Chapter 12

Configuring the System Clock

Use the procedures described in this chapter to configure the E-series router clock.

This chapter contains the following sections:

Overview

You can use the **clock** commands to set the time and date on your system manually. These commands allow you to specify settings such as the source of the time, the time zone, and dates for seasonal time changes.

You can configure your router to update its clock automatically by configuring it as a Network Time Protocol (NTP) client. NTP provides a method of synchronizing the system clocks of hosts on the Internet to Universal Coordinated Time (UTC). Using NTP allows the system to record accurate times of events. You can view the log file of events to monitor the status of the network.

Since there is only one system clock, you can configure an NTP client on one virtual router only. Other virtual routers obtain clock parameters from the system clock. However, multiple virtual routers can act as NTP servers.

NTP

NTP uses a hierarchical structure of hosts, such as computers and routers, that form client-server and peer *associations*. An NTP client synchronizes with an NTP server, which in turn synchronizes with another time source. If two hosts provide synchronization for each other, they are peers.

Primary or *stratum 1* servers synchronize directly with an accurate time source, such as a radio clock or an atomic clock. *Secondary* or *stratum n* servers synchronize with other servers, and are *n* hops from an accurate time source.

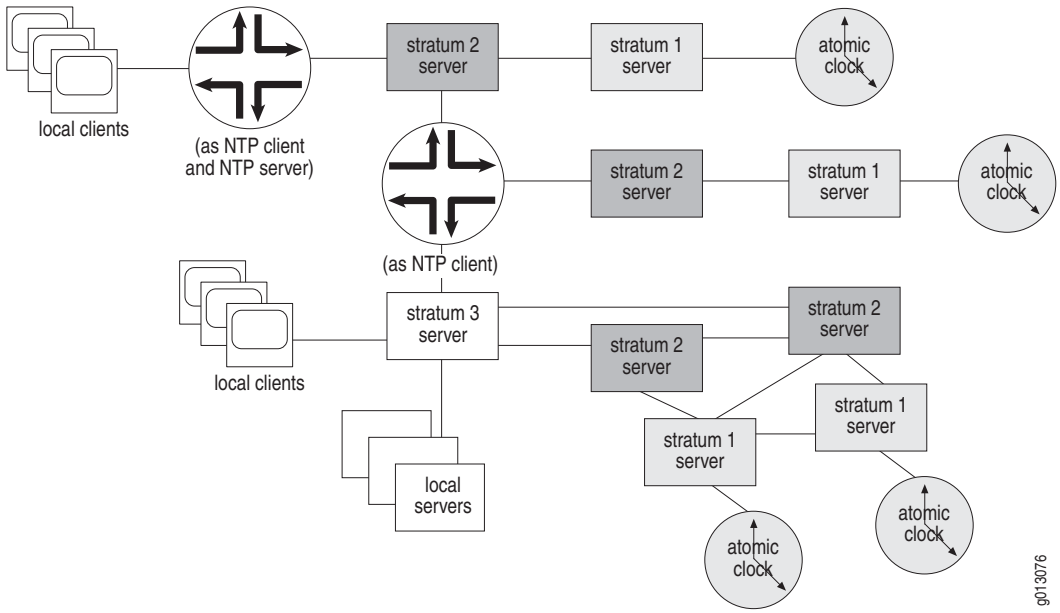
To obtain high precision and reliability with NTP, clients typically synchronize with several NTP servers at different physical locations. Peer associations, especially for stratum 1 and 2 servers, provide redundancy for the network.

Hosts synchronize by exchanging NTP messages through UDP. NTP uses the IP and UDP checksums to confirm data integrity.

By default, the router is an NTP client. You must configure NTP client parameters to start NTP client operation. You can also configure the router as an NTP server, whether or not you configure NTP client parameters.

Figure 30 shows an example of an NTP hierarchy.

Figure 30: Example of an NTP Hierarchy



System Operation as an NTP Client

To synchronize to the clock of a server, the system must receive time information from NTP servers recurrently. The way the system receives such information depends on how you configure it:

- If you configure the system to poll NTP servers, it sends time requests to the servers periodically. NTP servers receive the requests, add time information to the messages, and send replies to the system.
- If you configure the system as a broadcast client, it receives NTP broadcasts from servers periodically. The broadcasts include time information from the servers.

By default, NTP servers respond to the interface from which an NTP request originated. You can direct responses from all NTP servers to one interface on the system, or from a specific NTP server to a specific interface.

