

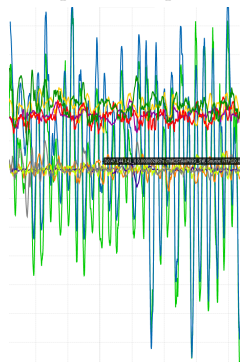
# Solved problems in enterprise clock synchronization

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**T**imekeeper Suite is a well tested, widely used production technology for time synchronization in the exceptionally demanding financial trading environment. TimeKeeper is used in production in exchanges, Tier1 banks, and leading edge automatic trading platforms providing capabilities that are still considered hard research problems or "to-be-done" in standards bodies and firms that committed to older technologies.

**Figure 1:** *TimeKeeper multiple source monitoring.*



## TimeKeeper

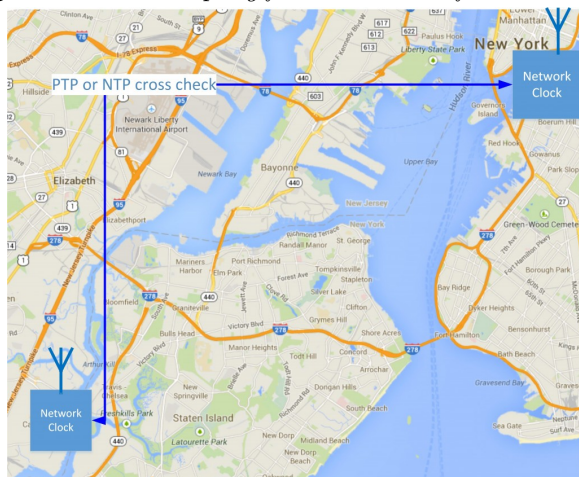
- Multi-source operation with automatic failover on time sources.
- Detection of faulty, compromised or spoofed time sources.
- Synchronize to within 100 Nanoseconds using GPS time source or pulse-per-second.
- Full support for NPT and PTP and multiple-sources mixing both. Synchronize to within 250 Nanoseconds of PTP and NTP sources. (It is widely and incorrectly believed in the industry that NTP accuracy cannot reach the levels TimeKeeper routinely achieves in production systems.)
- GrandMaster, Boundary Clock, and PTP Stratum Server operation.
- Automatic holdover when no source is available.
- Comprehensive alerting via SNMP, email, and/or logs for selectable events including warn-

ing of protocol failures or changes in one-way delay.

- Smart self-configuration and tuning without operator intervention.
- Configurable management so that one or more instances can monitor thousands of others.
- Powerful web based graphical presentation of timing data, including management data.
- Graphical tool to display map of time distribution
- 10Gbps and Infiniband native support.
- A 10Gbps native Time Server Appliance that supports both PTP and NTP.
- High quality time synchronization of virtual machine instances.
- Archival storage of audit trace of multiple sources.

## Examples.

**Figure 2:** *Cross coupling for monitor and fault-tolerance.*

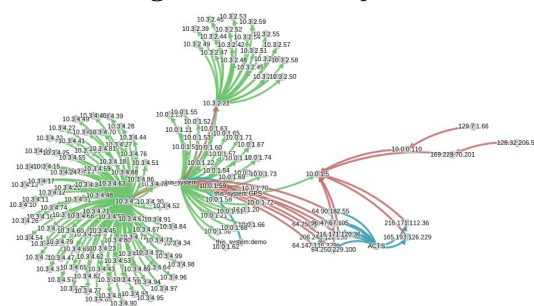


- There are a number of TimeKeeper installations where two or more TimeKeeper GPS Servers are cross linked with a high quality network link and one PTP or NTP feed going in each direction. Each server then has a primary source from GPS (using a GPS module with an attached high quality OXCO ). The two servers

then cross check each other, generating alerts if time is not synchronized sufficiently well - 1/2 microsecond is reasonable. In case of GPS failure, each server will seamlessly failover to the network time source and will return to GPS when the GPS signal is restored. The architecture can be expanded to many servers and many cross links, depending on level of fault-tolerance needed and available networking.

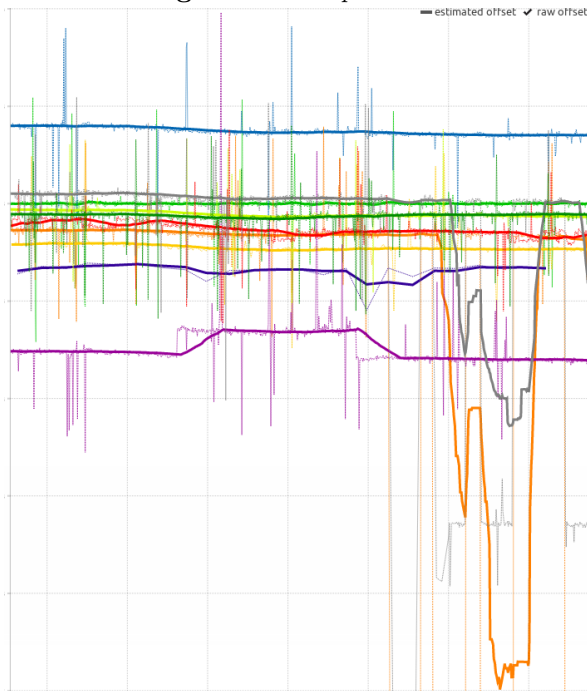
- Time Map. The Time Map provides a visualization of the entire timing network as seen from the client or server. TimeKeeper's protocol agnostic approach lets it analyze PTP (green), NTP (red), and signals like GPS (blue). Time Maps have been used by IT personnel in many cases to diagnose otherwise obscure problems in time distribution networks.

**Figure 3:** *Time Map.*



- The combination of the web based graphical tool and the multi-source capability provides an view of multiple sources of different quality.

**Figure 4:** *Multiple sources.*



alternative free-software tools and those additional capabilities provide the difference that keeps systems running.



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- 10Gbps Time Server. All the software management and high quality time synchronization, multi-source and failover capability, plus a high end server platform with IPMI and dual power supplies, and capability of archival storage of years of management data.

**Figure 5:** *Spectracom Velasync with TimeKeeper technology.*



- TimeKeeper multi-source capability and high quality synchronization through NTP allows low cost, low disruption modernization of time synchronization networks. Instead of highly disruptive changes to distribute PTP multicast everywhere, NTP distribution can be upgraded and mixed and matched with PTP to produce highly resilient networks.

TimeKeeper is synchronizing clocks of the fastest distributed transaction serving systems in the world - those used by high frequency financial traders. It offers capabilities that are far beyond those of the