JEREMY'S IT LAB

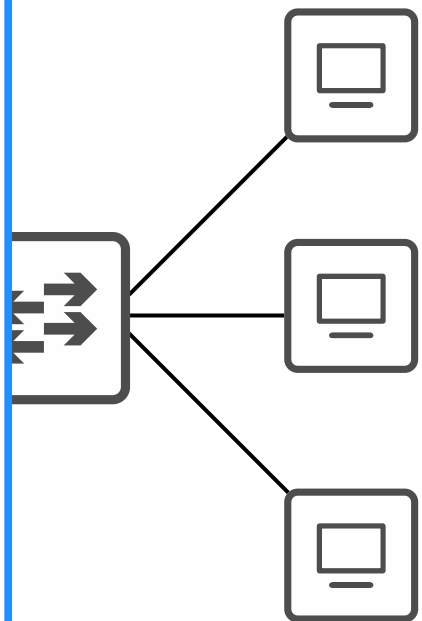
CCNA Day 37

Network Time Protocol

1.0 Network Fundamentals	20%
2.0 Network Access	20%
3.0 IP Connectivity	25%
4.0 IP Services	10%

4.1 Configure and verify inside source NAT using static and pools
4.2 Configure and verify NTP operating in a client and server mode
4.3 Explain the role of DHCP and DNS within the network
4.4 Explain the function of SNMP in network operations
4.5 Describe the use of syslog features including facilities and levels
4.6 Configure and verify DHCP client and relay
4.7 Explain the forwarding per-hop behavior (PHB) for QoS such as classification, marking, queuing, congestion, policing, shaping
4.8 Configure network devices for remote access using SSH
4.9 Describe the capabilities and function of TFTP/FTP in the network

5.0 Security Fundamentals	15%
6.0 Automation and Programmability	10%



Things we'll cover

- Why is time important for network devices?
- Manual time configuration
- NTP basics
- NTP configuration

The importance of time

- All devices have an internal clock (routers, switches, your PC, etc)
- In Cisco IOS, you can view the time with the **`show clock`** command.

```
R1#show clock
*00:16:00.857 UTC Sat Dec 26 2020
```

The default time zone is UTC (Coordinated Universal Time).

- If you use the **show clock detail** command, you can see the time source.

```
R1#show clock detail
*00:19:49.411 UTC Sat Dec 26 2020
Time source is hardware calendar
```

* = time is not considered authoritative

The hardware calendar is the default time source.

- The internal hardware clock of a device will drift over time, so it is not the ideal time source.
- From a CCNA perspective, the most important reason to have accurate time on a device is to have accurate logs for troubleshooting.
- **Syslog**, the protocol used to keep device logs, will be covered in a later video.

show logging

```
R2#show logging
!output abbreviated!
*Dec 27 00:50:20.005: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.122.192 on GigabitEthernet0/0 from LOADING to FULL,
Loading Done
*Dec 27 01:06:38.653: %OSPF-5-ADJCHG: Process 1, Nbr 10.0.0.6 on GigabitEthernet0/1 from LOADING to FULL,
Loading Done
*Dec 27 01:07:07.311: %OSPF-5-ADJCHG: Process 1, Nbr 10.0.0.6 on GigabitEthernet0/1 from LOADING to FULL,
Loading Done
*Dec 27 01:08:29.924: %OSPF-5-ADJCHG: Process 1, Nbr 10.0.0.6 on GigabitEthernet0/1 from FULL to DOWN, Neighbor
Down: Dead timer expired
*Dec 27 01:09:10.714: %OSPF-5-ADJCHG: Process 1, Nbr 10.0.0.6 on GigabitEthernet0/1 from LOADING to FULL,
Loading Done

R2#show clock
*01:17:06.706 UTC Sun Dec 27 2020
```

```
R3#show logging
!output abbreviated!
May 23 16:24:17.320: %OSPF-5-ADJCHG: Process 1, Nbr 10.0.0.5 on GigabitEthernet0/0 from LOADING to FULL, Loading
Done
May 23 16:25:08.758: %OSPF-5-ADJCHG: Process 1, Nbr 10.0.0.5 on GigabitEthernet0/0 from FULL to DOWN, Neighbor
Down: Interface down or detached
May 23 16:25:10.714: %LINK-5-CHANGED: Interface GigabitEthernet0/0, changed state to down
May 23 16:25:11.716: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0, changed state to down
May 23 16:26:14.976: %LINK-3-UPDOWN: Interface GigabitEthernet0/0, changed state to up
May 23 16:26:15.977: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0, changed state to up
May 23 16:26:20.618: %OSPF-5-ADJCHG: Process 1, Nbr 10.0.0.5 on GigabitEthernet0/0 from LOADING to FULL, Loading
Done

R3#show clock
16:30:37.020 UTC Fri May 23 2008
```

Manual Time Configuration

- You can manually configure the time on the device with the **`clock set`** command.

```
R2#clock set ?
  hh:mm:ss  Current Time

R2#clock set 14:30:00 ?
  <1-31>  Day of the month
  MONTH   Month of the year

R2#clock set 14:30:00 27 ?
  MONTH  Month of the year

R2#clock set 14:30:00 27 Dec ?
  <1993-2035>  Year

R2#clock set 14:30:00 27 Dec 2020 ?
  <cr>

R2#clock set 14:30:00 27 Dec 2020
R2#show clock detail
14:30:05.887 UTC Sun Dec 27 2020
Time source is user configuration
```

- Although the hardware calendar (built-in clock) is the default time-source, the hardware clock and software clock are separate and can be configured separately.

Hardware Clock (Calendar) Configuration

- You can manually configure the hardware clock with the **`calendar set`** command.

```
R2#calendar set 14:35:00 ?
  <1-31>  Day of the month
  MONTH   Month of the year

R2#calendar set 14:35:00 27 ?
  MONTH  Month of the year

R2#calendar set 14:35:00 27 Dec ?
  <1993-2035>  Year

R2#calendar set 14:35:00 27 Dec 2020 ?
  <cr>

R2#calendar set 14:35:00 27 Dec 2020
R2#show calendar
14:35:07 UTC Sun Dec 27 2020
```

- Typically you will want to synchronize the ‘clock’ and ‘calendar’.
- Use the command **`clock update-calendar`** to sync the calendar to the clock’s time.
- Use the command **`clock read-calendar`** to sync the clock to the calendar’s time.

