

# DOCSIS Modulation Modes

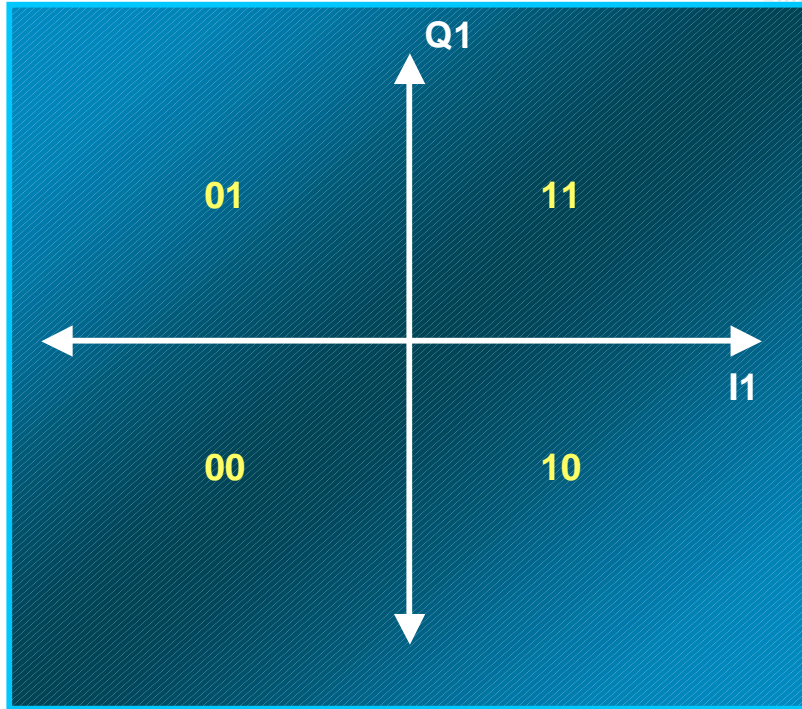
- **Downstream:**  
**64 QAM; 256 QAM**
- **Upstream:**  
**QPSK; 16 QAM**



