Introduction

Information systems in recent years have undergone dramatic changes in their configuration from operation centered on the mainframe computer to the distributed system implemented using UNIX servers.

In the distributed system that uses UNIX servers, the clocks must be synchronized among different servers for a number of reasons including individual application server management.

This manual explains the Network Time Protocol (NTP), which is a standard method of synchronizing UNIX servers. This manual also explains how to design and operate the NTP in the Solaris™ Operating Environment (Solaris OE) to assist the user in designing a distributed system with PRIMEPOWER.

This manual is organized as follows:
1. About NTP
   This chapter gives a brief explanation about NTP.
2. NTP Settings
   This chapter explains in detail the NTP server/client settings.
3. Application to Actual Operation
   This chapter explains issues to be handled before applying the NTP to actual operations, such as time changes and the co-existence of the NTP with its older versions.
4. NTP Status Information
   This chapter explains the status information recorded by the NTP.
5. Notes
   This chapter explains other notes.

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5. NOTES

5.1 About /etc/system

APPENDIX A  SLOW CLOCK SYNCHRONIZATION WITH NTP

APPENDIX B  NTP FAILURE
1. About NTP

This chapter explains the Network Time Protocol (NTP).

1.1 Overview

Network Time Protocol (NTP) is a network protocol used to synchronize a client machine or server machine with other server machines or clocks (hardware such as the radio, satellite receiver, and modem). For example, the clock of a server that uses the GPS (Global Positioning System) and that is synchronized with Coordinated Universal Time (UTC) can be set via LAN or WAN with precision on the order of milliseconds or several tens of milliseconds respectively.

The specifications of NTP are released by RFC 1305 (NTP Version 3) and others and its implementation is, in addition to freeware, incorporated in Solaris OE as standard equipment. Although the latest version is Version 4, the implementation for Solaris 2.6 OE to Solaris 8 OE is based on Version 3. The NTP implementation for Solaris OE has been developed based on freeware, but it is only one type of implementation that is not necessarily identical to NTP implementations of other operating systems.

1.2 Design Principles of NTP

- NTP is a framework used to synchronize the system clock of the router and host system with the reference clock, which keeps accurate time, at startup and then to maintain the time within a specified range. That is, if the NTP server time is changed, the NTP client time is not synchronized.

- NTP assumes the use of a reference clock (explained later) such as a cesium atomic clock or GPS with the accuracy on the order of microseconds. In a LAN environment, NTP can maintain the time within the range of several milliseconds. If a network with a longer latency time such as WAN is used, the time can be maintained within the range of several tens of milliseconds.

- It is assumed that the reference clock keeps accurate time and basically is not changed (Leap seconds are already taken into account in the protocol specifications). Thus, any change of the reference clock from outside is not taken into consideration in the protocol specifications.

- The time of more than 100,000 computer systems under an accurate reference clock (stratum 1) worldwide is already being maintained by NTP. In the US, an accurate reference clock is also used in the computer systems of financial and securities companies.

- For the operation of NTP, the reference to an accurate reference clock is assumed. It is desirable to limit the reference to a local system clock to temporary situations in which the accurate reference clock cannot be referenced due to a network error or hardware failure. In such cases, the local system depends on the accuracy (accuracy to within +128milliseconds and -128milliseconds recommended) of the local clock and thus the time is maintained with the accuracy below the local clock.

- NTP is controlled by the following three threshold values:
  1. Step threshold (+128ms, -128ms) : Upper and lower limit for the time maintenance (Basically, the time needs to be maintained within this range)
  2. Stepout threshold (900sec) : Threshold for the duration to ignore the offset value from the reference clock when it is equal to "+128milliseconds or more" or "-128milliseconds or less".
  3. Panic threshold (1000sec) : Threshold forgoing time synchronization (xntpd is exited) by NTP when the difference between the system clock and the reference clock is 1000 s or more

[Sources]
David L. Mills, Network Time Protocol (NTP) General Overview, Univ. Delaware, Nov.9, 1999
David L. Mills, Adaptive Hybrid Clock Discipline Algorithm for the Network Time protocol, IEEE ACM, 1999
1.3 NTP "Stratum"

An NTP network has a stratum structure. Whether on the Internet or intranet, the smaller the "stratum" number, the greater the proximity to the accurate clock (UTC). On the Internet, a little less than 100 stratum 1 servers and a little more than 100 stratum 2 servers are made available (public time server). Stratum 1 servers have reference clocks, but stratum 2 servers have no reference clock and thus reference the stratum 1 servers for time setting.

In operations in which time information is fetched from these servers, strata are built such that, for example, file servers are in stratum 3 and other workstations in stratum 4. Stratum 3 servers reference three or more servers of stratum 2 to distribute time information to many stratum 4 servers.

Sometimes, the term stratum 0 may be used in ntp.conf. This represents a clock itself and does not represent any server stratum.

