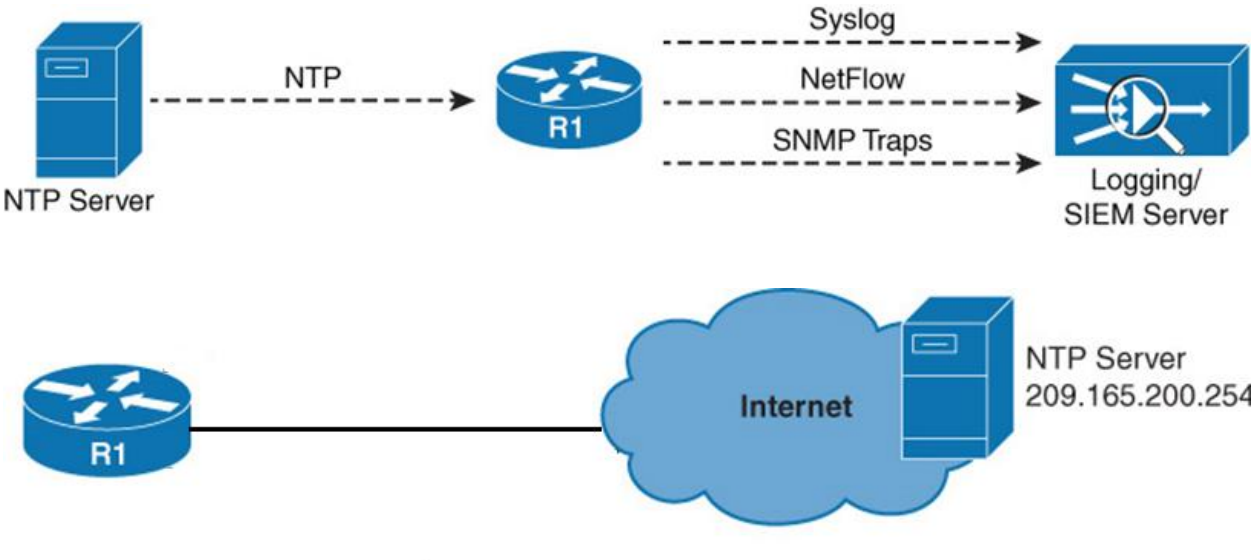
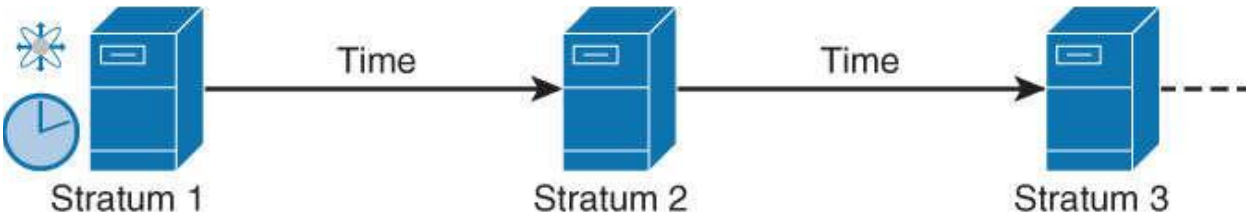
NTP (Network Time Protocol):

- NTP is a term which is stands for Network Time Protocol, use to provide Time.
- NTP is used to allow network devices to synchronize clocks with central source clock.
- NTP is very important for network devices like Routers, Switches, Severs or Firewalls.
- NTP make sure logging information and timestamps have the accurate time and date.
- Network Time Protocol (NTP) is runs over User Datagram Protocol (UDP).
- Network Time Protocol (NTP) is a protocol used on networks to maintain clock time.
- Network Time Protocol (NTP) uses a hierarchical system of time sources.
- Network Time Protocol (NTP) uses client-server architecture to work.
- Network Time Protocol (NTP) uses a well-known UDP port number 123.
- Currently there are two versions of NTP version 3 and NTP version 4.
- A Network Time Protocol (NTP) server is also referred to as an NTP Master.
- Router can be configured in three modes Server, Client and Server/Client mode.
- By default, Router works in Network Time Protocol (NTP) Server/Client mode.
- Stratum defines the reliability and accuracy of Network Time Protocol source.
- Network Time Protocol (NTP) uses of stratum 0 to stratum 15 for NTP sources.
- One 1 is the most reliable and 15 is the worst Network Time Protocol source.
- Stratum 0 represents Atomic Clock and not used in Cisco Router or Cisco Switch.
- Stratum 1 to 15 are valid levels and used in Cisco Routers and Cisco Switches.
- Stratum 16 represents Network Time Protocol (NTP) is not synchronized.
- Default stratum level of Cisco Router's or Switches internal clock is 8.
- Syslog messages timestamp using the Network Time Protocol (NTP).



