

The Role of Precise Timing in High-Speed, Low-Latency Trading



The race to zero...nanoseconds.

Whether measuring network latency or comparing real-time trading data from different computers on the planet, the common denominator is a precise time stamp. As trading networks and the computers connected to them get faster, the accuracy and precision of the time stamp must continuously improve.

Precise and accurate time stamps are used in a variety of places and purposes in the trading system

- Latency measurements across networks and up software stacks
- Server-to-server time synchronization
- Synchronization to universal time
- Network elements capable of time distribution

Accuracy and Precision

Accuracy and precision are key attributes that are equally essential to the success of any time sensitive trading system. A clock that keeps time precisely (i.e., with very little variation second to second) should still be referenced to a more accurate time source along with all of the other clocks in the system. This way the time across multiple servers either locally or worldwide will be more accurately bounded in time relative to one another.

Start with Accuracy

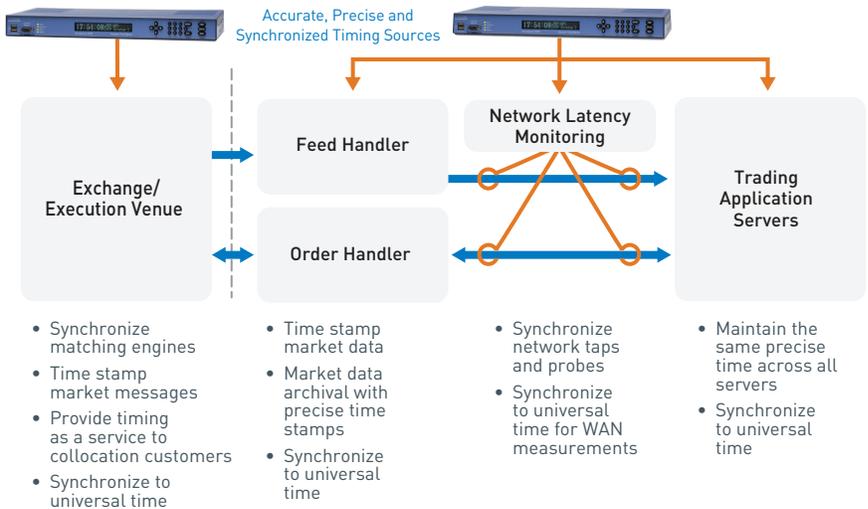
The Symmetricom® comprehensive time synchronization solutions provide varying degrees of accuracy depending on the trading application requirements. The key here is that the accurate and precise time be delivered to the application when it needs it. Time delivery can be over a



network to an application using a high accuracy timing protocol, like Precision Time Protocol (PTP) or even via a dedicated timing signal infrastructure, depending on the system(s) being synchronized.

Symmetricom End-To-End Time Synchronization

Symmetricom’s versatile end-to-end time synchronization solutions make it easy to synchronize the most demanding trading requirements. Efficient time synchronization uses a hierarchal time distribution model. Start with the versatile SyncServer® Network Time Server as the master to distribute time to a variety of clients and slaves. The clients can be either software or hardware based depending on the accuracy requirements.



- Synchronize matching engines
- Time stamp market messages
- Provide timing as a service to collocation customers
- Synchronize to universal time

- Time stamp market data
- Market data archival with precise time stamps
- Synchronize to universal time

- Synchronize network taps and probes
- Synchronize to universal time for WAN measurements

- Maintain the same precise time across all servers
- Synchronize to universal time

Precise timing locations in the trading network.

Applications that need single digit microsecond accuracy for the trading application can use a LAN based solution with a SyncServer as the local PTP grandmaster clock and PTP optimized software at the slaves. Sub-microsecond time accuracy across the LAN replaces software slaves with a PTP clock card in each server to deliver precise nanosecond caliber time to the server’s memory for application access.

Why Time Servers Matter

The Symmetricom SyncServer Time Servers are a critical resource in the network for precise time. Whether in the rack at distributed venues or in the main data center, these clocks provide a variety of timing outputs to deliver precise timing to trading operations. These feature rich and easy to use SyncServers can also assure the availability of the precise time by integrating atomic clocks for improved performance.



