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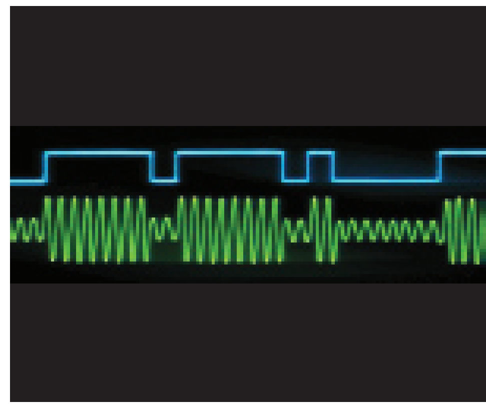
Synchronization for Next Generation Networks: Deploying Reliable DOCSIS Synchronization



WHITE PAPER

Synchronization for Next Generation Networks: Deploying Reliable DOCSIS Synchronization

Introduction

It is critical to maintain synchronization in a DOCSIS network. Cable modems (CMs) use synchronization to determine when to transmit. Without accurate and precise synchronization, CMs will transmit at the wrong time, causing complete loss of transmission of not only the errant CM, but also the CMs it transmits over. Modular-Cable Modem Termination System (M-CMTS) specifications include the DOCSIS Timing Interface (DTI) to ensure highly accurate and reliable synchronization of the entire M-CMTS DOCSIS network and to leverage the low cost of EdgeQAMs. For an overview of the DOCSIS Timing Interface and Synchronization, please refer to the list of documents at the end of this white paper.

DTI Root and Slave Servers

The cornerstone of DTI is a Root DTI Server. The Root Server controls the synchronization for an entire hub or headend. All M-CMTS devices, including the CMTS, EdgeQAMs and Upstream Receivers, synchronize either directly to the Root Server or through a subtending Slave Server. Since the Root Server is central to the operation of the DOCSIS network, the CableLabs DTI specifications suggest that a Root Server be extremely reliable. Symmetricom's TimeCreator 1000 has been designed with five nines or better reliability. The TimeCreator 1000 has a passive backplane architecture to eliminate single-point-of-failure active components. It can be configured with redundant clock cards (IOCs) and redundant power supplies to protect all of the active signals. Essentially, a TimeCreator 1000 with redundant cards is like two Root Servers in a single shelf, providing robust performance with 4-6 nines of availability.

Root Server Recovery Feature

Root Server Recovery (RSR) is a Symmetricom enhancement to the DTI specification to address a rare event with multiple servers when the Root Server is removed from operation or fails. The RSR feature allows a Root Server that is restarting to realign any subtending Slave Servers in a timely and orderly fashion, while ensuring a graceful recovery of the network.

Root Server Recovery consists of two separate mechanisms:

- Root Server acquiring time and phase (from one of the Slave Servers or GPS)
- Root Server slowly steering the subtending server's time and phase

In the absence of Root Server recovery, when the Root Server fails due to power outage or is taken off-line, the subtending server's clock drifts over time. Upon recovery from failure, the root server will acquire its time from the Time Of Day (TOD) source and realign the subtending server by forcing it into immediate alignment through jamming, rather than slowly bringing it back into alignment. The potential phase transient due to jamming could cause the cable modems to go offline or re-range, resulting in service outage.

Figure 1 illustrates the Root Server Recovery mechanism. The Root and subtending Slave Server are within nano-seconds of each other when the Slave Server is locked to the root. Upon Root failure, the Slave Server will go into holdover mode and begin drifting in phase. The clients connected to the Slave Server will drift, however, there will be no service outage for a certain period of time (longer for ATDMA than SCDMA). When the Root recovers from failure, it will slew the Slave Server(s) into alignment with the Root slowly enough to remain within specifications and thus not disturb the CMs. During this process, the DTI Clients that are embedded in the CMTS and EdgeQAMs will continue to follow the Slave Server(s). When recovery is complete, clients can then connect either the Root or the Slave Servers.