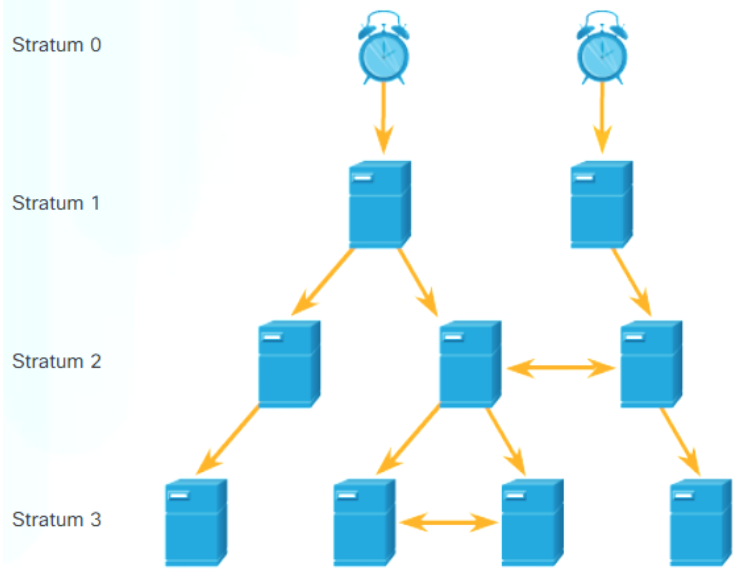
NTP Stratum:

- Network Time Protocol, stratum levels define distance from reference clock.
- A Stratum-0 device that is assumed to be the most accurate and it has no delay.
- Network Time Protocol Stratum-0 servers cannot be used on the network.
- For example, device with Network Time Protocol stratum 1 is very accurate device.
- Network Time Protocol (NTP) Stratum 1 might have an atomic clock attached to it.
- Another NTP using stratum 1 server to synchronize own time would be stratum 2 device.
- Because stratum 2 is one Network Time Protocol hop further away from the source.
- Configure multiple NTP servers, client will prefer NTP server with lowest stratum value.



NTP Architecture:

- NTP uses stratums 1 to 16 to define clock accuracy.
- A lower NTP stratum value represents higher accuracy.
- Clocks at NTP stratums 1 through 15 are in synchronized state.
- Clocks at Network Time Protocol stratum 16 are not synchronized.
- Stratums is like TTL number decreases every hop a packet passes by.



NTP Modes:

- The Cisco Routers and Cisco Switches can use Four (4) different NTP modes.
- NTP Server, NTP Client, NTP Server/Client and NTP Peer or Symmetric Active mode.

NTP Server Mode:

- Network Time Protocol, server is a network device, which is running NTP service.
- Network Time Protocol server is configured to provide Time information to NTP clients.
- Network Time Protocol (NTP) server provide only Time information to NTP Clients.
- NTP server never accept time synchronization information from other devices.
- NTP server mode router reads time from NTP source or uses its own clock as NTP source.

NTP Client Mode:

- Network Time Protocol (NTP) Client mode, Router only receives NTP updates.
- Network Time Protocol (NTP) Client does not advertise received updates.
- Network Time Protocol (NTP) Client uses them to synchronize its own clock.

NTP Server/Client Mode:

- Network Time Protocol Server/Client, Router receives updates from NTP server.
- Network Time Protocol Server/Client also advertises them from its own interfaces.
- Network Time Protocol Server/Client mode Cisco Router or Switch plays both roles.
- As NTP Client, it receives NTP updates & as NTP Server, it advertises NTP updates.
- NTP Server/Client mode, as an NTP Server, instead of using its own NTP Source.
- Network Time Protocol router uses received NTP updates from other NTP server.
- Network Time Protocol Server advertise the NTP updates to other NTP Clients.
- Feature allows using single centralized Network Time Protocol source at NTP Server.