1.4 Reference Clock

External clocks with high precision (hereafter reference clocks, many of which devices are connected serially) can be handled directly by xntpd. In addition to GPS devices, various kinds of reference clocks are available.

In ntp.conf, a reference clock is represented, like other servers, by an IP address in the format shown below:

127.127.t.u

Here, t indicates the type. In the latest xntpd, clocks of type 1 to 33 are mounted as standard equipment. Only type 1 is special and indicates "Local Clock Driver" or the kernel clock. Others are high precision clock hardware.

The clockwork (type name: PW007TC1/synchronized with NTT time signals (117)) is available as hardware commercialized by Fujitsu that can be used as a reference clock in Solaris OE. For details on how to set NTP, see Section 2.4, "Setting the NTP Server to Which a Clockwork is Connected."

1.5 Time Synchronization of the Reference Clock and NTP

The daemon xntpd of NTP has an internal NTP clock and performs time synchronization of the local clock and reference clock with the following logical structure:
1.6 Operation Mode of NTP

NTP has the following four operation modes:

- symmetric-active mode
- client mode
- broadcast mode
- multicast mode

1.6.1 symmetric-active mode

Mode used when a "peer" line is declared in ntp.conf. In this mode, the local time can be synchronized with the remote server and the remote server can be synchronized with the local server as well. This is not a mutual time setting, but synchronization with the accurate time source.

1.6.2 client mode

Mode used when a "server" line is declared in ntp.conf. In this mode, the local clock is synchronized with the clocks of other servers, but the remote server clocks are not synchronized with the local clock. By selecting and declaring three or more servers from groups of different operations, an operation can be performed at a stratum lower than that of such servers.

1.6.3 broadcast mode

Mode used when a "broadcast" line is declared in ntp.conf. In this mode, time information is obtained from a broadcast server in the same subnet. This operation can be applied when the reliability of time may be modest.

1.6.4 multicast mode

Mode used when a "multicast" line is declared in ntp.conf. In this mode, time information is obtained from a multicast server using IP multicasting. This operation can be applied when the reliability of time may be modest.
1.7 Configuration Design of NTP

Before using NTP, it is necessary to design how to synchronize the time among servers including the reference clock. The following explains the cases where an accurate reference clock is used and no accurate reference clock or time-correcting reference clock is used.

1.7.1 When an accurate reference clock is used

First, an accurate reference clock must be provided. The following can be used as a reference clock:

- **NTP server on the Internet**
  This is practical, but its accuracy and operation are not necessarily guaranteed. Also, connection to the Internet is required.

- **NTP server using GPS or clockwork**
  The clockwork (type name: PW007TC1) is available as a clock shipped by Fujitsu. The clockwork (type name: PW007TC1) is clockwork that synchronizes with NTT time signals (117). Fujitsu recommends a configuration in which an NTP server connected to clockwork (type name: PW007TC1) is synchronized. Also, devices are available on the market, though not shipped by Fujitsu, that can function as an NTP server by synchronizing with time information from GPS. They can be used as a reference server.

The reference server clock is relied on for time synchronization. In this operation, because the reference clock itself is in some way or other (atomic clock or GPS) synchronized with world time, no manual synchronization is required. However, a correction of about one second may be needed due to a leap second and so on.

The configuration is as shown below. In NTP server configuration (1), the reference server on the Internet is referenced and NTP strata are built for operation. In NTP server configuration (2), the reference server that is synchronized with the reference clock (clockwork (type name: PW007TC1)) is referenced and NTP strata are built for operation.

```
NTP server configuration (1)
Reference server stratum = 5
Reference server on the Internet
Reference server 1 stratum=7
Reference server 2 stratum=9
Reference server 3

NTP server configuration (2)
Reference server stratum = 1
Clockwork
Reference server 1 stratum=3
Reference server 2 stratum=3
Reference server 3 stratum=5
```
1.7.2 When no accurate reference clock or no time-correcting server as a reference clock is used (not recommended)

The clock of one or more servers is relied on to synchronize the time of other servers. In this operation, because the reference clock itself loses synchronization with world time on a daily basis, the time must be corrected manually sometime every week or every month.

Problems that arise are as follows: if the reference server clock is set back 10 seconds because it was ten seconds fast, the time of other servers that reference the reference server can be synchronized with difficulty only by drastically correcting the clock of each server. Also, sharply correcting the clock may cause active applications to malfunction.

Because of the above problems, to synchronize the clock of reference server with world time, it is necessary to stop all ntp servers, change the clock of reference server, and then synchronize the clock of each server. (For information on this procedure, see Chapter 3, "Application to Actual Operation.") Because it is very complicated, Fujitsu does not recommend this method.