NOTE: When the system is not configured as either an NTP client or an NTP server, it responds to NTP requests with an invalid stratum number.

Synchronization

There are three stages to synchronization:

- Preliminary synchronization
- Frequency calibration
- Progressive synchronization

Preliminary Synchronization

Preliminary synchronization is a stage during which the system evaluates the initial time situation and decides how to proceed with longer-term synchronization. This stage involves the following steps:

1. The system obtains several readings of time data from NTP servers.
2. The system analyzes time data in the messages and compares the readings from different servers. Using this information, the system identifies the initial best time source (the *best server*).
3. The system calculates the difference between its own clock and the best server's clock (the *offset*) and proceeds as follows:
   - If the offset is greater than 15 minutes, the system disables NTP and displays a message advising you to check the time zone and clock settings.
   - If the offset is less than 15 minutes, the system sets its clock to that of the best server.
4. Provided the system has not disabled NTP, it proceeds to the next stage:
   - If a frequency calibration is available, the system starts progressive synchronization.
   - If the system has never performed a frequency calibration or the calibration has been deleted, the system starts a frequency calibration.

Frequency Calibration

Frequency calibration takes place the first time you use NTP or when you reboot the system. During this stage, the system evaluates the frequency error of its clock by measuring change in the offset error. A frequency calibration takes 15 minutes.

Progressive Synchronization

After the system has established initial NTP parameters, it continues to synchronize to a server as follows:

1. The system acquires time information from servers periodically.
2. The system evaluates which server is currently the best time source (the *master*) by analyzing time data in the messages and comparing the data from different servers.
3. The system gradually synchronizes its clock to that of the master.

System Operation as an NTP Server

The NTP server supports both unicast (user-to-user addressing protocol) and broadcast modes. Depending on the server configuration you choose, the system functions in different ways:

- When the system is configured as a unicast NTP server, it synchronizes clients to its own clock by responding to NTP requests from clients as follows:
  1. Swaps the destination and source addresses in the request packet.
  2. Sets all timestamps and NTP attributes in the packet.
  3. Returns the packet to the client.
- When the system is configured as a broadcast NTP server, it periodically sends NTP time synchronization messages to the local network broadcast address (255.255.255.255). The broadcast server would also respond to any NTP unicast requests from clients.

If the system is configured both as an NTP client and an NTP server, the system effectively synchronizes its clients to its master's clock. If the system is configured as an NTP server but not an NTP client, the system synchronizes its clients to its own clock, which can be set by the **clock** commands.

NOTE: When the system is not configured as either an NTP client or an NTP server, it responds to NTP requests with an invalid stratum number.

Platform Considerations

The system clock is supported on all E-series routers.

For information about the modules supported on E-series routers:

- See the *ERX Module Guide* for modules supported on ERX-7xx models, ERX-14xx models, and the ERX-310 router.
- See the *E120 and E320 Module Guide* for modules supported on the E120 router and the E320 router.

References

This implementation of NTP meets the following specifications:

- RFC 1305—Network Time Protocol (version 3) Specification, Implementation and Analysis (March 1992)
- RFC 2030—Simple Network Time Protocol (SNTP) (Version 4) for IPv4, IPv6, and OSI (October 1996)

Setting the System Clock Manually

Before you set the system clock, obtain the following information about your time zone:

- The name of the time zone
- The difference (offset) between the time zone and UTC
- The dates and times of transitions to and from summer time (daylight saving time)
- The difference between the standard time and summer time (daylight saving time)

The international Web site *www.timeanddate.com* contains information about time zones.

NOTE: Be sure to set the time zone (default is UTC) and summer time dates before you set the clock.

You can set the system clock at any time. This process involves the following steps:

1. Set the time zone.
2. Set the summer time dates.
3. Set the time.
4. Check the clock settings.

clock set

- Use to set the time and date on your system manually.
- Use the following syntax for setting the time: HH:MM:SS. This is the current time in 24-hour format—hours:minutes:seconds.
- There are two acceptable date forms for this command. Both produce the same display when you run the **show clock** command.
  - Day:month:year
  - Month:day:year

- Examples

  host1#**clock set 08:12:42 12 March 2000**
  host1#**clock set 11:12:55 March 10 2000**

- There is no **no** version.

clock summer-time date

- Use to set the clock to switch automatically to summer time (daylight saving time).
- Example

  host1(config)#**clock summer-time PDT date 1 April 200X 2:00 31 October 200X 2:00 60**

- Use the **no** version to prevent automatic switching to summer time.

