Network Time Synchronization

Introduction

- Network Time Synchronization is an Internet time protocol used to synchronize the clocks of computers to some time references.
- It is widely used to synchronize the time for Internet hosts, routers and ancillary devices to Coordinated Universal Time (UTC).

Importance of Time Synchronization

Key areas where time synchronization directly effects network operations are:

- Log file accuracy, auditing & monitoring
- Network fault diagnosis and recovery
- File time stamps
- Directory services
- Distributed computing

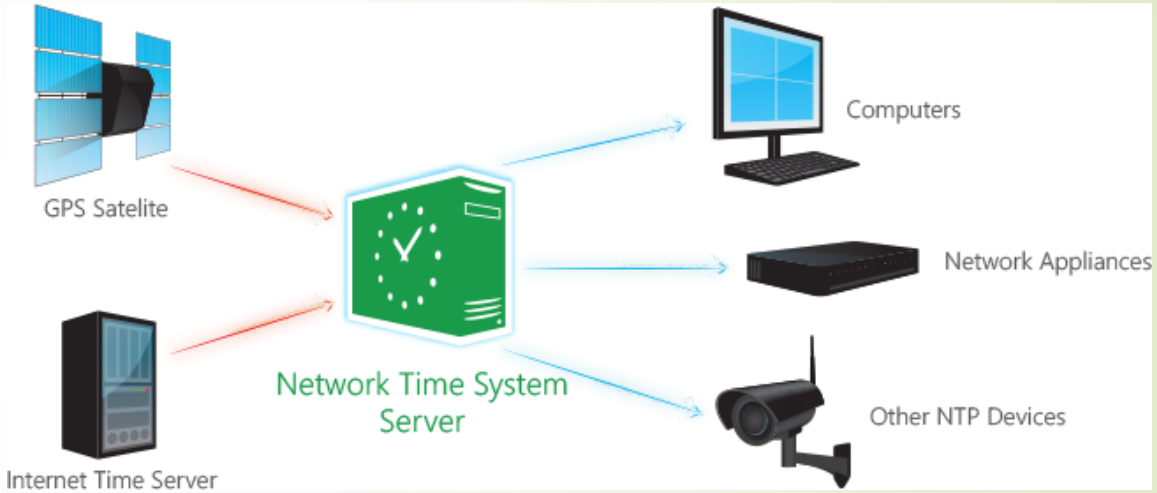
Time Synchronization directly effects Application

Key areas where time synchronization directly effects application are:

- Software development
- Email

Network Time Protocol (NTP)

- Network Time Protocol (NTP) synchronizes clocks of hosts and routers in the Internet.
- NTP runs over the User Datagram Protocol (UDP), using UDP port 123.
- It is widely used to synchronize the system clocks among a set of distributed time servers and clients.

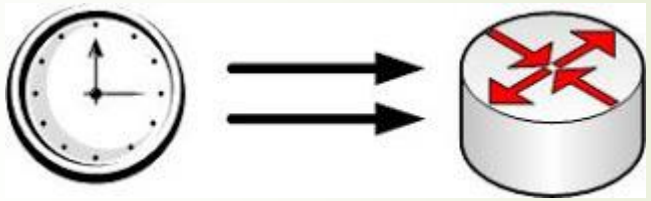


Source:https://nts.softros.com/

NTP Operating Modes

NTP can be configured one of three ways

- Client/Server mode
- Symmetric active/passive mode
- Broadcast and/or Multicast