The configuration example is as follows (NTP server configuration (3)). In this configuration, two NTP servers are required. One is used as the primary server and the other is used as the secondary server for operation. The secondary server and client (called the reference server 1 here) are synchronized with the clock of the primary server. If the primary server fails for some reason, the client is synchronized with the secondary server. For information on detailed settings, see Section 2.2, "Primary and Secondary Server Operation." (There is no problem even if it synchronizes by the "server-client" mode between a primary server and secondary server at time.)
2. NTP Settings

2.1 PRIMEPOWER 800/1000/2000/900/1500/2500/HPC2500

2.1.1 Design principles

PRIMEPOWER800/1000/2000/900/1500/2500/HPC2500 and GP7000F model 1000/2000 do not have clock hardware in each partition that can be used while the operating system is active. Thus, it is necessary to synchronize the time between each partition and System Management Console (SMC) using NTP.

Because the clock contained in SMC is not very accurate, **Fujitsu recommends setting an accurate external clock as the reference server**. Normally, SMC is selected as the NTP server and each partition is set to the client mode for operation.

Because SMC is dedicated for use with PRIMEPOWER800/1000/2000/900/1500/2500/HPC2500 and GP7000F model 1000/2000, do not reference SMC from another server (or client) machine in client mode.

For 24-hour operation, an accurate reference server must always be referenced.

2.1.2 SMC settings (When an external clock is used)

The settings for operating SMC on the NTP server are very simple. Execute the partition_setup command and /opt/FJSVscsl/etc/ntp.conf file is made. To use an external clock, modify ntp.conf as shown below:

```
server IP address of external NTP server 1
server IP address of external NTP server 2
server IP address of external NTP server 3
server 127.127.1.0
fudge 127.127.1.0 stratum 5

slowways yes
disable pll
```

Add if the time should be slowly synchronized by applying the applicable Patch (See Appendix A).

```
enable auth monitor
driftfile /var/ntp/ntp.drift
statsdir /var/ntp/ntpstats/
filegen peerstats file peerstats type day enable
filegen loopstats file loopstats type day enable
filegen clockstats file clockstats type day enable
```

The server line above specifies the external NTP server. Ideally, three or more NTP servers should be specified, but in the worst case, none of the time servers shows the accurate time. (This is because it is not known with which time server synchronization should be implemented.) Only one time server is sufficient if it is accurate and stable.

The stratum of SMC is obtained by adding "+1" to the smallest stratum number of external NTP servers. If the stratum number of the external server is larger than 5, synchronization with the local clock occurs because the local clock is positioned at stratum 5 (If this is the case, the stratum specified by fudge has to be made larger than that of the external clock.)

In the enable line, the auth flag is set to ensure the security of operation in symmetric-active mode and the monitor flag is set to enable the monitoring function of xntpd. (For more details, see xntpd (1M).)

The driftfile line specifies the file in which learning results about precision of the local clock will be recorded.

The statsdir line specifies the storage destination of the statistical information file specified in filegen.

Because the validity of time is checked before activating the NTP daemon, ntp.conf is not the standard /etc/inet/ntp.conf for the SMC. (As explained in the next section, activation of xntpd is inhibited if the clock on the main unit is fast when activating SMC.)
2.1.3 SMC settings (When no external clock is used)

The settings for operating SMC on the NTP server are very simple. Execute the partition_setup command by specifying the -n option and all settings will be made automatically. This command will set the following content to the /opt/FJSVscsil/etc/ntp.conf file.

```plaintext
server 127.127.1.0 prefer
fudge 127.127.1.0 stratum 5
enable auth monitor
driftfile /var/ntp/ntp.drift
statsdir /var/ntp/ntpstats/
filegen peerstats file peerstats type day enable
filegen loopstats file loopstats type day enable
filegen clockstats file clockstats type day enable
```

The server line above specifies the local clock of SMC as a server.
The fudge line sets the local clock to stratum 5. In this case, SMC itself will operate in stratum 6.
In the enable line, the auth flag is set to ensure the security of operation in symmetric-active mode and the monitor flag is set to enable the monitoring function of xntpd. (For more details, see xntpd(1M).)
The driftfile line specifies the file in which learning results about precision of the local clock will be recorded.
The statsdir line specifies the storage destination of the statistical information file specified in filegen.
Because the validity of time is checked before activating the NTP daemon, ntp.conf is not the standard /etc/inet/ntp.conf for the SMC. (As explained in the next section, activation of xntpd is inhibited if the clock on the main unit is fast when activating SMC.)
2.1.4 Partition settings

Partition settings are also simple. Install the Solaris OE in the partition using the partition_setup command and then the /etc/inet/ntp.conf file will be automatically be created. Make the following modifications as required:

```plaintext
server IP address of SMC prefer
server IP address of external NTP server 1
server IP address of external NTP server 2
server 127.127.1.0
fudge 127.127.1.0 stratum 9

slowways yes  } Add if the time should be slowly synchronized by applying the applicable Patch (See Appendix A).

disable pll

enable auth monitor
driftfile /var/ntp/ntp.drift
statsdir /var/ntp/ntpstats/

filegen peerstats file peerstats type day enable
filegen loopstats file loopstats type day enable
filegen clockstats file clockstats type day enable
```

Be sure to define SMC as the primary NTP server on the partition.