**16 QAM Constellation**

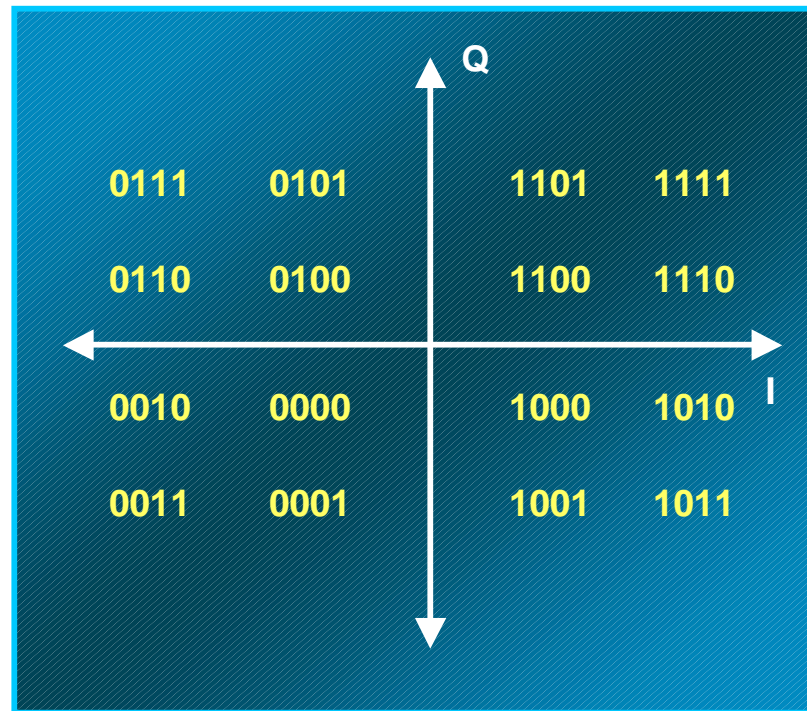


# Symbol Mapping

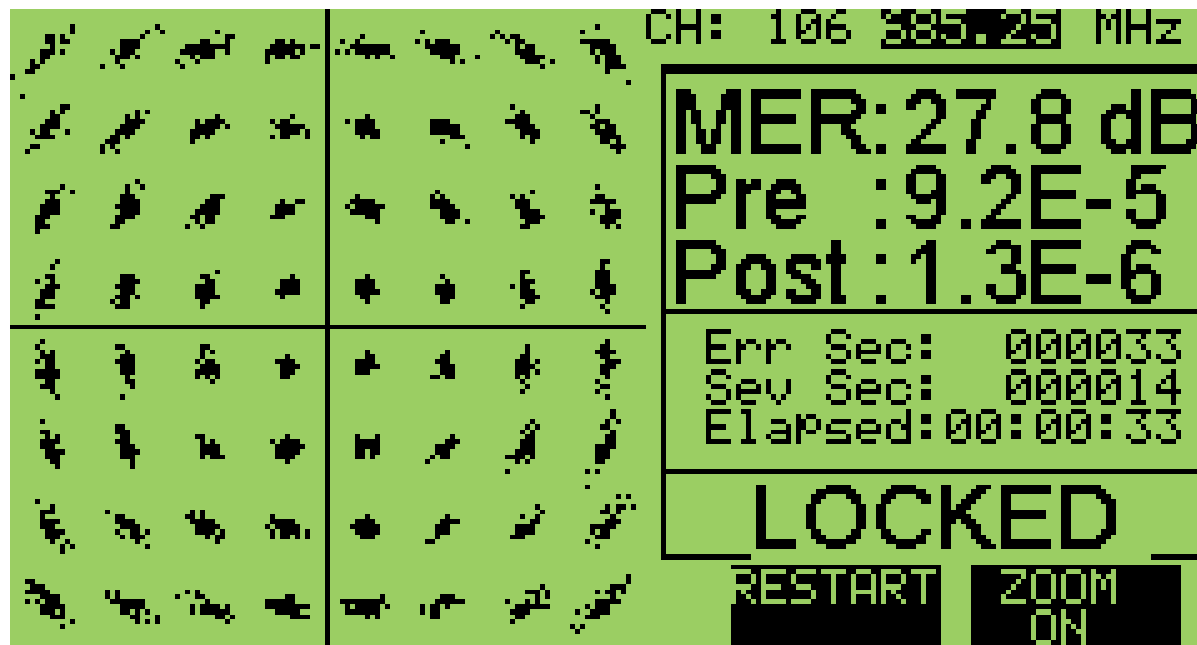


**QPSK Symbol Mapping**

**16QAM Gray-Coded  
Symbol mapping**



# Downstream Phase Noise



# Bit Error Rate

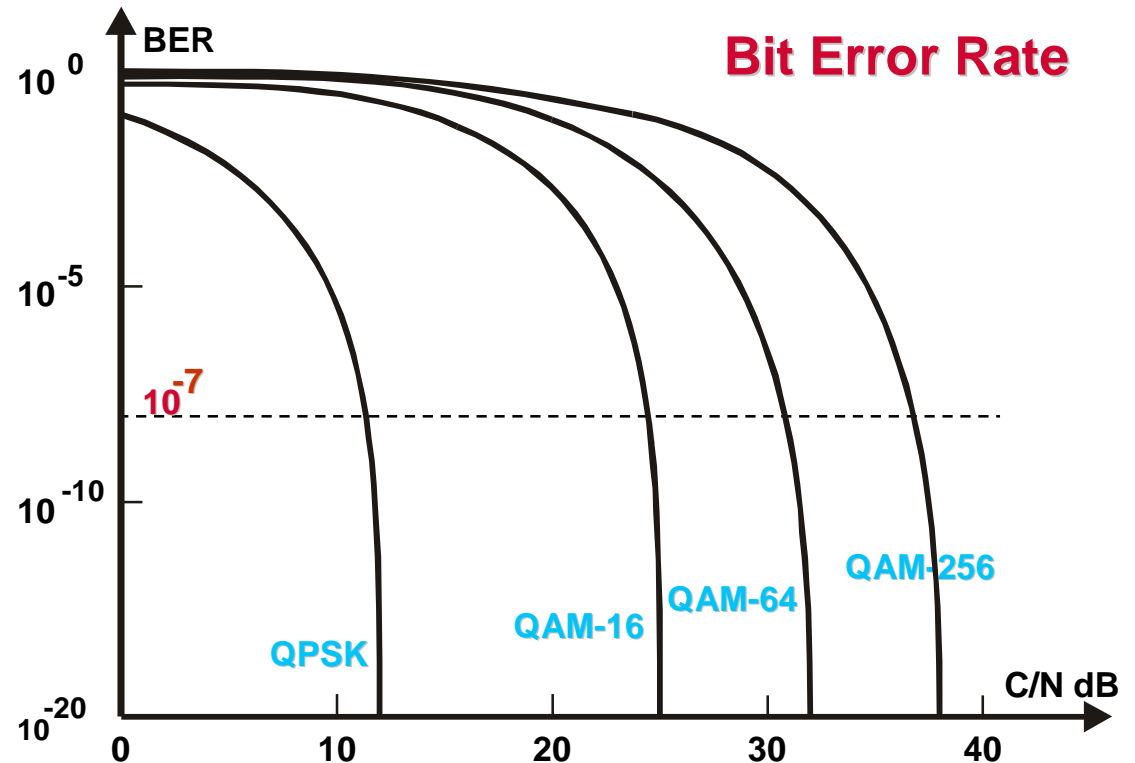
- **BER**

Erred bits  
among total  
transmitted  
payload

BER of 1 in 10  
million pay load  
bits acceptable

Main cause is  
low C/N

Sharp threshold



# Data Rates

TDMA Carrier	Freq Range MHz	Channel Width MHz	Baud Rate MSps	Raw Bit Rate Mbps	Payload Rate Mbps
QAM-256 8 b/Sym	54-860	6	5.3605	42.88	38
	54-860	8	7.15	57.2	51
QAM-64 6 b/Sym	54-860	6	5.057	30.34	27
	54-860	8	6.74	40.44	36
QAM-16 4 b/Sym	5-42	1.6	1.28	5.12	4.6
	5-42	3.2	2.56	10.24	9
QPSK 2 b/Sym	5-42	1.6	1.28	2.56	2.3
	5-42	3.2	2.56	5.12	4.6