clock summer-time recurring

- Use to set the clock to summer time at the same time each year.
- Example—This overrides the default settings for PDT,

  host1(config)#**clock summer-time PDT recurring first Sunday April 2:00 last Sunday October 2:00**

- Use the **no** version to prevent automatic switching to summer time.

clock timezone

- Use to set the time zone for display.
- Example—This sets the time zone to 5 hours behind UTC.

  host1(config)#**clock timezone EST -5**

- Use the **no** version to set the time zone to UTC, the default setting.

show clock

- Use to display the system time and the date.
- Example 1—Shows time source value when clock is manually configured

```
host1#show clock detail
TUE JAN 23 2007 11:50:47 UTC
time source: manually entered by user
timezone: UTC (0 minutes from UTC)
```

- Example 2—Shows time source value when clock is synchronized with NTP

```
host1#show clock detail
TUE JAN 23 2007 11:50:47 UTC
time source: Configured via NTP
timezone: UTC (0 minutes from UTC)
```

Before You Configure NTP

Before you configure NTP, complete the following procedures:

1. Configure at least one IP address on the router.
2. Check that the system clock reads the correct time to within 15 minutes, and that the time zone and summer time settings are correct.
3. Reset the system clock manually if the time, time zone, or summer time settings are incorrect.
4. If you want to configure the NTP system as an NTP client, choose the NTP servers.

Choosing NTP Servers

For the system, synchronizing to several stratum 2 or higher servers on the Internet provides sufficient accuracy for the timing of event messages. You can find a list of stratum 2 servers at *www.eecis.udel.edu/~mills/ntp.*

If you have access to an NTP server that you know to be reliable and accurate, you can synchronize the system to that server alone. You may prefer this method if you have used Simple Network Time Protocol (SNTP) with other equipment.

If you know that an NTP server broadcasts on a network to which the system has an interface, you do not need to configure NTP servers. Simply enable the system to accept NTP broadcasts on that interface.

NTP Configuration Tasks

By default, the system is an NTP client. You must configure NTP client parameters to start NTP client operation. You can also configure the system as an NTP server, whether or not you configure NTP client parameters.

Enabling NTP Services

Before you can configure NTP client parameters or enable a virtual router to act as an NTP server, you must enable NTP services. When you enable NTP services, the NTP client associates itself with the current virtual router. Because there is only one system clock to update, only the virtual router on which you configure NTP can act as the NTP client. However, any virtual router can act as an NTP server. To enable NTP services:

1. (Optional) Access the virtual router with which you want to associate NTP services.
2. Issue the **ntp enable** command.

ntp enable

- Use to enable NTP services on the system.
- This command associates NTP services and the NTP client with the current virtual router.
- Example

  host1:boston(config)#**ntp enable**

- Use the **no** version to disable NTP polling and clock correction and to remove the association between NTP services and the virtual router.

NTP Client Configuration

To configure the system as an NTP client:

1. Ping the selected NTP servers to ensure that the system can reach them.
2. Configure the system to acquire NTP data by completing one or both of the following actions:
   - Assign the NTP servers.
   - Enable the system to receive broadcasts on an interface.
3. If you enable the system to receive broadcasts on an interface, set the estimated round-trip delay between the system and an NTP broadcast server.
4. Disable NTP on interfaces that you do not want to receive NTP communications for security or other reasons.

ntp broadcast-client

- Use to enable the system to receive NTP broadcasts on an interface.
- Example

  host1(config-if)#**ntp broadcast-client**

- Use the **no** version to prevent the system from receiving NTP broadcasts.

ntp broadcast-delay

- Use to set the estimated round-trip delay in the range 0 to 999,999 microseconds between the system and an NTP broadcast server.
- Example

  host1(config)#**ntp broadcast-delay 2000**

- Use the **no** version to set the estimated round-trip delay to the default, 3000 microseconds.

ntp disable

- Use to disable NTP on an interface.
- Example

  host1(config-if)#**ntp disable**

- Use the **no** version to reenable NTP on an interface.

ntp server

- Use to assign an NTP server to the system and to customize the way the server communicates with the system.
- Specify the **source** option to direct responses from the NTP server to a specific interface on the system and override the **ntp source** command.
- Example

  host1(config)#**ntp server 192.35.42.1 version 3 prefer source atm 3/0.1**

- Use the **no** version to terminate communications between the system and an NTP server.

ping

- Use to check that the system can reach an NTP server.
- Example

  host1(config)#**ping 192.35.42.1**

- There is no **no** version.

