Clock Synchronization over IP (CSoIP)

Ron Blechman
Software Senior Engineer - Avaya

ABSTRACT

Over the past decade Avaya has transformed the interconnectivity of its gateways and port networks from proprietary TDM to IP. Enterprise customers expect similar voice, data, and video quality from an IP infrastructure as that delivered with a TDM connected system. Clock Synchronization over IP (CSoIP) provides a new method of providing timing information between IP-connected gateways in the absence of traditional synchronization facilities (i.e. ISDN, DS1) and is necessary to support circuit-based services imposed on an IP infrastructure. These services include:

- ISDN B-channel data applications (H.320 video, STE BRI, clear channel codec apps)
- Avaya ISDN Data Modules
- Voice band data (modem pass-through, fax pass-through)
- Avaya Administered Connection (Communication Manager feature)

The CSoIP feature was first introduced with Avaya Aura® Communication Manager Release 6.01 and is available on Avaya G450 and G430 Branch Gateways running release 6.1 and later.

External posting: URL TBD

Application Note

Issue 1.0
January 2011

COMPAS ID 150001

Clock Synchronization over IP (CSoIP)

Table of Contents

ABSTRACT

Over the past decade Avaya has transformed the interconnectivity of its gateways and port networks from proprietary TDM to IP. Enterprise customers expect similar voice, data, and video quality from an IP infrastructure as that delivered with a TDM connected system. Clock Synchronization over IP (CSoIP) provides a new method of providing timing information between IP-connected gateways in the absence of traditional synchronization facilities (i.e. ISDN, DS1) and is necessary to support circuit-based services imposed on an IP infrastructure. These services include:

- ISDN B-channel data applications (H.320 video, STE BRI, clear channel codec apps)
- Avaya ISDN Data Modules
- Voice band data (modem pass-through, fax pass-through)
- Avaya Administered Connection (Communication Manager feature)

The CSoIP feature was first introduced with Avaya Aura® Communication Manager Release 6.01 and is available on Avaya G450 and G430 Branch Gateways running release 6.1 and later.

1. BACKGROUND

Whenever media from circuit-based services are sent through a digital switch, the switch must be synchronized to the incoming data rate of 8000 frames per second. This timing reference may be derived from digital facilities such as ISDN or DS1, or from a gateway's local clock.

Traditionally, this timing information would be distributed throughout the switch using individual digital facility links or Center Stage Switch fabric (be it space-division bus or ATM). With the advent of IP networks and distributed architectures, the traditional methods of maintaining a common clock have become impractical. For this reason, Clock Synchronization over IP was conceived and designed.