Hardware Clock (Calendar) Configuration

```
R2#show clock
14:38:14.301 UTC Sun Dec 27 2020
R2#show calendar
00:00:03 UTC Sun Dec 27 2020
R2#clock update-calendar
R2#show clock
14:38:22.181 UTC Sun Dec 27 2020
R2#show calendar
14:38:23 UTC Sun Dec 27 2020
```

```
R2#show clock
00:00:15.788 UTC Mon Sep 6 1993
R2#show calendar
14:55:07 UTC Sun Dec 27 2020
R2#clock read-calendar
R2#show clock
14:55:12.522 UTC Sun Dec 27 2020
R2#show calendar
14:55:15 UTC Sun Dec 27 2020
```

Configuring the Time Zone

- You can configure the time zone with the **`clock timezone`** command.

```
R2(config)#do show clock
15:13:33.985 UTC Sun Dec 27 2020
R2(config)#clock timezone ?
  WORD  name of time zone

R2(config)#clock timezone JST ?
  <-23 - 23>  Hours offset from UTC

R2(config)#clock timezone JST 9 ?
  <0-59>  Minutes offset from UTC
  <cr>

R2(config)#clock timezone JST 9
R2(config)#do show clock
00:13:45.414 JST Mon Dec 28 2020
R2(config)#do clock set 15:15:00 Dec 27 2020
R2(config)#do show clock
15:15:02.129 JST Sun Dec 27 2020
```

Daylight Saving Time (Summer Time)

```
R2(config)#clock summer-time ?
  WORD  name of time zone in summer
R2(config)#clock summer-time EDT ?
  date       Configure absolute summer time
  recurring  Configure recurring summer time
R2(config)#clock summer-time EDT recurring ?
  <1-4>  Week number to start
  first  First week of the month
  last   Last week of the month
  <cr>
  MONTH  Month to start
R2(config)#clock summer-time EDT recurring 2 Sunday March ?
  hh:mm  Time to start (hh:mm)
R2(config)#clock summer-time EDT recurring 2 Sunday March 02:00 ?
  <1-4>  Week number to end
  first  First week of the month
  last   Last week of the month
R2(config)#clock summer-time EDT recurring 2 Sunday March 02:00 1 ?
  DAY  Weekday to end
R2(config)#clock summer-time EDT recurring 2 Sunday March 02:00 1 Sunday ?
  MONTH  Month to end
R2(config)#$r-time EDT recurring 2 Sunday March 02:00 1 Sunday November ?
  hh:mm  Time to end (hh:mm)
R2(config)#$ recurring 2 Sunday March 02:00 1 Sunday November 02:00 ?
  <1-1440>  Offset to add in minutes
  <cr>
R2(config)#$ recurring 2 Sunday March 02:00 1 Sunday November 02:00
```

Canada	Northern America	Northern	Second Sunday March at 02:00 local standard time (for most of Canada)	First Sunday November at 02:00 local daylight saving time (for most of Canada)

```
R1(config)#clock summer-time EDT recurring 2 Sunday March 02:00 1 Sunday November 02:00
```

Start of DST

End of DST

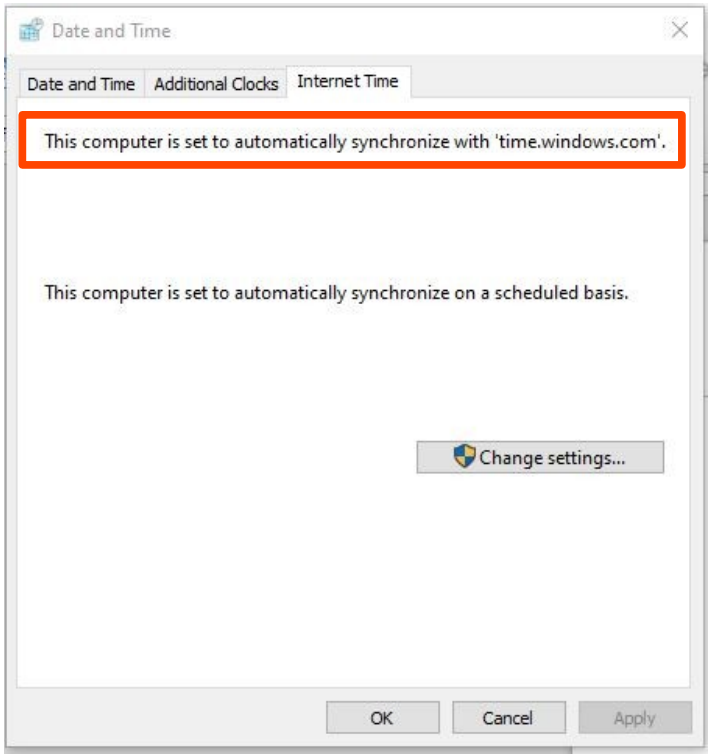
Manual Time Configuration

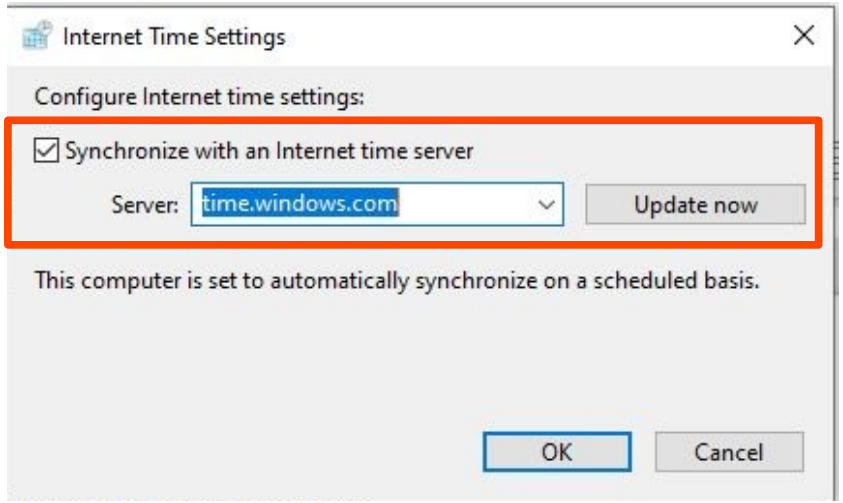
```
R1# show clock

R1# show clock detail

R1# clock set hh:mm:ss {day|month} {month|day} year

R1# show calendar

R1# calendar set hh:mm:ss {day|month} {month|day} year


R1(config)# clock timezone name hours-offset [minutes-offset]

R1(config)# clock summer-time recurring name start end [offset]
```

Network Time Protocol

- Manually configuring the time on devices is not scalable.
- The manually configured clocks will drift, resulting in inaccurate time.

- NTP (Network Time Protocol) allows automatic syncing of time over a network.





Network Time Protocol

```
C:\Users\user>nslookup time.windows.com
Server:  dns.google
Address:  8.8.8.8

Non-authoritative answer:
Name:    time.microsoft.akadns.net
Address:  20.43.94.199
Aliases:  time.windows.com


C:\Users\user>nslookup time.google.com
Server:  dns.google
Address:  8.8.8.8

Non-authoritative answer:
Name:    time.google.com
Addresses:  2001:4860:4806::
          2001:4860:4806:c::
          2001:4860:4806:8::
          2001:4860:4806:4::
          216.239.35.12
          216.239.35.8
          216.239.35.4
          216.239.35.0
```

Network Time Protocol

- Manually configuring the time on devices is not scalable.
- The manually configured clocks will drift, resulting in inaccurate time.

