Synchronizing Time Using NTP/NTS

Time synchronization in SUSE Linux Enterprise Server is managed using the Network Time Protocol (NTP) and its secure extension, Network Time Security (NTS), implemented via the `chrony` suite. By synchronizing the system clock against reliable remote or local time servers, administrators ensure accurate timekeeping across the network. This prevents sudden time leaps, ensures precise task scheduling and maintains synchronization across cluster nodes for critical applications.

Prerequisites

- Working network connection to the internal network or the Internet

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1 Introduction

Maintaining an accurate and synchronized system time on the computer is vital for teamwork. Planning and calendaring applications rely on it to track time correctly and notify users about appointments on time. For clustered applications, individual host machines often require synchronized system time for mutual communication.

The built-in hardware clock is not a reliable time source. A manual correction of the system time may cause malfunction of critical applications due to sudden time leaps. Therefore, the system time needs to be synchronized against an external reliable time source over the network.

1.1 What is NTP?

The Network Time Protocol (NTP) is designed to synchronize the system time over the network. Its goal is to maintain the absolute time and use it to synchronize the system time of all machines within a network.

1.2 What is NTS?

Network Time Security (NTS) is a security extension of NTP. NTS provides mechanisms to authenticate NTP messages and encrypt them, ensuring that the time data received is both secure and authentic. NTS is designed to be backward compatible with existing NTP infrastructure. This allows for gradual deployment without requiring changes to existing NTP servers that do not support NTS.

1.3 How does NTP work?

When the NTP service is properly configured, it continuously queries and adjusts the system time with reliable time servers. Typically, home computers and other devices connected to the internet are configured to query a public time server on the Internet.

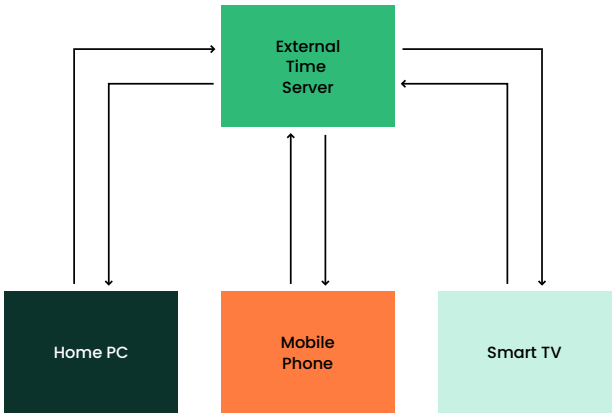


FIGURE 1: INDIVIDUAL DEVICES QUERYING A PUBLIC TIME SERVER

Conversely, desktop computers and servers that reside inside a corporate subnet are configured to query a dedicated time server within the local network. The time server itself synchronizes its time with a public time server.

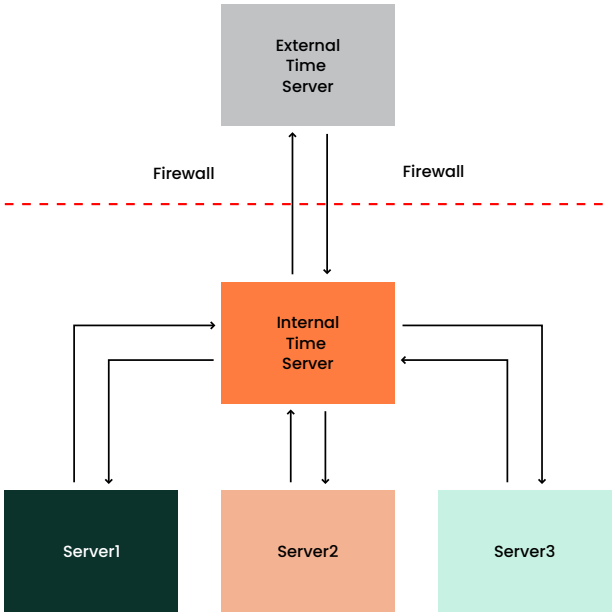


FIGURE 2: MULTIPLE HOSTS QUERYING AN INTERNAL TIME SERVER

1.3.1 Implementation

`chrony` is the default implementation of NTP in SUSE Linux Enterprise Server. `chrony` includes two parts:

- `chronyd` is a `systemd` service that can be started at boot time.
- **`chronyc`** is a command-line interface program to monitor the performance of `chronyd` and to change specific operating parameters at runtime.

1.4 Benefits

Using NTP to maintain the accurate time has the following benefits:

- People can rely on their clocks when following a planned schedule.
- Applications can trigger scheduled desktop or system actions accurately.
- Cluster nodes can keep their data synchronized and up to date.
- Using an internal time server helps maintain synchronized system time in networks with restricted access to the Internet.
- By integrating security measures into NTP through NTS, the protocol enhances its robustness and addresses the vulnerabilities associated with unsecured time synchronization.