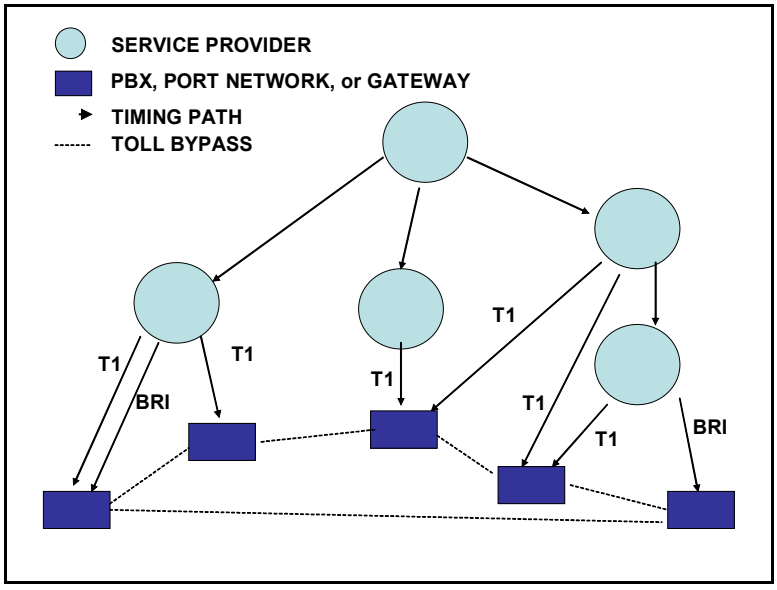

Figure 1 – Sync Traceability

2. TERMINOLOGY

CM	Avaya Aura® Communication Manager
CSoIP	Clock Sync over IP.
Default clock	The default clock is always the local clock on a gateway.
Default clock domain	If there are no master clocks in the system, this is the first gateway which comes into service. Its clock becomes the master clock.
Demotion	The operation of converting a master clock member to a secondary clock. Also, converting any clock master to a slave.
Domain (or Sync Domain)	An abstract concept defined as a source gateway and at least one gateway.
Fan out	The maximum number of IGC streams which can be sourced from a G450.
Hop Level	The number of gateways between a given gateway and the master source
IGC	Inter-Gateway Connections. Connections between gateways.
Master clock	A gateway with an administered clock reference board such as a DS1 or BRI. A gateway with such a board will be the source of a master clock domain.
Master clock domain	A sync domain sourced by a master clock.
Master Source	A gateway with an administered DS1 or BRI board. There can be multiple master sources. If there isn't any administered reference board, a gateway is chosen as a default master.
Member (or Sync Member)	A gateway which is part of a sync domain
MG	Media Gateway
NR	Network Region
Promotion	The operation of converting a domain member to a clock source. Also, converting a secondary clock to a master, or primary clock.
Secondary clock	A gateway which receives an IGC stream and sources IGC streams for other receivers. Sometimes called a 'tandem' clock.
Secondary clock domain	A sync domain sourced by a secondary clock
Slave Member	A gateway which only receives a timing IGC stream for clocking and doesn't source an IGC.
Tandem clock	See secondary clock
Tandem Source	A gateway which receives timing from one Inter Gateway Connection (IGC) and is providing one or more timing IGCs.

3. FEATURE OVERVIEW

3.1 TDM Clock Synchronization

It is important for digital interfaces to communicate with each other using synchronized TDM circuits since data being sent from one gateway to another must be written to and read from at the same rate to avoid slips. Traditionally, switch synchronization required that the gateway derive a timing signal from an external digital interface (i.e. T1/E1/BRI). In this case, the external interface served as a "master" clock source that provided timing to the gateway as a "slave".

For example, a T1 port board can be instructed to drive the gateway's backplane signal "SYSSYNC". The rate of SYSSYNC is derived from the incoming T1 data stream of a master switch. The regenerated SYSSYNC is passed to the system clock circuit to control the rate of the slave TDM bus. This effectively synchronizes the two TDM circuits.

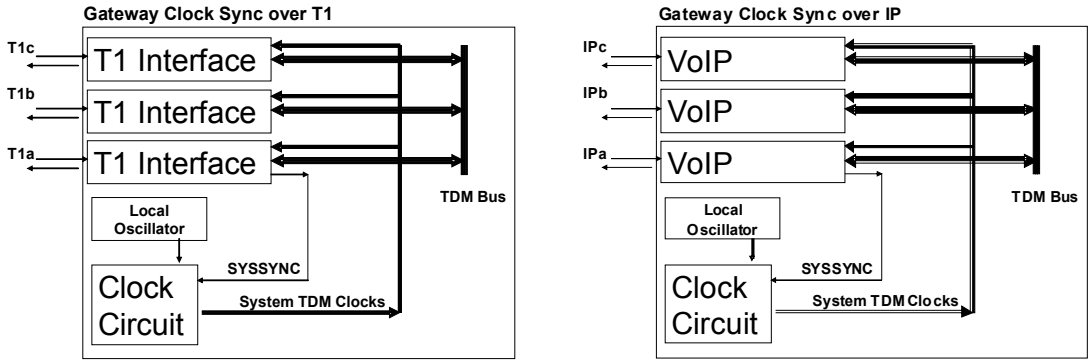

Figure 2 – TDM Clock Sync vs. Clock Sync over IP

Figure 2 has the internal details of the synchronization path within a gateway.
In the left side of Figure 2, three T1 interfaces (T1a, T1b, and T1c) are installed in the gateway.

- The T1 line *output* data rate is fixed at the system TDM bus rate.
- The T1 line *input* rate is independent. The T1 interface provides SYSSYNC at the incoming T1 rate.
- The System TDM clock rate is determined by the Clock Circuit, which can choose between a local oscillator and SYSSNC as a reference, among other options.

In this example the incoming data bit rate of T1a is used to generate SYSSYNC. When the clock circuit uses SYSSYNC as reference for the system TDM clocks, the system is said to be "synchronized to T1a", as incoming and outgoing data streams of T1a are at the same rate.