- NTP (Network Time Protocol) allows automatic syncing of time over a network.

- NTP clients request the time from NTP servers.

- A device can be an NTP server and an NTP client at the same time.

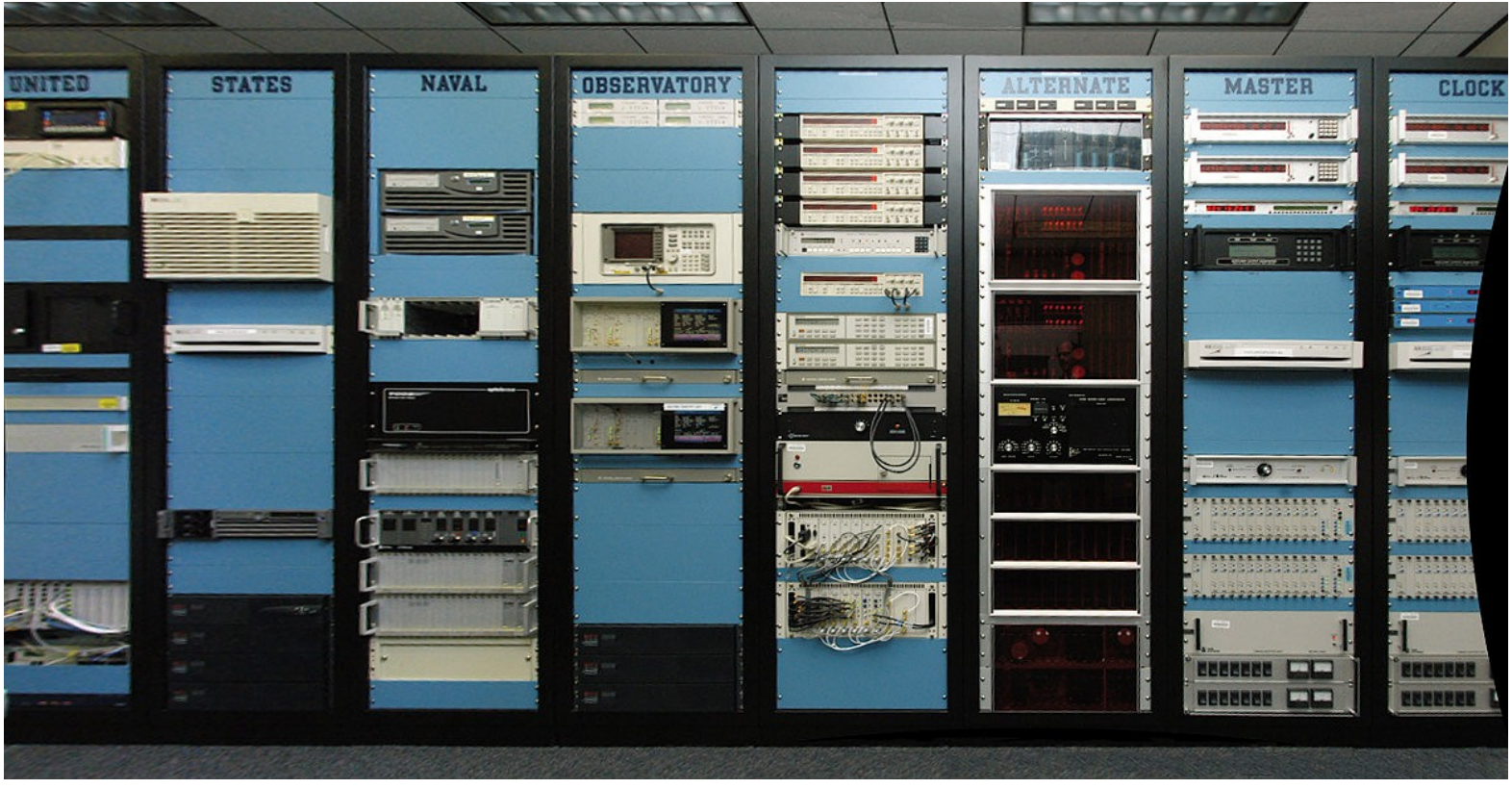
- NTP allows accuracy of time within ~1 millisecond if the NTP server is in the same LAN, or within ~50 milliseconds if connecting to the NTP server over a WAN/the Internet.

- Some NTP servers are ‘better’ than others. The ‘distance’ of an NTP server from the original **reference clock** is called **stratum**.

- NTP uses UDP port 123 to communicate.

Reference Clocks

- A reference clock is usually a very accurate time device like an atomic clock or a GPS clock.
- Reference clocks are **stratum 0** within the NTP hierarchy.
- NTP servers directly connected to reference clocks are **stratum 1**.

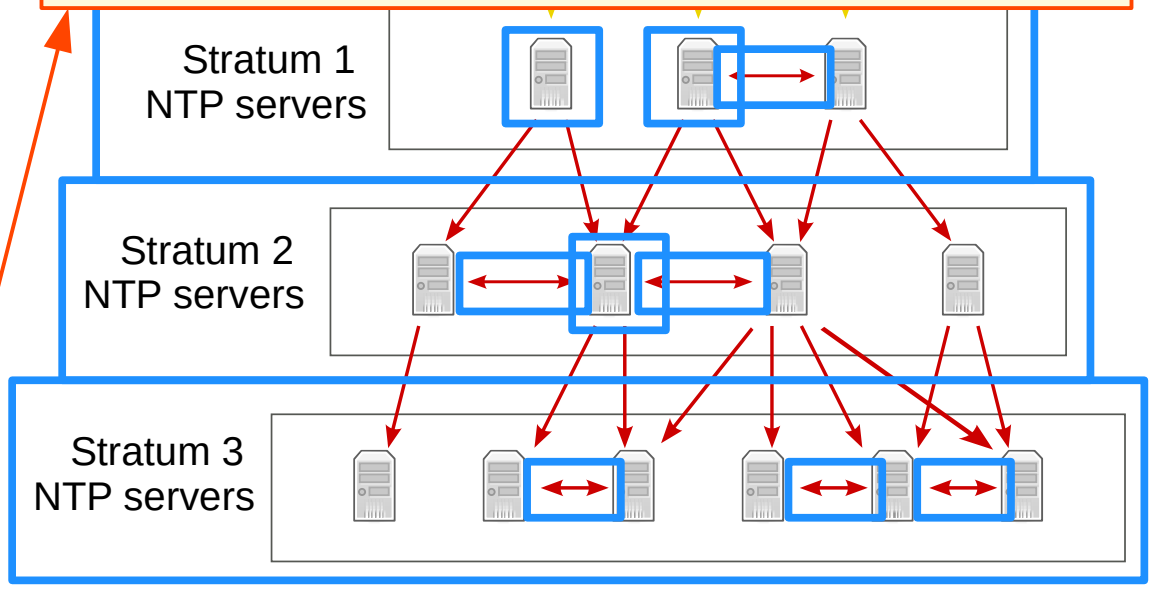


NTP Hierarchy

- Reference clocks are **stratum 0**.
- **Stratum 1** NTP servers get their time from reference clocks.
- **Stratum 2** NTP servers get their time from stratum 1 NTP servers.
- **Stratum 3** NTP servers get their time from stratum 2 NTP servers.
- **Stratum 15** is the maximum. Anything above that is considered unreliable.
- Devices can also ‘peer’ with devices at the same stratum to provide more accurate time.
- An NTP client can sync to multiple NTP servers.