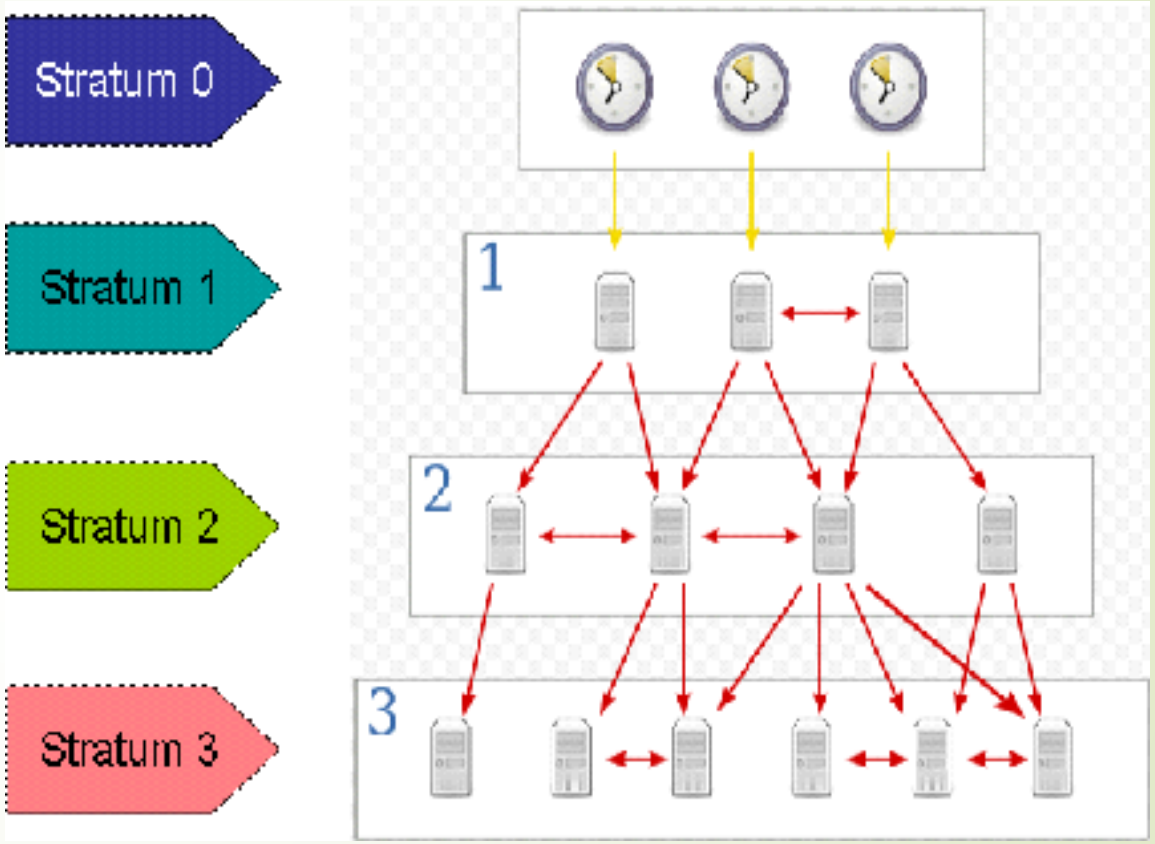
Source:http://www.cemaltaner.com.tr/ntp-network-time-protocol/

Technical Facts

- Timestamps are used in messages
- Accuracy over LAN and Internet

Synchronization subnet(Startum)

- NTP uses hierarchical system of “clock strata”.
- Stratum levels define distance from reference clock.



Source:http://basics974.rssing.com/chan-13445281/all_p1.html

History of Time

- Second defined in 1967
- UTC in 1st January 1972
- RFC 778-Internet Clock reference in 1981
- RFC 958-Description of NTP in 1985
- RFC 1059-NTPv1,protocols and algorithm in 1988
- RFC 1305-NTPv3 and formal correctness in 1992
- RFC 5905-NTPv4 in 2010

Basic features of NTP

- NTP uses UTC as reference time
- NTP is a fault-tolerant protocol
- NTP is highly accurate