With CSoIP, the VoIP DSP now provides a substitute for the synchronization function of the T1/E1/BRI interface. The SYSSYNC signal to the clock circuit is based on incoming packet data (IPa on the right side of Figure 2). Output packet streams indicating the TDM bus rate can be sent to synchronize downstream gateways.

Gateways that have an administered sync reference will use the administered board as its reference. Gateways without an administered sync reference that have CSoIP enabled will use a VoIP DSP as their sync reference.

3.2 System-Wide Synchronization

Ideally, timing in a customer's network is traceable to a single timing source via T1/E1/BRI master-slave interfaces. This timing information is then distributed throughout all the gateways within the switch. Prior to the CSoIP feature being introduced, synchronization was not possible if a gateway that did not include a T1/E1/BRI trunk.

CSoIP provides a way to synchronize gateways across an IP network. Typical configurations include mixing T1/E1/BRI and CSoIP to synchronize a set of gateways within a system to a common source. Also, if no T1/E1/BRI interface is available in the system, one can also use a gateway's local clock as the clocking source.

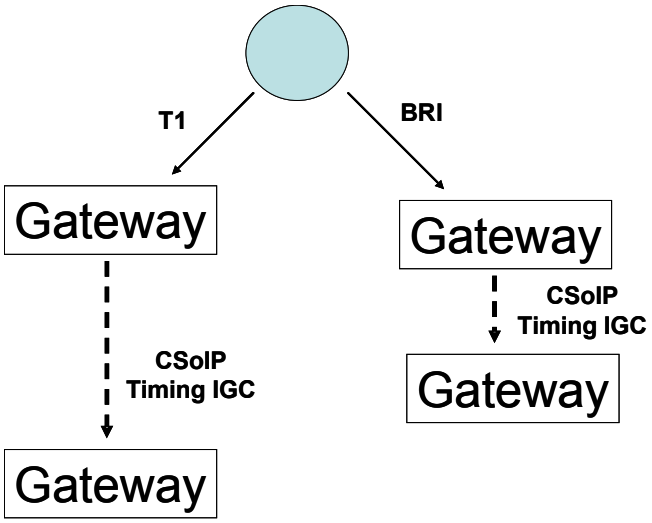

Figure 3 – Combined Synchronization

Note that the intention of CSoIP is to provide a drift-free VoIP timing circuit to gateways that do not have a T1/E1/BRI as a timing source. It is not recommended that CSoIP be used as a master clock source to a T1/E1/BRI.

3.3 Timing IGCs

The nature of T1/E1/BRI timing is that the circuit is always present; therefore the timing is always present. Since IP connections are normally torn down when completed to preserve transcoding resources, the CSoIP feature sets up a dedicated IP connection from the master to the slave system known as a “Timing Inter-Gateway Connection” or “Timing IGC”. This proprietary packet stream uses one 10ms G.711 VoIP channel and is not torn down.

Once this dedicated IP connection is setup, the gateway can derive the timing information from the IP packet streams sent across it.

