Voice System Clocking

The Cisco Integrated Services Routers offer a variety of mechanisms for implementing and distributing clocking when connecting to external interfaces. This paper describes the clock accuracies delivered by service providers, clocking methods available within the Cisco Integrated Services Routers and considerations for deployments.

Networks operated by service providers, such as PSTN or WAN providers, typically act as the clock source to any customer premises equipment (CPE) platforms connected to these networks. The service provider edge equipment, in turn, derives its timing from a primary reference source (PRS) such as a stratum 1 clock or global positioning satellite (GPS) signal elsewhere in the network. Stratum levels define the allowable maximum frequency variance from the actual reference clock, and therefore the accuracy of the clock compared to coordinated universal time (UTC). Stratum clock types and their free run accuracy data are shown in Table 1.

Table 1. Stratum Clock Types and Free Run Accuracy

Clock Types	Free Run Accuracy
Stratum 1	+/- 1 x 10^{-11}
Stratum 2	+/- 1.6 x 10^{-8} (+/- 0.025Hz at 1.544MHz)
Stratum 3	+/- 4.6 x 10^{-6} (+/- 7.1Hz at 1.544MHz)
Stratum 4	+/- 32 x 10^{-6} (+/- 50Hz at 1.544MHz)

Specifications such as Telcordia GR-1244-CORE describe in more detail stratum-level clocking performance criteria and specifications.

A CPE platform connected simultaneously to more than one service provider network via two or more separate trunks (e.g., one or more PSTN, one or more WAN) results in two or more different clock sources entering the CPE system. The variance in frequency of these two or more clocks from one another depends on the accuracy (stratum level) of the clock provided on each trunk. If both are stratum 1 level clocks, clock slips between the two ports will be rare. As the stratum level of the clocks decrease (higher stratum number), the potential for clock slips increases.

Effects of Clock Slips and Corrections

Clock slip corrections on CPE system trunks affect traffic handling in different ways. A clock slip on a TDM port carrying voice calls to the PSTN is likely to be inaudible or may cause a slight blip in the speech path. The effect on a fax or modem may be more visible, as the fax/modem may retrain, or the call setup may fail and retry. A clock slip on an ATM interface may cause a cell, frame, or packet loss, and depending on the buffering algorithm and protocol retransmission logic, is unlikely to adversely affect the end-user traffic stream.

Preventing clock slips requires that TDM traffic operate within a synchronized timing environment. This includes all the elements involved in manipulating TDM traffic, including T1/E1 port controllers, digital signal processors (DSPs), and other components providing supporting functions to TDM traffic in addition to the bus or backplane of the system connecting the elements. After TDM traffic has been packetized into IP traffic, clocking considerations are generally decoupled from traffic forwarding.

Clocking and Timing Options

The Cisco 2800 and 3800 Series Integrated Services Router architecture provides several tiers of clocking and timing options, which includes the ability to completely separate each clock source into an isolated clock domain (for example, voice circuits from different carriers and/or ATM WAN circuits):

- **Tier 1**: The platform-level clock domain includes Voice/WAN Interface Card (VWIC) T1/E1 ports installed directly into VWIC slots on the Cisco Integrated Services Router, onboard second-generation Packet Voice DSP Modules (PVDM2), and functions supported by Advanced Integration Module (AIM) cards, all of which operate in the Cisco Integrated Services Router's motherboard clocking domain.
- **Tier 2**: In addition to this clock domain, each voice network module card provides an additional clocking domain for the ports connected to that network module as well as for PVDM2 and DSPs resident on that network module.
- **Tier 3**: These separate clocking domains can optionally be synchronized or coupled into a single larger domain if needed by using the "network clock participate" command in Cisco IOS® Command-Line Interface (CLI). The primary and optional secondary clock sources for the combined domain are also set by using the "network clock select" command in Cisco IOS CLI.

If clock slips between two service provider-connected ports, which are each clocked externally on a CPE platform, must be completely avoided, these connections must operate in separate clock domains within the platform. This configuration may not be necessary in typical network deployments depending on the stratum level of the clocks supplied to the CPE, meaning clock slips may be seldom. The service provider clocks may already be synchronized (external to the CPE) to the same clock source or if clock slips do occur they may not adversely affect traffic.

Deployments may utilize only the platform-level clock domain and not separate clock domains using individual voice network modules. This method results in a lower-cost solution, but may result in clock slips if the service provider trunks are not synchronized to one another.

Guidelines for Reducing Clock Slips

The following guidelines reduce the frequency of clock slips when using a single timing/clocking domain on CPE connected to multiple TDM and/or ATM WAN carriers. An example of a single timing domain is utilization of only the platform-level clock domain on the Cisco Integrated Services Router for TDM and ATM.

- Obtain the most accurate clock possible from the service providers providing TDM and ATM WAN circuits (e.g., a stratum 2 source is better than a stratum 4 source).
- Configure the CPE as the timing source for any TDM equipment at the site. For example, if the Cisco Integrated Services Router is connected to both the PSTN and a PBX, derive the clock source from the PSTN and configure the Cisco Integrated Services Router pass on that same clock source to the PBX.
- If the two service provider connections are from two different voice carriers (such as one local access and one long-distance provider), take the most accurate clock as the primary source and configure the second voice port to synchronize to the Cisco Integrated Services Router's backplane (which may produce rare clock slips on the port that is not receiving the clock source).

- If the two service provider connections are from one voice carrier (PSTN) and one ATM WAN carrier, configure the PSTN port as the clock source and have the ATM port synchronize to the Cisco Integrated Services Router's backplane (which may produce rare clock slips on the WAN port that is not receiving the clock source). ATM ports use the TDM backplane to access the AIM ATM card. Clock slips on the ATM interface are typically less impacting on overall traffic handling than clock slips on the PSTN interface, especially if some TDM ports (e.g., the EVM-HD FXS ports) on the Cisco Integrated Services Router are also connected to fax machines or modems.
- If the two service provider connections are from one voice carrier (PSTN) and one serial WAN (HDLC/PPP/FR) carrier, separate the two ports onto different VWICs and clock each port externally. Serial WAN ports on the Cisco Integrated Services Routers do not use the TDM backplane: The traffic is converted to non-TDM before it is forwarded from the VWIC so the clock domain for the serial interface can be confined to the VWIC itself.
- If clock slips must be avoided altogether, connect each service provider circuit to a separate clocking domain on the Cisco Integrated Services Router.

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Printed in USA C11-389903-00 1/07

