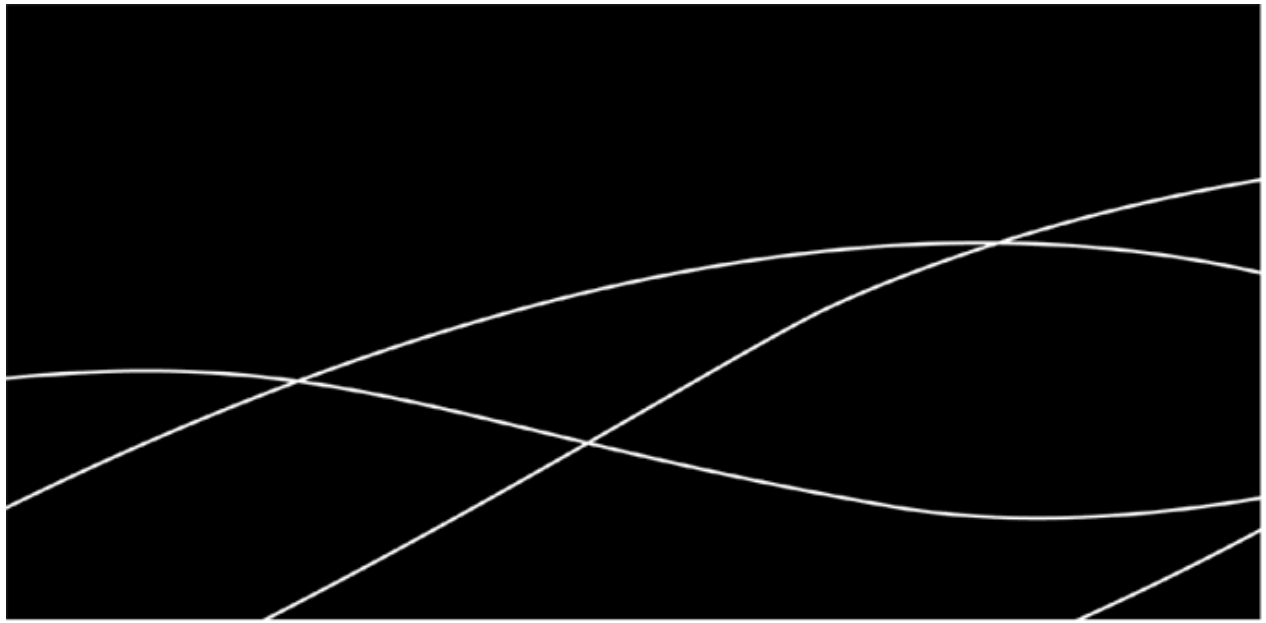
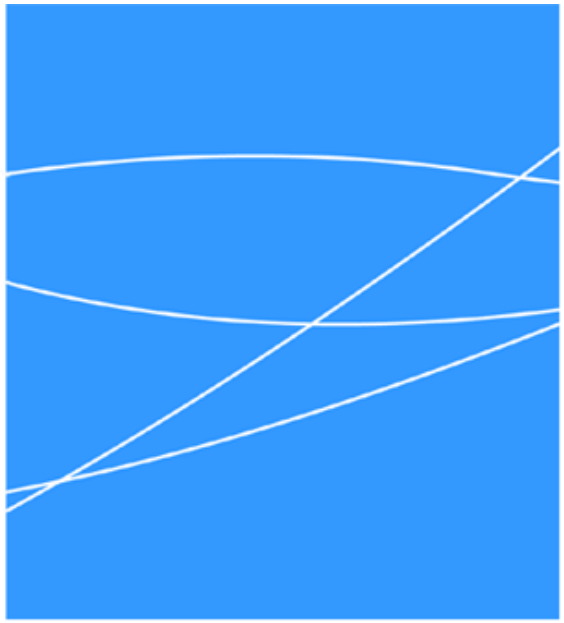
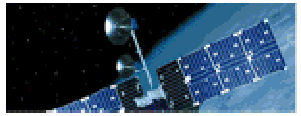




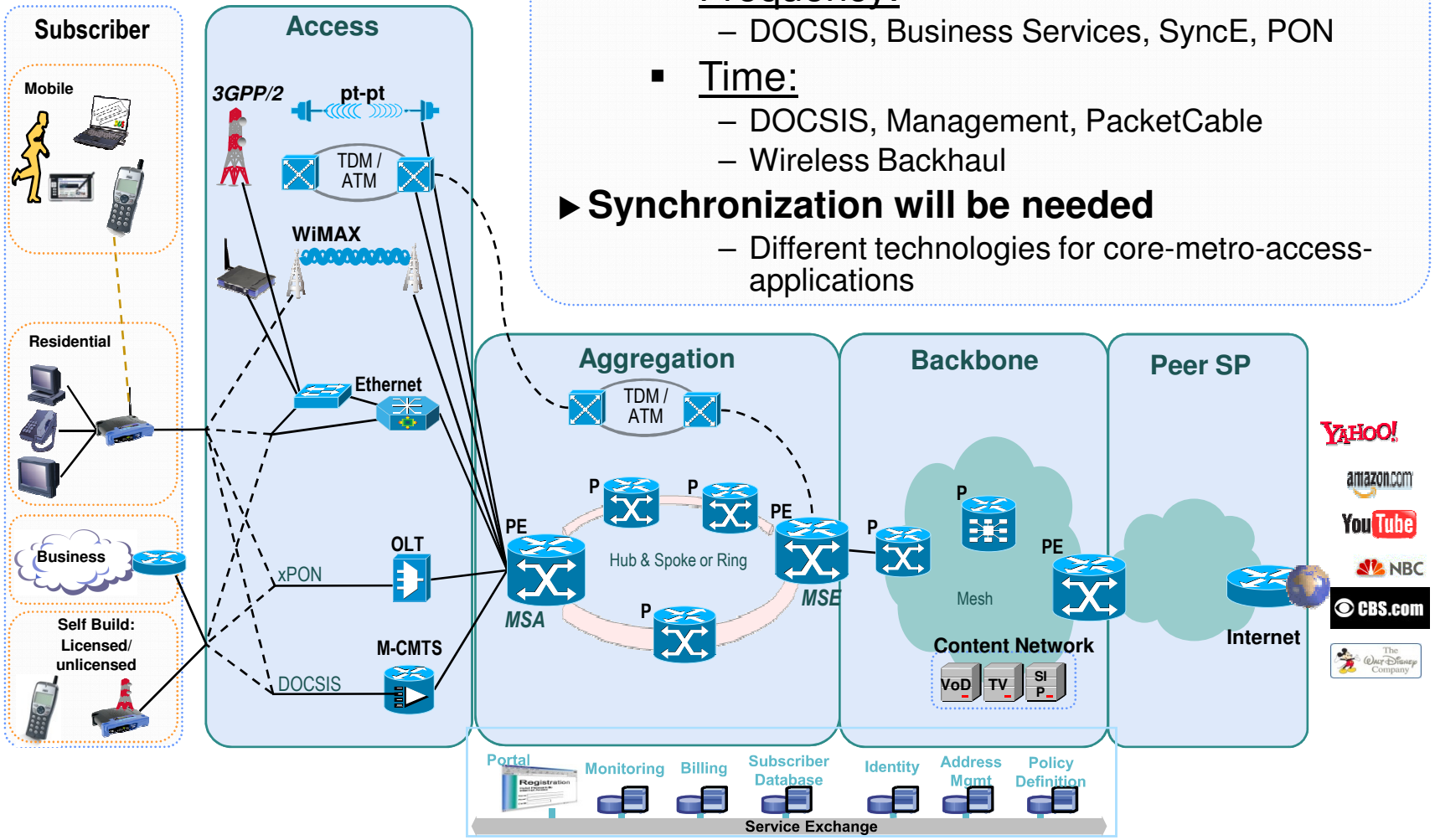


Cable Synchronization

Symmetricom®

Synchronization in Cable

- **Mix of applications and synchronization needs**
  - Frequency:
    - DOCSIS, Business Services, SyncE, PON
  - Time:
    - DOCSIS, Management, PacketCable
    - Wireless Backhaul
- **Synchronization will be needed**
  - Different technologies for core-metro-access-applications

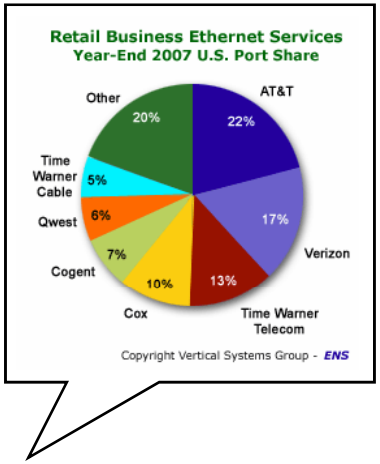


Cable Timing Requirements

Application	Service Requirement	Timing	Elements Requiring Timing	Business Implication
Modular CMTS	Modular system for DOCSIS.	DTI	Edge QAM, M-CMTS Core	Required for basic operation
DOCSIS 3.0	Wideband bonding, Security, IPv6, etc.	DTI	M-CMTS	Operation and reliable bonding
DOCSIS 1.0,1.1,2.0,3.0	Broadband Services	NTP	Cable Modems	User authentication and management
Circuit Emulation / Business Services / Cellular Backhaul	T1 or E1 services for business PBX/data traffic or cellular base station backhaul	1588, DTI	CMTS, CM, Gateway	Essential for Delivering Circuit Emulation
Network Monitoring & Performance Measurement	New Monitoring Requirements for Packet Based Networks	NTP & DTI	NEs, Network Probes, Test & Measurement Equipment	Network Uptime, Alarms, Diagnostics
SONET/SyncE	Interconnecting headends and hubs	BITS, J.211 (DTI)	All Network Equipment	Required for basic reliable operation
Packet Cable	Residential and SOHO Voice Services	NTP	MTA & Switches	Management, CallerID, call traceability, E911, etc.
Video	Broadcast, SDV, ad-insertion	NTP	Headend Video Equipment	Reliable video delivery
OCAP	Management	NTP	All Network Elements	Required for basic reliable operation

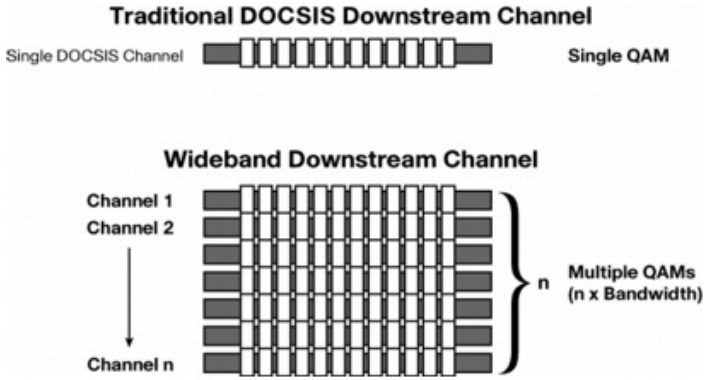
Time for Change

- Need for more bandwidth!
  - Applications & Competition's Fiber Services generating new demand
  - Existing DOCSIS 1.x & 2.x is limited to 40-50MB per channel
- Limited multicast ability (inefficient IPTV, VOD & Internet)
- DOCSIS 1.1 security not enough
- Running out of IP addresses in IPv4
- DOCSIS & EuroDOCSIS need to converge
- Need technology to address Businesses/Enterprise Customers
- Need cost efficient way to deploy DOCSIS 3.0
- Need a converged architecture for video and DOCSIS
- Reclaim un-used Upstream ports



DOCSIS 3.0 Solution

- Bandwidth!
  - DOCSIS 3.0 enables channel bonding (160MB+, 4TB possible)
  - Upstream and Downstream can be bonded
  - Competitive offering to FTTx for business or residential
- IP Multicast with QoS
- Enhanced Security
- Enhanced management & performance monitoring
- IPv6
- North American & European Convergence (upstream frequency now the same)
- Business Services over DOCSIS (T1/E1 CES & L2VPN)