This is called ‘symmetric active’ mode.
Cisco devices can operate in three NTP modes:

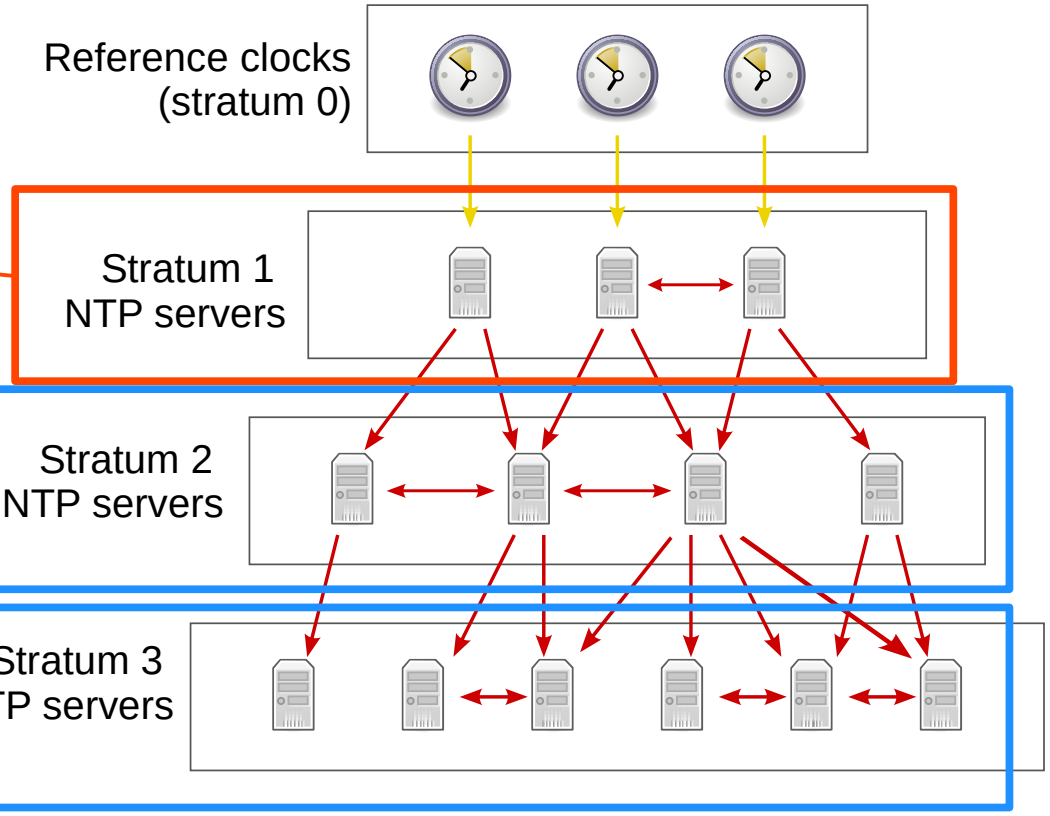
- Server mode
- Client mode
- Symmetric active mode



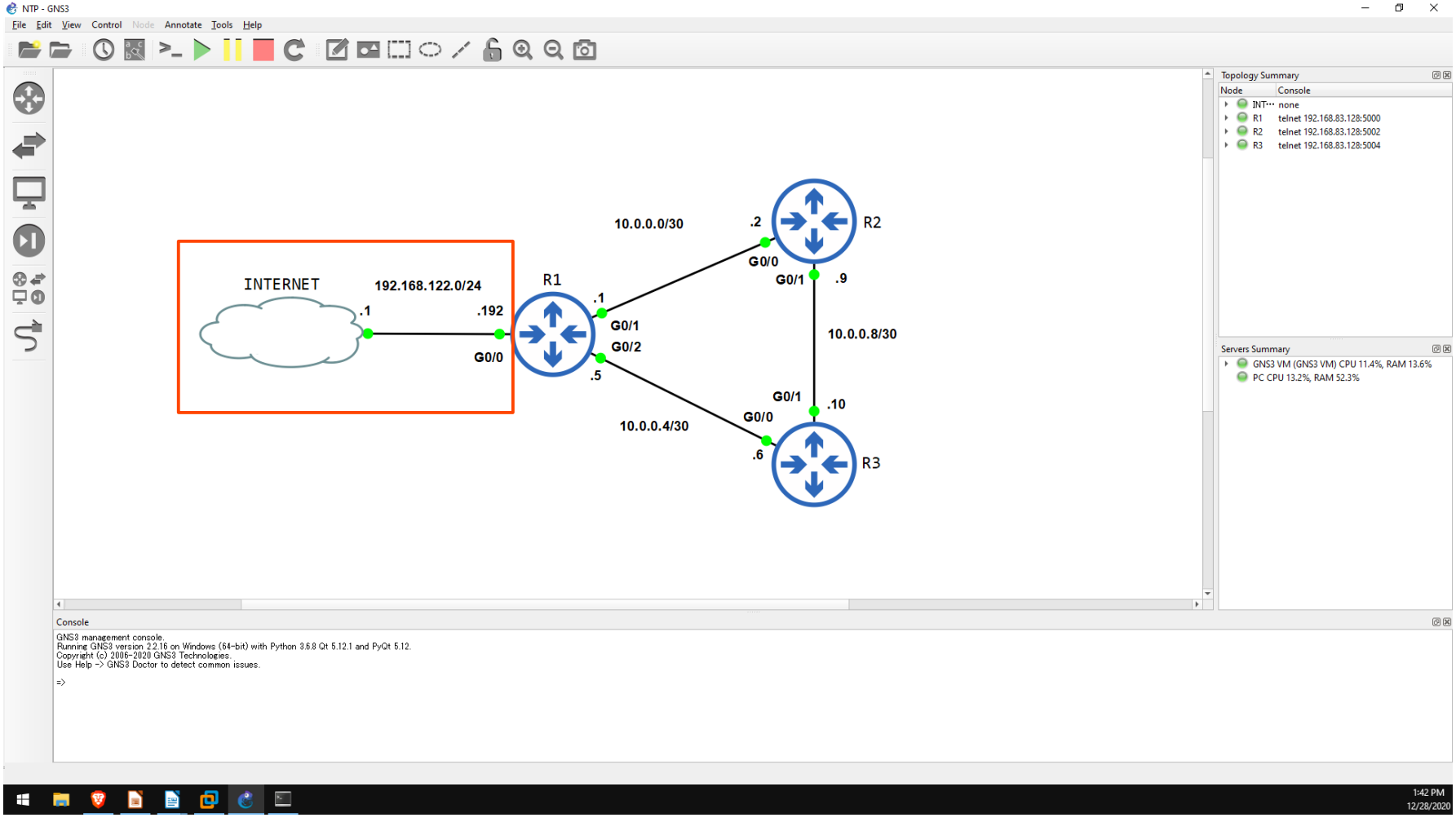
NTP Hierarchy

NTP servers which get their time directly from reference clocks are also called **primary servers**.