Directing Responses from NTP Servers

By default, an NTP server sends a response to the interface from which an NTP request originated. You can now direct responses from all NTP servers to one interface on the system or direct responses from a specific NTP server to a specific interface.

ntp source

- Use to direct responses from all NTP servers to a specific interface. Using the **source** option with the **ntp server** command overrides the **ntp source** command.
- Example

  host1(config)#**ntp source atm 3/1**

- Use the **no** version to direct all servers to reply to the interface from which the NTP request was sent (the default setting).

Refusing Broadcasts from NTP Servers

You can prevent the system from receiving certain types of broadcasts and specify the servers from which the system will accept NTP broadcasts. To do so:

1. Issue the **ntp access-group** command.
2. Configure an access list.

access-list

- Use to configure an access list.
- Example

  host1(config)#**access-list europe permit any**

- Use the **no** version to remove the access list.

ntp access-group

NOTE: The system can accept, but does not use, NTP control queries.

- Use to specify the types of broadcasts that the system will accept and respond to, and to specify an access list of servers from which the system will accept broadcasts.You can enable the system to:
  - Receive time requests, receive NTP control queries, and synchronize itself to the servers specified on the access-list
  - Only receive time requests and NTP control queries from specified servers
  - Only receive time requests from specified servers
  - Only receive NTP control queries from specified servers
- Example

  host1(config-line)#**ntp access-group peer europe**

- Use the **no** version to enable the system to receive all NTP broadcasts on interfaces configured to receive broadcasts.

NTP Server Configuration

To enable a virtual router to act as an NTP server:

1. Access the virtual router context.
2. Specify that the virtual router acts as an NTP server.

CAUTION: Be sure that you do not override a valid time source if you specify the stratum of the NTP server. Issuing the **ntp master** command on multiple systems in the network might lead to unreliable timestamps if those systems do not agree on the time.

3. (Optional) Specify the stratum of this NTP server.

ntp broadcast

- Use to enable broadcast server on an interface to send NTP broadcast messages periodically.
- The server sends the NTP broadcast messages to the local network broadcast address (255.255.255.255).
- Example—In this example, the interface supports NTP software, version 4, and a poll interval of 5 (32 seconds) for broadcasting NTP messages.

  host1:boston(config-if)#**ntp broadcast version 4 5**

- Use the **no** version to prevent the interface from sending NTP broadcast messages.

ntp master

- Use to specify the stratum number of a virtual router you configured as an NTP server
- By default, the stratum number is set to the stratum number of the master plus one.

CAUTION: Although you can specify a stratum number of 1, the system does not support stratum 1 service. The system can synchronize only with an NTP server, and not directly with an atomic clock or radio clock.

- Specify a stratum number for the system in the range 1 – 15. A stratum *n* server is *n* hops from an accurate time source.
- Example

  host1:boston(config)#**ntp master**

- Use the **no** version to restore the default stratum number.

ntp server enable

- Use to enable a virtual router to act as an NTP server.
- Example

  host1:boston(config)#**ntp server enable**

- Use the **no** version to prevent a virtual router from acting as an NTP server.

Configuration Examples

The following examples show how to configure the system as an NTP client and an NTP server.

Example 1 NTP communications are established on the virtual router boston. The system is a client of the NTP server with IP address 172.16.5.1.

```
host1#virtual-router boston
host1:boston#ping 172.16.5.1
Sending 5 ICMP echos to 172.16.5.1, timeout = 2 sec.
.....
Success rate = 100% (0/5), round-trip min/avg/max = 0/0/0 ms
host1:boston#configure terminal
host1:boston(config)#ntp server 172.16.5.1
host1:boston(config)#ntp enable
```

Example 2 NTP communications are established on the virtual router boston. The system is specified as an NTP server.

```
host1#virtual-router boston
host1:boston#configure terminal
host1:boston(config)#ntp server
```

Example 3 NTP communications are established on the virtual router boston. The router is specified as an NTP broadcast server and synchronizes with NTP server 172.16.5.1. The specified interface enabled for NTP broadcasting is configured with version 4 and poll interval 5 for broadcasting NTP messages.

```
host1#virtual-router boston
host1:boston#configure terminal
host1:boston#ntp enable
host1:boston(config)#ntp server 172.16.5.1
host1:boston(config)#interface fastethernet 9/3
host1:boston(config-if)#ntp broadcast 4 5
```

NOTE: In Example 3, the router that acts as the NTP broadcast server must either synchronize to another server or master (specified by the **ntp server** command) or act as master (**ntp master** command).