2 Configuring NTP by adjusting `/etc/chrony.conf`

When `chronyd` starts, it reads its configuration from the `/etc/chrony.conf` file. The following sections list important parameters that can affect `chronyd` behavior.

2.1 Specifying time sources

To keep the computer clock synchronized, you need to tell `chronyd` what time sources to use. For this purpose, use `server`, `pool` and `peer` directives. You can use each of them multiple times.

The `server` directive tells `chronyd` to use a specific host as a time server by its name or IP address.

```
server 0.europe.pool.ntp.org offline❶
server 1.europe.pool.ntp.org offline prefer❷
```

```
server 192.168.2.254
```

1. The `offline` option prevents `chronyd` from querying the time server. This option is useful if the server is not reachable when `chronyd` is started. You need to put the time server online when it is reachable by using **`chronyc`**. Refer to *Section 3, "Managing `chronyd` at runtime"* for more details.
2. The `prefer` option tells `chronyd` to prefer the time source over others that do not include such an option.

The `pool` directive lets you specify a network name that resolves to multiple IP addresses that may change over time.

```
pool pool.ntp.org iburst❶ maxsources 3❷
```

1. The `iburst` option means that `chronyd` starts with a burst of 4 to 8 requests to make the first update of the clock sooner.
2. The `maxsources` option tells `chronyd` to use up to three sources from the pool.

The `peer` directive specifies an NTP peer host instead of a time server. System time synchronization among *peers* uses a symmetric architecture instead of the client/server mode invoked by `server` and `pool` options. You can use `peer` multiple times to specify more than one peer.

```
peer 192.168.1.116
peer ntp.example.com
```

2.2 Running chronyd as an NTP server

By default, `chronyd` works as a client to specified NTP servers. To make it operate as an NTP server as well, add the `allow` directive to the `/etc/chrony.conf` file. It opens the NTP server port (123 by default) and responds to client requests.

You can either specify a single IP of an NTP client, or a subnet to include multiple clients. You can use the `allow` directive multiple times:

```
allow 1.2.3.4
allow 3.4.5.0/24
```



Tip

If you do not specify an IP address or a subnet, the stand-alone `allow` directive allows access from all IPv4 and IPv6 addresses.

To limit the access of the previous `allow` directive, use the `deny` directive:

```
allow 1.2.3.4
deny 1.2.3.0/24
allow 1.2.0.0/16
```

In the above example, the effect is the same regardless of the order of the three directives. The `1.2.0.0/16` subnet is allowed access except for the `1.2.3.0/24` subnet, which is denied access. However, the host `1.2.3.4` is allowed access.

2.3 Configuring a local reference clock

`chronyd` relies on other programs (such as `gpsd`) to access the timing data via a specific driver. Use the `refclock` directive in `/etc/chrony.conf` to specify a hardware reference clock to be used as a time source. It has two mandatory parameters: a driver name and a driver-specific parameter. The two parameters are followed by zero or more `refclock` options. `chronyd` includes the following drivers:

PPS

Driver for the kernel *pulse per second* API. For example:

```
refclock PPS /dev/pps0 lock NMEA refid GPS
```

SHM

NTP shared memory driver. For example:

```
refclock SHM 0 poll 3 refid GPS1
refclock SHM 1:perm=0644 refid GPS2
```

SOCK

Unix domain socket driver. For example:

```
refclock SOCK /var/run/chrony.ttyS0.sock
```

PHC

PTP hardware clock driver. For example:

```
refclock PHC /dev/ptp0 poll 0 dpoll -2 offset -37
refclock PHC /dev/ptp1:nocrossts poll 3 pps
```



Tip

For more information on individual drivers' options, see **`man 8 chrony.conf`**.

2.4 Activating offline time sources

Although `chronyd` starts up normally on a system that boots without a network connection, it cannot access the time servers specified in `/etc/chrony.conf`. To prevent `chronyd` from trying to query inaccessible time servers, use the `offline` option next to the time source directive, for example:

```
server ntp.example.org offline
```

`chronyd` then does not try to poll the server until it is enabled using the following command:

```
# chronyc online ntp.example.org
```



Tip

When the `auto_offline` option is set instead of the `offline` option, `chronyd` assumes that the time server has gone offline when two requests have been sent to it without receiving a response. This option avoids the need to run the **`offline`** command from **`chronyc`** when disconnecting the network link.

3 Managing chronyd at runtime

3.1 What is **chronyc**?

`chronyc` is the client part of the `chrony` NTP implementation. You can use the **`chronyc`** command to change the behavior of the `chronyd` service at runtime. It also generates status reports about the operation of `chronyd`.