NTP servers which get their time from other NTP servers are called **secondary servers**. They operate in server mode and client mode at the same time.



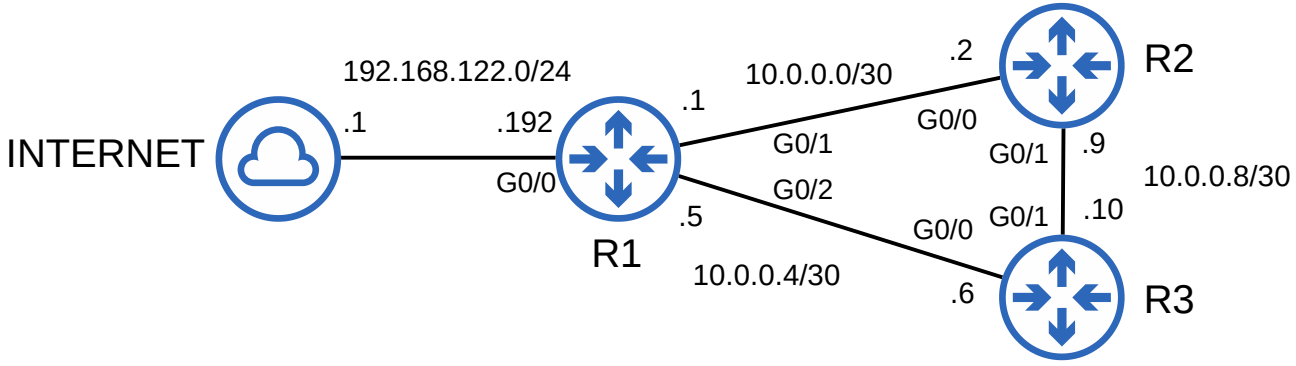
NTP Configuration



NTP Configuration

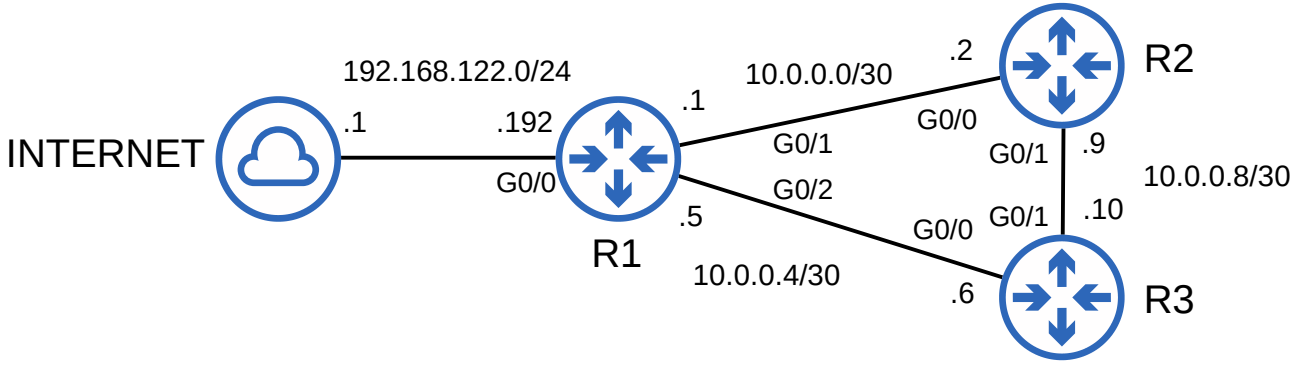
```
C:\Users\user>nslookup time.google.com
Server:  dns.google
Address:  8.8.8.8

Non-authoritative answer:
Name:    time.google.com
Addresses:  2001:4860:4806::
          2001:4860:4806:c::
          2001:4860:4806:8::
          2001:4860:4806:4::
          216.239.35.12
          216.239.35.8
          216.239.35.4
          216.239.35.0
```

```
R1(config)#ntp server 216.239.35.0 prefer
R1(config)#ntp server 216.239.35.4
R1(config)#ntp server 216.239.35.8
R1(config)#ntp server 216.239.35.12
```



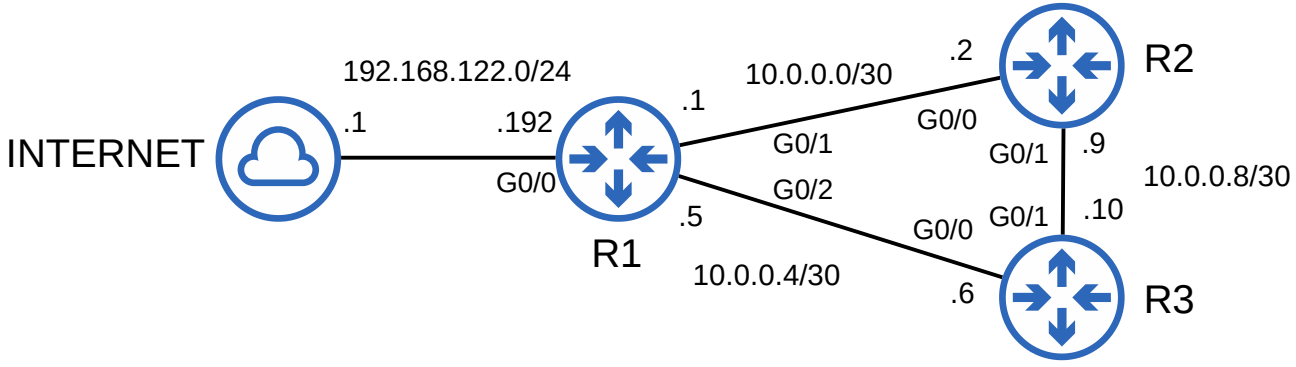
NTP Configuration

```
R1#show ntp associations

  address         ref clock       st   when   poll reach  delay  offset   disp
*~216.239.35.0    .GOOG.           1     43     64    17 62.007 1401.54  0.918
+~216.239.35.8    .GOOG.           1     43     64    17 64.220 1416.65  0.939
+~216.239.35.4    .GOOG.           1     47     64    17 57.669 1402.11  0.916
+~216.239.35.12   .GOOG.           1     39     64    17 62.229 1409.03  0.960
 * sys.peer, # selected, + candidate, - outlyer, x falseticker, ~ configured
```