The partition of PRIMEPOWER and GP7000F model 800/1000/2000 references the clock of SMC at the firmware level when activated. Thus, if the partition is synchronized with another external NTP server, the time will be unstable during activation.

If NTP is already in use in the installation organization, Fujitsu recommends making settings so that each partition is synchronized with at least three NTP servers including SMC. Thus, it is necessary to make modifications using the vi command or others like the above file and then add definitions of NTP servers other than SMC. The time of SMC and that of other NTP servers other than SMC must be synchronized.

If the partition time is two seconds or more faster than the SMC time, activation of the NTP daemon of SMC is inhibited. In this case, it is necessary to manually synchronize with the correct time the clocks of the console system and partition.

Also, if the SMC time is faster than the partition time by at least 1000 seconds, the clock cannot be synchronized (because activation of the NTP daemon of SMC is inhibited). Also, in this case, the clock needs to be synchronized manually.

Synchronize the clock after changing the mode of SMC and each partition to single user mode or by following the method explained in Section 3.2, "Method of Changing the Time in an NTP Operation Environment."
2.2 Primary and Secondary Server Operation

To implement a redundant NTP operation by relying on the local clock of two NTP servers in an environment without a reference clock, make the following setting. The secondary server and client will be synchronized with the local clock of the primary server. If the primary server fails for some reason, the client will be synchronized with the local clock of the secondary server.

However, Fujitsu does not recommend this operation because of the problem involving the precision of the local clock.

Follow the SMC settings because the locations of ntp.conf for SMC and so on are different from those shown below.

**Primary server setting**
Set the following content to /etc/inet/ntp.conf of the node of the primary server.

```plaintext
server 127.127.1.0 prefer
fudge 127.127.1.0 stratum 5

peer IP address of secondary NTP server

enable auth monitor
driftfile /var/ntp/ntp.drift
statsdir /var/ntp/ntpsstats/
filegen peerstats file peerstats type day enable
filegen loopstats file loopstats type day enable
filegen clockstats file clockstats type day enable
```

* Specify the IP address of a network interface connected to a communication channel used for NTP as the IP address of the secondary server.

**Secondary server setting**
Set the following content to /etc/inet/ntp.conf of the node of the secondary server.

Define the value to be set to the stratum of fudge such that it is greater than the setting for the primary server by at least 2.

```plaintext
server 127.127.1.0
fudge 127.127.1.0 stratum 7

peer IP address of primary NTP server

slewalways yes      Add if the time should be slowly synchronized by
disable pll         applying the applicable Patch (See Appendix A).

enable auth monitor
driftfile /var/ntp/ntp.drift
statsdir /var/ntp/ntpsstats/
filegen peerstats file peerstats type day enable
filegen loopstats file loopstats type day enable
filegen clockstats file clockstats type day enable
```

- Specify the IP address of a network interface connected to a communication channel used for NTP as the IP address of the primary server.
Client setting

Set the following content to /etc/inet/ntp.conf of all nodes other than the primary and secondary servers.

```plaintext
server IP address of primary NTP server
server IP address of secondary NTP server
server 127.127.1.0
fudge 127.127.1.0 stratum 9

slew always yes  Add if the time should be slowly synchronized by
disable pll              applying the applicable Patch (See Appendix A).

enable auth monitor
driftfile /var/ntp/ntp.drift
statsdir /var/ntp/ntpstats/
filegen peerstats file peerstats type day enable
filegen loopstats file loopstats type day enable
filegen clockstats file clockstats type day enable
```
2.3 Referencing External NTP Servers

If a server that is guaranteed to have been synchronized with an intranet within an organization, etc., is an external one, specify the server as server.

Ideally, three or more NTP servers should be specified, but in the worst case, none of the time servers shows the accurate time. (This is because it is not known with which time server synchronization should be implemented.) Only one time server is sufficient if it is accurate and stable.

| server IP address of external NTP server 1 |
| server IP address of external NTP server 2 |
| server IP address of external NTP server 3 |
| server 127.127.1.0 |
| fudge 127.127.1.0 stratum 9 |
| slewalways yes | Add if the time should be slowly synchronized by applying the applicable Patch (See Appendix A). |
| disable pll |
| enable auth monitor |
| driftfile /var/ntp/ntp.drift |
| statsdir /var/ntp/ntpstats/ |
| filegen peerstats file peerstats type day enable |
| filegen loopstats file loopstats type day enable |
| filegen clockstats file clockstats type day enable |
2.4 Settings of the NTP Server to Which a Clockwork is Connected

To use a clockwork (type name: PW007TC1), it is necessary to install and activate the time synchronization application supplied with the clockwork. For more details, see the manuals supplied with the hardware.