Note: Temporary changes

Changes made using **`chronyc`** are not permanent. They are lost after the next `chronyd` restart. For permanent changes, modify `/etc/chrony.conf` as described in *Section 2, "Configuring NTP by adjusting `/etc/chrony.conf`"*.

3.2 How does **chronyc** work?

You can run **chronyc** either in an interactive or non-interactive mode. To run **chronyc** interactively, enter **chronyc** on the command line and press **Enter** . It displays a prompt and waits for your command input. For example, to check how many NTP sources are online or offline, run the **activity** command:

```
# chronyc
chronyc> activity
200 OK
4 sources online
2 sources offline
1 sources doing burst (return to online)
1 sources doing burst (return to offline)
0 sources with unknown address
```

To exit **chronyc**'s prompt, enter **quit** or **exit**.

If you do not need to use the interactive prompt, enter the command directly, for example:

```
# chronyc activity
```

4 Configuring NTS

NTP protocol does not introduce security mechanism to make the communication between the time server and client authenticated and encrypted. Network Time Security (NTS) is an extension that improves the security of NTP. `chrony` supports NTS and can authenticate time sources and protect against certain network attacks.

The following procedures outline how to configure the time server and client machine for secure time synchronization.

PROCEDURE 1: CONFIGURING NTS TIME SERVER

1. *(Optional)* It is a good idea to configure the time server to update its time via NTS. This ensures secure time synchronization from the very beginning of the synchronization chain. Comment out any existing time sources in `/etc/chrony.conf` that do not support NTS and add at least one that supports NTS, for example:

   ```
   server time.cloudflare.com iburst nts
   ```



Tip

The `nts` option requests NTS connection if it is available, otherwise it falls back to NTP if NTS is not available.

2. Restart the `chronyd` service.

```
> sudo systemctl restart chronyd.service
```

3. Verify the configured time sources.

```
> chronyc sources -v
MS Name/IP address         Stratum Poll Reach LastRx Last sample
===============================================================================
^? time.cloudflare.com           3   6     1     2   -947ms[ -947ms] +/-   12ms
^? pyrrha.fi.muni.cz             2   6     1     1   -948ms[ -948ms] +/-   39ms
^* whitesoft-intex16.c.cbsn>     1   6     1     2   -948ms[ -948ms] +/- 5444us
^? mail.combatostrich.dev        2   6     1     1   -948ms[ -948ms] +/-   28ms
```



Note

The line that starts with `^*` includes the time source that was selected as best.

Verify that the configured time source uses the NTS mode.

```
> chronyc -N authdata
Name/IP address             Mode KeyID Type KLen Last Atmp  NAK Cook CLen
=========================================================================
[...]
time.cloudflare.com          NTS     1   15  256    3    0    0    8   96
```

4. Verify that the server configuration includes the `allow` option that specifies which clients can synchronize time with the time server, for example:

```
allow 192.168.1.0/24
```

5. *(Optional)* If the time server is running behind a firewall, allow communication on ports for both NTP and NTS. They are 123 and 4460 by default.

6. Obtain a TLS certificate and a corresponding private key and copy them to `/var/lib/chrony/`. Verify that they are readable by `chrony`, for example:

```
> sudo install -m 0440 -o chrony -g chrony nts.key /var/lib/chrony/
> sudo install -m 0440 -o chrony -g chrony nts.crt /var/lib/chrony/
```



Tip

Find detailed information about TLS certificates in a dedicated article. (https://documentation.suse.com/smart/security/html/tls-certificates/index.html)

7. Edit `/etc/chrony.conf` and verify that the `ntsdumpdir /var/lib/chrony` option is active. Then append the paths to the TLS key and certificate.

```
ntsdumpdir /var/lib/chrony
ntsserverkey /var/lib/chrony/nts.key
ntsservercert /var/lib/chrony/nts.crt
```

8. Restart the `chronyd` service.

```
> sudo systemctl restart chronyd.service
```

PROCEDURE 2: CONFIGURING NTS CLIENTS

1. Disable existing NTP sources, for example:

```
#server 192.168.1.1 iburst
```

The sources configurations are included in `/etc/chrony.conf` or in files under `/etc/chrony.d/`.

2. The client host needs to trust the Root CA that signed the TLS certificate. Find details on how to manage the CA certificate store in a dedicated article (https://documentation.suse.com/smart/security/html/tls-certificates/index.html#tls-certificates-store).