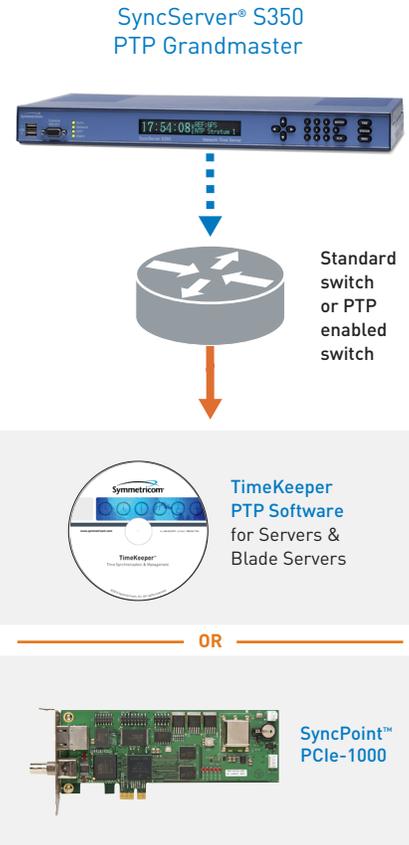
Delivering Accurate Time.

Precise Time to the Trading Application

An accurate and precise time stamp matters only when a critical trading application needs it. Symmetricom timing solutions deliver that time stamp to the application with extremely low latency and outstanding time accuracy. TimeKeeper™ software for Linux can deliver single digit microsecond accurate time. If sub-microsecond accurate time is needed, the Symmetricom bc750PCIe PTP Clock Card synchronizes with the SyncServer over the network and writes the sub-microsecond accurate time to host memory. The time is updated so fast that an application can read the time over a million times per second and get precise monotonically advancing time stamps with every read.

Measuring Time Accuracy in Different Network Topologies

Trading system network architects are faced with several choices in distributing time. They include; running timing packets in-band with market data, out-of-band, or deploying PTP enabled switches (called boundary clocks or transparent clocks). The SyncServer end-to-end solution can be configured to work well in all cases. In fact, features in the SyncServer can make time transfer accuracy measurements to help you decide the best network timing topology for your application.



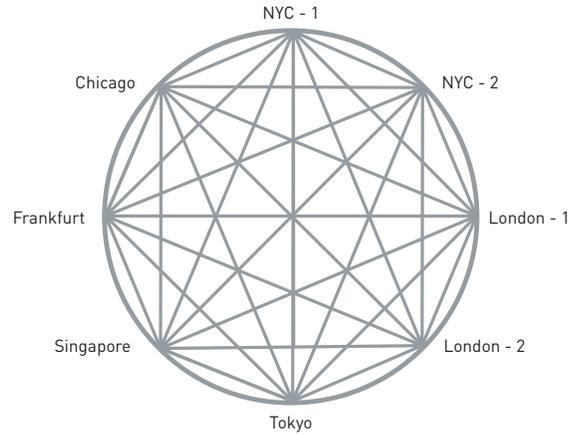
End-to-End price time synchronization



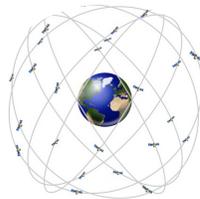
Accurate Worldwide Time Stamps

Time stamp accuracy is essential when time stamping market data that is collected at different venues located across town or around the world. These critical system clocks need to be referenced to the same exact time scale. Enter Global Navigation Satellite Systems (GNSS), such as GPS.

The Symmetricom SyncServer Network Time Servers synchronize within nanoseconds of each other anywhere on the planet via the GPS satellite system. These SyncServers in turn synchronize the critical trading systems at the different venues. The result, time stamps on trading data are well correlated in time with data collected elsewhere around the planet. This facilitates better decision making and the ability to save historical data with very high time stamp accuracy and integrity.



