

Timing and synchronization

A timing and synchronization system is a network infrastructure component that

- ensures precise alignment of time across network devices,
- supports the security and efficiency of time-dependent network services, and
- enables accurate logging, data correlation, and coordinated operations.

Accurate timing and synchronization help you manage network security, availability, and efficiency by ensuring that all devices share the same time base. Configure and synchronize clocks on routers and switches to ensure the network displays accurate time. Accurate time is critical for troubleshooting, auditing, and maintaining network integrity.

- Network Time Protocol (NTP) is commonly used to synchronize router clocks.
- Time-sensitive applications, such as financial trading or telecommunication services, rely on precise network synchronization.

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Synchronization

A synchronization is a network timing mechanism that

- aligns the clocks of network elements to the same time, phase, and frequency,
- prevents data loss, corruption, or misinterpretation caused by desynchronized devices, and
- supports accurate operation of applications that require precise timing.

Frequency synchronization ensures all networking equipment (NEs) operate at the same clock rate or frequency, preventing issues like data loss or call quality degradation.

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 the phase of signals is consistent across the network, so devices agree on the timing of data bits, critical for functions like seamless mobile handover. Phase synchronization is achieved mainly using PTP.

Time synchronization also called Time of Day (ToD), ensures network elements agree on the current time for applications requiring precise timing, such as financial transactions. Time synchronization is achieved using NTP (millisecond accuracy) and PTP (nanosecond accuracy).

Synchronous Ethernet (SyncE)

A Synchronous Ethernet (SyncE) is a network synchronization technology that

- uses the Ethernet physical layer to deliver precise frequency synchronization,
- integrates synchronization directly into existing Ethernet infrastructure, and
- eliminates the need for separate synchronization equipment or cabling.

SyncE is defined by the ITU-T and relies on Ethernet interfaces for transport. Because it operates at the physical layer, SyncE is robust against packet-based issues such as delay and jitter, making it especially reliable in high-traffic environments.

However, SyncE only provides frequency synchronization; applications requiring time or phase synchronization need additional protocols such as the Precision Time Protocol (PTP). Every network element between the source and destination must support SyncE to extend frequency synchronization to network edges.

ESMC

A Ethernet Synchronization Messaging Channel (ESMC) is a SyncE protocol that

- communicates Synchronization Status Messages (SSM) as defined in ITU-T G.8264,
- allows SyncE network nodes to exchange information about the quality level of their synchronization source, and
- enables nodes to optimize network performance by selecting and switching to the best available synchronization source.

ESMC helps you maintain network resilience. If your current synchronization source fails, your nodes can switch to another source. This process minimizes the impact on network performance.

Enhanced ESMC

An Enhanced Ethernet Synchronization Messaging Channel (ESMC) channel is an Ethernet synchronization messaging mechanism that

- extends the standard ESMC protocol with additional features,
- provides extra synchronization quality level indicators for improved accuracy, and
- enables faster and more precise network switching to alternative synchronization sources during failures or changes.

Enhanced ESMC channels improve network responsiveness and allow for better management of frequency synchronization within Ethernet networks by providing more detailed data about the synchronization source quality.

GPS, an external clock interface

A global positioning system (GPS) is a satellite-based timing and navigation technology that

- transmits highly accurate time and frequency signals from atomic clocks in orbit,
- enables precise synchronization for geographically dispersed devices, and
- functions independently of terrestrial network infrastructure.

Use GPS for frequency synchronization to obtain precise timing and frequency references from atomic clocks on satellites. A GPS receiver uses these references to synchronize network devices. Most locations with a clear view of the sky can receive a GPS signal. This capability makes GPS ideal for institutions with distributed equipment.

Configure GPS settings for the grandmaster clock section details the configuration steps involved for frequency synchronization using GPS.

BITS, an external clock interface

A Building Integrated Timing Supply (BITS) system is a timing distribution system that

- uses a centralized clock to generate timing signals distributed to network equipment,
- relies on high-quality oscillators to ensure a stable and accurate reference frequency, and
- operates independently from external systems such as GPS.

Use BITS systems for single buildings, campuses, or data centers, not for wide-area or geographically distributed networks. BITS systems synchronize many network elements (NEs) within a confined area. Use dedicated infrastructure and perform regular maintenance to maintain accuracy and reliability. If the centralized clock fails, synchronization across the entire network will be disrupted.

For configuration steps, see the Configure BITS, an external Clock Interface for Frequency Synchronization section.

Precision Time Protocol (PTP)

A Precision Time Protocol (PTP) is a time synchronization protocol that

- delivers precise time and frequency synchronization over packet-based networks,
- operates independent of specific hardware or physical layer protocols, and
- scales efficiently across large industrial, scientific, and telecommunications networks.

PTP can synchronize the clocks of network elements (NE) with accuracy of 1 nanosecond (0.000000001 seconds), making it suitable for high-precision environments. It is flexible and widely applicable across many network architectures.

PTP traffic affects network performance, especially in large or high-traffic networks. Latency, jitter, and packet loss reduce synchronization accuracy. PTP includes mechanisms that mitigate these problems.

PTP profiles allow adaptation for specific use cases. For example:

- The G.8265.1 profile fulfills frequency synchronization requirements for telecom networks.
- The G.8275.1 profile meets time of day (ToD) and phase synchronization needs.

Network Time Protocol (NTP)

A Network Time Protocol (NTP) is a time synchronization method that

- synchronizes clocks among devices on a network using primary reference clocks,
- operates independently of hardware and network architecture, and
- provides accuracy of 1 millisecond (0.001 seconds) in time coordination.

NTP servers obtain time from reference clocks, such as Global Positioning System (GPS) receivers or telephone modem services. Then they distribute synchronized time to network devices. You can use NTP in small local networks or in large environments spread across different locations.

Use PTP instead of NTP for applications where extremely high precision is required. Because it is an older protocol, NTP can be targeted by various types of attacks. To manage NTP security, you must take extra precautions.