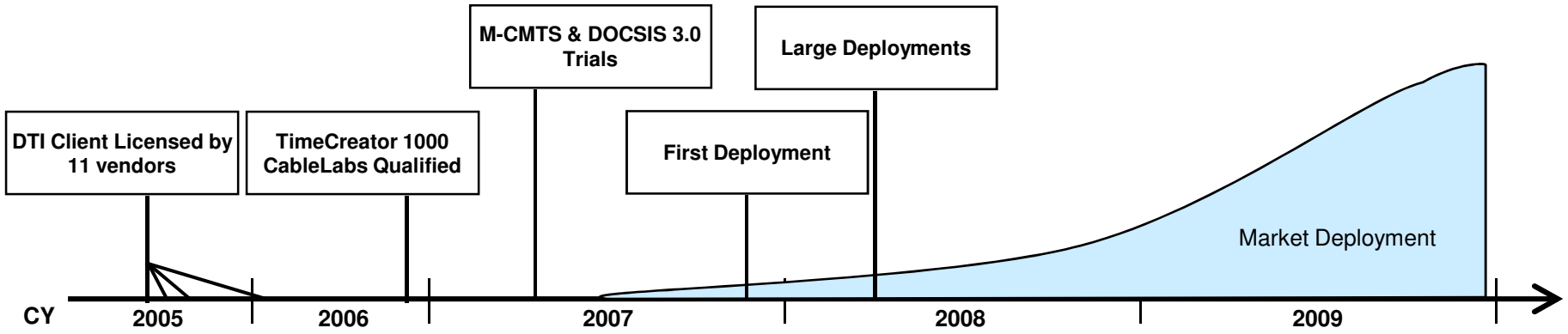


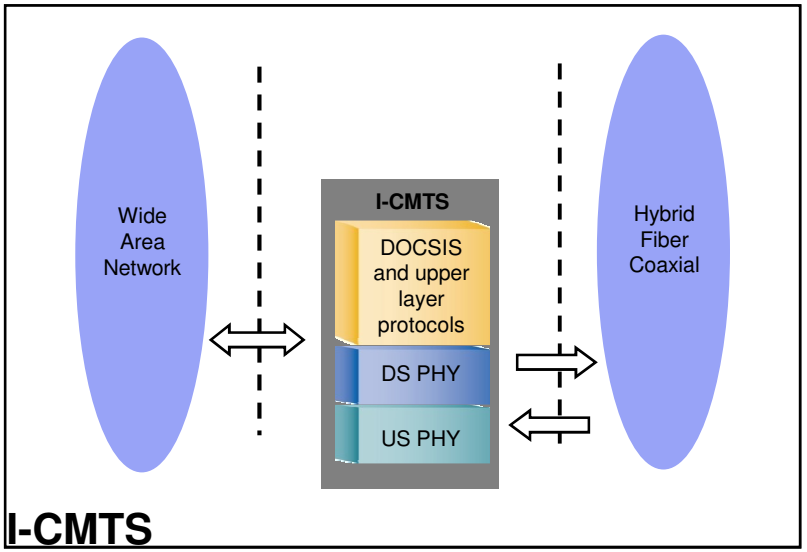
M-CMTS Solution

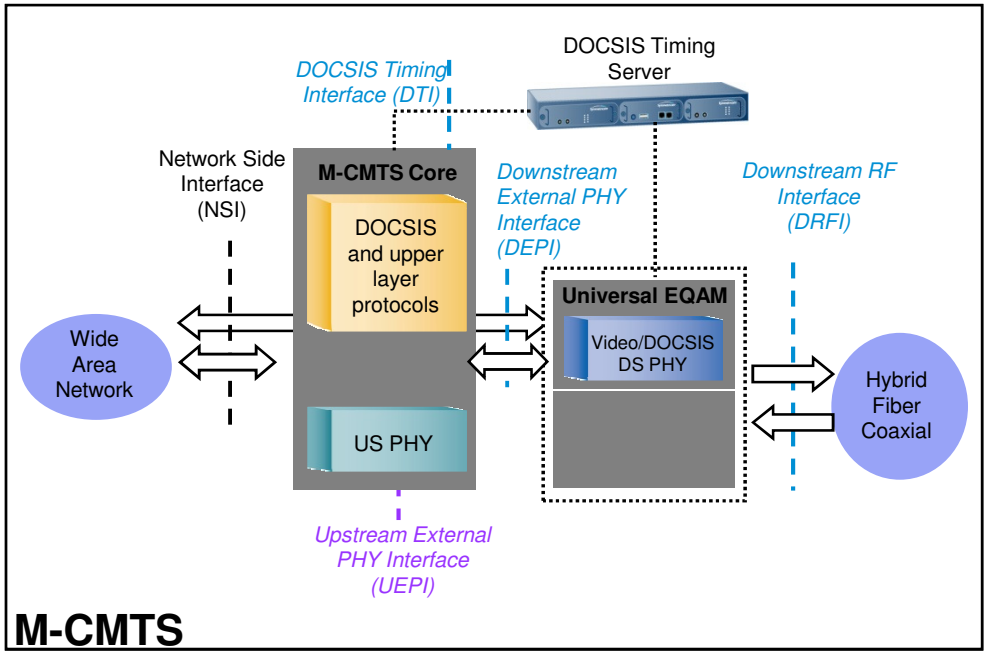
Symmetricom

- Lower cost downstream for Quad Play
  - Converge all downstream traffic on a single “Converged EdgeQAM”
  - Leverage low cost, high capacity EdgeQAM from video
  - Lower cost of delivery for high data rates (DOCSIS 3.0)
- Scale routing, upstream & downstream independently
  - Flexible Bandwidth for Quad Play
  - Balance load across multiple channels
  - Flexible assignment of downstream & upstream channels
- Interoperability / Standardization
- Protect investment for future IP services
- Can be used for DOCSIS 1.1/2.0
  - Use the un-used upstream ports

M-CMTS & DOCSIS 3.0



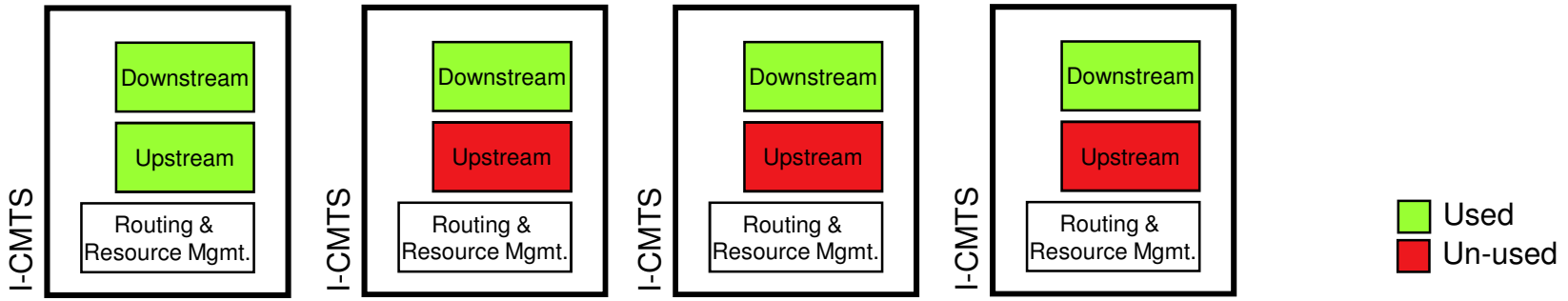




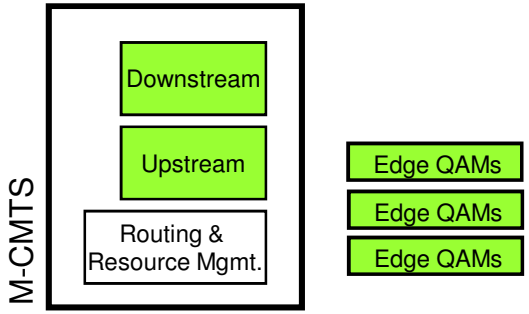
Symmetricom Prime Author of DTI Spec.
ABI Forecast 60% DOCSIS 3.0 by 2011
DTI ratified as ITU J.211

Why M-CMTS?

- Economical Downstream Expansion
  - I-CMTS requires a fixed US:DS ratio…Upstream is often unused
  - M-CMTS separates DS from US…. all capacity can be used
  - M-CMTS leverages EdgeQAM DS economics from video
  - M-CMTS EdgeQAM can be used for DOCSIS & Video… flexible devices & spectrum
  - I-CMTS locks you into a single vendor for growth
- Integrated-CMTS = Idle (wasted upstream ports)



- M-CMTS = Full utilization of install base (economical D1.0, 2.0 & 3.0)

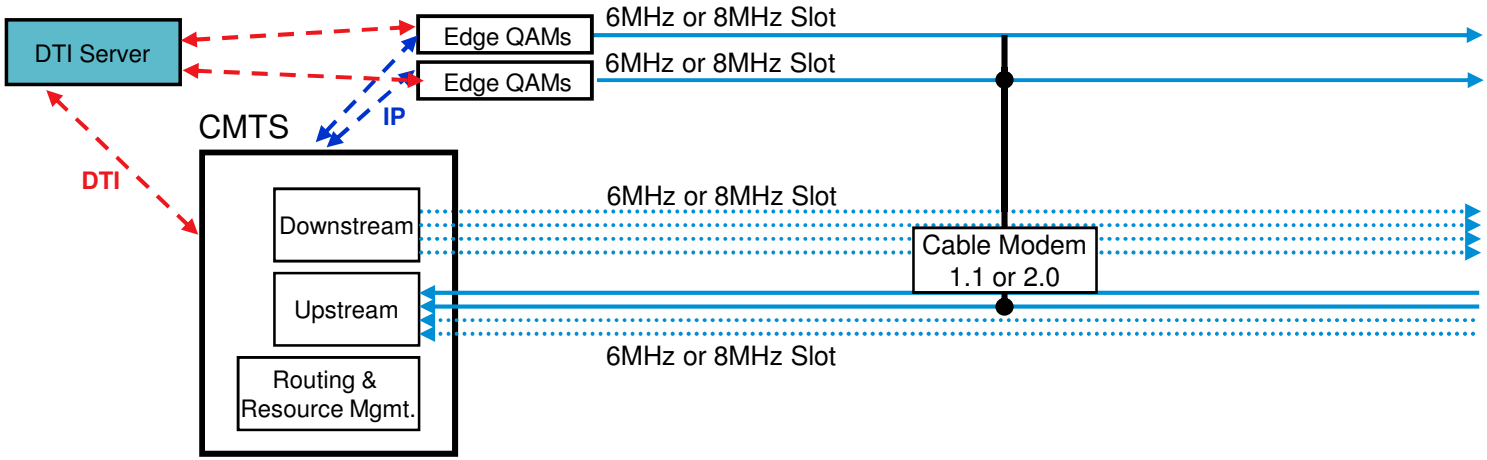


Why M-CMTS?