Some Definitions

- Reference clock
- Accuracy
- Precision

What NTP Does Not

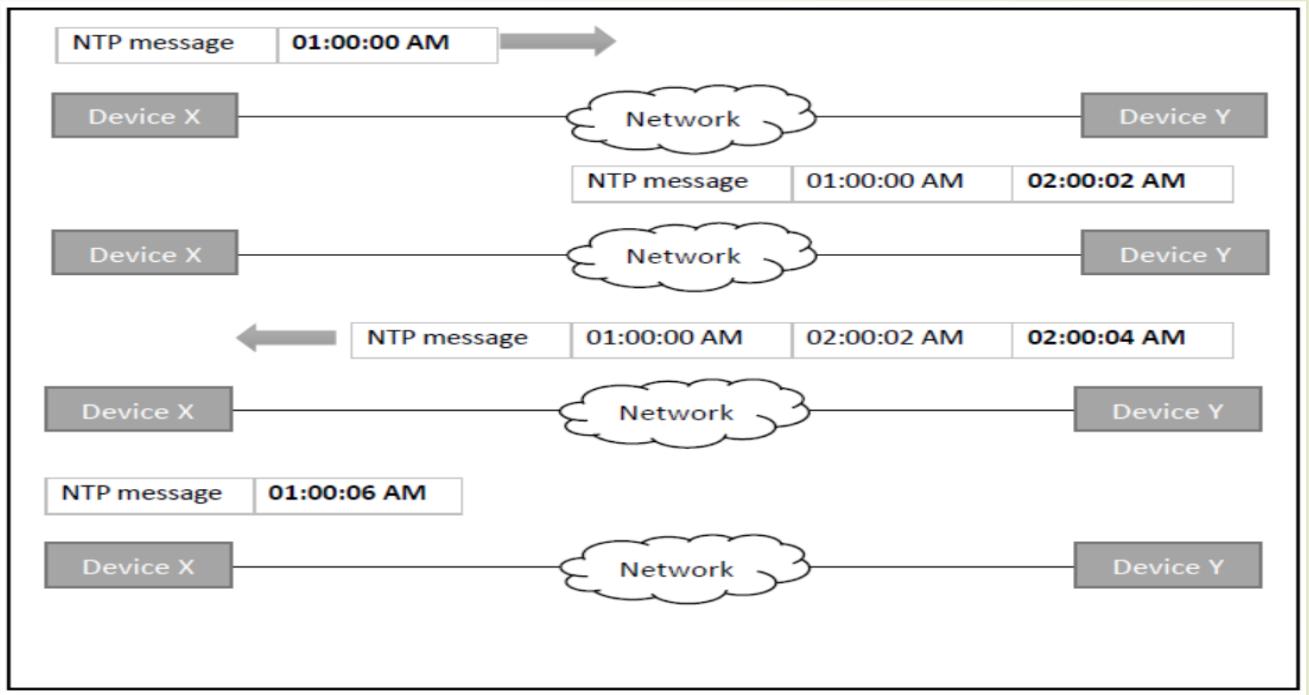
- Convert NTP timestamps into system time format.
- Set the hardware clock.
- Handle time-zones/summer time.

Advantages of NTP

- A number of security features(Using MD5 encryption).
- Uses stratum that describe the clock precision.
- Used for all timing applications.