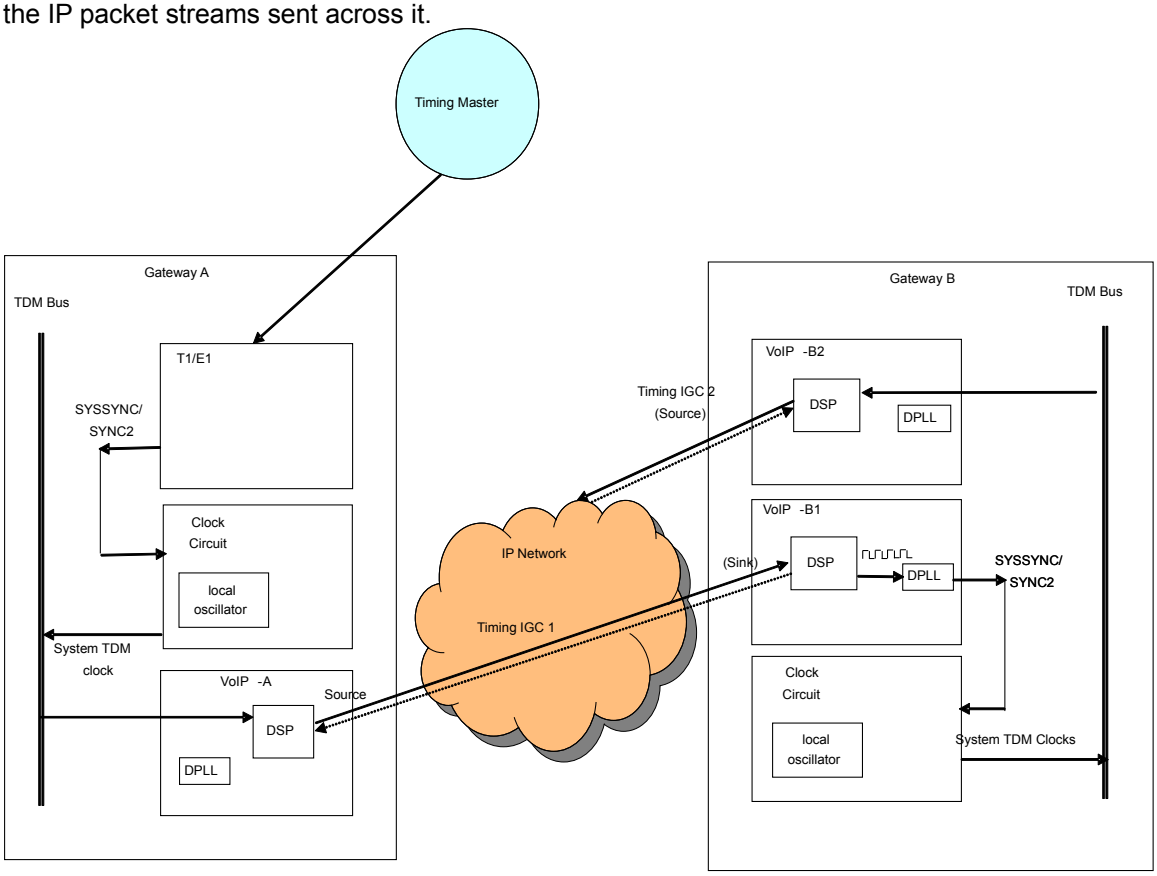

Figure 4 – Timing IGC

Figure 4 shows an example of a system with Gateway A and Gateway B. Gateway A uses timing from a master clock, through a T1/E1 trunk, as a reference for its system clock. A VoIP resource on VoIP-A on Gateway A runs off that clock, generates IP packet on Timing IGC1 toward a VoIP-B resource on Gateway B. VoIP-A acts as a Timing IGC source and VoIP-B acts as a Timing IGC sink.

3.4 Distribution of Timing IGCS

Communication Manager (CM) automatically creates Timing IGCs to distribute the clock reference to all of the gateways within the system that have CSoIP enabled.

1. CM automatically generates Timing IGCs to pass timing **from** Master gateways using T1/E1/BRI as a reference **to** Slave gateways within the same network region that were originally using their own local oscillator as a reference.

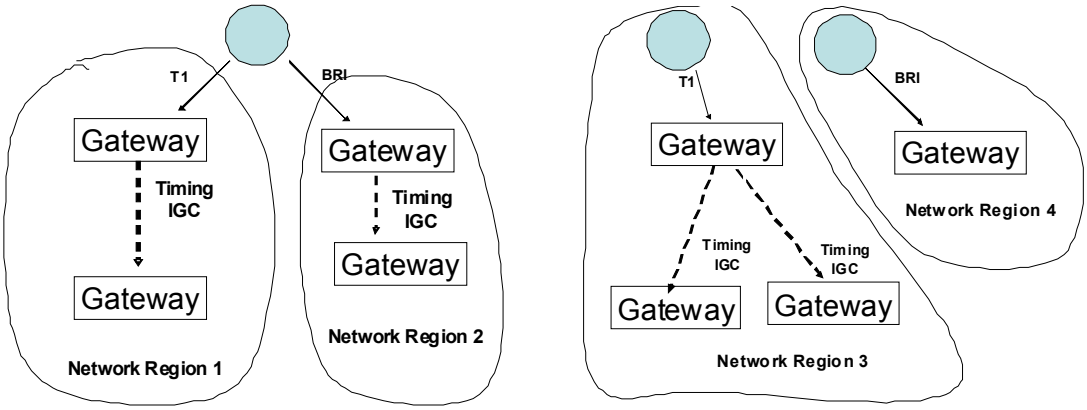

Figure 5 – Timing IGCs based on network region

2. CM creates a Timing IGC from the master to any network region with no T1/E1/BRI reference, and creates timing IGCs within that network region. In this case SRC is the external timing source.

