Symmetricom®

Timing Two Different Networks with One TimeSource

APPLICATIONS NOTE

Timing Two Different Networks with One TimeSource

Network Synchronization Versus Network Time

Network synchronization is the process of providing an extremely stable frequency reference across a telecommunications network or networks. The frequency, or sync, reference keeps all the telecom network elements in sync such that data is read (or clocked) in and out a the same rate and does not get dropped or become unintelligible as it passes through the network. Synchronization Primary Reference Sources (PRS) using specialized GPS receivers are widely used to provide the necessary extremely stable frequency reference for telecom networks. Synchronization distributors are used in conjunction with the PRS clock to distribute the sync reference to all the network elements within the telecom network.

Network time is the process of providing an accurate timestamp to all the clocks residing in the computers and other datacom equipment that are connected together across a datacom network. The timestamp provides a single, coordinated time of day data packet. Time primary reference sources, also known as TimeServers, provide the accurate timestamp that is distributed across the datacom network over the Internet or via a direct Ethernet connection to a private LAN.

Products that use GPS technology to provide network synchronization have been on the market for many years. Likewise, products that use GPS technology to provide network time have also been on the market for many years. A new generation of products that provide network synchronization and network time in one single system is now becoming available. This white paper introduces network time concepts, network time implementation alternatives including implications of NTP and SNTP, and emerging integrated network synchronization PRS and network TimeServer products.

FIG.1 TimeSource Primary Reference Source and TimeServer.

So, Why Synchronize Time?

Time, by definition, is a non-spatial continuum in which events occur in apparently irreversible succession from the past through the present to the future. In other words, one could simply say that time just advances. One wristwatch can be one or two seconds off from another wristwatch but as long as they both advance, what difference does it make to Everyday Joe? Absolutely nothing!

Things start to change significantly when computers are brought into the picture. Computer clocks, like most electronic clocks, detect the oscillations of a quartz crystal and calculate the passing time

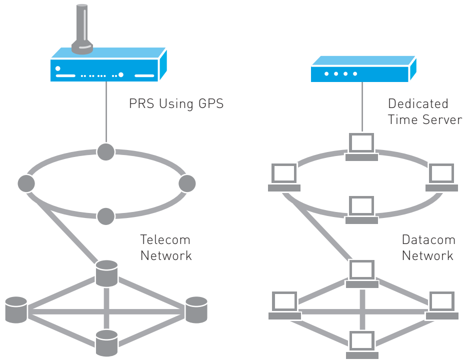

FIG.2 Dedicated PRS and TimeServers require separate equipment,installation and maintenance.

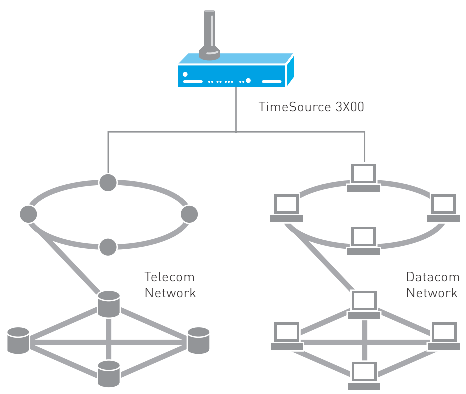

FIG.3 TimeSource provides single network synchronization and network time in one single system.

based on these oscillations. The physical properties of the quartz crystal exhibit a gradual change with time, resulting in a cumulative frequency drift called ageing. Ambient temperature changes also result in frequency drift. Large temperature variations usually result in a significant quartz time error. Power supply noise, magnetic fields, air humidity, air pressure, vibration, etc will also cause time errors. As a result, a typical computer clock can lose or gain from several seconds to more than a minute per week if left free running (not synchronized). This, plus the fact that while one quartz crystal may be gaining time another may be losing it, will easily cause the time on two computers to differ.

On standalone computer applications, database systems using transactions and crash recovery need to know the time of the last good state. If there are communicating programs running on different computers with different times, switching between computers will cause time to jump forward and back. Isolated networks may run their own incorrect time, but once the network is connected to the Internet, the effects of having incorrect time will be apparent. Adjusting the clock by stepping time backwards is worse than having inaccurate time. A very simple example would be receiving an email message a minute before it was really sent. More important applications for synchronized time include: billing, fault isolation, air traffic control, network security, and almost any on-line transaction processing system.