NTP Peer Mode:

- An Network Time Protocol (NTP) peer does not have authority over the other.
- In NTP peer mode, each device can provide time synchronization to other.
- So, one Network Time Protocol can synchronize the other in case of failures.

NTP Master:

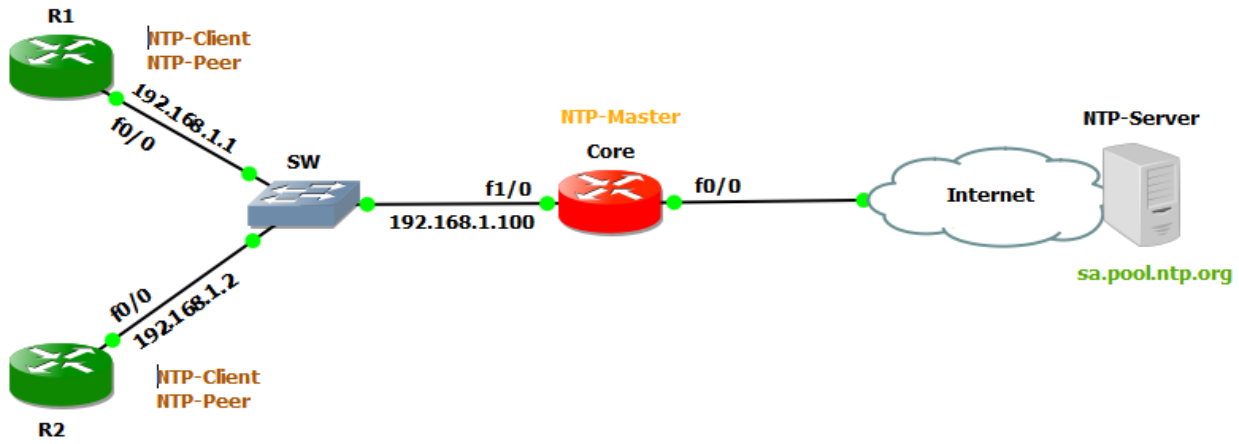
- To make a router to become an authoritative Network Time Protocol server.
- Where internal devices can synchronize use NTP master command.
- Network Time Protocol master command tells router that it is an NTP server.
- Network Time Protocol (NTP) server is also referred to as an NTP Master.
- If Network Time Protocol (NTP) is using its hardware clock is a reference.

NTP Versions:

- Cisco IOS use many versions, but version 3 & 4 are most commonly used.
- Version 4 supports IPv6 and is backwards compatible with NTP version 3.
- Network Time Protocol (NTP) Version 4 also adds DNS support for IPv6.
- Another difference is that NTPv3 use broadcast messages & NTPv4 use multicast.
- NTPv4 also allows for increased security using public key cryptography & certificates.

NTP Security & Authentication:

- NTP communications can be secured using an Access Control List.
- NTP can be secured by authentication mechanism that uses MD5 algorithm.
- All NTP packets that can update the clock have to be authenticated.
- The packets will be authenticated using HMAC MD5, which carries a key number.
- To use ACL, write ACL to allow certain IP addresses or a range then apply to NTP.
- Access-group command has these options, ordered from least restrictive to most restrictive.



Routers Basic Configuration
Core(config)# interface f0/0 Core(config-if)# ip address dhcp Core(config-if)# no shutdown
Core(config)# interface f1/0 Core(config-if)# ip address 192.168.1.100 255.255.255.0 Core(config-if)# no shutdown
Core(config)# ip name-server 8.8.8.8
Core(config)# ip domain-lookup
R1(config)# interface f0/0 R1(config-if)# ip address 192.168.1.1 255.255.255.0 R1(config-if)# no shutdown
R2(config)# interface f0/0 R2(config-if)# ip address 192.168.1.2 255.255.255.0 R2(config-if)# no shutdown

Adjust Router Clock
Core# show calendar
Core# show clock
Core# show clock detail
Core# clock set 4:14:1 Jan 1 2019
Core(config)# clock timezone UTC + 3
Core# show clock