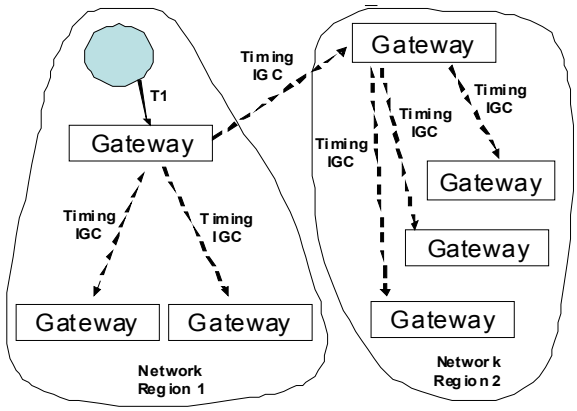

Figure 6 – Timing IGC Distribution between network regions

3. CM changes IGC distribution dynamically as a gateway changes its timing reference. The timing reference change could be from administrative action or from loss of signal error switching.

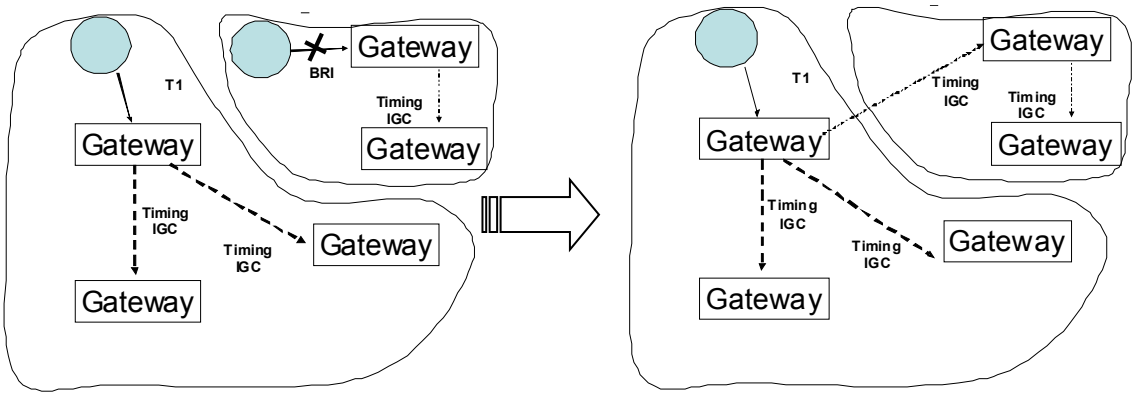

Figure 7 – Dynamic change - New timing IGC added

3.5 Synchronization Domains

Communication Manager organizes the Timing IGCs it creates into synchronization domains, also known as sync domains.

- A sync domain is a clock source that emanates IGC streams to clock receivers.
- A master domain is a clock source derived from a T1/E1/BRI, which is used to emanate IGC streams to clock receivers.
- All gateways within a sync domain are referred to as members.
- A master source is a gateway with an administered DS1 or BRI board. If there isn't any gateway with an administered reference board, a gateway is automatically chosen by CM as a default master and its local clock is used as a reference.
- Members that use an incoming IGC stream for internal clocking are known as slaves,
- A secondary clock domain uses an incoming IGC stream as a clock source which is then used to clock outgoing IGC streams to other members. A secondary clock domain is also known as a "Tandem Source".
- There can be several T1/E1/BRI boards capable of providing a reference from the PSTN, and each can be used by the CSoIP feature to provide sync to a group of members.