- M-CMTS for DOCSIS 1.1 & 2.0
  - M-CMTS can be enabled for DOCSIS 1.1 or 2.0 to ~double the subs on a CMTS
  - DOCSIS 3.0 is not the only driver for M-CMTS
  - Existing CMTS have un-used Upstream ports

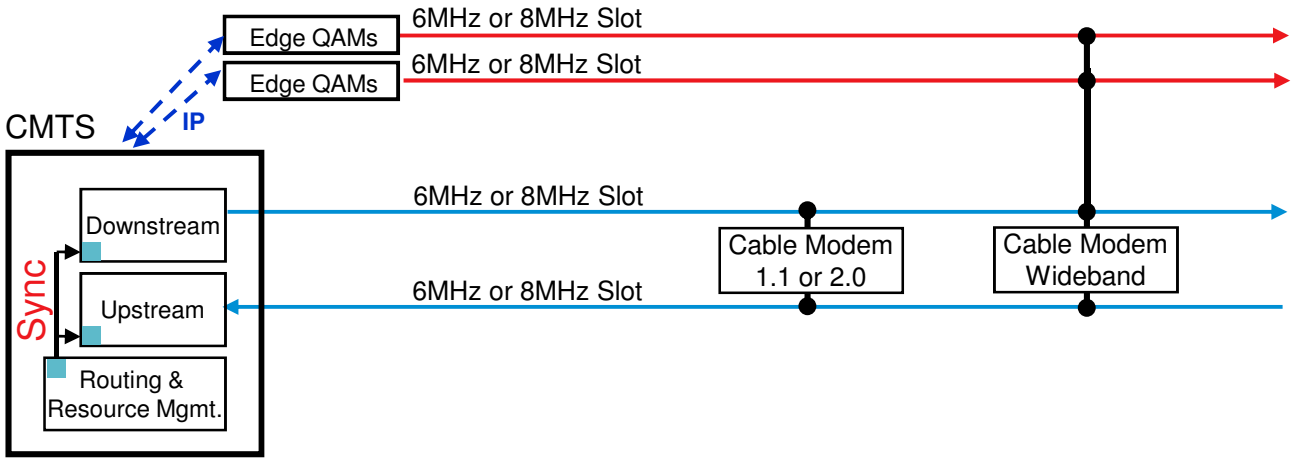
  - **Solution**
    - Add 1-2 EQAMs per CMTS
    - Add SPA & TCC to CMTS
    - Add DTI Server for every 6 devices

    - Less expensive than overlay or new CMTS
    - By the way, you get D3.0 is you want it



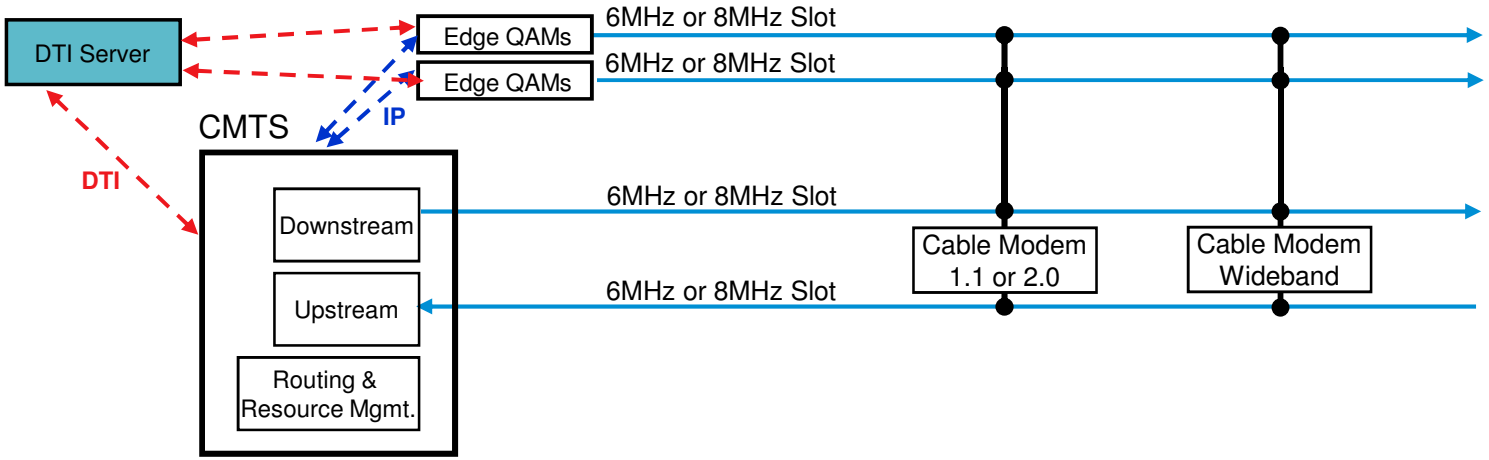
Why M-CMTS?

- Prior Implementations
  - Limited compatibility with existing DOCSIS 1.1 & 2.0
  - Required dedicated 6MHz or 8MHz slots for D3.0
    - Wideband slots carry only bonded data, are non-synchronous and do not carry control messages they can only be used by wideband cable modems
    - Do you want to dedicate slots for new modems? Or, use for all customers?



Why M-CMTS?

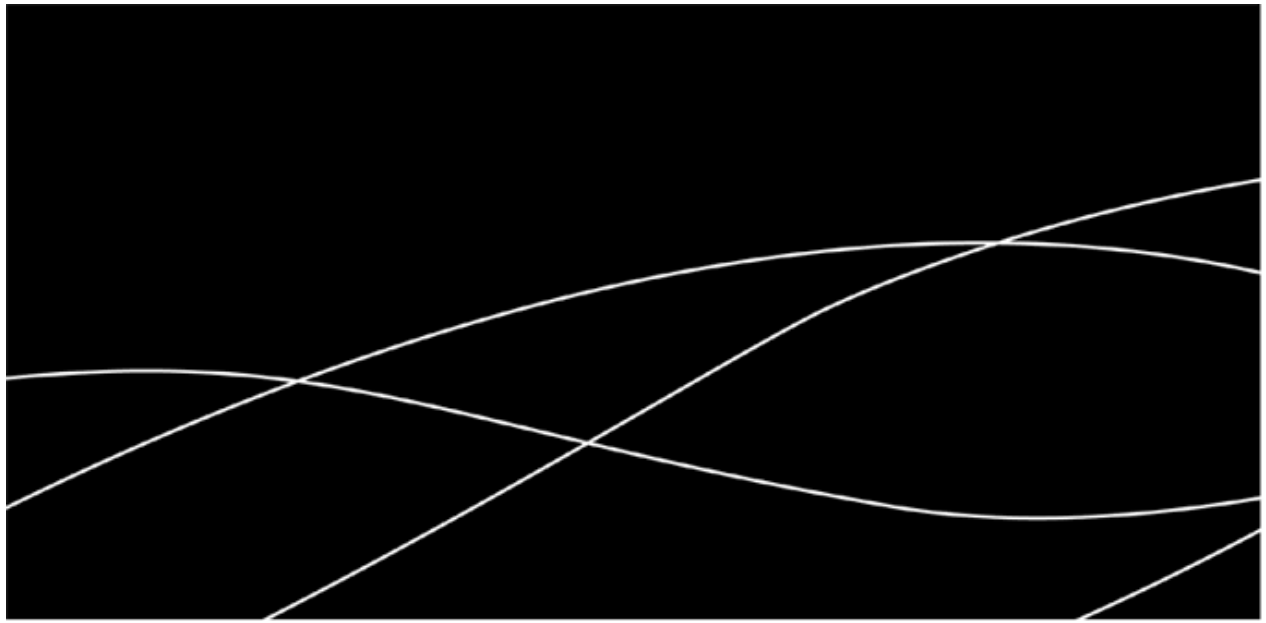
- M-CMTS for DOCSIS 1.1, 2.0, 3.0
  - Interoperable & Backward compatible
  - Dedicated or shared slots for DOCSIS 1.1, 2.0, 3.0
    - Enables 100MB+ DOCSIS 3.0 modems, but also allows existing DOCSIS 1.1 and 2.0 modems to use the new slots
    - DOCSIS 3.0 can use all the slots at the same time
    - DOCSIS 1.1 & 2.0 can use one slot at a time

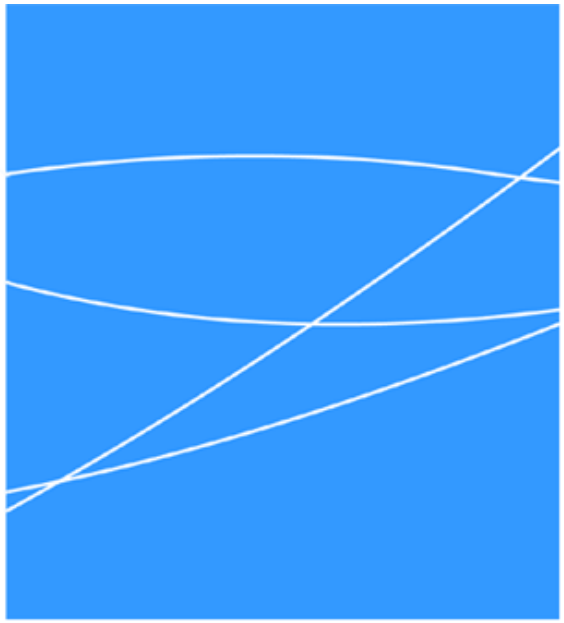


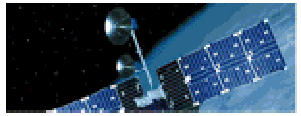
Announced M-CMTS Products

Symmetricom

M-CMTS Core		
Arris	C4	
Cisco	uBR10K	
EdgeQAM		
Arris	D5	
BigBand	BME	
Cisco & SA	Rf Gateway Series	
Harmonic	NSG 9000	
Motorola	Apex	
RGB	USM	
Tandberg	EQ8096	
Vecima	HyperQAM	





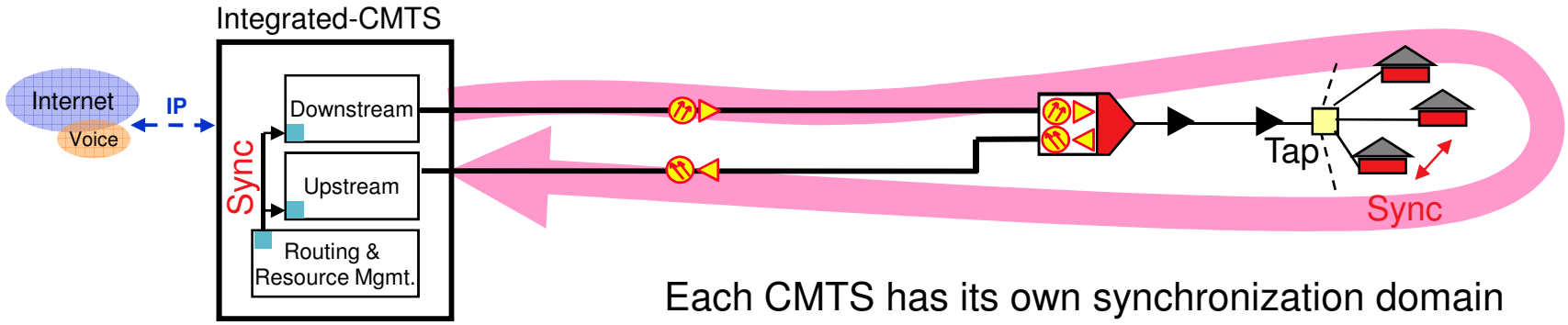


How DTI Works

DOCSIS Timing Interface

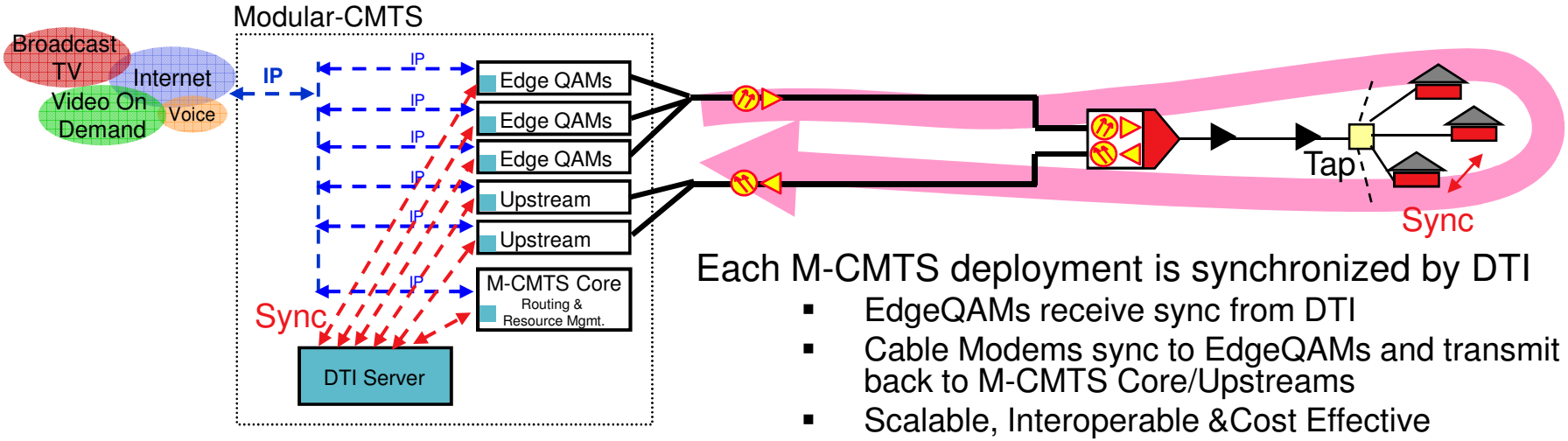
Symmetricom®

How DOCSIS Sync Works



Each CMTS has its own synchronization domain

- Limited scalability
- No interoperability
- Higher Cost



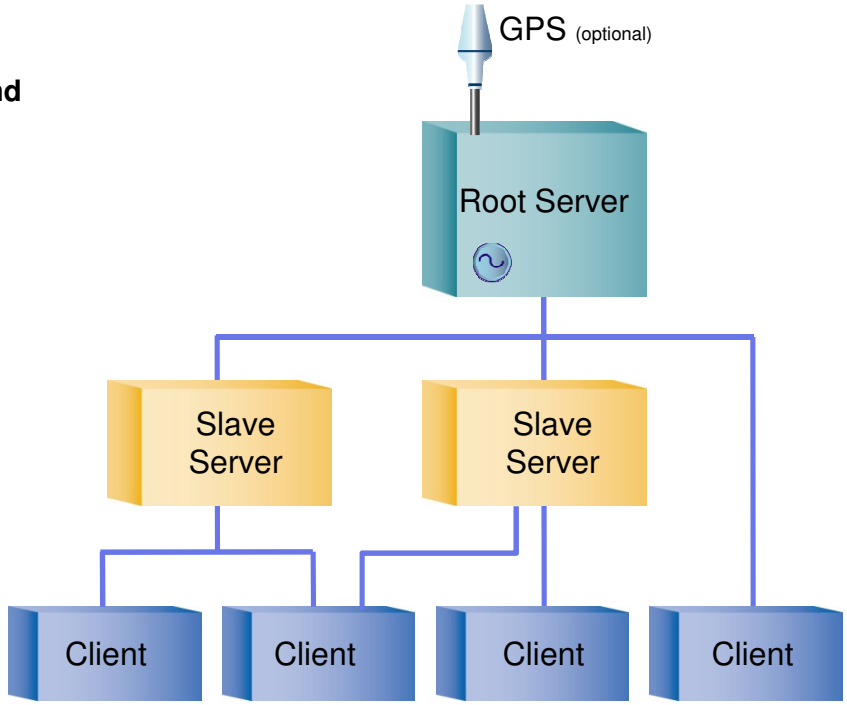
Each M-CMTS deployment is synchronized by DTI