In this case, set ntp.conf of the NTP server as shown below:

```
server 127.127.1.0
fudge 127.127.1.0 stratum 1
enable auth monitor
driftfile /var/ntp/ntp.drift
statsdir /var/ntp/ntpstats/
filegen peerstats file peerstats type day enable
filegen loopstats file loopstats type day enable
filegen clockstats file clockstats type day enable
```

The local clock (127.127.1.0) is operated at stratum 1.

2.5 When Settings are Complete

After all settings of each server and client are completed, execute the following command on all servers and clients as a superuser to start the NTP operation. If NTP settings have been completed, NTP operation will be started automatically when the system is restarted. Thus, the following operation need not be repeated each time the system is restarted.

```
#/etc/rc2.d/S74xntpd start <RETURN>
```

Use the ntpq command to check whether NTP is actually operating.

```
# ntpq -np
remote           refid      st t when poll reach   delay   offset    disp
+192.168.246.9   192.168.246.16   7 u   61   64  377     0.67  -103.51    0.72
*192.168.246.16  127.127.1.0      6 u   60   64  377     0.67  -102.50    0.56
127.127.1.0      127.127.1.0      9 l   59   64  377     0.00    0.000   10.01
```

It is clear in this example that synchronization occurs with the NTP server whose IP address is 192.168.246.16 with a time difference of -102.5 milliseconds. Another reference server 192.168.246.9 is synchronized with 192.168.246.16 with a time difference of about 1 millisecond (103.51-102.5). (For details of ‘*’ and ‘+’, see Section 4.1, “ntpq Command.”)
3. Application to Actual Operation

3.1 Specifications about Time Changes

In actual operation, it may sometimes be necessary to synchronize the clock manually by applying NTP in an environment without an accurate reference clock. This section explains the specifications of NTP and Solaris OE related to time changes.

3.1.1 NTP specification

If a closed NTP operation within an organization is performed without referencing NTP servers on the Internet, manual clock synchronization is required periodically if the NTP primary server within the organization does not have any reference clock. However, NTP was originally a protocol intended for synchronizing the clock in accordance to the accurate time (UTC) and thus the case of “clock synchronization” is not assumed (*1). Therefore, the time must be synchronized after stopping NTP.

*1) 5.3. Step Phase Adjustments of RFC-1305(NTP V3) states that synchronization is required immediately if a shift of 128 milliseconds or more from the server is detected when 900 seconds or more have elapsed after the last synchronization with the server. However, there is no detailed specification of operations related to time changes and a greater part of them may well depend on the actual implementation. Operations of NTP Version 3.4y of Solaris 7 OE are as listed below:

(However, it is likely to differ from the value of the table, depending on the condition such as NTP configuration.)

<table>
<thead>
<tr>
<th>Server status</th>
<th>Client status</th>
<th>Operation</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>xntpd operating</td>
<td>xntpd operating</td>
<td>Change the time with the server. (synchronization up to 128 milliseconds)</td>
<td>The time is corrected little by little every 64 seconds on the client.</td>
</tr>
<tr>
<td>xntpd operating</td>
<td>xntpd operating</td>
<td>Change the time with the server. (synchronization exceeding 128 milliseconds)</td>
<td>The time is forced to change on the client after 64 X 15 seconds (about 16 min). Remark: The time may be set back.</td>
</tr>
<tr>
<td>xntpd not activated</td>
<td>xntpd operating</td>
<td>Change the time with the server (change exceeding 128 milliseconds) and then activate xntpd of the server after waiting for 900 seconds.</td>
<td>The time is forced to change on the client after activating xntpd. Remark: The time may be set back.</td>
</tr>
</tbody>
</table>

Remark: If a patch is applied, the time will never be set back. (For more details, see Appendix A.)

3.1.2 Specification for clock synchronization in Solaris(TM) Operating Environment

In Solaris OE, changing the time is prohibited while the Windows system is running and the multi-user mode is being used. (See the main page of the date command.) Actually, if the time is turned back, a hang-up may occur in the X Windows system.

If the date/time of the system is changed for test purposes, be sure to use the date command in single user mode.
3.2 Method of Changing the Time in an NTP Operation Environment

Basically, the clock must be synchronized on the client and server machines using NTP in single user mode. However, this method cannot be applied to an environment in which around-the-clock operations are performed.

In a system in which the NTP client operation cannot be stopped, -a option of the date command can be used. In the -a option, specify a relative time (seconds) to be changed. In this case, the clock is synchronized by quickening or retarding the clock. More concretely, the time can be corrected according to the following procedure:

1) Stop xntpd on each client.

```bash
# /etc/rc2.d/S74xntpd stop
```

2) By executing date -a by each client simultaneously, a time difference with respect to the NTP server can be reduced to a minimum. (In the following example, the clock is put back by seven seconds.)

```bash
# date -a -7
```

3) Wait until a time difference with respect to the NTP server is eliminated on all clients (*1). At this point, no client may be in the stopped state. The server time can be fetched, for example, by using the daytime protocol as shown below (13 is the port number of the daytime protocol).

```bash
# telnet IP address 13
```

4) Reactivate xntpd.

```bash
# /etc/rc2.d/S74xntpd start
```

(*1) In Solaris 8 OE, use the -B option of the ntpdate command to synchronize the clock slowly. However, if the time difference is too large, quite a long time will be required for the synchronization. Thus, start the synchronization after setting as close a time to the server time as possible. (See Appendix A, "Slow Clock Synchronization with NTP.")

