Tuesday, July 22, 2025 3:10 PM

WHY IS TIME IMPORTANT FOR NETWORK DEVICES?

- All DEVICES have an INTERNAL CLOCK (ROUTERS, SWITCHES, PCs, 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's 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

Command: 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
```

Note : R3's time stamp is completely different than R2's !!!

```
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

```
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
```

```
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
```

```
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]
```

NTP BASICS

- 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 synchronization 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 with ~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

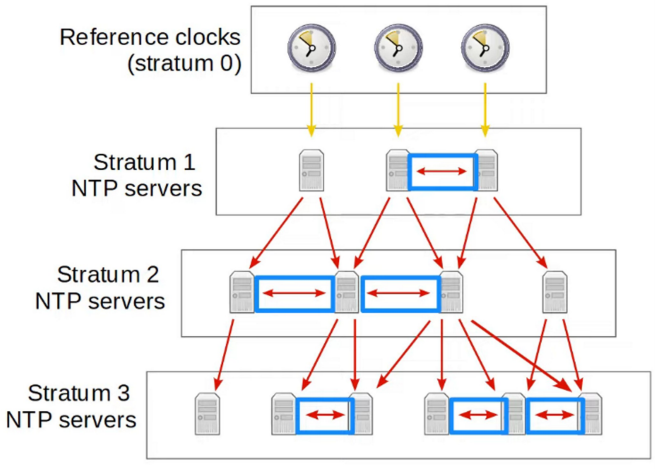
💡 NTP uses UDP port 123 to communicate

REFERENCE CLOCK

- A REFERENCE CLOCK is usually a VERY accurate time device like an ATOMIC CLOCK or GPS CLOCK
- REFERENCE CLOCKS are stratum 0 within the NTP hierarchy
- NTP SERVERS directly connected to REFERENCE CLOCKS are stratum 1

NTP Hierarchy

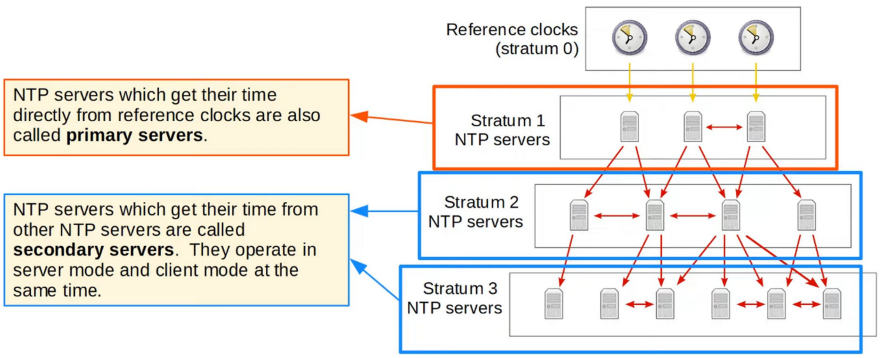
- Reference clocks are **stratum 0**.
- **Stratum 1** NTP servers get their time from reference clocks.
- **Stratum 2** NTP servers get their time from stratum 1 NTP servers.
- **Stratum 3** NTP servers get their time from stratum 2 NTP servers.
- **Stratum 15** is the maximum. Anything above that is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



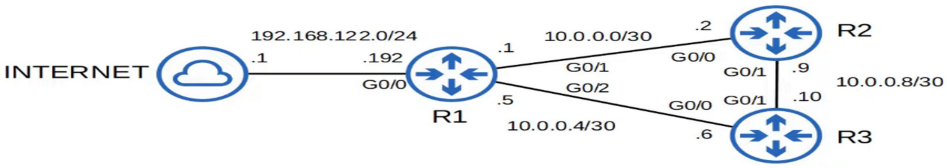
(Peering with Devices is called …)

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

- An NTP CLIENT can SYNC to MULTIPLE NTP SERVERS



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
```

Using key argument “prefer” makes a given server the PREFERRED SERVER

(To show configuration servers)

```
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
```

sys.peer = This is the SERVER that the current ROUTER (R1) is being synchronized to

st = Stratum Tier

(To show NTP Status)

```
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.
```

stratum 2 because it's synchronizing from Google (stratum 1)

(To show NTP clock details)

```
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
```

This command configures the ROUTER to update the HARDWARE CLOCK (Calendar) with the time learned via NTP

R1(config)# ntp update-calendar

The HARDWARE CLOCK tracks the DATE and TIME on the DEVICE - even if it restarts, power is lost, etc.

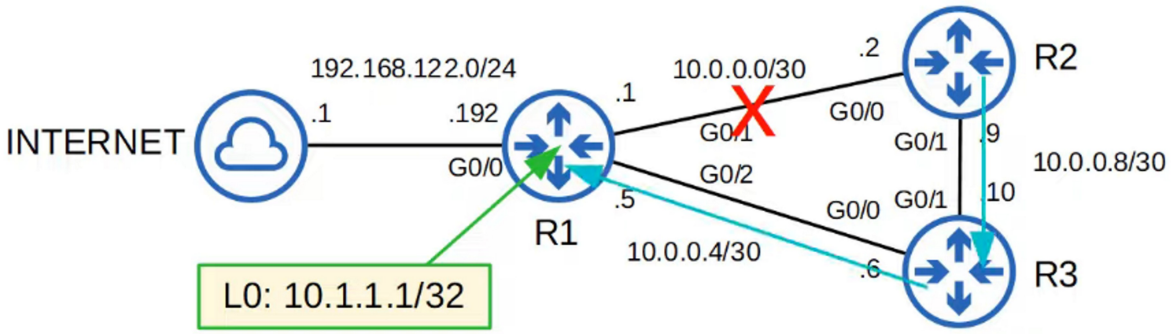
When the SYSTEM is restarted, the HARDWARE CLOCK is used to INITIALIZE the SOFTWARE CLOCK

CONFIGURE A LOOPBACK INTERFACE FOR AN NTP SERVER

```
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
```

Why configure a LOOPBACK DEVICE on R1 for NTP ?

If one of R1's ROUTER INTERFACES goes down, it will still be accessible via R3's ROUTING path



SET NTP SERVER for R2 using the LOOPBACK INTERFACE on R1

```
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
...
```

SETTING R3 NTP SOURCE SERVERS using R1 and R2

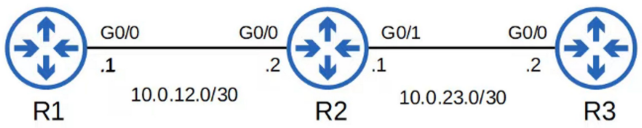
```
R3(config)#ntp server 10.1.1.1
R3(config)#ntp server 10.2.2.2
R3(config)#do show ntp associations

  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.

NOTE : R1 has PREFERENCE because it's STRATUM TIER is HIGHER than R2s

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
```

```
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.

```
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

Command to configure NTP SYMMETRIC MODE R2(config)#ntp peer <peer ip address>

```
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
```

CONFIGURE 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 authenticate (Enables NTP AUTHENTICATION)
  - ntp authenticate-key *key-number* md5 *key* (Create the NTP AUTHENTICATION Key(s))
  - ntp trusted-key *key-number* (Specify the Trusted Key(s))
  - ntp server *ip-address* key *key-number* (Specify which key to use for the server)

EXAMPLE CONFIGURATIONS

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

```
R2(config)#ntp authenticate
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 authenticate
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 authenticate
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
```