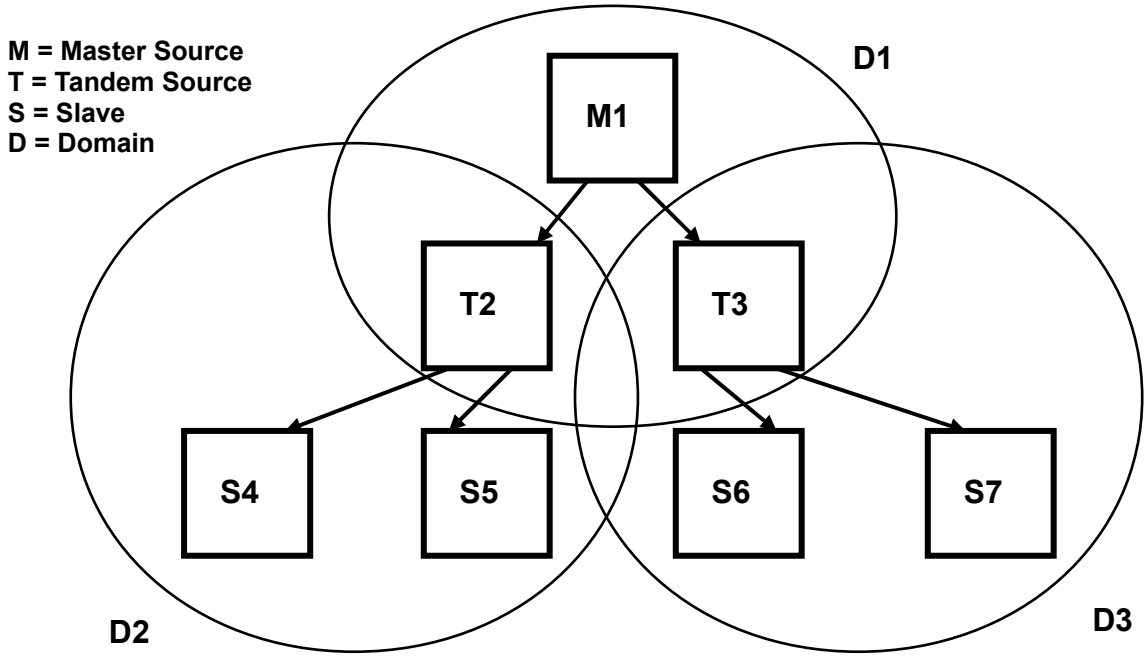

Figure 8 – Synchronization Domains

The maximum number of gateways supported by CM (250 gateways) cannot be sourced by a single clock source stream. The maximum number of gateways that can be sourced from a single clock source is known as the "fan-out" limit. The fan-out limit is equal to 10% of the number of channels available on the gateway, up to a maximum of 15. As a result of these fan-out limitations, some clock receivers will also become clocking sources, known as secondary or tandem clock sources. These, in turn, also constitute sync domains.

As gateways come into and out of service, the sync domains are created, modified, or deleted as needed. When the first IGC source comes into service, it becomes the default system clock source. All other IGC sources become slaves until the fan-out limit is reached. After the fan-out limit is reached, a slave is promoted to a secondary clock source. Subsequent receivers are then clocked from the secondary source until its fan-out is reached. Once this occurs, another slave from that sync domain is promoted to a tandem clock. This process will repeat as each clock source reaches its fan-out limit.

When a T1/E1/BRI board that is administered as a sync source comes into service, it is used to create a master clock domain if there is a VoIP DSP source already providing IGC streams. The highest level clock source that was the default system clock source is demoted and becomes a receiver of a master clock source and becomes a tandem clock. There can be as many master clock domains as there are administered sync sources.

3.6 Board Outages

The CSoIP feature does not attempt to mitigate any reference board outages. If a board goes out of service, the traditional sync feature raises an alarm and the customer will need to rectify the problem.

Removing a reference board from CM translations will cause the CSoIP feature to move any members that used it as a clock source to another source. Similarly, adding a new reference board could cause existing members to be moved to the new source.