Since the -B option of the ntpdate command is not usable in Solaris 7 OE or earlier, synchronization must be performed so that the time difference becomes less than 0.5 seconds. (If the time difference with respect to the server is less than 0.5 seconds just after activating xntpd, the time is corrected slowly with the ntpdate command using adjtime.) However, such synchronization is actually very difficult to implement. Thus, apply a patch (see Appendix A, "Slow Clock Synchronization with NTP") in advance that corrects the time slowly before starting operation, comment out the execution locations of the ntpdate command from /etc/rc2.d/S74xntpd, and then execute the script of 4). Also, in this case, since quite a long time will be required if the time difference is large, start the synchronization after setting as close a time to the server time as possible.

3.3 Method of Specifying a Server of NTP Version 2

Synchronization of an NTP Version 3 server of Solaris OE with a Version 2 server shall be prohibited. Be sure to exercise sufficient caution.
4. NTP Status Information

This chapter explains the status information of NTP.

4.1 ntpq Command

If the ntpq command (-np option) is executed, the following information will be displayed. For details of the command option, see ntpq (1M).

```
# ntpq -np
remote refid st t when poll reach delay offset disp
=======================================
+192.168.246.9 192.168.246.16 7 u   61  64  377 0.67  -103.51  0.72
*192.168.246.16 127.127.1.0    6 u   60  64  377 0.67  -102.50  0.56
127.127.1.0    127.127.1.0    9 l   59  64  377 0.00    0.000   10.01
```

The clock runs slow with respect to the * marked server 192.168.246.16 with a time difference of -102.5 milliseconds. If the time difference with respect to the server becomes larger, "*" will not be displayed.

The offset value displayed for the ntpq command shows a time difference between the NTP clock in xntpd and the reference server NTP clock.

Items displayed for the ntpq command are as listed below from left:

<table>
<thead>
<tr>
<th>remote</th>
<th>Host name or IP address of the referenced NTP server</th>
</tr>
</thead>
<tbody>
<tr>
<td>refid</td>
<td>Host name/IP address of the high-level server referenced by the server displayed in &quot;remote&quot;</td>
</tr>
<tr>
<td>st</td>
<td>Stratum value of the server displayed in &quot;remote&quot;</td>
</tr>
<tr>
<td>t</td>
<td>Server type</td>
</tr>
<tr>
<td></td>
<td>u : unicast</td>
</tr>
<tr>
<td></td>
<td>l : local</td>
</tr>
<tr>
<td></td>
<td>m : multicast</td>
</tr>
<tr>
<td></td>
<td>b : broadcast</td>
</tr>
<tr>
<td>when</td>
<td>Elapsed time after synchronization (s)</td>
</tr>
<tr>
<td>poll</td>
<td>Interval for synchronization (s)</td>
</tr>
<tr>
<td>reach</td>
<td>Reachable register (octal number)</td>
</tr>
<tr>
<td>delay</td>
<td>Delay time (milliseconds)</td>
</tr>
<tr>
<td>offset</td>
<td>Time difference with respect to the NTP server (milliseconds)</td>
</tr>
<tr>
<td>disp</td>
<td>Dispersion (time dispersion) (milliseconds)</td>
</tr>
</tbody>
</table>

Symbols displayed at the head of each remote item have the following meanings:

<table>
<thead>
<tr>
<th>Blank</th>
<th>Removed from the synchronization candidate list due to a high Stratum value (low accuracy) or unreachability</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>Removed from the synchronization candidate list (determined to be an inaccurate clock by an algorithm)</td>
</tr>
<tr>
<td>.</td>
<td>Removed from the synchronization candidate list (culled from the end of the candidate list)</td>
</tr>
<tr>
<td>-</td>
<td>Removed from the synchronization candidate list (by the clustering algorithm)</td>
</tr>
<tr>
<td>+</td>
<td>On the synchronization candidate list</td>
</tr>
<tr>
<td></td>
<td>Description</td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>#</td>
<td>Server currently synchronized, but distant</td>
</tr>
<tr>
<td>*</td>
<td>Server currently being synchronized</td>
</tr>
<tr>
<td>o</td>
<td>Synchronized (pps signal in use)</td>
</tr>
</tbody>
</table>

4.2 **ntptrace Command**

If the `ntptrace` command is executed, the following information will be displayed.

```
# ntptrace
localhost: stratum 2, offset 0.000066, synch distance 0.02495
technical: stratum 1, offset 0.000088, synch distance 0.00000, refid 'GPS'
```

Displayed items have the following meanings from left:

1. Host name of the reference server
2. Stratum value of the reference server
3. Time difference between the system clock of the local machine and the reference server system clock (seconds)
4. Synchronizing distance
5. Reference clock ID (displayed for stratum1 only)

Remark: The offset value displayed for the `ntptrace` command is the time difference between the system clock of the local machine and the NTP clock of the reference server. When, for example, the option (slew option) to synchronize the clock slowly is selected, this value may be different from the offset value displayed for the `ntpq` command.
4.3 Peerstats File

The /var/ntp/ntpstats/ directory (or directory specified by statsdir of ntpd.conf) contains daily time difference information like peerstats. For example, it contains the following record:

(Example)  51933 27.688 10.34.150.1  9614 -0.000903 0.00523 0.00035

Each field is explained in the paragraph of peerstats in xntpd (1M).

The fields are arranged in the following sequence and format:

1. Julian Date date
2. UTC time (unit: seconds)
3. Remote IP address (*1: 127.127.1.0 is a local clock)
4. peerstatus in hexadecimal notation
5. Offset in seconds (-> time difference from the reference clock)
6. Delay in seconds
7. Dispersion in seconds

The date and time (in seconds) are UTS times. (For conversion to the Japanese standard time, +9 hours (+9*60*60) need to be added.)

The above example means that there is a time difference of -0.903 milliseconds with respect to the server 10.34.150.1. By analyzing changes in the time difference of this file, it is possible to verify how large the time difference was during operation with respect to the reference server. The following figure shows an example of changes in the time difference with respect to the reference server.

*1) The offset value in peerstats is information about the time difference between the NTP clock in xntpd and the clock of the reference server. The reference server clock does not necessarily match the system clock of the operating system. The time difference between the system clock of the operating system and the reference clock can be examined with the ntptrace command.
Almost all information about NTP operation (for example, the time difference with respect to the reference server and the synchronous state, etc.,) can be referenced using the ntpq command, ntptrace command, and peerstats file. However, when checking whether a response from the NTP server is delayed in Server-Client mode operation or referencing details of response packets, snoop data needs to be analyzed.

Since NTP uses port 123 of UDP, it is possible to retrieve only NTP data. The following shows an example of NTP snoop data.

```
522   1.91667 10.34.151.57 -> netst11  NTP  symmetric active (Mon Jun 3 12:13:03 2002)
550   0.41989 10.34.197.112 -> netst11  NTP  client (Mon Jun 3 12:11:54 2002)
551   0.00037      netst11 -> 10.34.197.112 NTP server (Mon Jun 3 12:13:09 2002)
552   0.06355      netst11 -> 10.34.184.26 NTP client (Mon Jun 3 12:13:09 2002)  --------(1)
553   0.01175 10.34.184.26 -> netst11  NTP  server (Mon Jun 3 12:13:09 2002)  --------(2)
554   0.99211      netst11 -> 10.34.151.57 NTP  symmetric active (Mon Jun 3 12:13:10 2002)  ------(3)
```

(1) Operation when "server" is specified in ntp.conf (client mode). This packet is used to make inquiries of the server about the time.

(2) Response from the NTP server to the inquiry of (1)

(3) Operation when "peer" is specified in ntp.conf (symmetric-active mode)

*1) Responses are returned from the NTP server only in Server-Client mode.

The following shows details of snoop (-v option specified) data of (3) (NTP part only).

```
NTP:
NTP: Leap = 0x0 (OK)
NTP: Version = 3
NTP: Mode = 4 (server)
NTP: Stratum = 1 (primary reference)
NTP: Poll = 6
NTP: Precision = 242 seconds
NTP: Synchronizing distance = 0x0000.0000 (0.000000)
NTP: Synchronizing dispersion = 0x0000.0000 (0.000000)
NTP: Reference clock = GPS
NTP: Reference time = 0xc0a55d3c.00000000 (Mon Jun 3 12:13:00 2002)
NTP: Origin time = 0xc0a55d45.4d01d000 (Mon Jun 3 12:13:09 2002)
NTP: Receive time = 0xc0a55d45.51a60d27 (Mon Jun 3 12:13:09 2002)
NTP: Transmit time = 0xc0a55d45.53e6b1d4 (Mon Jun 3 12:13:09 2002)
```
Details of the packet format are as shown below.

Among various kinds of information, to check the time synchronization state in Server-Client mode, reference the Leap value in a response packet from the NTP server.

It is possible to check whether a response packet is delayed in the NTP server by examining the difference between Receive Time and Transmit Time.

**[Details]**

The following explains the packet format using display results of snoop data. Though some field names are different from those used in RFC1305, they describe the same contents.

**Leap:** 2bit

- 0x00: no warning (OK) -> Synchronous state
- 0x01: last minute has 61 seconds
- 0x02: last minute has 59 seconds
- 0x11: alarm condition (clock unsynchronized)

-> This value is set just after startup of the server or when out of synchronization.