The obvious advantage of Root Server Recovery is that there is no service disruption upon Root removal or failure. It therefore increases the availability of the network to beyond 6 nines and makes the

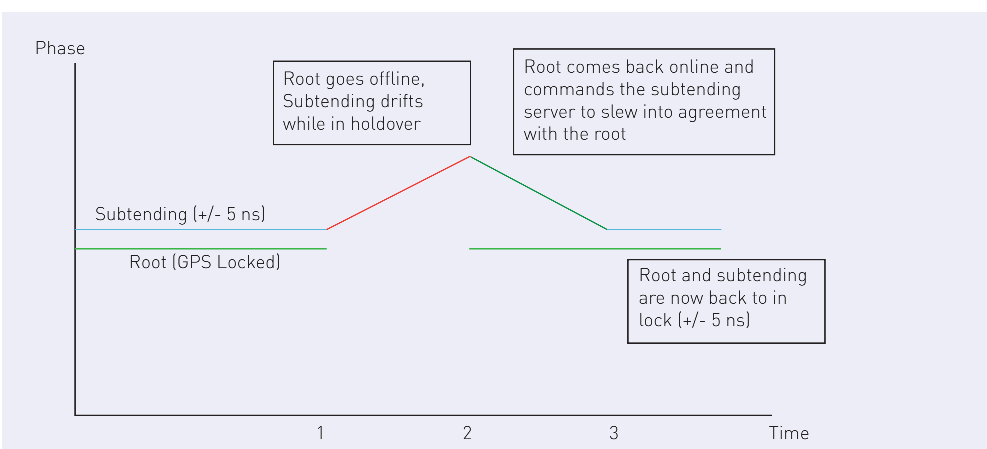


FIG. 1 Root Server Recovery Mechanism

network very robust. Another derived benefit of the feature is that even in the event of Root removal or failure, it gives the MSO a window of time to repair the Root and get it restarted, instead of having to do so immediately if the RSR feature is not enabled.

In summary, the Symmetricom TimeCreator 1000, with redundant clock cards, is architected with enough redundancy to provide high availability. Therefore it is not incumbent upon the MSO to use the RSR feature if only one DTI Server is needed. Symmetricom recommends the use of RSR for larger deployments where multiple DTI Servers are needed and the EdgeQAMs and CMTS can be single-homed (cross-connected) to multiple subtending servers. This provides maximum protection through scale, diversity and redundancy. (Refer to Figure 5 on Large Deployment with Root Server Recovery.)

Small Scale Deployment without RSR

DTI deployment is a balance of economics, scalability and reliability. A Root Server can be deployed without redundancy, although this creates a single point-of-failure in the network. DTI should be deployed using two connections (primary & secondary inputs) between a DTI Server and the M-CMTS device. A typical initial deployment would consist of a single Root DTI Server with two connections to each M-CMTS device (Figure 2). The suggested configuration is a TimeCreator 1000 with redundant power supplies and clock cards. When using this initial architecture, the operator should consider leaving two to four ports on the Root Server free to allow the connection of future Slave Servers without the need to re-cable existing connections.

GPS may be used in DTI deployments to enable support for T1/E1 circuit emulation for Business Services or Root Server Recovery when multiple DTI Servers are deployed. GPS may also be used in advanced M-CMTS architectures where the M-CMTS Core and EdgeQAM are not co-located in the same site. In this advanced architecture, GPS is needed to allow both sites to use the same time. GPS is strongly recommended if a larger architecture or Business Services are in the long-term strategy. Adding GPS to an operational DOCSIS network requires a brief outage to re-align the network to GPS time. An NTP Server may also be added to the Root DTI Server to support IP applications, OCAP, PacketCable, CM registration and other applications needing NTP.