3. Add the NTS time server source that you configured in *Procedure 1, "Configuring NTS time server"* to the client `chrony` configuration in `/etc/chrony.conf`, for example:

```
server nts1.example.com iburst nts
```

4. Restart the `chronyd` service.

```
> sudo systemctl restart chronyd.service
```

5. Verify configured time sources on the client and confirm that the connection is authenticated.

```
> sudo chronyc sources -v
> sudo chronyc -N authdata
```

6. On the NTS time server, verify per client statistics about NTS connections.

```
> sudo chronyc -N clients -k
```

5 The chronydsystemd service

The main part of `chrony` is the `chronyd` `systemd` service that runs in the background and synchronizes system time with selected time servers. You can use the following `systemd` commands to operate the `chronyd` service:

`systemctl status chronyd.service`
: Prints extended information about the current status of the `chronyd` service.

`systemctl is-enabled chronyd.service`
: Checks whether the automatic start of the `chronyd` service at system boot is enabled.

`systemctl enabled chronyd.service`
: Enables the automatic start of the `chronyd` service at system boot.

`systemctl disable chronyd.service`
: Disables the automatic start of the `chronyd` service at system boot.

`systemctl is-active chronyd.service`
: Checks whether the `chronyd` service was started and is running.

`systemctl start chronyd.service`
: Starts the `chronyd` service.

`systemctl stop chronyd.service`
: Stops the `chronyd` service.

`systemctl restart chronyd.service`
: Restarts the `chronyd` service and reloads `/etc/chronyd.conf`.

6 Troubleshooting

In case of errors, check the following.

- Verify that your computer is connected to a network and that the network is configured correctly:

```
> sudo systemctl status network.service
● NetworkManager.service - Network Manager
     Loaded: loaded (/usr/lib/systemd/system/NetworkManager.service; enabled; vendor
 preset: disabled)
     Active: active (running) since Sat 2021-08-07 20:09:44 CEST; 4 days ago
[...]
```

- Verify that the time servers that you entered as a time source exist and are reachable over the network. For example:

```
> ping pool.ntp.org
PING pool.ntp.org (85.199.214.101) 56(84) bytes of data.
64 bytes from 85.199.214.101 (85.199.214.101): icmp_seq=1 ttl=37 time=29.9 ms
[...]
```

- If the `firewalld` service is active on your computer, verify that the NTP service is allowed.

- Verify that the `chronyd` service is running:

```
> sudo systemctl status chronyd.service
● chronyd.service - NTP client/server
     Loaded: loaded (/usr/lib/systemd/system/chronyd.service; enabled; vendor
 preset: disabled)
     Active: active (running) since Sat 2021-08-07 20:09:44 CEST; 4 days ago
 [...]
```

- If the system time on a virtualized guest diverges from the exact time, make sure that the VM Host Server system time is synchronized with a valid time server and that the guest is synchronized with the same time source as the host.

- If the NTP service fails to start properly during system boot, it can be caused by network switches configured to use the `Spanning Tree Protocol` while ports are not configured as `Edge Ports` but `Portfast`. In this case, it can take up to a minute until the network connectivity is established.

- If the NTP service fails to start during system boot when the NetworkManager is used, edit the `/etc/sysconfig/network/config` file and change the value of `NM_ONLINE_TIMEOUT` value to 30. If the problem persists, increase the timeout value by 15 and try again.

- If NTP sources cannot be reached, identify them with the following command:

```
> chronyc sources -v
[...]
MS Name/IP address         Stratum Poll Reach LastRx Last sample
===============================================================================
^* time.mydomain.com             3  10   377    81  -5354us[-8257us] +/-  191ms
^? ntp1.example.com              0  10     0     -     +0ns[   +0ns] +/-    0ns
^? 77.177.77.177                 0  10     0     -     +0ns[   +0ns] +/-    0ns
^? ntp3.example.com              0  10     0     -     +0ns[   +0ns] +/-    0ns
^? ntp4.example.net              0  10     0     -     +0ns[   +0ns] +/-    0ns
^? 2a02:3d8:1::1:1               0   6     0     -     +0ns[   +0ns] +/-    0ns
^? ntp2.example.org              0  10     0     -     +0ns[   +0ns] +/-    0ns
```

  In this case, the only server that is really serving time is `time.mydomain.com`. It is necessary to generally troubleshoot the network connection to the failing remote NTP time sources.

7 For more information

- Securing your computer with `firewalld` is described in https://documentation.suse.com/sles/16.1/html/SLES-intro-firewalld/.

- Commands for operating `systemd` services are listed in https://documentation.suse.com/sles/16.1/html/SLES-systemd-basics/index.html#systemctl-commands.

- For a complete reference, see related manual pages:
  For a complete list of configuration directives, run **`man 1 chrony.conf`**.
  For a complete list of **`chronyc`** commands, run **`man 1 chronyc`**.
  For a complete list of `chronyd` command-line options, run **`man 8 chronyd`**.

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