Precise time synchronization for trading networks



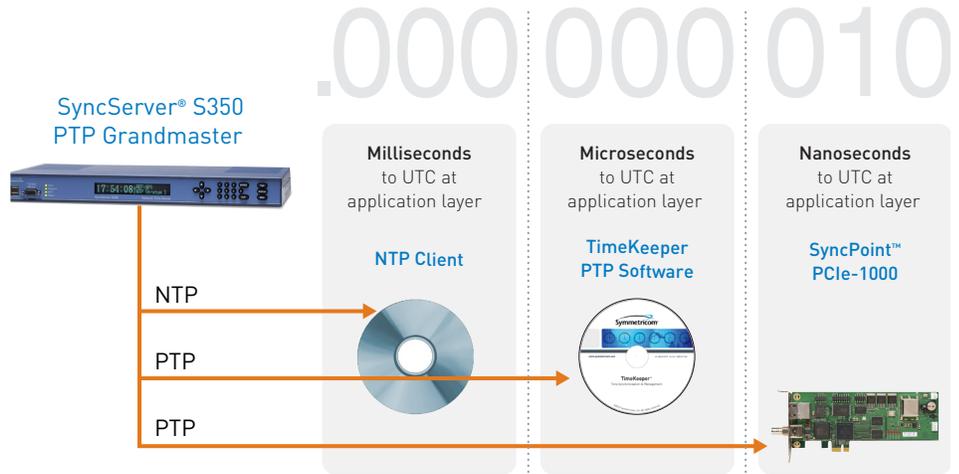
The Global Positioning System (GPS) is a satellite navigation system that provides position and time information. Each satellite has several atomic clocks onboard and this time is precisely transferred to SyncServers on the ground. GPS is the accurate global time reference used to synchronize trading systems anywhere on earth provided the SyncServer GPS antenna has a reasonably clear view of most the sky (in any type of weather even). Since the satellites are continuously moving, SyncServers can track as few as 1 satellite and maintain accurate time. With the optional rubidium atomic clock it can even maintain precise time during periods of no visible satellites.



Selecting the Right Time Protocol and Technology

Time precision and accuracy can be improved by your selection of time protocol and deployment. It all has to do with clock drift and timing packet delays. Clocks naturally drift and if you use a protocol like NTP in its standard form to correct the clock, time packets are exchanged between the client and the server no faster than once every 16 seconds. This provides time typically in the single digit millisecond realm of time accuracy using NTPd.

If you use PTP software, the timing packets can be exchanged at much higher rates allowing the PTP software to better steer the server clock and accommodate some of the network induced packet delays. This can get time accuracy into the 10 of microsecond realm assuming the PTP software has good packet filtering and servo algorithms.*



Packet delays are not only caused by the network but also between the network interface card and the software application in the server (stack delay). By using the PTP packet hardware time stamping present in both the SyncServer and the PTP clock card, these delays are eliminated. Thus the only time error inducing packet delays are related to the intervening network.

If PTP hardware time stamping and increased timing packet exchange rates are combined with a high quality OCXO oscillator, it becomes possible to synchronize a PTP clock card to a master to better than 10 nanoseconds. Moving that time to an application running in the server can result in time accuracy at the application layer as good or better than six hundred nanoseconds accuracy to the master.



*See the Symmetricom whitepaper titled "A Comparison of PTP Software Slave Accuracy, Precision and Effectiveness"

Symmetricom's End-to-End Low Latency Trading

SyncServer S300/S350
PTP Grandmaster



TimeKeeper
PTP Software



SyncPoint™
PCIe-1000



KEY FEATURES

- IEEE 1588-2008 v2 PTP Grandmaster functionality
- Hardware based time stamping
- Any S300/S350 can upgrade to PTP support with hardware time stamping via easy software upgrade
- PTP Slave Activity monitoring from SyncServer
- PTP Grandmaster internal performance monitoring
- Chart key PTP performance metrics from web interface
- Sync Interval rates up to 64/second
- Up to 4000 Delay_Requests processed per second
- S350: Real-time, time interval measurements and statistics of PTP slave 1PPS accuracy
- S350: Real-time charting of time interval data in time series or histogram formats

KEY FEATURES

- Kernel level PTP and NTP Linux time client
- Easy plug-and-play installation
- Transparent to applications and legacy timekeeping utilities
- Improves time accuracy and determinism of local clock and system-wide time synchronization
- No application software modifications required
- Minimal impact on system load and throughput
- Improves log file timestamp accuracy
- Easy installation on commercial and in-house Linux distributions
- Multi-core machine friendly

KEY FEATURES

- 10 ns accuracy to master, typical
- 10 ns time stamping precision
- Gigabit Ethernet interface
- Very stable OCXO oscillator standard
- Precision 1PPS output
- DMA time writes to host memory with accuracy as good or better than 600 ns
- Time available in major.minor or total nanoseconds
- Linux driver with application source code included
- IEEE 1588/PTP 2008 compliant
- Low profile PCIe form factor



Symmetricon. Leading the world in precise time solutions.