4. ADMINISTRATION

4.1 Gateway - CLI

Prior to the introduction of CSoIP, selecting a sync source was done locally on the gateway using the “set sync interface”, “set sync source”, and “set sync switching” CLI commands. These CLI commands can still be entered locally on the gateway if the CSoIP feature is not enabled. However, if CSoIP is enabled, all clock sync administration must be done remotely using the CM SAT screens. Any attempt to enter these CLI commands locally on the gateway will result in the following message being displayed:

```
The gateway clock synchronization is currently remotely controlled.
Changes can only be made after local control is restored under
the 'change media-gateway' form on the controller.
```

The “`show sync timing`” command can be used to view the current clock synchronization status on the gateway and whether it is being controlled locally on the gateway or remotely by CM.

```
# show sync timing
SYNCHRONIZATION CONTROL: --- Remote ---

SOURCE     MM or VoIP           STATUS                    FAILURE
---------  -------------------  ------------------------
---------------
Primary    VoIP                 Active                    None
Secondary                       Not Configured
Local      v0                   -

Active Source: VoIP             Sync Source Switching: Enabled
```

Figure 9 – Gateway CLI command - show sync timing

4.2 Communication Manager - SAT

All administration of CSoIP is done from the CM SAT. The following describes the CM SAT commands that are used to administer and monitor CSoIP:

4.2.1 Administering CSoIP

`change|display system-parameters features`
specifies if IP synchronization feature is enabled (system-wide).

`add|change|display media-gateway <MG#>`
specifies if IP synchronization is enabled for the given gateway.

`change|display ip-network-region <NR#>`
specifies if IP synchronization is enabled for the given network region.

`add|change|display bri-trunk-board <slot>`
specifies whether the BRI trunk board can be used as a sync source.

`add|change|display ds1 <slot>`
specifies whether the DS1 board can be used as a sync source.

`change|display synchronization media-gateway <MG#>`
specifies which DS1 or BRI boards (if any) will serve as the Primary and Secondary sync references for a given gateway.

`list synchronization media-gateway`
shows all administered Primary & Secondary sync references.

`enable synchronization media-gateway <MG#>`
enables automatic sync source switching for a given gateway

`disable synchronization media-gateway <MG#>`
disables automatic sync source switching for a given gateway

`set synchronization <slot>`
sets which sync source is used for a particular gateway.
(Note: sync source switching must be disabled).

4.2.2 Monitoring CSoIP

`status ip-synchronization system-information`
shows the global status of the sync over IP feature.

`status ip-synchronization member media-gateway <MG#>`
shows the timing source for a given media gateway.

`status ip-synchronization master`
shows the master sync sources in the system.

`status ip-synchronization source media-gateway <MG#>`
shows all the media gateways whose sync is sourced by the given media gateway.

`status ip-synchronization oos-members`
shows all the members who are not synchronized and their service states.

4.2.3 Example output:

The following is an example of output with the following configuration:

- Master Source: Media Gateway 4 has BRI board administered in slot 2
- Slaves: Media Gateway 1 and 7

status ip-synchronization system-information

```
                IP Synchronization System Information
   Master Domain Count:   1
   Total Domain Count:    1
   Member Count:          3
   Max Level:             1
   Out of Sync:           0
   Building domains:      n
   Removing domains:      n
```

status ip-synchronization master

```
          IP Synchronization Master Members
Member  Ref Stat
   4V0   on-line
```

status ip-synchronization source media-gateway 4

```
           IP Synchronization Source Media Gateway 200

   Member                      DSP Status                    Tandem
                        Input                Output Sync
            Inp Jit Bad Ord Dup  Loss%      Lock   Ref
   7V0       Rec   n   n   n   n     0        yes    y        n
   1V0       Rec   n   n   n   n     0        yes    y        n
```

status ip-synchronization member media-gateway 1

```
           IP Synchronization Media Gateway
Member                      DSP Status
                    Input                Output Sync
           Inp Jit Bad Ord Dup  Loss%     Lock   Ref
1V0        Rec   n   n   n   n    0         yes    n
4V0        Rec   n   n   n   n    0
4V2
```

status ip-synchronization oos-members

```
                IP Synchronization Out Of Synch Members

Member                      DSP Status                 Role     Fail
                    Input                Output Sync           Reason
         Inp Jit Bad Ord Dup  Loss%       Lock   Ref
```

REFERENCES

The following documentation is available at http://support.avaya.com (Version 6.0.x):

- Administration for the Avaya G450 Media Gateway (03-602055)
- Administration for the Avaya G430 Media Gateway (03-603228)
- Avaya G450 CLI Reference (03-602056)
- Avaya G430 CLI Reference (03-603234)
- Avaya Aura® Communication Manager Change Description for Release 6.0.1 (03-603723)