NTP Configuration

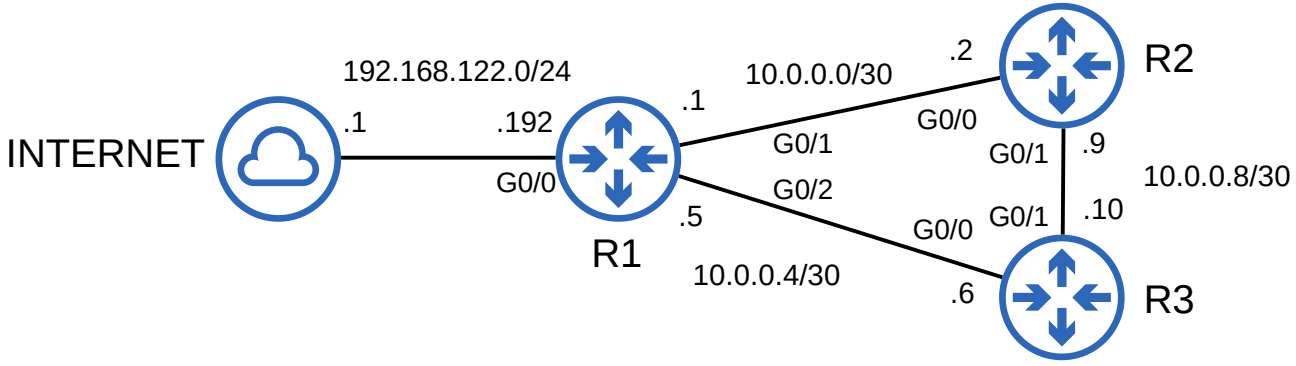
```
R1#show ntp associations

  address         ref clock       st   when   poll reach  delay  offset   disp
 ~216.239.35.0    .GOOG.           1     22     64     1 50.637   1.087 939.58
 ~216.239.35.8    .GOOG.           1     19     64     1 60.279  -4.402 939.83
*~216.239.35.4    .GOOG.           1     20     64     1 63.205 1351.20 938.52
 ~216.239.35.12   .GOOG.           1     20     64     1 49.130 1343.72 938.34
 * sys.peer, # selected, + candidate, - outlyer, x falseticker, ~ configured
```



NTP Configuration

```
R1#show ntp status
Clock is synchronized, stratum 2, reference is 216.239.35.12
nominal freq is 1000.0003 Hz, actual freq is 999.5003 Hz, precision is 2**14
ntp uptime is 295800 (1/100 of seconds), resolution is 1001
reference time is E393F0A9.1F758C5B (05:50:33.122 UTC Mon Dec 28 2020)
clock offset is 1343.7280 msec, root delay is 49.13 msec
root dispersion is 2275.31 msec, peer dispersion is 3.44 msec
loopfilter state is 'SPIK' (Spike), drift is 0.000499999 s/s
system poll interval is 64, last update was 173 sec ago.
```

Because R1 is synchronizing its time to Google's NTP servers, it automatically becomes an NTP server itself (stratum level 1 higher than Google's NTP servers). Now other devices can synchronize their time to R1.



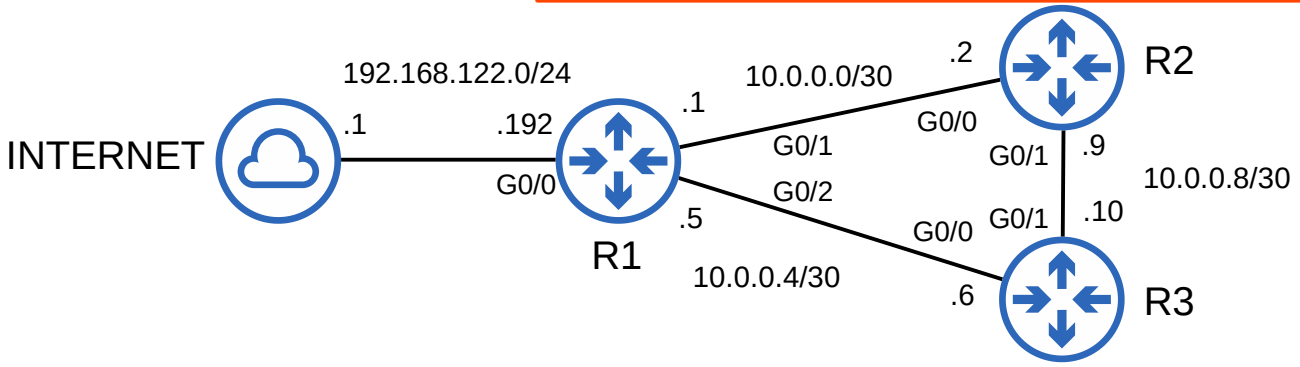
NTP Configuration

```
R1(config)#do show clock detail
06:56:32.315 UTC Mon Dec 28 2020
Time source is NTP
R1(config)#do show calendar
05:23:06 UTC Mon Dec 28 2020
R1(config)#clock timezone JST 9
R1(config)#ntp update-calendar
R1(config)#do show clock detail
15:57:33.078 JST Mon Dec 28 2020
Time source is NTP
R1(config)#do show calendar
15:57:36 JST Mon Dec 28 2020
```

NTP uses only the UTC time zone. You must configure the appropriate time zone on each device.

Configures the router to update the hardware clock (calendar) with the time learned via NTP.

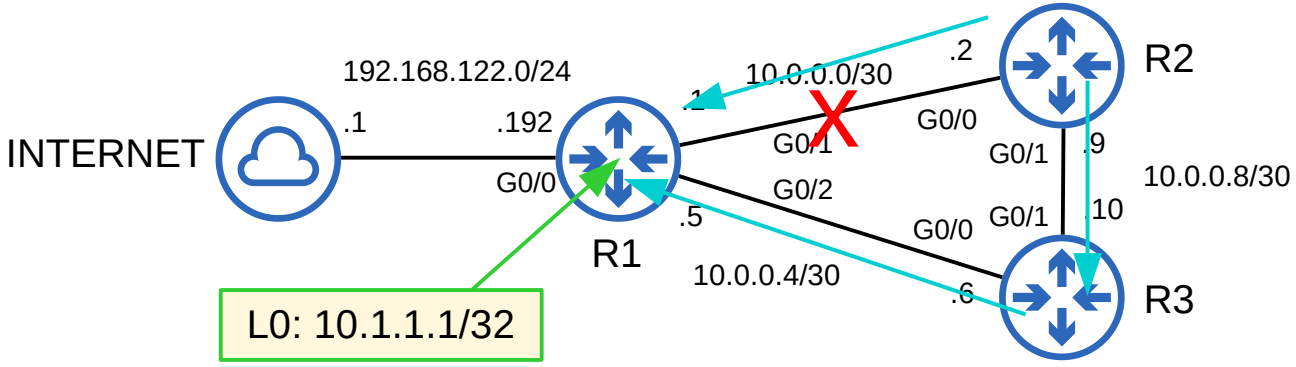
The hardware clock tracks the date and time on the device even if it restarts, power is lost, etc. When the system is restarted, the hardware clock is used to initialize the software clock.