How to Synchronize Computers?

Synchronizing computers in a network requires three elements:

- A time reference (or standard)
- A mechanism to acquire the time reference
- A mechanism to distribute the time over the network

The time reference can be either a network time stratum 1 server available via Internet access or Coordinated Universal Time (UTC) via the Global Positioning System (GPS). Advanced Communications Technology Satellite (ACTS) dial up is a third, rarely used option.

The most popular time reference is UTC obtained via user-owned GPS receivers. This method results in a highly accurate, secure, inexpensive and user controlled solution. UTC is the basis for legal time worldwide. GPS is usable in all weather conditions and continuously available worldwide with no applicable user fees. GPS receivers acquire time from the constellation of GPS satellites. The satellite time is continuously monitored and corrected by ground stations connected to UTC. This provides precision of billionths of a second. The GPS receiver then distributes the time throughout the network using the Network Time Protocol (NTP) or Simple Network Time Protocol (SNTP). GPS receivers are very secure because they can be installed behind the network firewall and self-contained within the LAN. The user can choose to distribute the time packets across a MAN or WAN.

Accessing time via the Internet is also popular because it is free. However, the Internet is not secure, and it is a network firewall hole. This can lead to many problems, from the relatively harmless hacker spoofing the system into accepting inaccurate time packets to a severe all out hacker network attack. Since NTP was designed to be distributed over the Internet with many stratum 1 sources from all over the world, sophisticated algorithms are contained within NTP to deal with network latency (delay) issues and peer-to-peer communications. These sophisticated algorithms aren't necessarily needed if only one stratum 1 source is used and the time is not obtained via the Internet (for example, in a private network using a GPS stratum 1 source). This is one reason why SNTP was developed. More about NTP versus SNTP is discussed in the next section.

NTP Versus SNTP: What is NTP?

Network Time Protocol (NTP) is an Internet protocol for synchronizing computer clocks across the network to standard time, and is also a program (NTP daemon with utilities) that implements the protocol and controls the computer clock. Both the protocol and software were developed by Professor David L. Mills from the University of Delaware. The full NTP implementation is specified in RFC-1305 [MIL92].

Internet NTP servers are arranged in hierarchies. Stratum 1 servers, at the top of the hierarchy, always act as the absolute source of time for the hierarchy below them. Below stratum 1 servers are many stratum 2 servers and stratum 3 servers below that and so on. NTP supports up to 15 different stratums, but being closer to the top implies being closer to the most accurate source of time. Clients, which are computers and other types of equipment with NTP client "freeware" loaded onto them, request (a.k.a., ping) servers for the time packet. NTP servers and clients don't blindly accept another system's notion of time, even if it comes from a higher stratum.

What is SNTP?

Simple Network Time Protocol, SNTP, is a subset of NTP. SNTP is used when the full NTP implementation is not required or justified.

SNTP uses the standard NTP timestamp format described in RFC-1305. SNTP can operate in either unicast (point to point) or broadcast (point to multipoint) modes like NTP. Both NTP and SNTP are clients of the User Datagram Protocol (UDP) [POS80], which itself is a client of the Internet Protocol (IP) [AR81] like NTP.