Monitoring NTP

After you configure the system as an NTP client, you can use **show** commands to view information about the NTP servers you assigned and the status of NTP on the interface.

NOTE: For about 30 minutes after you configure the system as an NTP client, the data varies rapidly, and then starts to stabilize. Wait at least 1 hour before using the data to make decisions about NTP servers.

Many of the fields in the displays of these **show** commands take their values from the NTP messages. The NTP client uses this data to compare the performance of its NTP servers and to choose a master.

show ntp associations

- Use to view the information about the NTP servers you assigned.
- Field descriptions
  - * (Master)—System is synchronizing to this server
  - # (Master - unsynchronized)—System has chosen this server as master, but the master has not yet synchronized to UTC
  - + (Selected)—System will consider this server when it chooses the master
  - - (Candidate)—System may consider this server when it chooses the master
  - x (Unusable)—Server does not meet the initial criteria for master
  - p (Preferred)—Server that you specified as the preferred server
  - ~ (Configured)—Server is a configured server; no tilde indicates a broadcast server
  - Peer Address—IP address of server
  - Stratum—Number of hops between the server and the accurate time source
  - Poll—Time between NTP requests from system to server
  - Reachable—8-bit number that shows whether or not the NTP server responded to the last eight requests from the system; one indicates a response, zero indicates no response. For example, 11111111 indicates that the NTP server responded to the last eight requests. If the system reaches one server less often than it does other servers, that server is not a good choice for the master.
  - Precision—Length of the clock tick (interrupt interval) of server's clock
  - Delay—Round-trip delay, with the lowest dispersion value in the sample buffer, between the system and the server

  - Offset—Difference, with the lowest dispersion in the sample buffer, between the system's clock and the server's clock
  - Disp.—Lowest measure, in the sample buffer, of the error associated with the peer offset, based on the peer delay
- Example

```
host1#show ntp associations

Peer Address      Stratum   Poll  Reachable  Precision  Delay   Offset  Disp.
- 10.6.129.58        3      512s  01111111   0.000000s  0.000s  0.052s  0.010s
+~152.2.21.1         2      256s  11111111   0.000015s  0.070s  0.039s  0.020s
+~128.182.58.100     2      256s  11011111   0.000004s  0.030s  0.019s  0.074s
*p128.118.25.3       2      256s  10111111   0.000015s  0.020s  0.038s  0.073s
  (* Master, + Selected, - Candidate, x Unusable) (p Preferred, ~ Configured)
```

show ntp associations detail

- Use to view the information about the NTP servers you assigned.
- Field descriptions
  - Peer—IP address of server, status of the server: configured, master, selected, candidate, correct, or unusable
    - configured—Confirmation that you assigned this NTP server to the system
    - master—System has chosen this server as the master
    - selected—System will consider this server when it chooses the master
    - candidate—System may consider this server when it chooses the master
    - correct—System considers the server's clock to be reasonably correct
    - unusable—Server does not meet the initial criteria for the master
    - stratum—Number of hops between the server and its stratum 1 server
    - Peer is a Broadcast/Configured Server—Type of NTP server: one that broadcasts NTP messages or one you have configured for NTP services
    - version—Version of NTP on the server
    - polled every—Time between NTP requests from the system to the server
    - polls every—Time between NTP requests from the server to its NTP servers
    - Root Delay—Round-trip time between the server and its stratum 1 root server
    - Root Dispersion—Measure of all the errors associated with the network hops and servers between the server and its stratum 1 server
    - Sync Dist.—Measure of the total time error since the update in the path to the stratum 1 server
    - Peer Delay—Round-trip delay, with the lowest dispersion value in the sample buffer, between the system and the server
    - Peer Dispersion—Lowest measure, in the sample buffer, of the error associated with the peer offset, based on the peer delay and precision

- Offset—Difference, with the lowest dispersion in the sample buffer, between the system's clock and the server's clock
- Reachability—8-bit number that shows whether or not the NTP server responded to the last eight requests from the system; one indicates a response; zero indicates no response. For example, 11111111 indicates that the NTP server responded to the last eight requests. If the system reaches one server less often than it does other servers, that server is not a good choice for the master.
- Precision—Length of the clock tick (interrupt interval) of the server's clock
- Source—IP address of the interface to which NTP servers should send NTP responses