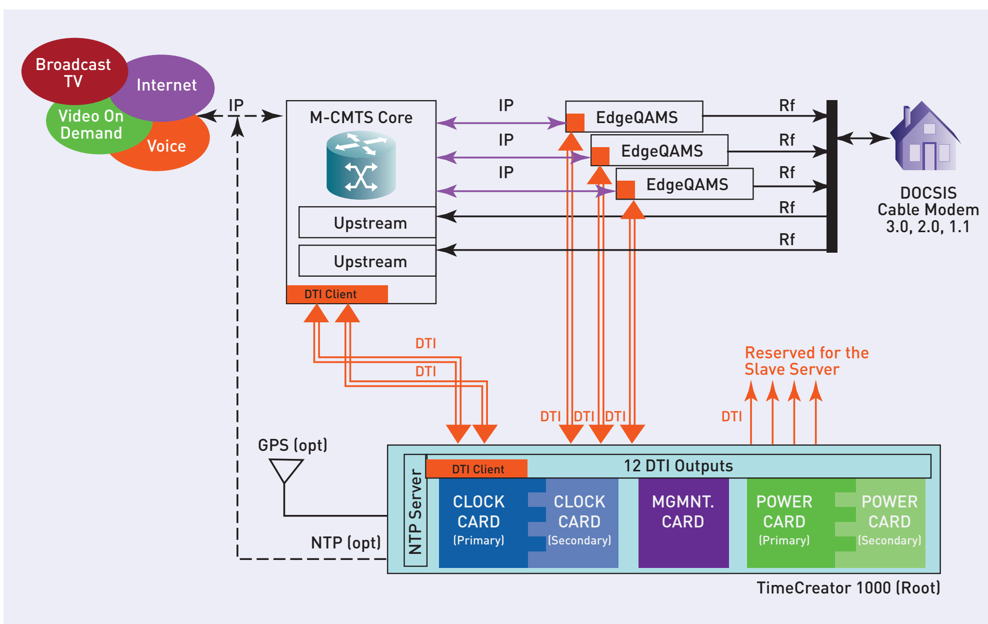


FIG. 2 Small Scale Deployment without RSR.

A Growing Deployment without RSR

Since there can be only one Root Server in each site, the DTI specification allows for Slave Servers to be directly connected to a Root Server to add capacity and support more sophisticated deployment architectures. With more than one DTI Server, the primary and secondary connection to the M-CMTS devices can be cabled in different ways. One way is to dual-home each M-CMTS device to a single server where both primary and secondary inputs are connected to the Root or a Slave Server. A second way is to single-home each M-CMTS device to two servers where the primary and secondary inputs are connected to different servers (traceable to the Root).

Single or dual-homing the M-CMTS devices allows for several architectures, each with its advantages and disadvantages. Figure 3 shows one way to grow a DTI deployment by adding a single Slave Server to a site and dual-homing the M-CMTS devices. In this architecture, the Slave Server is dual-homed to the Root Server using a standard DTI connection. This ensures that the Slave Server has a reliable synchronization signal from the Root. Since each M-CMTS device is dual-homed to either the Root or the Slave Server, each server should have redundant clock cards and power supplies.

The advantages of this architecture are that it is the simplest way to grow, and it requires the fewest servers. The disadvantages are that if a server fails, it will cause the connected devices to fail, and that this architecture can only scale to 60 outputs per site using the TimeCreator 1000. To avoid an outage, the Root Server and each Slave Server should have redundant cards. Root Server Recovery is typically not enabled in this architecture since the CMTS and EdgeQAMs are not cross connected to different Servers, so when the Root is offline some devices will fail and cause an outage. The subsequent jam sync caused when the Root is restarted won't make a difference since the network is already offline.