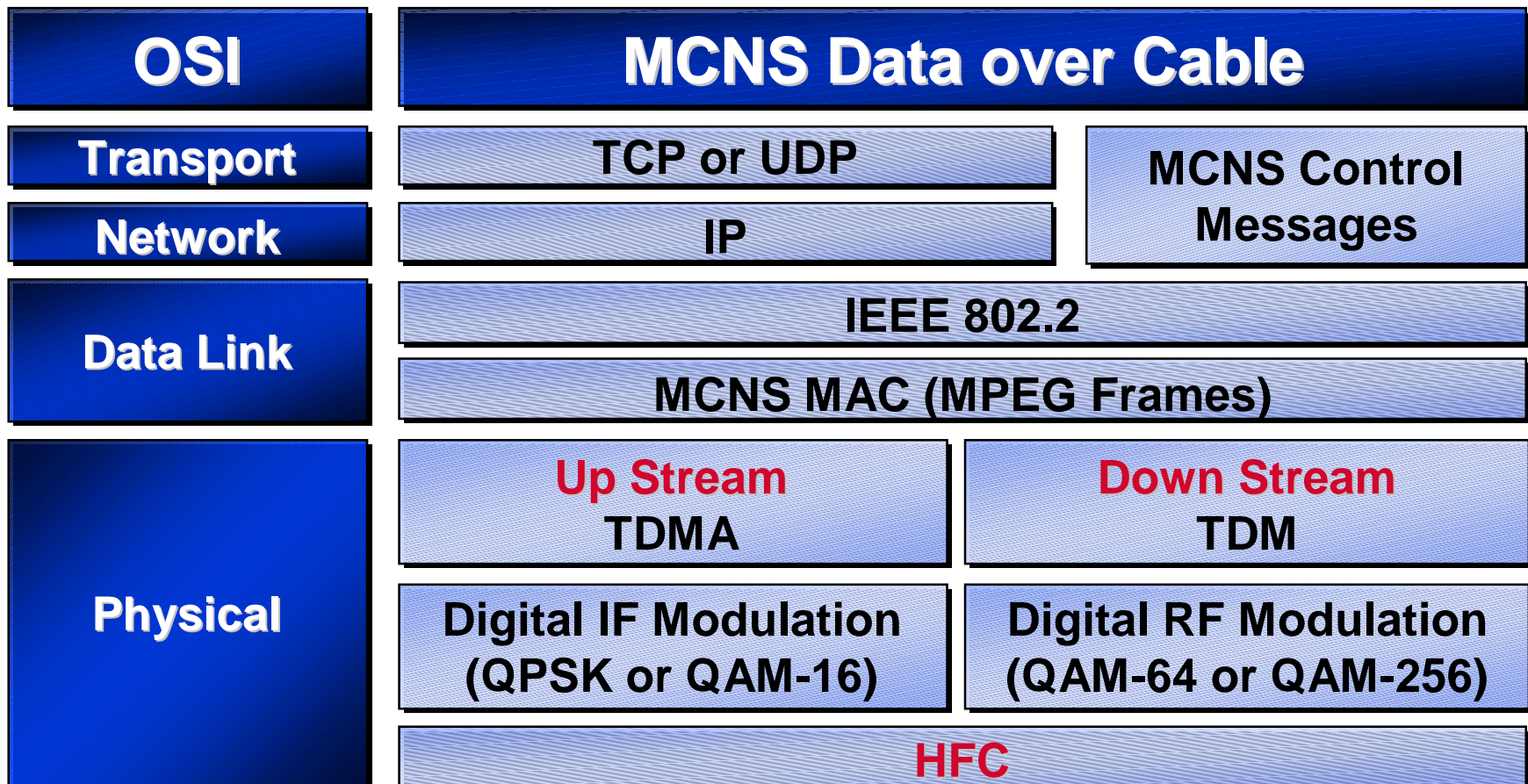


# DOCSIS

## Cable Modem Provisioning

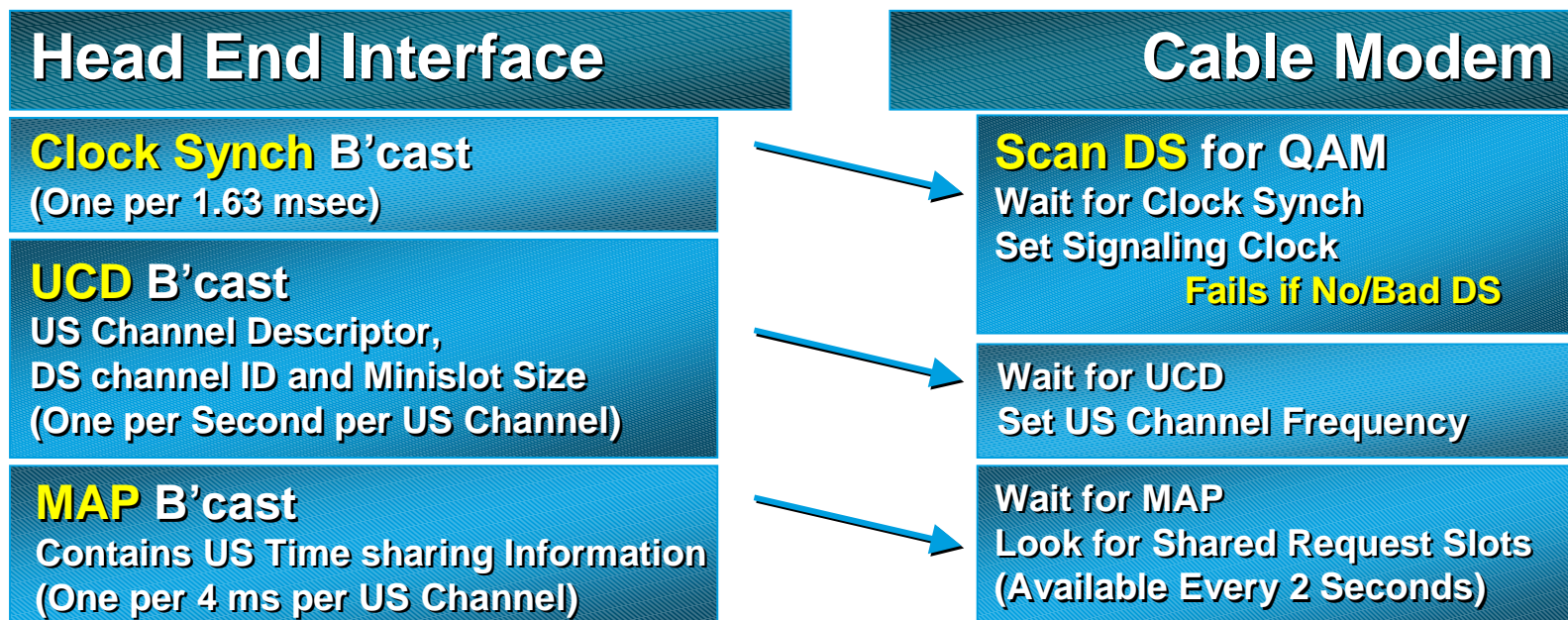


# Protocols



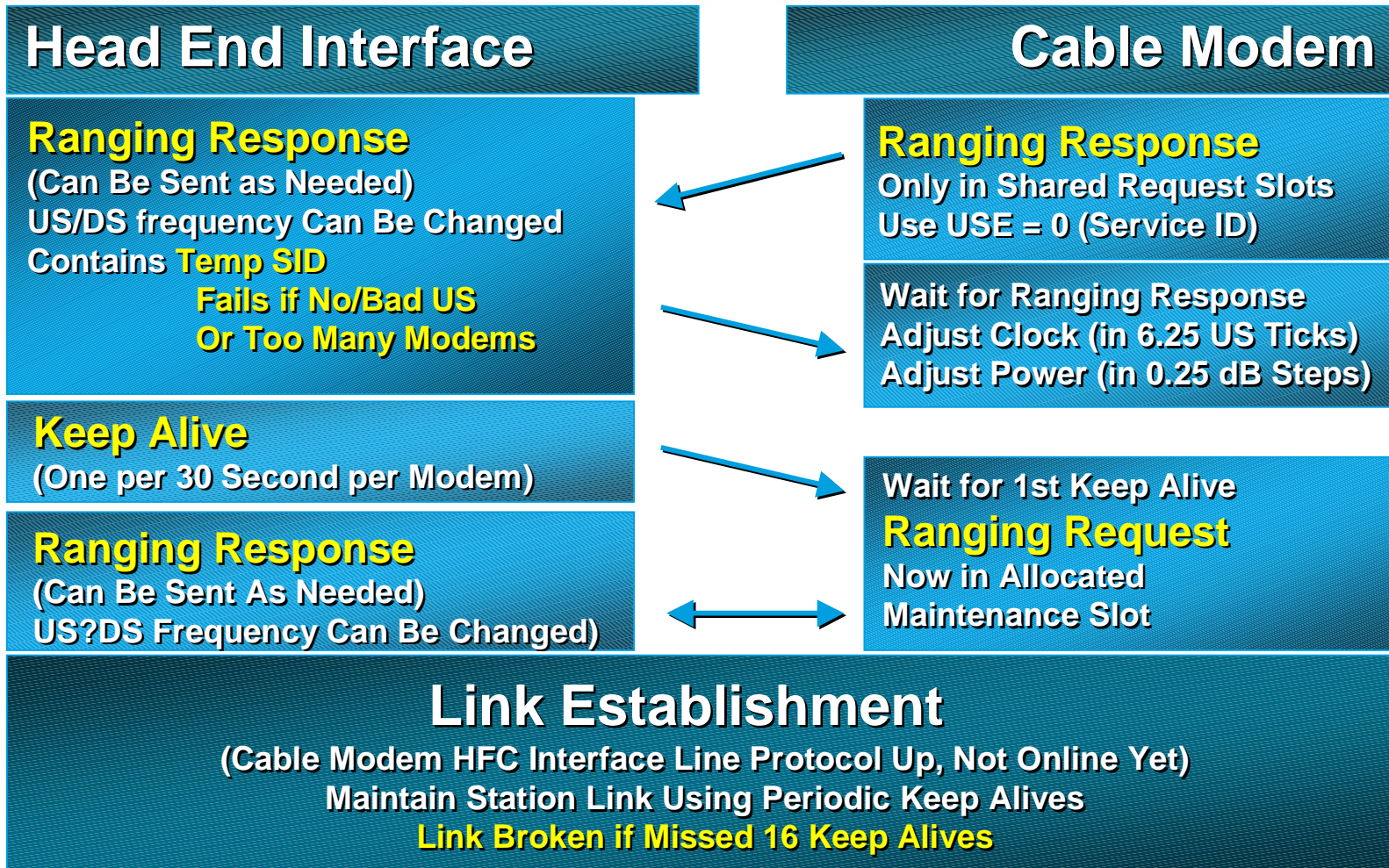
# DOCSIS CM Self Provisioning Process

(Downstream Scan)



# DOCSIS CM Self Provisioning Process

(Power Ranging)





# DOCSIS CM Self Provisioning Process

(IP / TOD Registration)

## Head End Interface

### Map B'Cast

Contains US Time Sharing Info  
(One per Four ms per US Channel)

### DHCP Response

Contains **ID Addr**, Default GW, ToD Server, TFTP Server Addr and TFTP Boot Config File Name  
From a DHCP Server

### ToD Response

Contains Time of Day  
**RFC 868**, not NTP  
From a ToD Server

## Cable Modem

### Bandwidth Request

Only in Shared Request Slots  
Use **Temp SID** (Service ID)  
(Needed for Every Use of US)