- EdgeQAMs receive sync from DTI
- Cable Modems sync to EdgeQAMs and transmit back to M-CMTS Core/Upstreams
- Scalable, Interoperable &Cost Effective

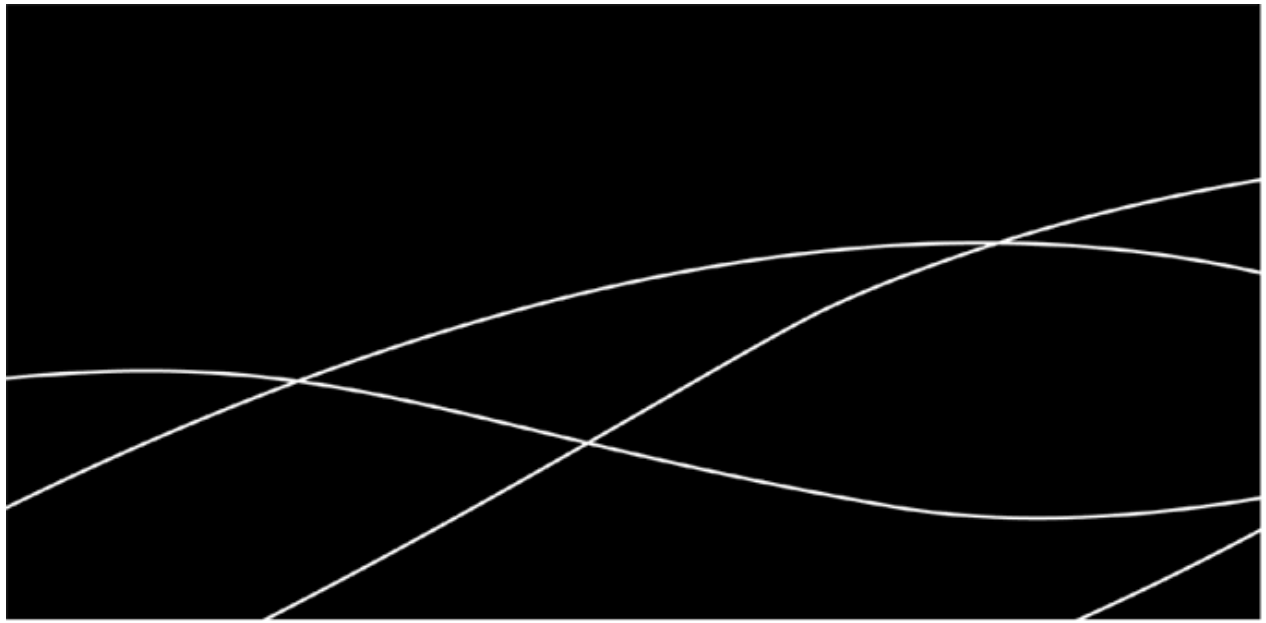
Sources: DOCSIS 2.0 CableLabs

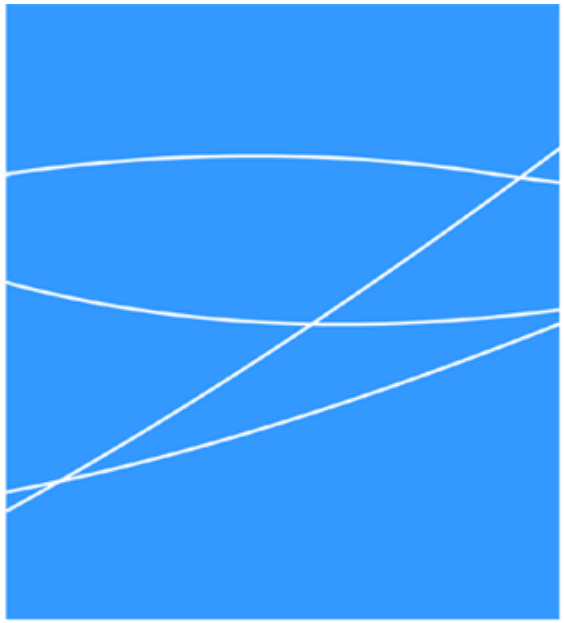
DTI Hierarchy

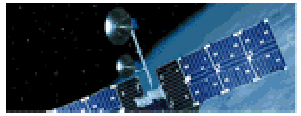
- **DOCSIS Timing Interface (DTI)**
  - **Root DTI Server**
    - Contains Master Time & Frequency
    - Must scale to support future Slave Servers
    - Must be reliable since there can only be one per Headend
  - **Slave DTI Servers**
    - Must synchronize to the Root DTI Server
    - Adds additional DTI ports to the site
  - **DTI Client**
    - Embedded in an EdgeQAM, M-CMTS Core or Upstream Receiver
    - Must synchronize to a DTI Server
    - May have 1 or 2 inputs
  - **DTI Protocol**
    - Uses Cat5 wiring (same as Ethernet)
    - Does not connect to an hub, router or switch
    - May be network traceable to 100ns & Stratum1
    - Uses automatic configuration and calibration
  - **GPS**
    - Supports Business Services (T1/E1 CES)
    - Supports future remote Packet Shelf architecture & UEPI



NOTE: You **cannot** connect a Slave Server to another Slave Server



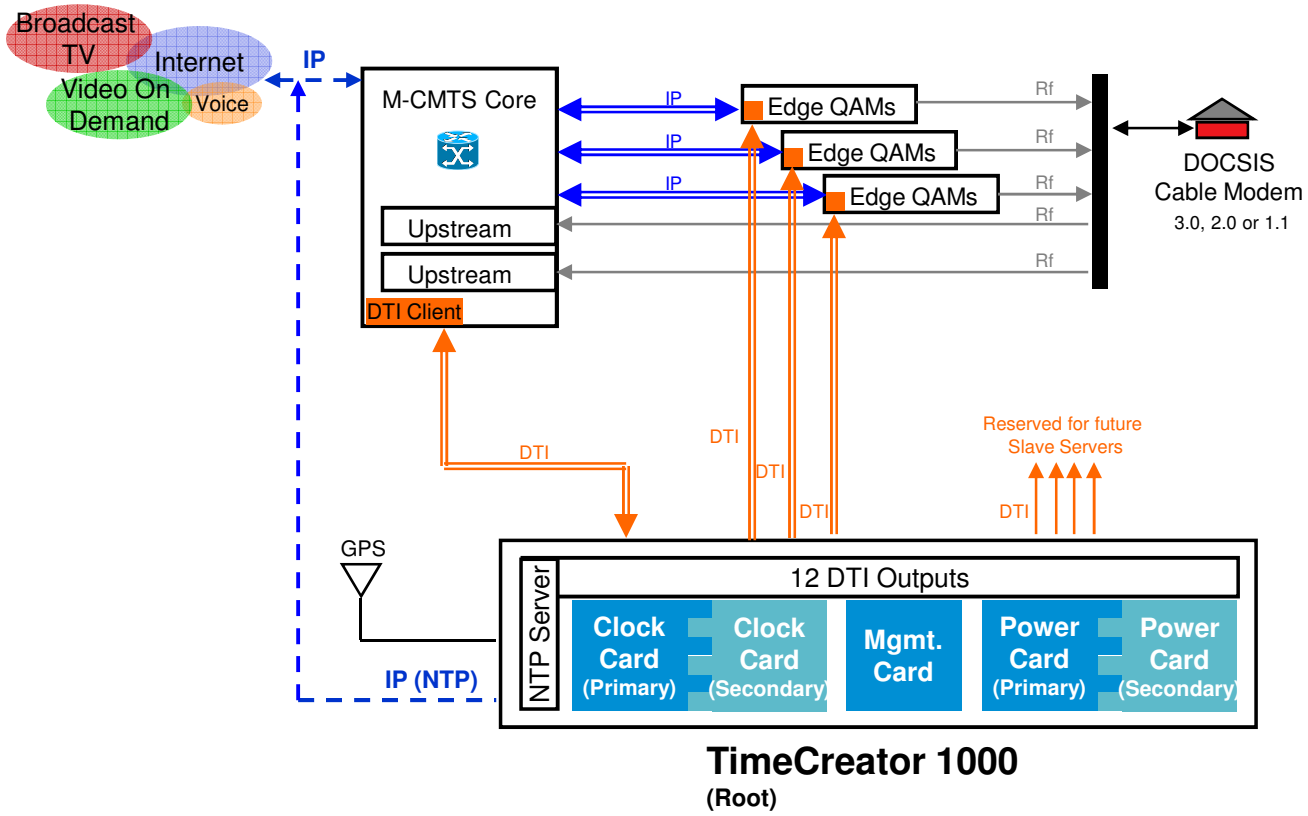




Best Practices Deployment

Symmetricom®

Deployment Scenario
Initial Deployment (Dual homed/Single Server)



TimeCreator 1000
(Root)