Working procedure of NTP

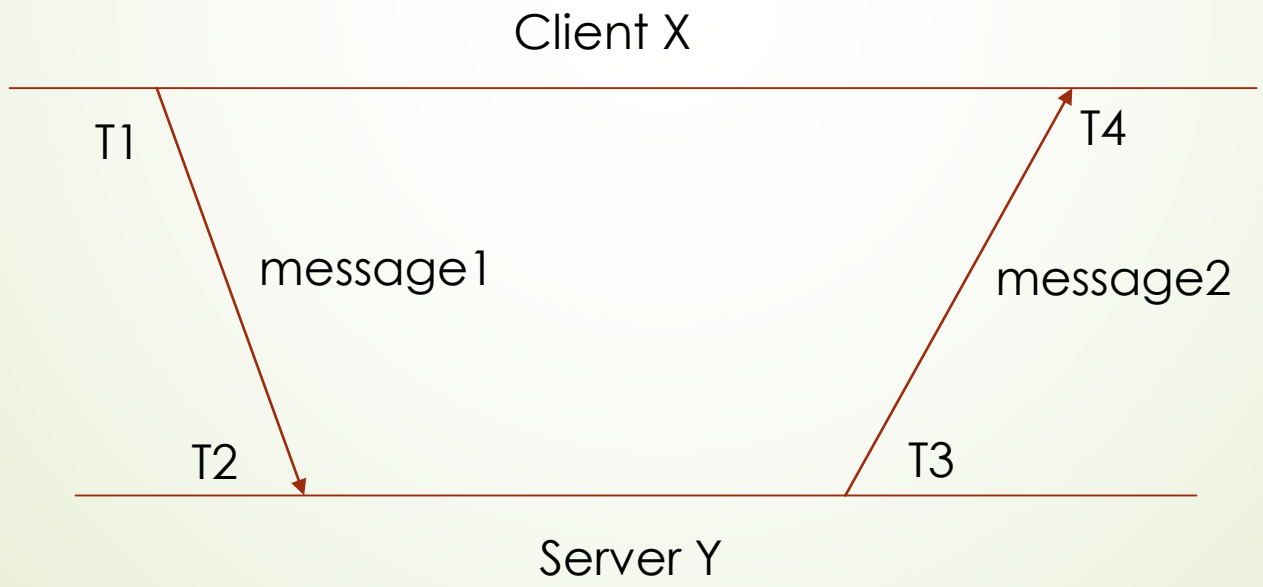
- Let assume that there are two devices which stated as Device X and Device Y.
- Device X and Device Y are interconnected via a network.
- Both have different time settings.



Source : http://www.h3c.com.hk/Products___Technology/Technology/IPv4___IPv6_Services/Technology_Introduction/200701/195572_57_0.htm