### DHCP Request

Now in Allocated Slots

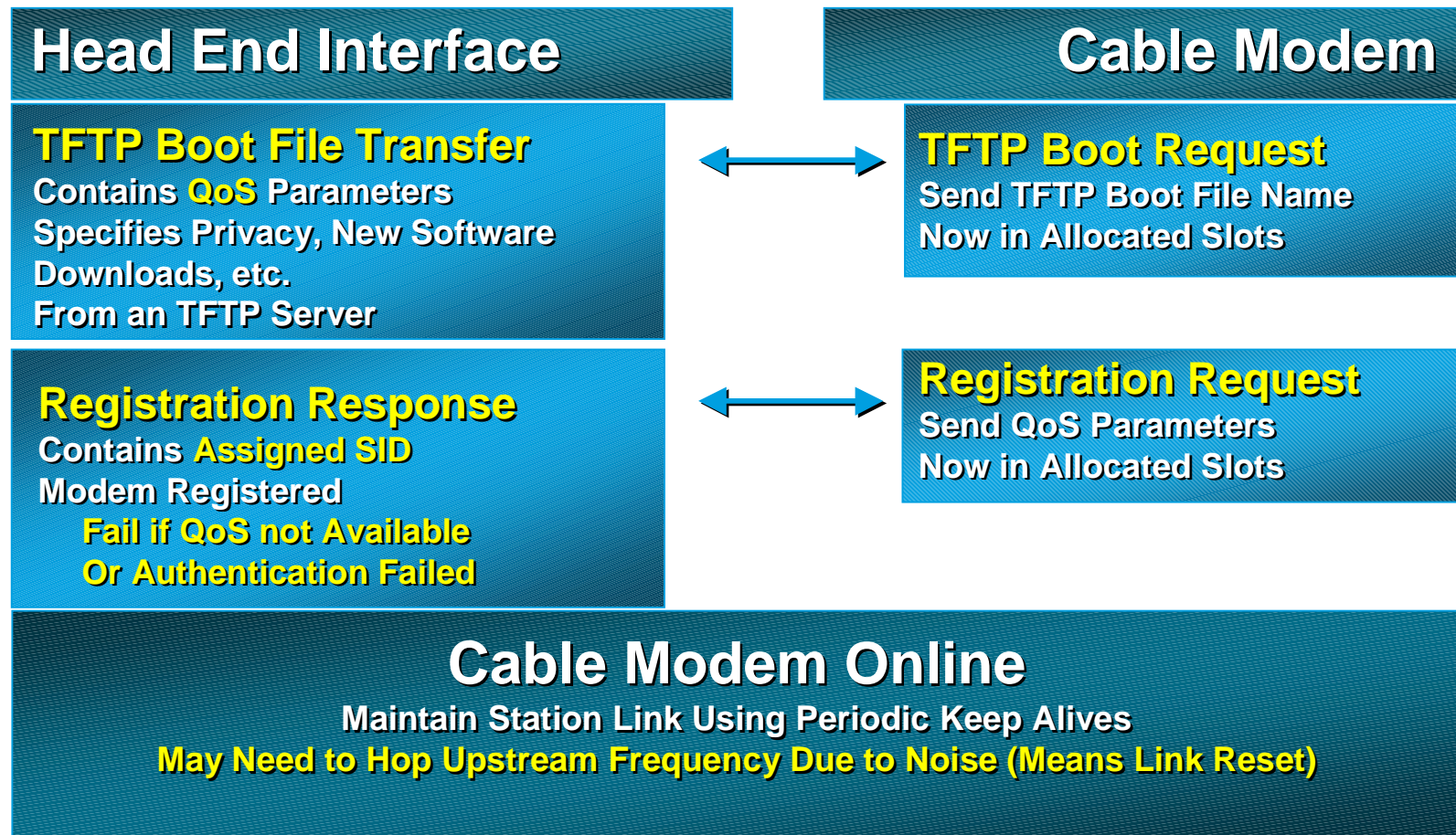
### ToD Request

Now in Allocated Slots



# DOCSIS CM Self Provisioning Process

(Authentication / QoS Configuration)



# DOCSIS CM Self Provisioning Process

(Baseline Privacy)

## Head End Interface

Generate Private KEK  
**Key Encryption Key**  
Encrypt KEK by Public Key

Generate Private TEK  
**Traffic Encryption Key**  
Encrypt TEK by KEK

## Cable Modem

Send **Public Key**  
Request KEK

Decrypt KEK Using Public Key  
**KEK Life** Is Seven Days  
(Configurable One to 70 Days)  
Request TEK

Decrypt TEK Using KEK  
**TEK Life** Is 12 Hours  
(Configurable 30 Min. to  
Seven Days)

