What is Timing and Synchronization?

Timing and synchronization is critical for network services that depend on precise, synchronized timing on network devices. Accurate and reliable synchronization of any network device helps manage the security, availability, and efficiency of the network devices. You can configure and synchronize the clocks on the routers so that the network displays accurate time.

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Basic Concepts of Timing and Synchronization

Synchronization

Synchronization is the alignment of clocks to the same time/phase and frequency and is categorized into frequency synchronization, phase synchronization, and time synchronization.

- **Frequency Synchronization**—ensures that all the Networking Equipments (NEs) operate at the same clock rate or frequency. Different NEs each have their own internal clocks. If NEs operate at varying frequencies, it could result in data loss, corruption, or misinterpretation, leading to dropped calls or reduced call quality in telecommunications networks. Frequency synchronization ensures all NEs operate in unison by matching the frequency of their clock to a source clock.

  There are four types of sources for frequency synchronization:

  - **Line interfaces** include Synchronous Ethernet (SyncE) interfaces.
  - **Clock interfaces** are external connectors for connecting other timing signals, such as BITS and GPS.
  - **PTP clock** If IEEE 1588 version 2 is configured on the router, a Precision Time Protocol (PTP) clock may be available to frequency synchronization.
  - **Internal oscillator** This is a free-running internal oscillator chip.

- **Phase Synchronization**—ensures that the phase of the signal is consistent throughout the network. Phase refers to a specific point in time on a waveform cycle. Phase synchronization ensures that all NEs agree on the timing of the "start" and "end" of each bit in a data stream. This is critical in applications where data from multiple sources have to be combined or compared. For instance, in a mobile network, phase synchronization ensures seamless handover between different base stations as a user moves.

  PTP is used to achieve phase synchronization across the network.

- **Time Synchronization**—also called Time of Day (ToD), ensures that all NEs agree on the current time, which is critical in applications where timing is crucial. For example, in financial transactions, it's vital to know the exact order in which trades occurred.

  Network Time Protocol (NTP) and PTP are used for time synchronization in the network. While NTP provides millisecond accuracy, PTP provides nanosecond accuracy, and also achieves phase synchronization.

Synchronous Ethernet (SyncE)

SyncE is an ITU-T standard that uses the physical layer (Ethernet interfaces) to provide frequency synchronization.

It’s a reliable source of frequency synchronization with a high precision. It integrates synchronization into the physical layer, eliminating the need for separate cabling or equipment. Since SyncE operates at the physical layer, it’s less susceptible to packet delays and jitter, making it robust and reliable, especially in heavy traffic networks.

However, SyncE only offers frequency synchronization. For applications requiring time or phase synchronization, another protocol, such as PTP, is needed. Also, SyncE requires support from both ends of a link. Therefore, every NE between the source clock and the edge needs to support SyncE to deliver frequency synchronization to the edge.

ESMC

Ethernet Synchronization Messaging Channel (ESMC) is a protocol defined in the ITU-T G.8264 standard and used to communicate Synchronization Status Messages (SSM) in SyncE networks. ESMC provides a way for nodes in a SyncE network to exchange information about the quality level of their synchronization source. This information can optimize network performance and facilitate switching to a different source if needed. By enabling nodes to select the best available synchronization source, ESMC enhances network resilience. If the current source fails, nodes can quickly switch to another source, minimizing the impact on network performance.

Enhanced ESMC

Enhanced Ethernet Synchronization Messaging Channel (ESMC) is an extension of the standard ESMC protocol. It incorporates features and improvements to augment the functionality and effectiveness of frequency synchronization in Ethernet networks. It introduces extra synchronization quality level indicators, providing more detailed and accurate information about the quality of the synchronization source. Enhanced ESMC enhances the ability of the network to respond to changes or failures in the synchronization source, which allows for faster and more precise switching to alternative sources when required.

GPS, an external Clock Interface

Global Positioning System (GPS) for frequency synchronization refers to the use of GPS signals to provide an accurate frequency reference for devices in a network. GPS satellites carry highly stable atomic clocks that provide precise time signals, which can be converted into frequency references by a GPS receiver.

Due to the atomic clocks on GPS satellites, GPS provides highly precise time and frequency information. As long as there's a clear view of the sky, GPS signals can be received almost anywhere worldwide, making it ideal for synchronizing geographically dispersed devices. Also, because GPS synchronization doesn't rely on network infrastructure, it's less prone to network-related issues like congestion or failures.

However, factors like weather conditions or indoor locations can cause loss or degradation of GPS signals, which would mean losing synchronization. Implementing GPS synchronization also requires GPS receivers and antennas, which can increase setup cost and complexity.

Configure GPS, an external Clock Interface for Frequency Synchronization section details the configuration steps involved for frequency synchronization using GPS.

BITS, an external Clock Interface

Building Integrated Timing Supply (BITS) uses a centralized clock to generate a timing signal, which is then distributed to the equipment in the network to ensure they operate in sync. It's typically used in single buildings, campuses, or data centers where there's a need to synchronize many NEs within a confined area. However, it's less suitable for wide-area or geographically distributed networks.

BITS systems typically use high-quality oscillators, providing a stable and accurate reference frequency. In contrast to GPS, BITS doesn't rely on external systems, making it less susceptible to external disruptions or control.

BITS systems require dedicated infrastructure and regular maintenance to ensure their accuracy and reliability. As BITS relies on a centralized clock, any failure or issue with this clock can disrupt synchronization throughout the entire network.

Configure BITS, an external Clock Interface for Frequency Synchronization section details the configuration steps involved for frequency synchronization using BITS.

Precision Time Protocol (PTP)

PTP delivers time synchronization services with precise time and frequency over packet-based networks. PTP can synchronize the real-time clocks of NEs with nanosecond accuracy. It's not tied to specific hardware or physical layer protocols, making it flexible and broadly applicable across various network types and architectures. It can scale to large networks and support many devices, making it suitable for large industrial, scientific, or telecommunications networks.

PTP messages can create a significant load on the network, potentially affecting network performance, particularly in large, or high-traffic networks. Network conditions such as latency, jitter, and packet loss can affect the accuracy of PTP. While PTP includes mechanisms to compensate for these factors, they can still impact the synchronization accuracy.

PTP lets you define separate profiles to adapt itself for use in different scenarios. G.8265.1 profile fulfills the frequency synchronization requirements in telecom networks, while G.8275.1 profile fulfills the ToD and phase synchronization requirements.

Network Time Protocol (NTP)

NTP provides time synchronization to all devices on a network. The primary NTP servers are synchronized to a reference clock, such as GPS receivers and telephone modem services. An NTP server receives the time service from a time source, a clock that is attached to a time server, and then distributes and synchronizes the time across all devices on a network. NTP provides millisecond accuracy in synchronizing network device clocks.

NTP is a versatile protocol that operates independently of specific hardware or network architectures. It can be applied to a range of network environments, from small local networks to large, geographically dispersed ones.

NTP is less precise than PTP, making it unsuitable for applications needing extreme precision. Furthermore, since NTP is an older protocol, it has been targeted by various types of attacks. While security measures exist, managing NTP security can be a concern.