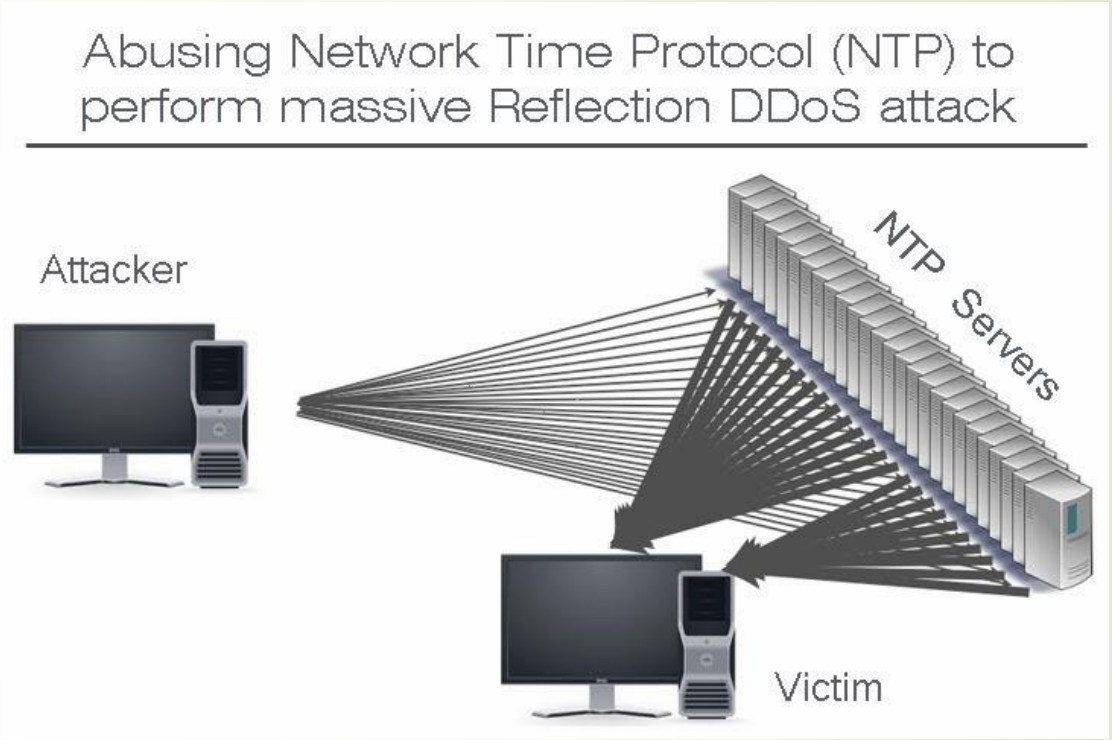
Working procedure of NTP

- Let Client X and Y NTP server exchanging messages with each other.
- Message1 X sends to Y.
- Message2 Y replies to X.
- T1 to T4 are timestamps
- Roundtrip delay = (T4-T1) – (T3-T2)
- Offset = [(T2–T1) + (T3–T4)]/2



Five Possible Attacks on NTP

- A non-time server impersonates a time server (masquerade)
- An attacker modifies messages sent by time server (modification)
- An attacker resends a timer server's message (replay)
- An attacker intercepts a time server's message and deletes it (denial of service)
- An attacker delays time messages (delay)



http://thehackernews.com/2014/01/Network-Time-Protocol-Reflection-DDoS-Attack-Tool.html

Suggested Improvements

- Authentication should be used with keys issued on a per-path, not per-host basis.
- Access control should be based on routes recorded, not simply on IP address.
- Servers should have several other source servers to limit effectiveness of delay and denial of service attacks.

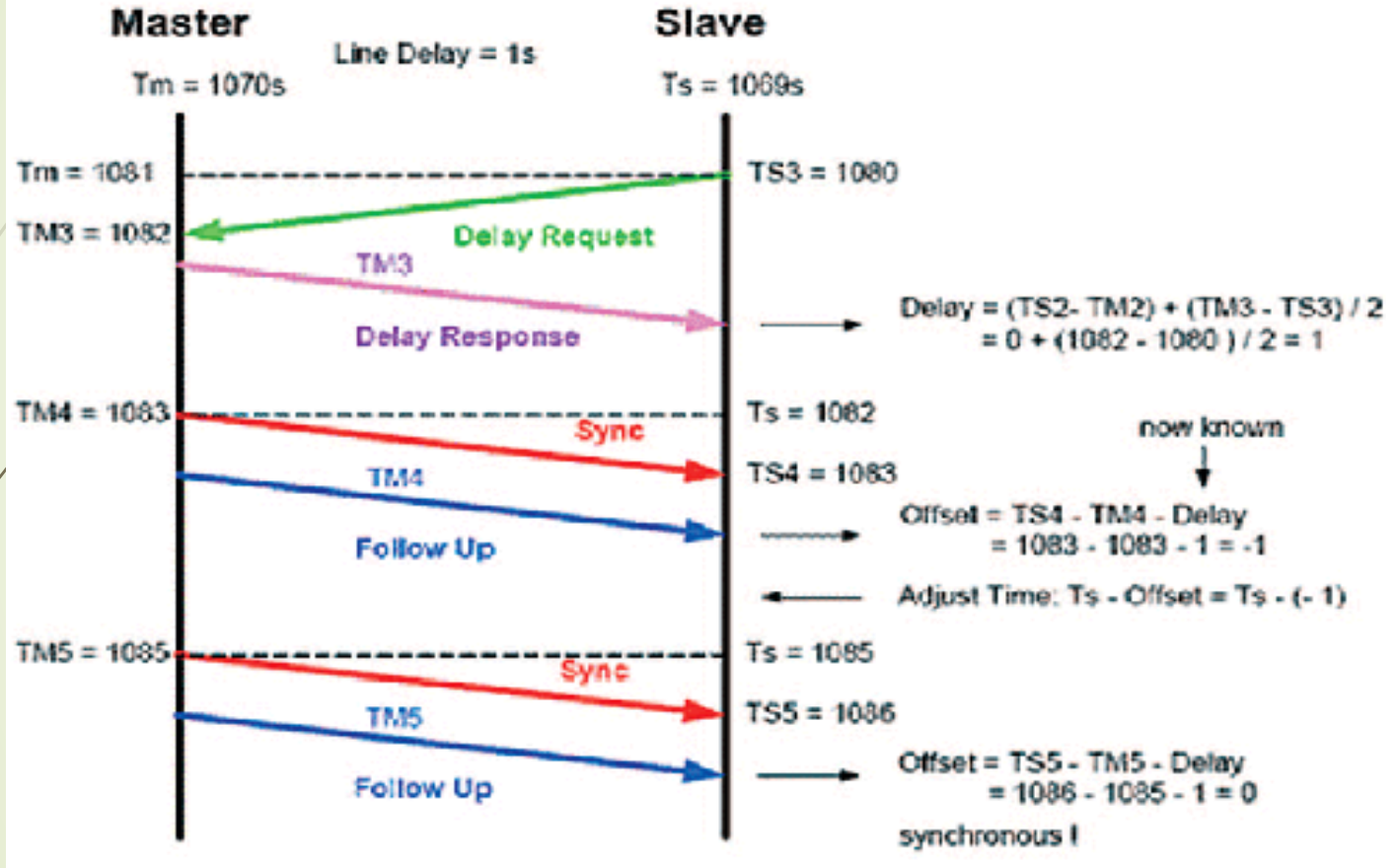
Precision Time Protocol (PTP)