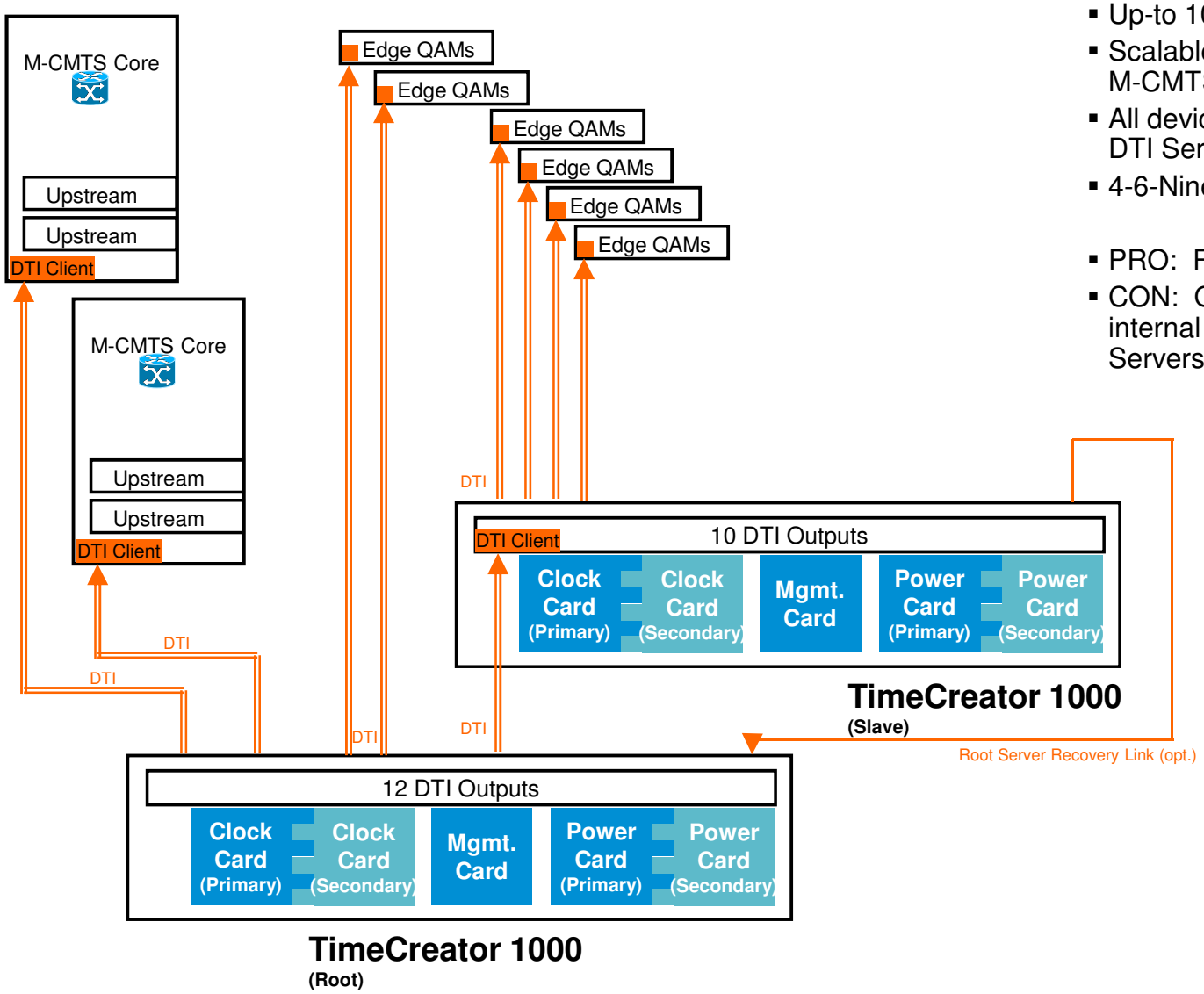
- **Initial Deployment**
  - Up-to 6 M-CMTS devices
  - All devices are dual homed to a single DTI Server
  - 4 to 6-Nine's Reliability
  - GPS should be installed if Commercial Services (T1/E1) are planned or NTP Server option is used. Adding GPS later requires network interruption
  - PRO: Reliable and simple way to start deploying M-CMTS.
  - CON: If the M-CMTS architecture grows rapidly re-wring may be needed.

Single DTI Link

Two DTI Links

Deployment Scenario

Growing Deployment (Dual homed/Multiple Servers)

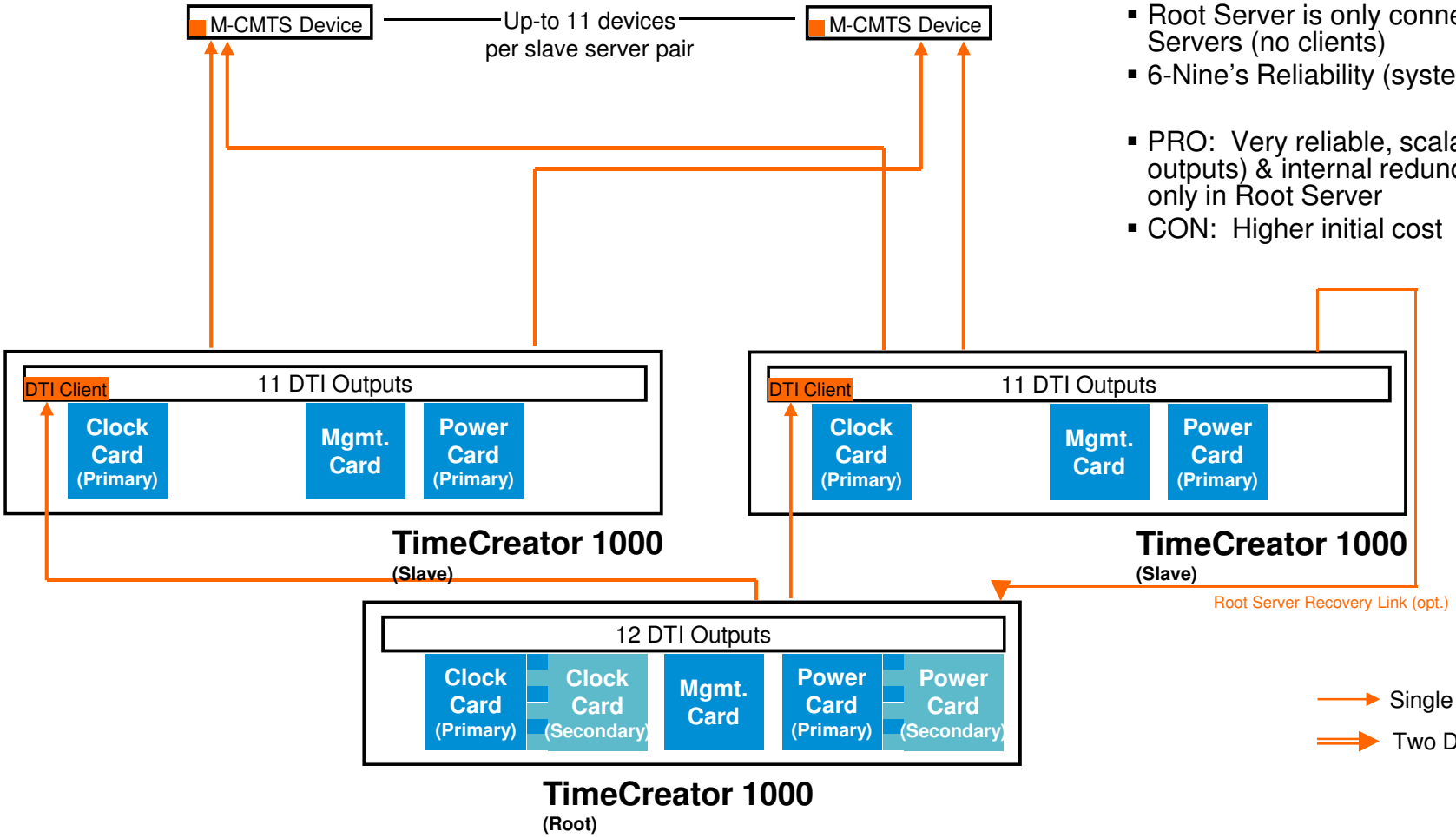


- **Growing Deployment**
  - Up-to 10 M-CMTS devices (as shown)
  - Scalable to 30 protected M-CMTS devices (60 ports)
  - All devices are dual homed to a single DTI Server
  - 4-6-Nine's Reliability
  - PRO: Requires fewer DTI Servers
  - CON: Only scales to 60 outputs & internal redundancy needed in all Servers

Deployment Scenario
Large Site (Single homed/Multiple Servers)

Symmetricom

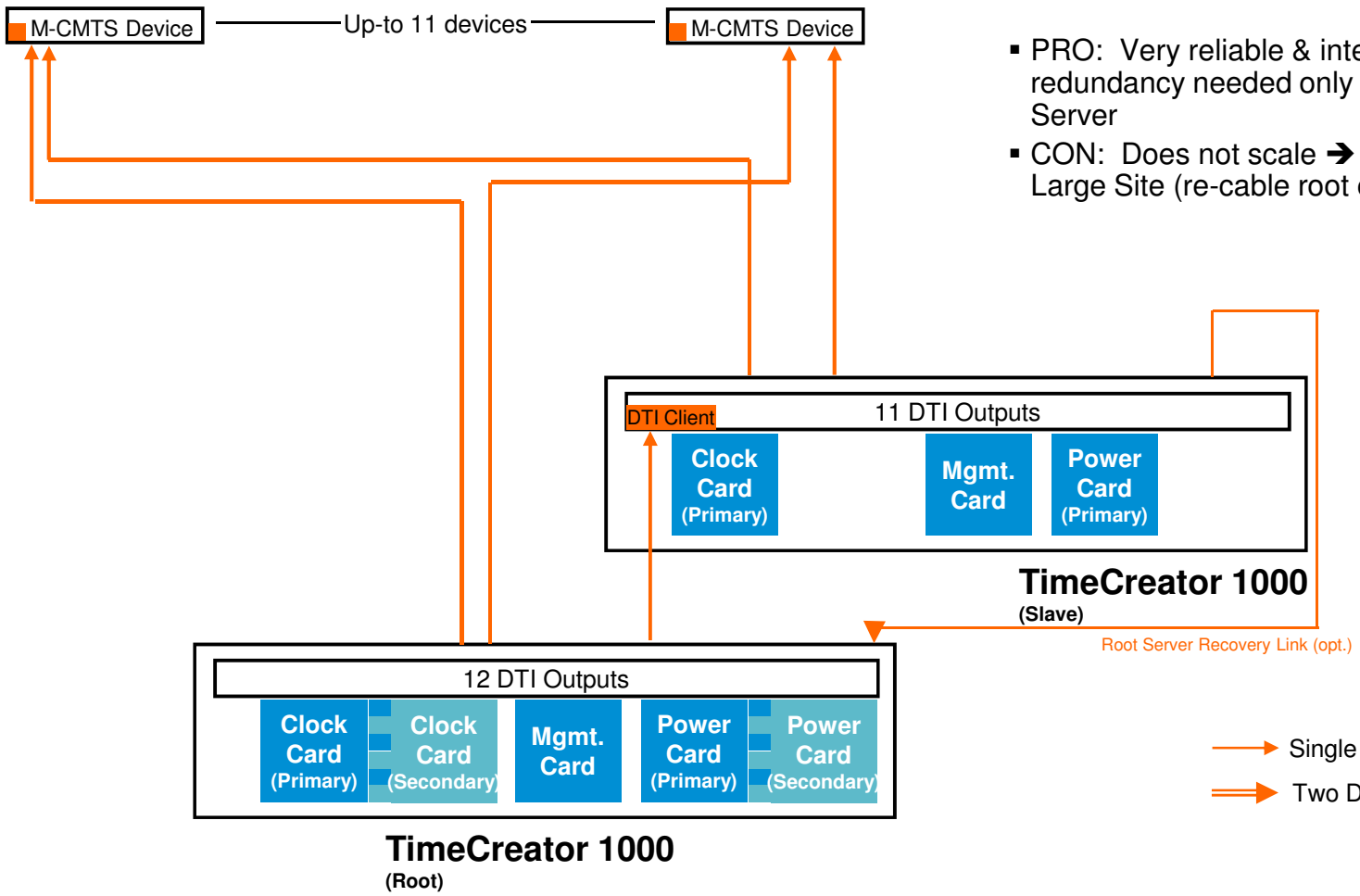
- **Large Deployment**
  - Up-to 11 M-CMTS devices (as shown)
  - Scaleable to 66 protected M-CMTS devices (132 ports)
  - All devices are homed to two Slave Servers
  - Root Server is only connected to Salve Servers (no clients)
  - 6-Nine's Reliability (system)
  - PRO: Very reliable, scalable (132 outputs) & internal redundancy needed only in Root Server
  - CON: Higher initial cost



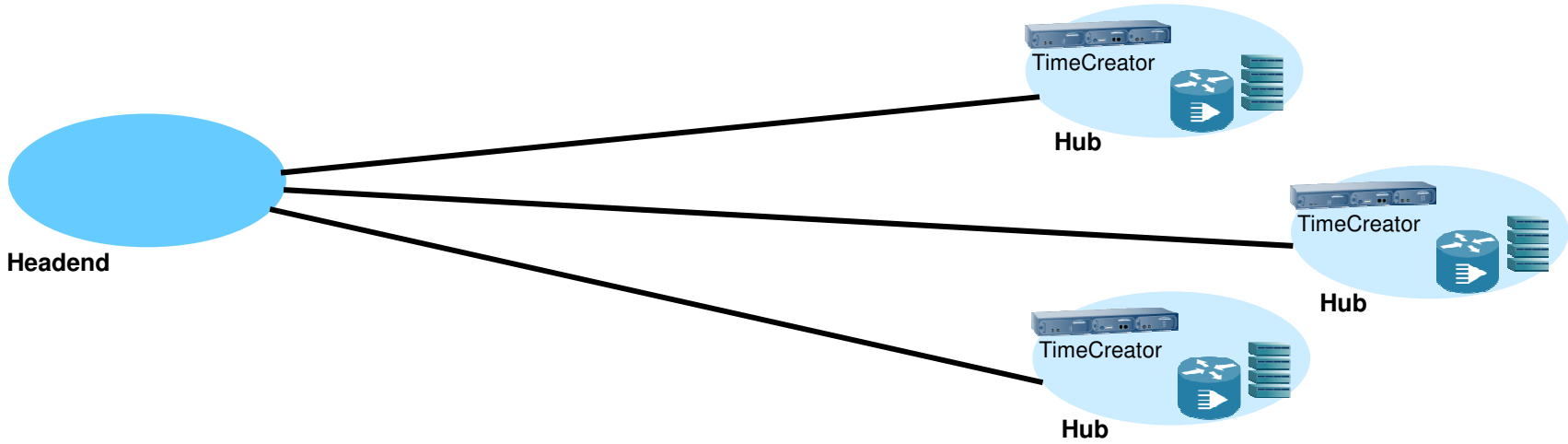
Deployment Scenario
Moderate Site (Single homed/Two Servers)