NTP Configuration

```
R1(config)#interface loopback0
R1(config-if)#ip address 10.1.1.1 255.255.255.255
R1(config-if)#exit
R1(config)#ntp source loopback0
```

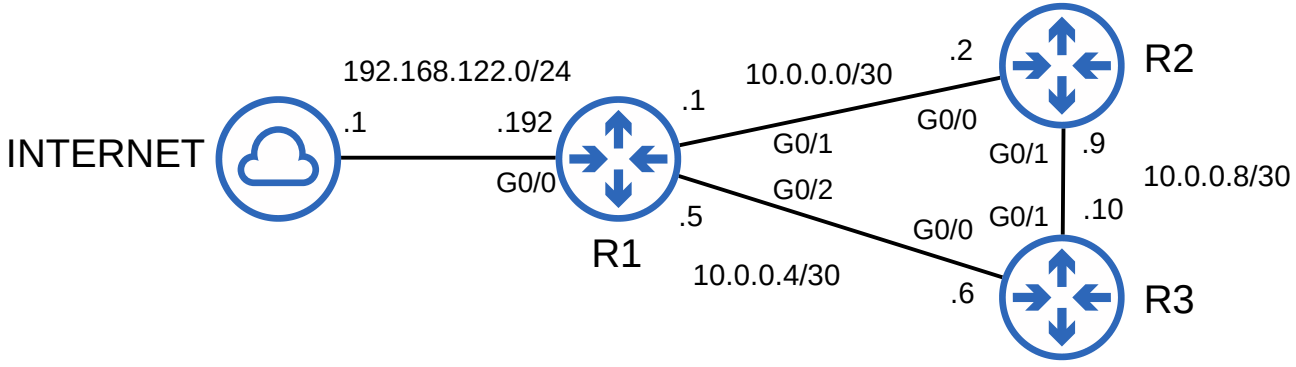
```
R2(config)#ntp server 10.1.1.1
R2(config)#do show ntp associations

  address         ref clock       st   when   poll reach  delay  offset   disp
*~10.1.1.1        216.239.35.12    2      0     64     1  7.038 -13.128 3937.5
 * sys.peer, # selected, + candidate, - outlyer, x falseticker, ~ configured
R2(config)#do show ntp status
Clock is synchronized, stratum 3, reference is 10.1.1.1
...
```



NTP Configuration

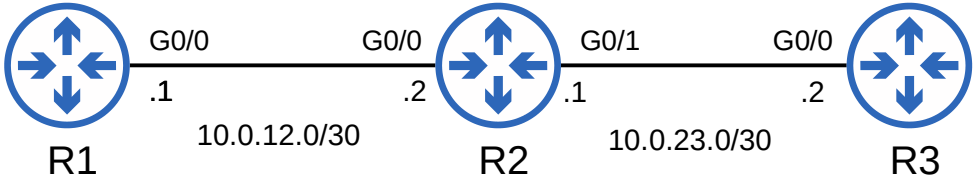
```
R3(config)#ntp server 10.1.1.1
R3(config)#ntp server 10.2.2.2
R3(config)#do show ntp associations

  address         ref clock       st   when   poll reach  delay  offset   disp
*~10.1.1.1        216.239.35.0     2      1     64     0  0.000   0.000 15937.
 ~10.2.2.2        10.1.1.1         3      1     64     0  0.000   0.000 15937.
 * sys.peer, # selected, + candidate, - outlyer, x falseticker, ~ configured
```

Servers with lower stratum levels are preferred.



Configuring NTP server mode

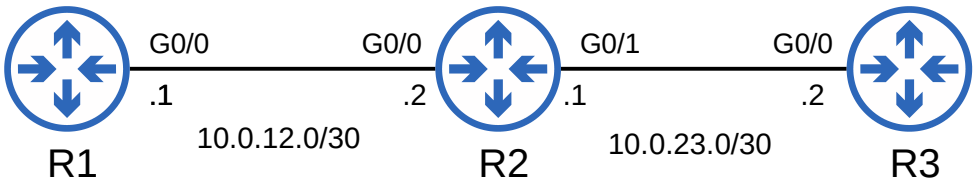
```
R1(config)#ntp ?
  access-group         Control NTP access
  allow                Allow processing of packets
  authenticate         Authenticate time sources
  authentication-key   Authentication key for trusted time sources
  broadcastdelay       Estimated round-trip delay
  clock-period         Length of hardware clock tick
  logging              Enable NTP message logging
  master               Act as NTP master clock
  max-associations     Set maximum number of associations
  maxdistance          Maximum Distance for synchronization
  mindistance          Minimum distance to consider for clockhop
  orphan               Threshold Stratum for orphan mode
  panic                Reject time updates > panic threshold (default 1000Sec)
  passive              NTP passive mode
  peer                 Configure NTP peer
  server               Configure NTP server
  source               Configure interface for source address
  trusted-key          Key numbers for trusted time sources
  update-calendar      Periodically update calendar with NTP time
```



Configuring NTP server mode

```
R1(config)#ntp master ?
  <1-15>  Stratum number
  <cr>

R1(config)#ntp master
R1(config)#do show ntp associations

  address         ref clock       st   when   poll reach  delay  offset    disp
*~127.127.1.1     .LOCL.           7      2     16   377  0.000   0.000  0.292
 * sys.peer, # selected, + candidate, - outlyer, x falseticker, ~ configured
R1(config)#do show ntp status
Clock is synchronized, stratum 8, reference is 127.127.1.1
...
```

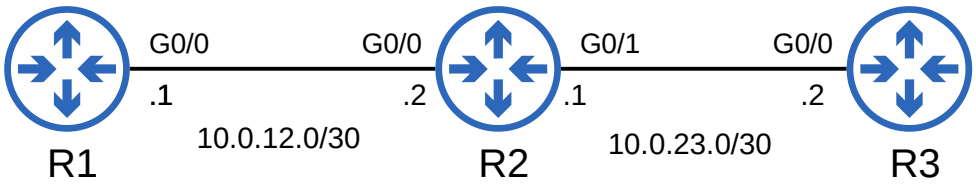
The default stratum of the **ntp master** command is 8.