## Encrypted Data Flow Enabled

Only Data inside IEEE 802.2 Frame is Encrypted Using TEK  
40/56 Bit DES Encryption Supported  
Must re-establish Keys within configured Grace Period before Life Expiry

# Show Cable Modem States

**offline**—modem considered offline

**init(r1)**—modem sent initial ranging

**init(r2)**—modem is ranging

**init(rc)**—ranging complete

**init(d)**—dhcp request received

**init(i)**—dhcp reply received; IP address assigned

**init(t)**—TOD request received.

**init(o)**—TFTP request was received.

**Online**—modem registered, enabled for data

**online(d)**—modem registered, but network access is disabled

**online(pk)**—modem registered, BPI enabled and KEK assigned

**online(pt)**—modem registered, BPI enabled and TEK assigned

**reject(m)**—registration refused due to bad MIC

**reject(c)**—registration refused due to bad COS

**reject(pk)**—KEK modem key assignment rejected

**reject(pt)**—TEK modem key assignment rejected



# DOCSIS

## DOCSIS 1.1 Key Features



# DOCSIS 1.0 QoS Limitations

- **Per CM QoS**
- **Based on SID and QoS Profile**
- **No means to distinguish different types of CM traffic**
- **All CM traffic is treated equal**
- **Unsuitable for simultaneous Data/Voice/Video traffic**

# DOCSIS 1.1 Key Features

- **Flow based QoS for multiple simultaneous traffic streams to a CM**
- **Advanced upstream scheduling services for different traffic types**
- **Flexible signaling model for “on-demand” QoS**
- **Improved provisioning and authorization**
- **Features for improved bandwidth utilization**
- **Extra “security” features (BPI+)**

# Key Features Overview

- **Best Effort**
- **CIR**
  - data with rate guarantees
- **Real Time Polling (RTPS)**
  - periodic contention free request slots
- **Unsolicited Grants (UGS)**
  - CBR like - fixed size slots at fixed interval
- **Unsolicited Grants with Activity Detection (UGS-AD)**
  - combination of UGS and RTPS
- **Non Real Time Polling (nRTPS)**



# Key Features continued

- **QoS can be setup on-demand using Dynamic Service MAC Messages**
  - DSA (Dynamic Service Add)**
    - Add a new service flow**
  - DSC (Dynamic Service Change)**
    - Modify existing service flow parameters**
  - DSD (Dynamic Service Delete)**
    - Delete a service flow**
- **Geared towards VoIP style applications**

# Key Features continued

- **Fragmentation**

- Allows grants to be fragmented to improve scheduling efficiency**

- Improves MAC latency characteristics**

- **Payload Header Suppression**

- Allows for suppression of constant header fields and transmission of variable payloads**

- Especially useful in VoIP type applications where header size is comparable to payload size**

# Other Sources of Information

- **QoS in Cable Data Networks**  
[http://www.cisco.com/warp/public/cc/pd/rt/ub7200/ub7246/tech/ca/qos\\_wp.htm](http://www.cisco.com/warp/public/cc/pd/rt/ub7200/ub7246/tech/ca/qos_wp.htm)
- **IP Quality of Service**  
<http://www.ciscopress.com/book.cfm?series=1&book=173>
- **Configuring Head-End Broadband Access Router Features**  
[http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/multi\\_c/mcprt3/mcdhubr.htm](http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/multi_c/mcprt3/mcdhubr.htm)
- **Data Over Cable Services Interface Specification**  
<http://www.cablelabs.com>
- **Configuring Voice over IP (VoIP)**  
[http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/multi\\_c/mcprt1/mcdvoip.htm](http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/multi_c/mcprt1/mcdvoip.htm)

# DOCSIS Summary

- **You need a CMTS, DHCP, TFTP, TOD, and CM along with the cable plant to make a DOCSIS system**
- **DOCSIS is a standard based system that provides data over cable**

# CISCO SYSTEMS



EMPOWERING THE  
INTERNET GENERATION<sup>SM</sup>