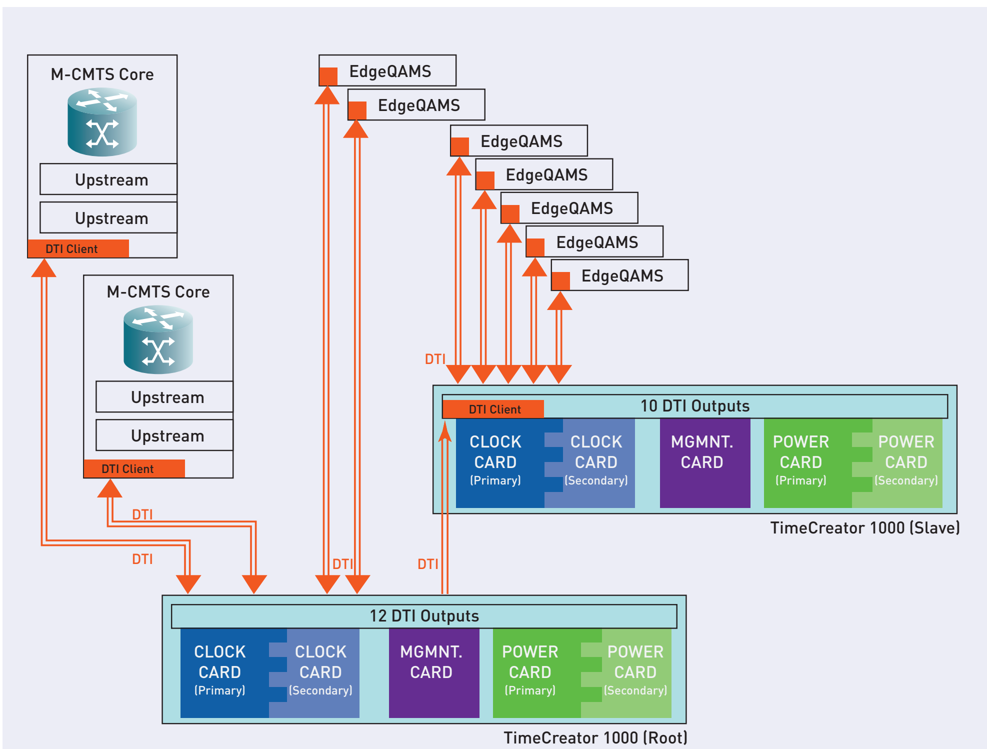


FIG. 3 Growing Deployment without RSR

Small Scale Deployment with Root Server Recovery

Figure 4 shows the simplest architecture for an initial deployment with Root Server Recovery feature using a single Slave Server and a Root Server. All the M-CMTS devices are single-homed to a root and a slave (cross-connected). Note that when the Root is not connected to a GPS, you need to have a feedback loop from the output of the Slave Server to the input port (port 12) of the Root Server.

This is how the Root Server Recovery feature works in this scenario: The subtending Slave Server is synchronized to the Root Server. M-CMTS devices or clients will lock to the first connection (Root or Slave) you make on their DTI ports. When the Root Server fails, the Slave Server will go into holdover and, if the M-CMTS device is deriving its timing from the Root, it will switch to the Slave Server with no affect on the cable modems. There will be no service outage and the network will be available to the subscribers.

When the Root is restarted, it will take its reference time from the Slave Server and slowly slew the phase of the Slave Server to align with its own phase. When the Root recovery is complete, M-CMTS devices can connect to either of the servers.

The advantage of this architecture is that it does not require redundant cards in the Slave Server. The disadvantage is that it only scales to 10 M-CMTS devices. Once there are no more outputs left on the Root Server, this architecture must be migrated to an architecture where the M-CMTS devices are cross-connected between Slave Servers, and the Root Server outputs are primarily used to connect Slave Servers, similar to Figure 5 on the following page.

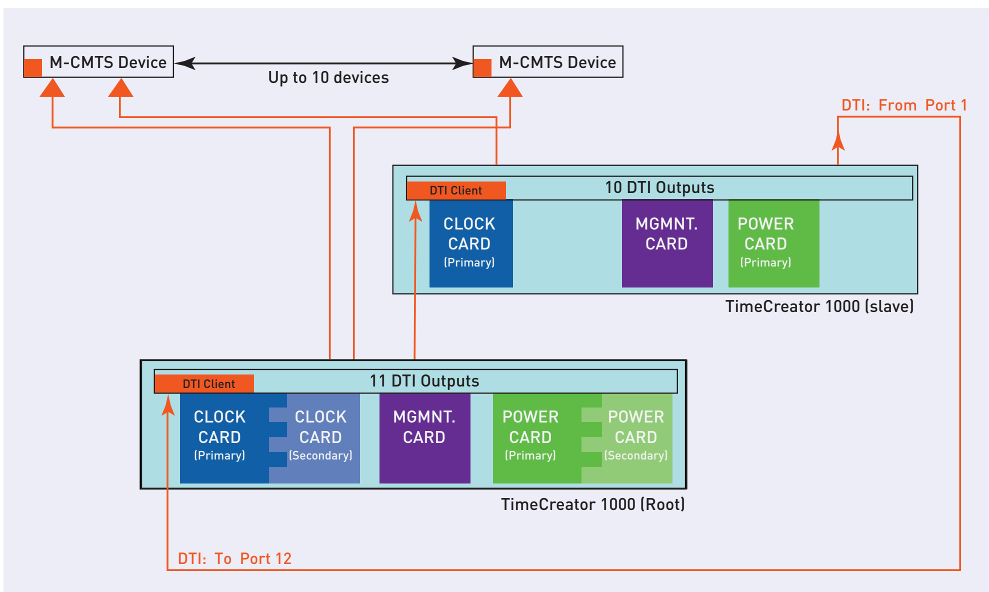


FIG.4 Initial Deployment with RSR

Large Scale Deployment with Root Server Recovery

Figure 5 shows a deployment where M-CMTS devices are single-homed to two different Slave Servers. In this deployment, Slave Servers are deployed in pairs, and each M-CMTS device is single-homed to each Slave Server in the pair (cross-connected). Each Slave Server does not need internal redundancy and is connected to the Root Server using a single DTI connection. Note that when the Root is not connected to a GPS, there is a feedback loop from the output of one Slave Server to the input port (port 12) of the Root server. This architecture provides each M-CMTS device two redundant paths to the Root Server, but through different Slave Servers.