Symmetricom

- **Initial Deployment**
  - Up-to 11 M-CMTS devices (as shown)
  - All devices are homed to the Root and Slave Server
  - 6-Nine's Reliability (system)
  - PRO: Very reliable & internal redundancy needed only in Root Server
  - CON: Does not scale ➔ Migrate to Large Site (re-cable root connections)

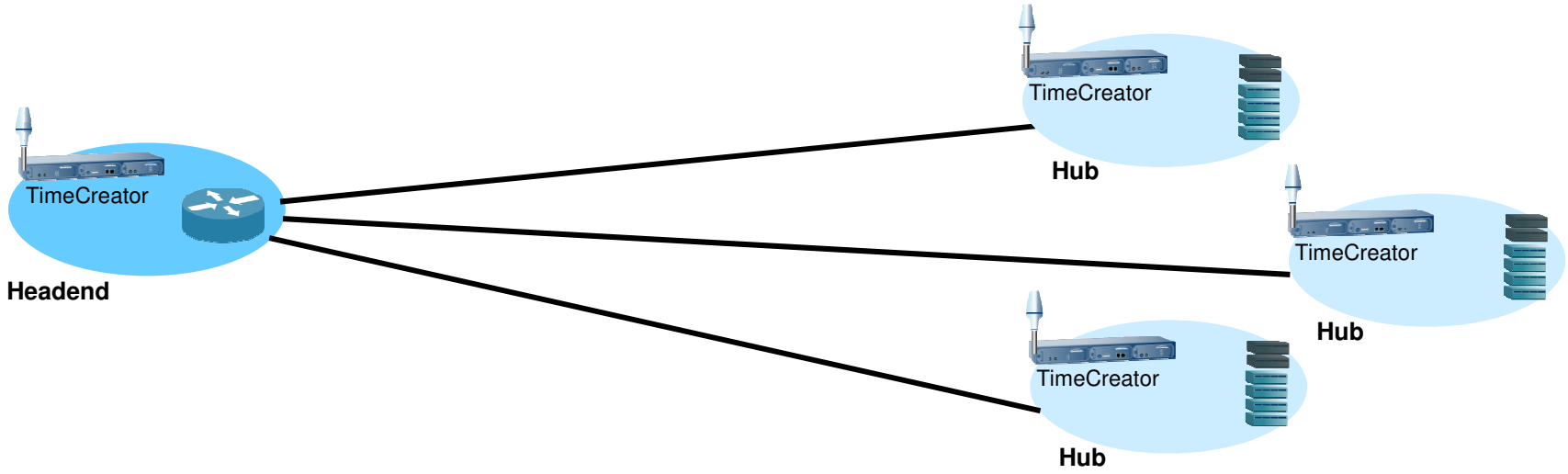


Regional M-CMTS Deployment



- Current M-CMTS Deployment
  - Upstream/Downstream must maintain 5ns alignment
    - Root DTI Server at each Hub site
    - Each Hub site has its own local time

Regional M-CMTS Deployment



- M-CMTS Deployment with Upstream separated from M-CMTS Core
  - Routing and DOCSIS scheduling now at Headend, must maintain ~1us alignment to hubs
  - Upstream/Downstream must maintain 5ns alignment
    - Root DTI Server at each Hub site and Headend maintain 5ns local alignment
    - Root DTI Servers have GPS for 1us network alignment
  - Separation of Rf and IP allows for lower cost and greater innovation

Symmetricom DTI Portfolio

We Know Time

- It's what we do!
- Trusted
- Viable

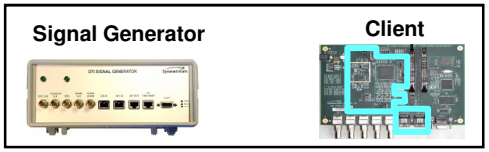
We Wrote the Book

- Author of M-CMTS (DTI)
- Co-Author of BSoD
- Telecom Timing Heritage

DTI Products

TimeCreator 1000

CableLabs Qualified



Client Reference Design

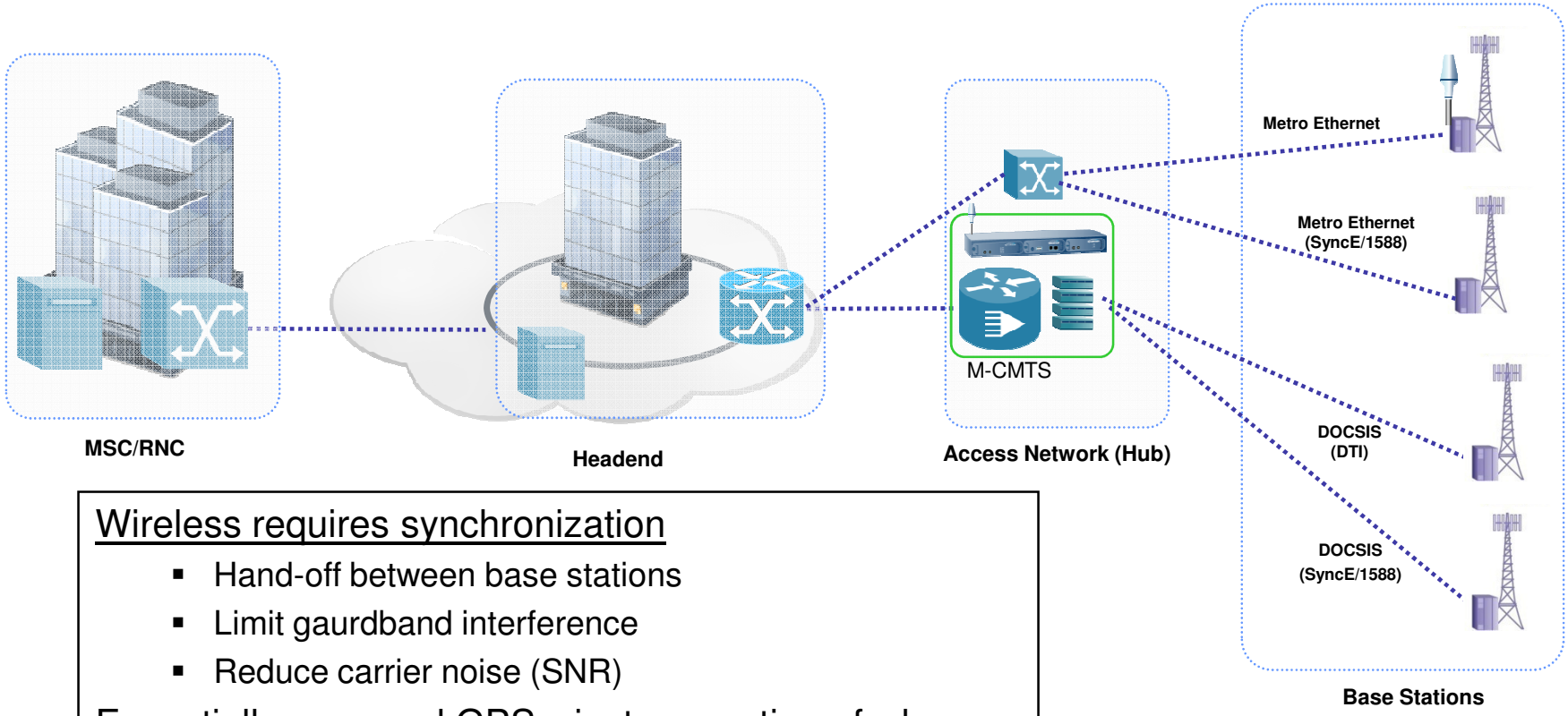
Interoperable

- 11 Manufactures using Symmetricom's Client
- We have set the "bar" for Servers

Best in Class Solution

- Reliable & Economic
- Scalable & Compact
- Easy to Setup
- Multipurpose **(DTI & NTP)**

Wireless Networks in Cable



Wireless requires synchronization

- Hand-off between base stations
- Limit gaurdband interference
- Reduce carrier noise (SNR)

Essentially you need GPS…just a question of where

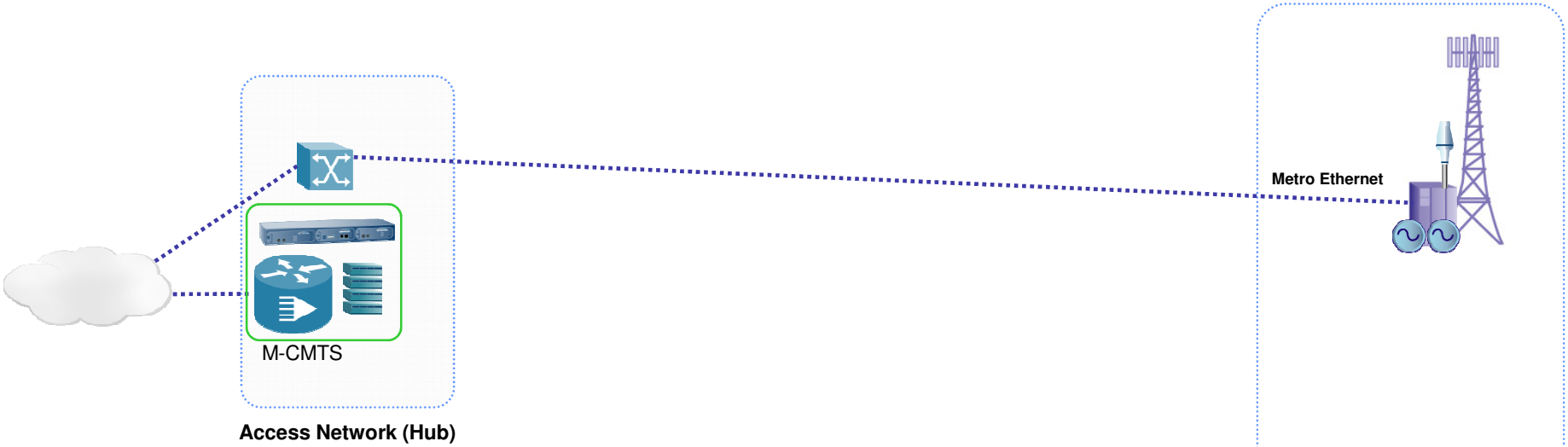
- GPS in the Base Station
  - Expensive. Requires holdover at each BTS (Qz or Rb)
- GPS in the Hub/Headend
  - Distribute via Metro Ethernet using SyncE &/or 1588
  - Distribute via DOCSIS using embedded DTI clock
  - Distribute via DOCSIS using SyncE &/or 1588

Mobile Sync Requirements

Symmetricom

Wireless requirement category	Frequency	Phase (System specific time)	Global Time
GSM / UMTS	Carrier frequency shall hold between +/- $5x10^{-8;}$ for air interface only	Not Applicable	E911 location & services: target to within 20m; accuracy of the time stamping translates directly to position location and likewise its error Other applications & services requiring time of day (sub-second accuracy sufficient)
CDMA / CDMA 2000	Achievement of alignment error sufficient	Time alignment error must be less than 10 µs	
WiMAX	Achievement of alignment error sufficient	Time alignment error must be between 5-15 µs (depends on guard band width)	
LTE	Achievement of alignment error sufficient	Time alignment error must be less than 3 µs	