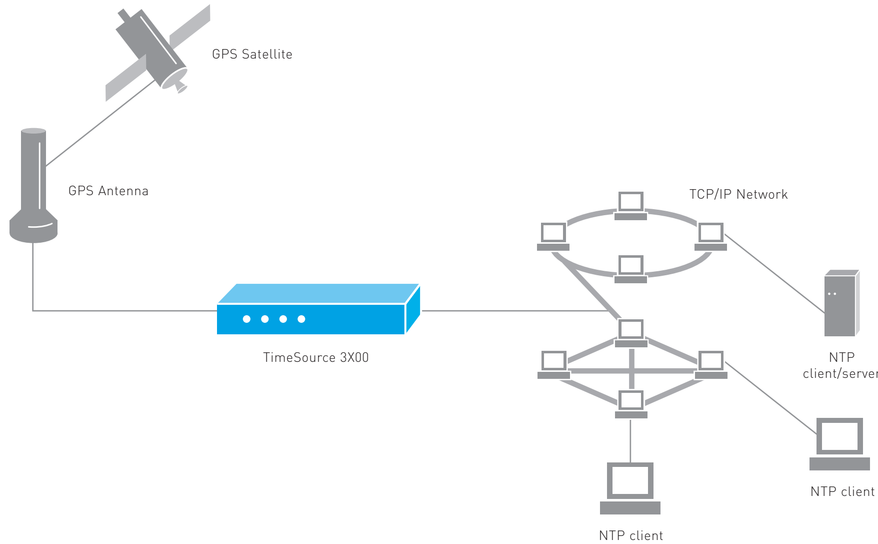

FIG.4 GPS TimeServers provide UTC traceable time for datacom networks.

SNTP does not:

- Implement the full set of NTP algorithms intended to support redundant peers and diverse network paths
- Calculate upstream network delays

For these reasons, SNTP is used at the edges of the synchronization subnet or in private networks. This means:

- SNTP clients operate at the highest stratum of the subnet and in configurations where peer-to-peer client synchronization is not utilized
- SNTP servers operate at the stratum 1 of the subnet and in configurations where no other Internet source of time is utilized

Dedicated TimeServers

All dedicated TimeServers currently available require a roof mount GPS antenna and clear view of the sky. Total cost of ownership includes hardware, installation and maintenance. This is important to note because installation and maintenance costs can be significantly more than the hardware costs. This is due to the need to access the roof to mount the antenna and run the cable from the roof to the receiver equipment located within the building. Depending on the specifics of the site, roof rights may need to be negotiated and purchased, cabling may need to be run and holes cut through several floors. Unfortunately, it is not uncommon for the TimeServer installation to fail because access to the roof is impossible or because portions of the sky are blocked by tall buildings.

TimeSource 3X00 as SNTP TimeServer

Symmetricom's TimeSource 3X00 family of standalone stratum 1 primary reference sources can now be used to synchronize computers in your network by distributing stratum 1 time using SNTP via the Ethernet port and associated IP address. Figure one illustrates the recommended configuration for a TS 3X00 product as an SNTP server. The TimeSource 3X00 unit is at the root of the subnet where it is receiving timing directly from GPS via an antenna.

With Symmetricom's TimeSource 3500 and 3600, computers can be synchronized to UTC via GPS without the expense and hassle of mounting the antenna on the roof. This is because the TimeSource 3500/3600 uses a window or wall mounted GPS antenna which greatly reduces installation and maintenance costs. In addition, all of Symmetricom's TimeSource 3X00 family GPS receivers can be managed locally or remotely via TimeScan Craft, TimeScan NMS, or TimePictra to monitor SNTP alarms and GPS status.

Redundancy can be achieved using a second TimeSource 3X00. New units can be ordered with the SNTP feature while existing units in the field are easily upgraded. No additional hardware is required. In fact, TimeSource 3X00 units operating for many months as a network PRS have been upgraded with the TimeServer software and are working reliably and providing accurate time.

Conclusion

Although the reasons to synchronize time within a telecommunications network and a computer network differ, timing matters in both cases. Symmetricom is the first to combine TimeServer and network synchronization primary reference source functionality into a single, compact unit. Telecom and datacom networks can now receive precise time in an affordable manner. TimeSource 3X00 products receive timing directly from GPS and are therefore operating at the highest stratum in a datacom network. There are no concerns over using SNTP at this level.

References

1. Various articles and publications, Professor David Mills, University of Delaware, Newark, DE
2. Time, with focus on NTP and Slovenia, Mark Martinec, J. Stefan Institute, Ljubljana, Slovenia
3. Beating the Clock on Security, Rik Farrow, Network Magazine

Specifications

PROTOCOL TYPE	SNTP compliant with RFC-1769 for unicast applications
SNTP ACCURACY	SNTP timestamp derived from UTC time via integrated GPS receiver
SNTP ALARM INDICATIONS	1. SNTP packet will indicate Stratum 2 in NTP packet header if GPS is out of lock 2. The 'ref id' field changes from GPS to at Stratum 1 to the IP address at Stratum 2 to signify that the reference is the TimeSource itself 3. SNTP packet will indicate 'clock not synchronized' after user defined alarm integration time

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