- The Precision Time Protocol (PTP) is a protocol used to synchronize clocks throughout a computer network.
- *"Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems"*
- it improves accuracy, precision and robustness but is not backward compatible with the original 2002 version.

Architecture of PTP

- The IEEE 1588 standards describe a hierarchical master-slave architecture for clock distribution.
- Under this architecture, a time distribution system consists of one or more communication media (network segments), and one or more clocks.
- An *ordinary clock* is a device with a single network connection and is either the source of (master) or destination for (slave) a synchronization reference.

Architecture of PTP



Source:iebmedia.com/images/art_images/ieb4735_3.gif

Optional features

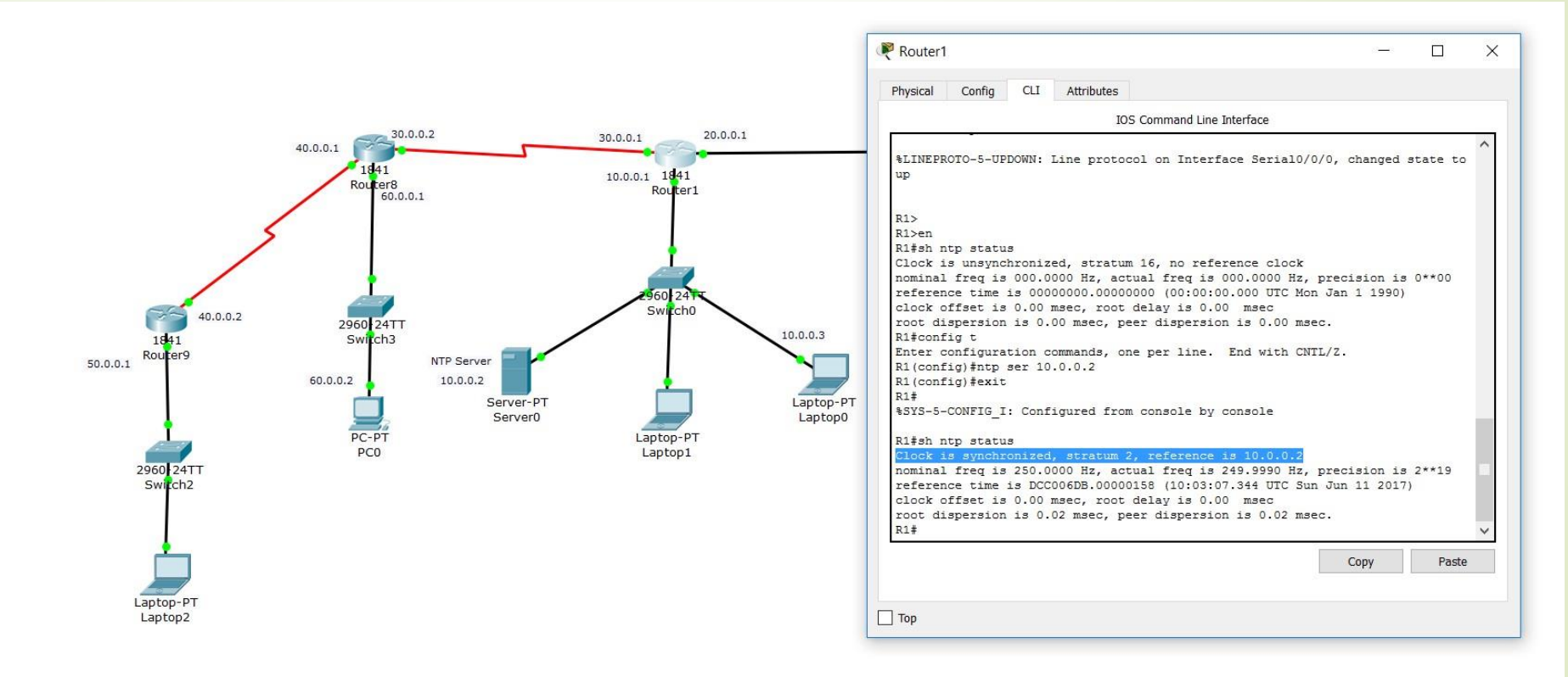
IEEE 1588-2008 standard lists the following set of features that implementations may choose to support:

- Alternate Time-Scale
- Grand Master Cluster
- Unicast Masters
- Alternate Master
- Path Trace

NTP vs PTP

Criteria	NTP	PTP
Peak time transfer error	*>1ms*	*>100ns*
Primary error source	Routers	Router, switches, port connection, network etc
Implementation	Hardware or software servers, software clients.	Hardware master or Hardware and software clients(Slaves).
Mode of operation	Clients pull time from server.	Master push time to slaves (clients).
On path support	Not existent and not possible.	Not required but possible.
Relative cost of solution	Not expensive.	More expensive(Higher precision solutions cost more).
Metrics, monitoring and management	Exists but minimal.	Extensive in bad metrics for monitoring and management.

- **Live Demo**


40.0.0.1
30.0.0.2
1841
Router8
60.0.0.1
30.0.0.1
20.0.0.1
10.0.0.1
1841
Router1
40.0.0.2
1841
Router9
50.0.0.1
2960-24TT
Switch3
60.0.0.2
PC-PT
PC0
NTP Server
10.0.0.2
Server-PT
Server0
2960-24TT
Switch0
10.0.0.3
Laptop-PT
Laptop0
Laptop-PT
Laptop1
2960-24TT
Switch2
Laptop-PT
Laptop2
Router1
Physical
Config
CLI
Attributes
IOS Command Line Interface
%LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0/0, changed state to up
R1>
R1>en
R1#sh ntp status
Clock is unsynchronized, stratum 16, no reference clock
nominal freq is 000.0000 Hz, actual freq is 000.0000 Hz, precision is 0**00
reference time is 00000000.00000000 (00:00:00.000 UTC Mon Jan 1 1990)
clock offset is 0.00 msec, root delay is 0.00 msec
root dispersion is 0.00 msec, peer dispersion is 0.00 msec.
R1#config t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#ntp ser 10.0.0.2
R1(config)#exit
R1#
%SYS-5-CONFIG_I: Configured from console by console
R1#sh ntp status
Clock is synchronized, stratum 2, reference is 10.0.0.2
nominal freq is 250.0000 Hz, actual freq is 249.9990 Hz, precision is 2**19
reference time is DCC006DB.00000158 (10:03:07.344 UTC Sun Jun 11 2017)
clock offset is 0.00 msec, root delay is 0.00 msec
root dispersion is 0.02 msec, peer dispersion is 0.02 msec.
R1#
Copy
Paste
Top

References

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- https://www.eecis.udel.edu/~mills/database/brief/overview/overview.pdf
- http://www.ntp.org/ntpfaq/NTP-s-algo.htm
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