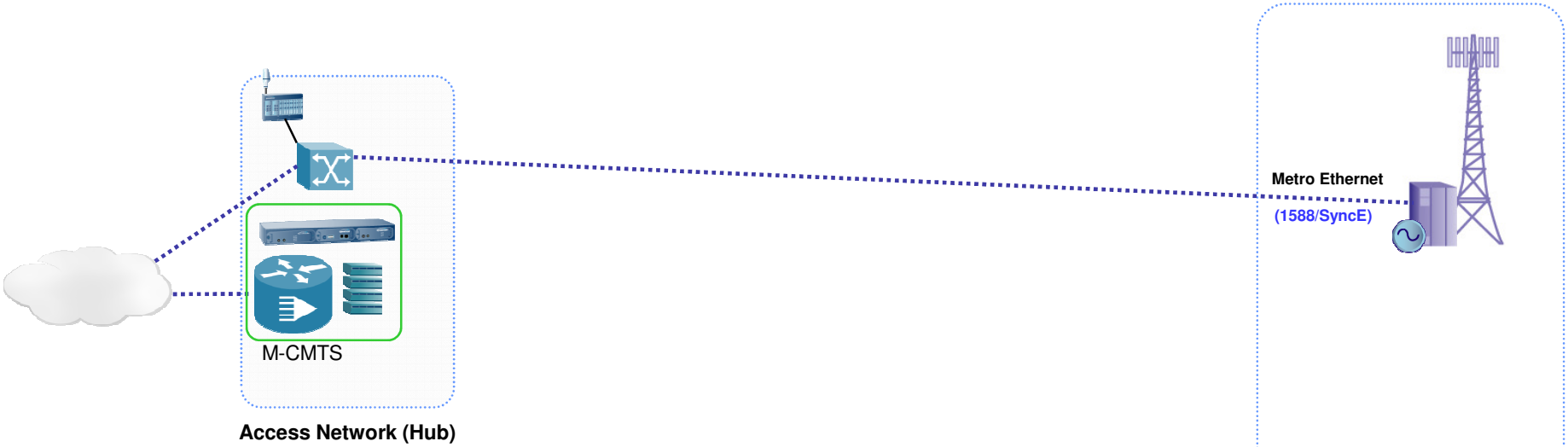
Wireless Networks in Cable (GPS)



GPS in the Base Station

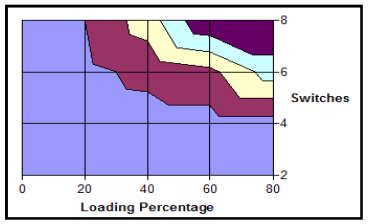
- Traffic is independent from sync
- GPS Receiver is embedded in the BTS
- Redundant clock cards lock to GPS
- Each cards has Holdover
  - HQ-Quartz or Rubidium (Vz uses Rb)
  - Backup using 1588 or SyncE is recommended
- Maintenance and installation costs are high
- GPS not available in all areas (urban canyons, tunnels, etc.)
- Currently only used in CDMA

Wireless Networks in Cable (Metro Ethernet)



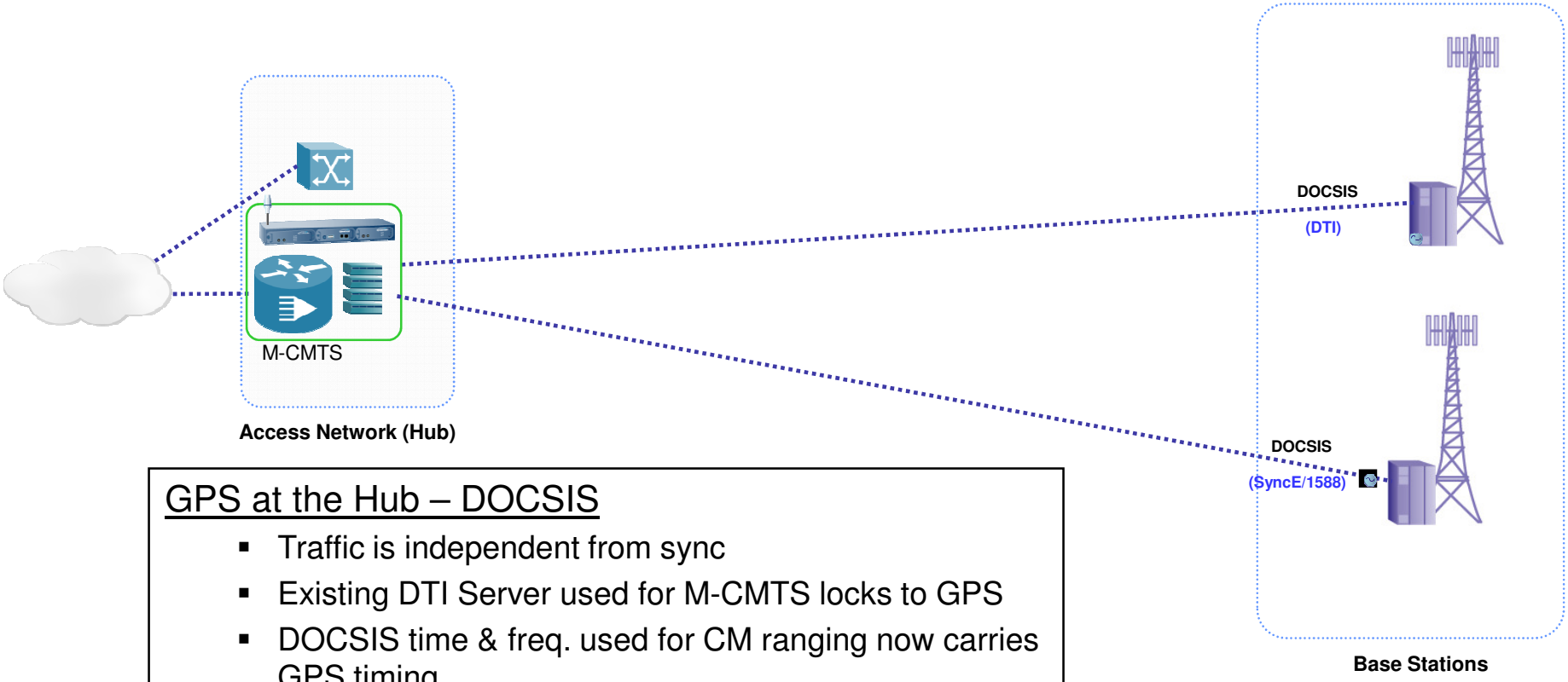
GPS at the Hub – Metro Ethernet

- 1588
  - Traffic and sync are inter-dependant for time & freq.
  - Requires engineering of the network (no routers)
  - 1588 Grandmaster at Hub/Headend
  - 1588 Client embedded in the BTS
    - Quartz, HQ-Quartz or Rubidium
- SyncE & 1588
  - Traffic and sync are inter-dependant for time
  - SyncE allow the freq to be independent from traffic
  - Requires engineering of the network (few routers)
  - 1588 Grandmaster at Hub/Headend
  - 1588 Client embedded in the BTS
    - Quartz



1588 Performance Contours

Wireless Networks in Cable (DOCSIS)



GPS at the Hub – DOCSIS

- Traffic is independent from sync
- Existing DTI Server used for M-CMTS locks to GPS
- DOCSIS time & freq. used for CM ranging now carries GPS timing
- Two BTS solutions:
  - Embedded DOCSIS CM
    - CM functionality put in a BTS line card for traffic & sync
  - External DOCSIS CM
    - CM recovers GPS sync from DOCSIS
    - Local interface to BTS using SyncE/1588
- Both DOCSIS solutions are low cost and non-traffic sensitive

Summary (Why DTI?)

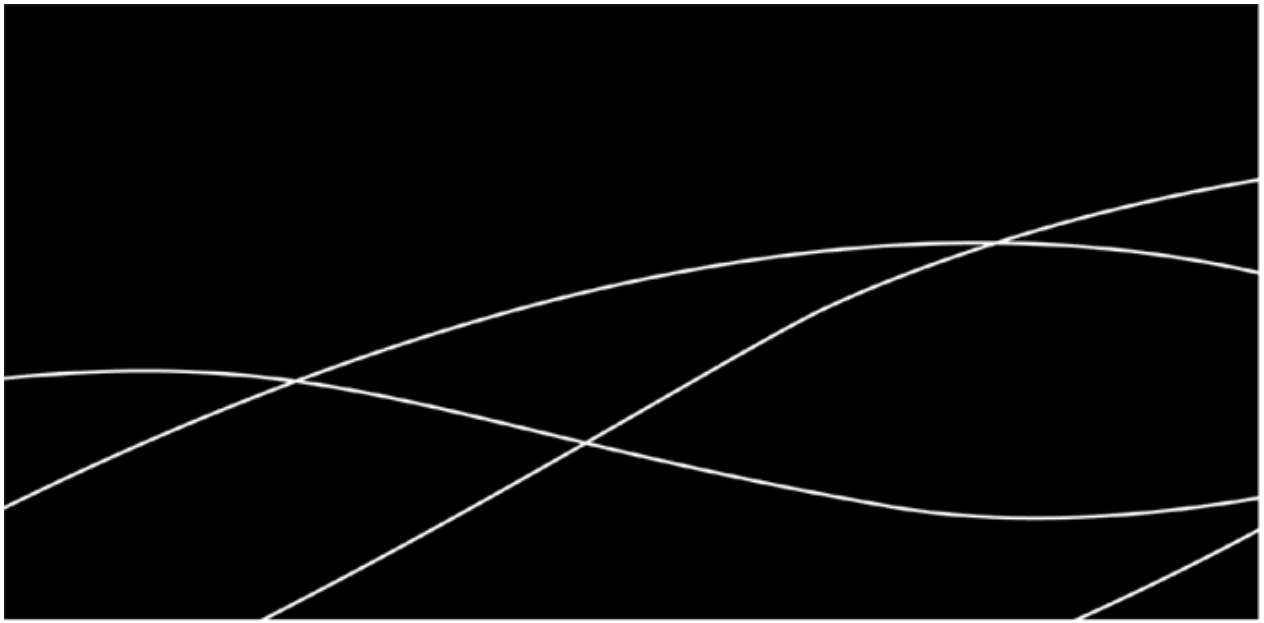
Symmetricom

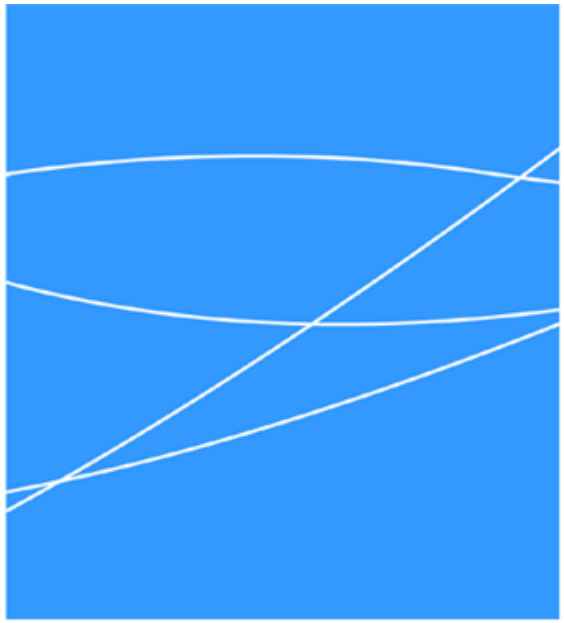
- A DTI Server is required for any CableLabs M-CMTS standard deployment
- If you do not use DTI for a M-CMTS
  - The channels/slots from the EQAMs cannot be used by D1.1 or D2.0 modems.
  - That is a huge waste of resources and a possibly a negative ROI
- In order for a D1.0 or D2.0 modem to use a channel/slot it must be a synchronized “Primary Channel”
- DTI & M-CMTS enable existing CMTS’s to be leveraged
  - If there are un-used upstream ports you can add downstream capacity by adding EQAMs at a lower cost

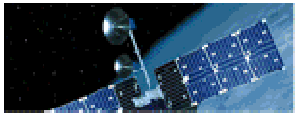
Summary

- M-CMTS & DOCSIS 3.0
  - M-CMTS is the best platform for DOCSIS
    - Economic wideband or narrowband (DOCSIS 1.1, 2.0, 3.0 & beyond)
    - Flexible bonding from any EdgeQAM
    - High Reliability
    - Unlimited Scalability
    - Interoperability
    - Backward Compatible
  - DOCSIS 3.0 enables all next generation services
    - Wideband = 140MB+ bandwidth
    - IPv6, Security, etc.
    - Business Services & Mobility