- Timestamps of latest time samples from this peer; actual timestamps displayed depends on how the server is configured
  - Root reference at—Last time at which the stratum 1 server sent an NTP reply to the server
  - Last request sent—Last time at which the system sent an NTP request to the server
  - Response/Broadcast was sent—Last time at which the server sent an NTP reply or broadcast to the system
  - Response/Broadcast received—Last time at which the system received an NTP reply or broadcast from this server
- Sample buffer for this peer contains the following samples:
  - Delay—Round-trip delay from client to server
  - Offset—Difference between client's and server's clocks
  - Dispersion—Measure of the errors of the offset values, based on the round-trip delay and the precisions of the system and the server

- Example

```
host1#show ntp associations detail

Peer 10.6.129.58 is selected, stratum 3
   Peer is a Broadcast Server, version 3, broadcasts every 64 sec
   Root Delay 0.059052 sec, Dispersion 0.189056 sec, Sync Dist. 0.229679 sec
   Peer Delay -0.000016 sec, Dispersion 0.009665 sec, Offset 0.050714 sec
   Reachability 11111110, Precision 0.000000 sec
   'Source' Interface : default (transmit interface)
 Timestamps of latest time sample from this peer:
   Root reference  at:  Thu, Apr 13 2000 17:27:17.145 from 128.118.25.3
   Broadcast was sent:  Thu, Apr 13 2000 17:42:02.118
   Broadcast received:  Thu, Apr 13 2000 17:42:02.067
 Sample buffer for this peer contains the following samples:
   Delay      (sec):   0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
   Offset     (sec):   0.049  0.050  0.050  0.050  0.050  0.050  0.051  0.051
   Dispersion (sec):   0.015  0.015  0.014  0.013  0.012  0.011  0.010  0.009
```

show ntp status

- Use to view the configuration and status of the system.
- Field descriptions
  - NTP Status—State of NTP on the system and the stratum number of the server
  - No. of associations—Number of peer associations for the NTP server
  - Clock Status:
    - Offset Error—Time difference between the system and the master, in seconds
    - Frequency Error—Error in the frequency of the system's clock, in seconds per second
    - Last Update—Last time received from the master
    - Root Dispersion—Measure of all the errors associated with the network hops and servers between the system and its stratum 1 server, in seconds
  - Configuration:
    - Admin. State—Status of NTP on the router (enabled or disabled)
    - Virtual Router Name—Name of the virtual router to which you attached NTP
    - Broadcast Delay—Time for a broadcast message to travel between the server and the client, in microseconds
    - Client Mode—NTP client status (True – system is an NTP client; False – system is not an NTP client)
    - Master Mode—NTP server status (True – system is configured as an NTP server; False – system is not configured as an NTP server)
    - Stratum No.—Stratum number of system if configured as NTP server
    - Summer Time—Status of seasonal time, True or False
    - Summer Timezone Name—Name of summer time zone
    - Timezone Name—Name of time zone
    - Timezone Offset—Time difference between the time zone and UTC, in hours:minutes
    - Access List—Identities of access lists of servers from which the system does not accept broadcasts
    - 'Server Source' Interface—Interface through which responses from the NTP server are directed; configured through the **ntp server source** command, which overrides the interface configured through the **ntp source** command.
    - 'Client Source' Interface—Interface through which all NTP server responses are directed; configured through the **ntp source** command.
    - Source Interface—IP address of the interface to which NTP servers should send NTP responses
    - Address—IP address of interface

- Enable—Status of NTP on the interface, On or Off
- BcastClient—Indication of whether or not this interface accepts broadcasts from NTP servers, On or Off
- BcastServer—Indication of whether or not this interface functions as a broadcast server, On or Off
- Name—Type of interface and its location

- Example

```
host1#show ntp status
Network Time Protocol (NTP v.4)

 NTP Status                   :No valid NTP server available
   No. of associations        : 0
 Clock Status                 :Initializing: frequency to be calibrated
   Offset Error               : 0 sec, amortizing asymptotically
   Frequency Error            : 0 sec/sec, compensating every second
   Last Update                :
   Root Dispersion            : 0 sec
 Configuration:
   Admin. State               : NTP Enabled
   Virtual Router Name        : default
   Broadcast Delay            : 3000 microseconds
   Client Mode                : True
   Master Mode                : False
   Stratum No.                : Unspecified
   Summer Time                : False
   Summer Timezone Name       :
   Timezone Name              : UTC
   Timezone Offset            : 00:0  hours:minutes
   Access List                :
   'Server Source' Interface  :
   ‘Client Source’ Interface  : Default (transmit interface)
 Interface Configuration      :
   Address     Enable    BcastClient  BcastServer   Name
   1.1.1.1      ON          ON           ON        FastEthernet1/0
```