In the event of Root failure with the RSR feature enabled, Subtending Slave Servers go into holdover mode while M-CMTS devices continue to derive their timing from the Slave Servers. When the Root Server recovers from failure, it will take its reference time from the Subtending Slave and slowly slew the phase of the Subtending Servers to align with its own phase. While all the Slave Servers are slewing, attached M-CMTS devices will follow the Slave Servers and all Cable Modems will continue to operate normally. Therefore, there is no service outage. When the Root Server Recovery is complete, all Slave Servers are once again synchronized to the Root Server.

The advantage of this architecture is that only the Root Server needs to have redundant clock and power cards. The Slave Servers do not require this, since they are deployed in pairs. This architecture has greater than six nines reliability and can scale to 120 outputs in a single site using the TimeCreator 1000.

GPS enhances the performance of root server recovery. Without GPS, the root server recovery period may be extended. Also, without GPS, it is imperative that the feedback loop from the slave to the root be connected, and be connected properly.

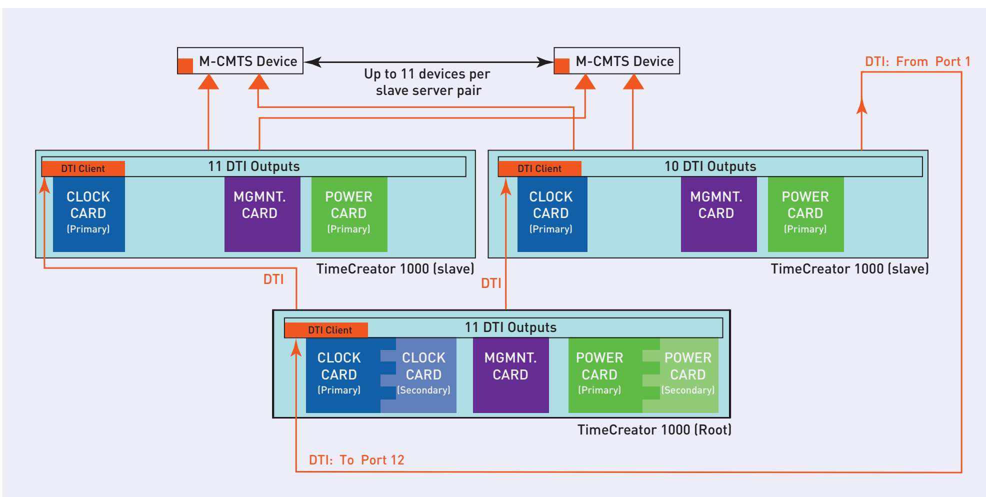


FIG.5 Large Scale Deployment with RSR

Meeting the Need for A Highly Reliable Network

The first two architectures described above rely on a reliable Root Server. Symmetricom's TimeCreator has been designed with this in mind. It provides over five nines of reliability and is fully compliant to the CableLabs specification.

However, in some installations, five nines reliability for a Root Server may not be enough for some operators, especially in large deployments. The CableLabs specification did not foresee this requirement and does not consider the corner case where a Root Server is taken off-line or fails. If this was to happen and M-CMTS devices are dual-homed, there would be a failure in the network. To address the omission of "Root Server recovery from failure condition" in the DTI specification, Symmetricom has added the Root Server Recovery feature to the TimeCreator 1000 to ensure a graceful recovery of the network.

In Figures 3 and 4, both Slave Servers will go into holdover, but remain in normal output mode when a Root is offline. With Root Server Recovery enabled, there will be no impact on the network when the Root Server re-starts and conveys the new DOCSIS timestamp. The DOCSIS timestamp is derived from GPS or NTP or set by the user. In the case where GPS is not used, the feedback loop from a Slave Server to the Root is mandatory. With the Root Server Recovery feature, all timestamps will have less than 270ps of offset every 35 second ranging window from the previous window. This enables the DTI Servers to re-align without a network outage.

With the TimeCreator 1000 from Symmetricom, an M-CMTS architecture can be reliably deployed with a variety of configurations to meet the scalability and economic requirements of each cable operator. Symmetricom is committed to enabling synchronization for DOCSIS deployment and quality assurance for voice, video and data though our solutions.

For more information, visit www.symmetricom.com.

Related Documents

- Synchronization Requirements For High-Performance Cable Networks
  http://www.symmetricom.com/media/files/secure/application-notes/AB_Cable.pdf
- Time To Sync Up
  http://www.cable360.net/ct/sections/columns/telephony/22840.html
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