Configuring NTP server mode

```
R2(config)#ntp server 10.0.12.1

R2(config)#do show ntp associations

  address         ref clock       st   when   poll reach  delay  offset   disp
*~10.0.12.1       127.127.1.1      8      2     64     1  5.263  62.494 187.64
 * sys.peer, # selected, + candidate, - outlyer, x falseticker, ~ configured
```

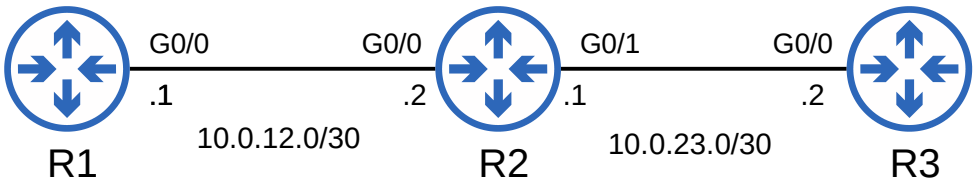
```
R3(config)#ntp server 10.0.12.1

R3(config)#do show ntp associations

  address         ref clock       st   when   poll reach  delay  offset   disp
*~10.0.12.1       127.127.1.1      8     45     64    17 21.534 -21.440  0.976
 * sys.peer, # selected, + candidate, - outlyer, x falseticker, ~ configured
```



Configuring NTP symmetric active mode

```
R2(config)#ntp peer 10.0.23.2

R2(config)#do show ntp associations

  address         ref clock       st   when   poll reach  delay  offset    disp
*~10.0.12.1       127.127.1.1      8     60     64    17 24.040 206.682  0.987
 ~10.0.23.2       10.0.12.1        9     33     64     0  0.000   0.000 15937.
 * sys.peer, # selected, + candidate, - outlyer, x falseticker, ~ configured
```

```
R3(config)#ntp peer 10.0.23.1

R3(config)#do show ntp associations

  address         ref clock       st   when   poll reach  delay  offset    disp
*~10.0.12.1       127.127.1.1      8     11     64    37 12.605  -7.406 63.575
 ~10.0.23.1       10.0.12.1        9      1     64     0  0.000   0.000 15937.
 * sys.peer, # selected, + candidate, - outlyer, x falseticker, ~ configured
```



Configuring NTP Authentication

- NTP authentication can be configured, although it is optional.
- It allows NTP clients to ensure they only sync to the intended servers.
- To configure NTP authentication:

```
ntp authentication-key key-number md5 key
ntp trusted-key key-number
ntp server ip-address key key-number
```

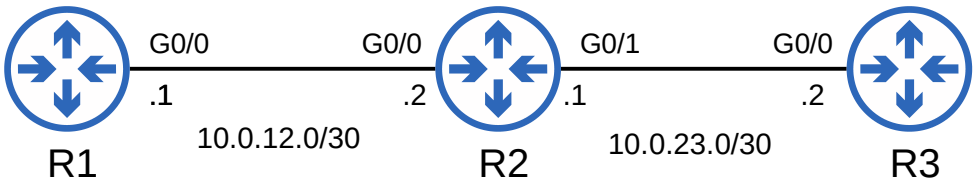
Create the NTP authentication key(s)

Specify the trusted key(s)

Specify which key to use for the server

This command isn't needed on the server (R1).

`ntp authentication` isn't needed!

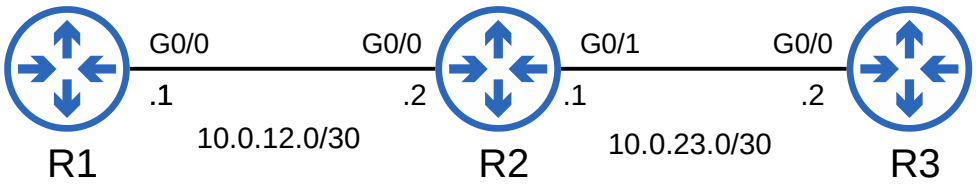


Configuring NTP Authentication

```
R1(config)#ntp authentication-key 1 md5 jeremysitlab
R1(config)#ntp trusted-key 1
```

```
R2(config)#ntp authentication-key 1 md5 jeremysitlab
R2(config)#ntp trusted-key 1
R2(config)#ntp server 10.0.12.1 key 1
R2(config)#ntp peer 10.0.23.2 key 1
```

```
R3(config)#ntp authentication-key 1 md5 jeremysitlab
R3(config)#ntp trusted-key 1
R3(config)#ntp server 10.0.12.1 key 1
R2(config)#ntp peer 10.0.23.1 key 1
```



NTP Command Review

```
!Basic Configuration Commands

R1(config)# ntp server ip-address [prefer]
R1(config)# ntp peer ip-address
R1(config)# ntp update-calendar
R1(config)# ntp master [stratum]
R1(config)# ntp source interface

!Basic Show Commands

R1# show ntp associations
R1# show ntp status

!Basic Authentication Commands

R1(config)# ntp authentication-key key-number md5 key
R1(config)# ntp trusted-key key-number
R1(config)# ntp server ip-address key key-number
R1(config)# ntp peer ip-address key key-number
```

Things we covered

- Why is time important for network devices?
- Manual time configuration
- NTP basics
- NTP configuration

Quiz 1

Which of the following commands will cause the router to adjust its software clock to match the hardware clock?

a) `R1#calendar update-clock`

b) `R1#calendar read-clock`

c) `R1#clock read-calendar`

d) `R1#clock update-calendar`

Quiz 2

Which of the following commands can be used to configure the time zone of the device?

a) `R1#clock set hh:mm:ss day month year time-zone`

b) `R1#clock timezone name offset`

c) `R1(config)#clock set hh:mm:ss day month year time-zone`

d) `R1(config)#clock timezone name offset`

Quiz 3

Examine the output below. Which of the following commands was configured on R1?

```
R1#show ntp associations

  address         ref clock       st   when   poll reach  delay  offset   disp
*~127.127.1.1     .LOCL.           8      2     16   377  0.000   0.000  0.292
 * sys.peer, # selected, + candidate, - outlyer, x falseticker, ~ configured
```

a) R1(config)#ntp master 9

b) R1(config)#ntp server 127.127.1.1

c) R1(config)#ntp master

d) R1(config)#ntp master 8

Quiz 4

Which of the following commands configures the router to operate in NTP client mode?

a) `R1(config)#ntp peer 10.0.12.2`

b) `R1(config)#ntp master`

c) `R1(config)#ntp server 216.239.35.0`

d) `R1(config)#ntp client 216.239.35.4`

Quiz 5

In a standard client-server configuration, which of the following commands must be configured on the client to enable NTP authentication? (select all that apply)

a) `R1(config)#ntp authentication`

b) `R1(config)#ntp master`

c) `R1(config)#ntp authenticate`

d) `R1(config)#ntp authentication-key key-number md5 key`

e) `R1(config)#ntp key key-number trust`

f) `R1(config)#ntp trusted-key key-number`

g) `R1(config)#ntp server ip-address key key-number`