- DTI is Required
  - TimeCreator 1000 is Reliable, Scaleable & Cost Effective
  - Symmetricom invented the technology
  - Symmetricom has been providing sync systems for over 30 years





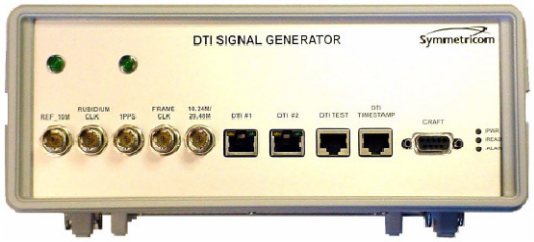


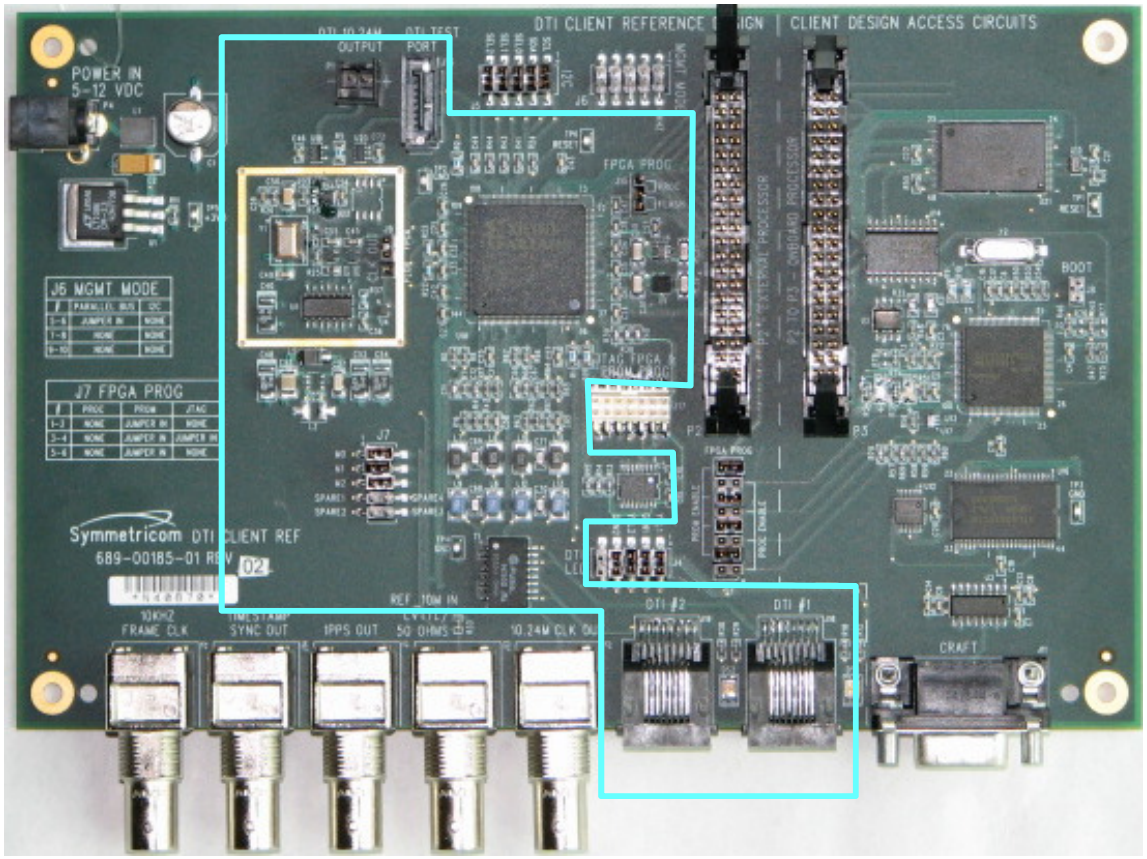
Symmetricom DTI Product Portfolio

TimeCreator

Symmetricom®

DTI Client Reference Kit





Reference Kit is for Vendors **only**
Licensed to over 11 vendors

Signal generator
- Similar to a DTI Server except:
  - Only has 2 DTI Links
  - Not CableLabs Compliant
- Used for lab testing
- Has special diagnostic modes

DTI Client Reference Board
- Golden reference DTI client for industry
- Used to help a vendor design their Client
- The "blue outline" shows what a vendor will put in their product

DTI Client Reference Design (no picture)
- Source code
- Schematic
- Design files
- Documentation so the vendor can implement a DTI Client in their product (put the "blue outline" in their product)
- Support (hourly or annual contract)

TimeCreator 1000

CableLabs Qualified

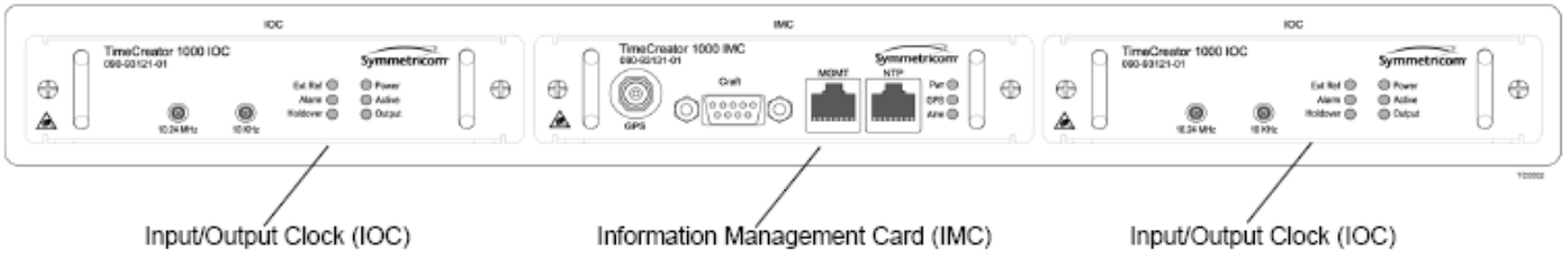
Symmetricom

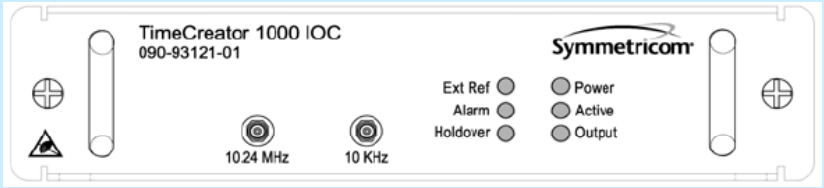
Key Features

- **DTI features**
  - Root & Slave Capability
  - 10+2 Ports (outputs/dual mode)
- **Carrier Class**
  - Fully Redundant within 1RU
  - Hitless Switching
- **Management**
  - SNMP (V2c & V3) & CLI Manageable
  - Events, Alarms notification
  - RADIUS and TACACS+ Authentication
  - Continuous health management of DTI Clients
- **NTP server option**
  - Synchronization and traceability for hub equipment
  - Local, accurate NTP source for PacketCable & OCAP

- **GPS option for TOD & BSoD support**
- **SSH (secure shell), SFTP**
- **Compact 1RU design**
- **AC or DC options**
- **DTI root or slave server configurable with dual path protection & 24hr holdover**
- **Software upgradeable for future features & compatibility**

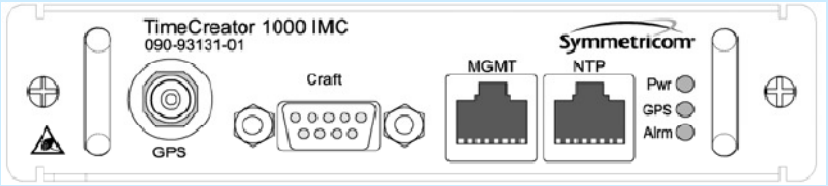
TimeCreator 1000
Front Panel View





Input/Output Clock (IOC)

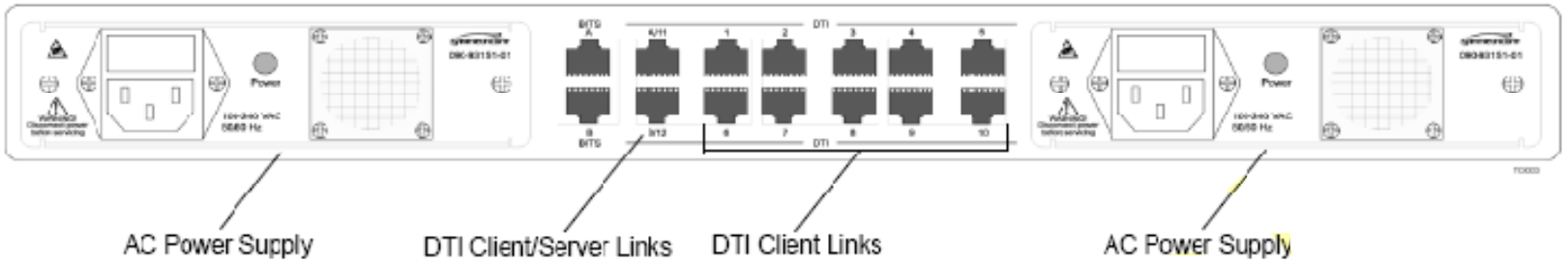
- This is the “heart” of the TimeCreator
- Contains the oscillator
- Drives the DTI links
- TimeCreator can be configured with <u>two</u> IOC cards for redundancy
- TC must have at least one operating at all times

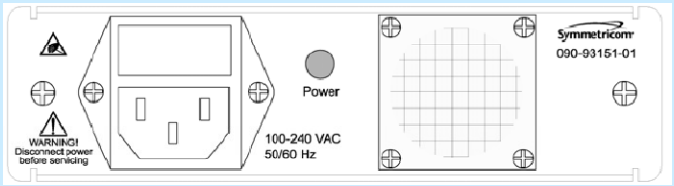


Information Management Card Clock (IMC)

- This is the “brains” of the TimeCreator
- IMC communicates with the rest of the network
  - Configuration of the TC
  - Performance & Alarms of the TC
  - Performance of every connected DTI Client
  - Receives the GPS signal from the Two-Way Timing Antenna
- Can be upgraded to provide NTP Server functions
- TC must have an IMC, however if it fails the IOC and DTI links continue to operate

TimeCreator 1000
Rear Panel View

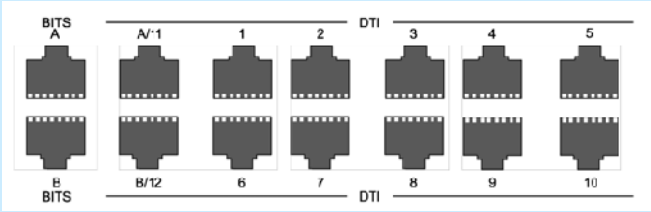




AC Power Supply

DC Power Supply (not shown)

- TimeCreator can be configured with **two** power supplies for redundancy
- TC must have at least one operating at all times



TimeCreator 1000 Shelf

- 1RU x 19” x 20” (H x W x D)
- 2 IOC Slots, 1 IMC Slot, 2 Power Supply Slots & 10+2 DTI Links
  - 2 BITS ports are in-operable in this release
  - 10 DTI Links are always in a Server mode (connect to DTI Clients)
  - 2 DTI Links can operate in a Server or Client mode (can connect to a Root DTI Server or be a Server to a DTI Client)

TimeCreator 1000 what's new

Symmetricom

- Rel 1.1, October 2008
  - DTI Root Server Recovery feature
    - Upon root server recovery, subtending servers and DTI clients do not synchronize immediately but slew to prevent the Cable Modems from ranging
  - Capability to configure RADIUS port via CLI to meet backward compatibility with obsolete RFC 2138
  - Capability to configure TACACS+ more flexibly
  - Added IP address filtering via Command Line Interface to prevent malicious attacks
  - Ability to restore and save IOC configuration file for downloading
  - Ability to define the SNMP community string
  - Ability to do live-upgrade on the system in the field without manual intervention

Resources

- Product Pages
  - http://www.symmetricom.com/products/time-frequency-distribution/docsis-solutions/TimeCreator-1000-DTI-Server/
- Technical Support
  - http://www.symmetricom.com/support/phone-support/
  - Questions to support@symmetricom.com
  - For EMEA support please use emeasupport@symmetricom.com.
- Related links
  - CableLabs DOCSIS Specifications
    - http://www.cablemodem.com/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