Configure NTP Server
Core(config)# ntp master
Core(config)# ntp master 3
Core(config)# ntp source loopback 1
Core(config)# interface f1/0 Core(config-if)# ntp broadcast
Core# show clock
Core# show clock detail

Configure NTP Server/Client
R1(config)#ntp server 192.168.1.100
R1(config)#ntp server 192.168.1.100 version 3
R1# show clock
R1# show clock detail

Configure NTP Client
R2(config)#ntp server 192.168.1.1
R2(config)#ntp server 192.168.1.1 version 3
R2(config)# interface f0/0 R2(config)# ntp broadcast client
R2# show clock
R2# show clock detail

Configure NTP Peer
R1(config)# ntp peer 192.168.1.2
R2(config)# ntp peer 192.168.1.1
R1(config)# ntp peer 192.168.1.2 version 3
R2(config)# ntp peer 192.168.1.1 version 3
R1#show ntp associations

Configure Authentication on NTP Server
Core(config)# ntp master 5
Core (config)# ntp authenticate
Core (config)# ntp trusted-key 1
Core (config)# ntp authentication-key 1 md5 test

Configure Authentication on NTP Client
R1(config)# ntp server 192.168.1.100 key 1
R1(config)# ntp authenticate
R1(config)# ntp trusted-key 1
R1(config)# ntp authentication-key 1 md5 test

Configure Authentication on NTP Peer
R2(config)# ntp peer 192.168.1.1 key 1
R2(config)# ntp authenticate
R2(config)# ntp trusted-key 1
R2(config)# ntp authentication-key 1 md5 test
R2# debug ntp packet
R2# debug ntp auth

Configure ACL on NTP Server
Core (config)# access-list 1 permit public-IP
Core (config)# ntp access-group peer 1
Core (config)# access-list 11 permit 192.168.1.1
Core (config)# access-list 11 permit 192.168.1.2
Core (config)# ntp access-group serve-only 11

Configure ACL on NTP Client
R1 (config)# access-list 3 permit 192.168.1.100
R1 (config)# ntp access-group peer 3

Troubleshoot and Verify NTP:

To verify NTP there many commands to use some of them are the following:

show ntp status

show ntp associations

show ntp associations detail

debug ntp packet

debug ntp events

debug ntp authentication

```
R1#show ntp associations

      address         ref clock       st   when   poll reach   delay   offset    disp
*~192.168.1.100    127.127.7.1       8      0     64   377    56.0    49.01    45.7
 * master (synced), # master (unsynced), + selected, - candidate, ~ configured
```

Field	Description
characters in display lines	* —Synchronized to this peer # —Almost synchronized to this peer + —Peer selected for possible synchronization - —Peer is a candidate for selection ~ —Peer is statically configured
Address	Address of peer.
ref clock	Address of reference clock of peer.
St	Stratum of peer.
When	Time since last NTP packet was received from peer.
Poll	Polling interval (in seconds).
Reach	Peer reachability (bit string, in octal).
Delay	Round-trip delay to peer (in milliseconds).
Offset	Relative time of peer clock to local clock (in milliseconds).
Disp	Dispersion

```
R1#show ntp status
Clock is synchronized, stratum 9, reference is 192.168.1.100
nominal freq is 250.0000 Hz, actual freq is 250.0000 Hz, precision is 2**18
reference time is C029435B.BAE5C0C0 (00:01:31.730 UTC Fri Mar 1 2002)
clock offset is 51.8989 msec, root delay is 27.94 msec
root dispersion is 1934.72 msec, peer dispersion is 1882.80 msec
```

Field	Description
Synchronized	System is synchronized to an NTP peer.
Unsynchronized	System is not synchronized to any NTP peer.
Stratum	NTP stratum of this system.
Reference	Address of peer the system is synchronized to.
nominal freq	Nominal frequency of system hardware clock.
actual freq	Measured frequency of system hardware clock.
Precision	Precision of the clock of this system (in Hertz).
reference time	Reference time stamp.
clock offset	Offset of the system clock to synchronized peer.
root delay	Total delay along path to root clock.
root dispersion	Dispersion of root path.
peer dispersion	Dispersion of synchronized peer.