**Version:** NTP Version (3bit)

- 2: Version 2
- 3: Version 3

**Mode:** Indicates the mode (3bit).

- 0: reserved
- 1: symmetric active
- 2: symmetric passive
- 3: client
- 4: server
- 5: broadcast
- 6: reserved for NTP control message (See Appendix B of RFC1305)
- 7: reserved for private use

**Stratum:** Indicates the Stratum value (8bit).

- 0: unspecified
- 1: primary reference
- 2-255: secondary reference

**Polling:** Polling interval (8bit)

This value is represented as $2^x$ (unit: seconds). In the above example, the value is $2^6$. Thus, the polling interval is 64 s.

**Precision:** Indicates the precision of local clock (8bit).

This value is represented as $2^x$ (unit: seconds).

**Synchronizing distance:** (32bit)

Indicates the round-trip delay time to the primary or reference source as a 32-bit fixed-point number.

**Synchronizing dispersion:** (32bit)

Indicates the maximum error regarding the primary or reference source as a 32-bit fixed-point number.
Reference Clock: Reference clock identifier (32bit)

32-bit code to identify a specific reference clock. For details, see RFC1305.

Reference Time: (64bit)
Indicates the time at which the local clock was set or corrected for the last time in the 64-bit timestamp format.

Origin Time: (64bit)
Indicates the time at which the client made a request to the server in the 64-bit timestamp format.

Receive Time: (64bit)
Indicates the time at which the server received a request from the client in the 64-bit timestamp format.

Transmit Time: (64bit)
Indicates the time at which the server returned a response to the client in the 64-bit timestamp format.
5. Notes

5.1 About /etc/system

Do not make the setting below. (If this setting is made, it will affect the system clock.)

```
set dosynctodr=0
```
Appendix A  Slow Clock Synchronization with NTP

The following patch is needed so that clock synchronization is not forced (the adjtime function is used for synchronizing the clock slowly) to eliminate a time difference (aggregated in R01111).

Solaris 2.6 OE  107298-03
Solaris 7 OE  109409-04
Solaris 8 OE  109667-04

If the patch is applied to synchronize the clock slowly (using the slew option), the following needs to be added to ntp.conf.

    slewalways yes
disable pll

Before applying a patch, be sure to read README.

Remark: If slew is set correctly, time reset (slew) is displayed.

As a result of verification, however, it became clear that there is a significant difference in the clock synchronization speed with the slew option set using VL of xntpd.

The operation verification results after applying the above patch and specifying the slew option are as listed below:

<table>
<thead>
<tr>
<th>OS version</th>
<th>xntpd version</th>
<th>Patch ID</th>
<th>Time required to correct one second</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solaris 2.6 OE</td>
<td>xntpd-3.4y</td>
<td>107298-03</td>
<td>About 16 - 17 s</td>
</tr>
<tr>
<td>Solaris 7 OE</td>
<td>xntpd-3.4y</td>
<td>109409-04</td>
<td>About 16 - 17 s</td>
</tr>
<tr>
<td>Solaris 8 OE</td>
<td>xntpd-3.5.93e</td>
<td>109667-04</td>
<td>About 2000 s</td>
</tr>
</tbody>
</table>

Only Solaris 8 OE requires quite a long time to correct one second of time difference. This is because NTP has internally a value called "maximum time to be synchronized within one second" and it was changed for the Solaris 8 OE version (xntpd-3.5.93e).

If synchronized with an accurate reference server, the time difference with respect to the reference server seldom exceeds +128 and -128 milliseconds. However, if an inaccurate Solaris OE clock is corrected manually for operation, quite a long time may be required for clock synchronization. In such case, adopt one of the following methods to avoid such a situation:

Stop xntpd, synchronize the clock using ntpdate -B, and then reactivate xntpd.

- If the time difference with respect to the reference server is large, start up the system after synchronizing the clock to a certain degree in single user mode.
- Provide an accurate reference server.

*1) Operation specification of xntpd when the slew option is specified

xntpd has an internal clock. If the slew option is specified, the internal clock of xntpd is synchronized in steps. (The offset value displayed for the ntpq command and peerstats seems to indicate synchronization in steps.) However, the specification requires that synchronization of the system clock be performed slowly using the ajtime function.
Appendix B  NTP Failure

Under the following conditions, the system clock time may not be corrected using xntpd.

[Conditions]
1) Solaris 2.6 OE FCS to 109386-01 is applied or
   Solaris 7 OE FCS to 109409-01 is applied, and
2) an absolute time difference of 128 milliseconds to less than 3 seconds is detected for correction.

[Cause]
If a time difference of 128 milliseconds to less than 3 seconds was detected, the time was not corrected properly.

[Action]
The following corrected patches are provided (aggregated in R01111).

Solaris 2.6 OE  107298-03
Solaris 7 OE     109409-04
Solaris 8 OE     109667-04

Remark: If the clock should be synchronized slowly, see Appendix A, “Slow Clock Synchronization with NTP.”