Services:
network time protocol

Staying on the beat

“The ntpd program is [a daemon] which sets and maintains the system time of day in synchronism with Internet standard time servers. …[It] operates by exchanging messages with one or more configured servers at designated poll intervals.”

ntpd man page
But first…

… a word about the clock(s)

“There are two main clocks in a Linux system:

“The Hardware Clock...runs independently of any control program running in the CPU and even when the machine is powered off.

“The System [Clock] is...inside the Linux kernel and...has meaning only while Linux is running on the machine. The System Time is...the number of seconds since 1969 [and] is the time that matters. The Hardware Clock’s basic purpose in a Linux system is to keep time when Linux is not running. You initialize the System Time to the time from the Hardware Clock when Linux starts up, then never use the Hardware Clock again.

hwclock man page

Workstation has 2 clocks

- a “hard” one a.k.a.
  - bios clock
  - motherboard clock
  - cmos clock
  - realtime clock
  - hardware clock
- a “soft” one a.k.a.
  - OS clock
  - software clock
  - system clock
Clocks’ interrelationship

- machine off
  - none, system clock nonexistent
- upon transition (off⇒on, on⇒off)
  - one-time setting of one clock from the other
- machine on
  - clocks operate independently
  - some fixed differential

2 commands: date & hwclock

- date
  - sets or shows the system clock exclusively
- hwclock
  - sets or shows the hardware clock exclusively
  - but can also cross-set either from the other
Ways to set hardware clock

- manual commands
  - `hwclock --set --date="<date>"` e.g. “9/22/96 16:45:05”
  - `hwclock --systohc`
- BIOS interface

Ways to set system clock

- manual commands
  - `date`
  - `hwclock --hctosys`
- syncing to another time source
  - a network time server
  - connected hardware (radio, GPS)
System clock

- stored as seconds since midnight UTC, 1/1/70
- displayed with possible timezone adjustment
Cross-setting clocks w/ hwclock

- hwclock --hctosys
- hwclock --systohc

or

Automated setting junctures

- **bootup** (in `/etc/rc.d/rc.sysinit`):
  - hwclock --hctosys

- **shutdown** (in `/etc/rc.d/init.d/halt`):
  - hwclock --systohc
Any adjustments needed?

- in society
  local time = UTC time + a timezone adjustment

- in unix
  system clock represents local time
  hardware clock represents *either*
    - local time *or*
    - UTC

  so, *either:*
    - system clock = hardware clock *or*
    - system clock = hardware clock + a timezone adjustment

Time adjustment

adjusts upon transfer *if* hardware clock represents UTC

adjustment purpose is timezone compensation
So hwclock needs to know…

• which time hardware clock represents

  “It is your choice whether to keep your clock in UTC or local time, but nothing in the clock tells which you’ve chosen.”

  hwclock man page

• which timezone to use if hardware clock is UTC

How does hwclock know which time hardware clock represents?

• you tell it via command line option
  --localtime
  --utc or

• what it represented last time
  – as stored in /etc/adjtime else

• local time
**hwclock's "--localtime" vs "--utc"**

- informs hwclock how to interpret the time value it finds in the hardware clock
- assume that’s 1 o’clock pm (13h)

```bash
hwclock --show --localtime
```

means “Output the local time, find out what it is from the hardware clock whose time assume to be the local time.” Will output 1 o’clock pm.

```bash
hwclock --show --utc
```

means “Output the local time, find out what it is from the hardware clock whose time assume to be UTC time.”

In Los Angeles will output 6am or 5am, 7 or 8 hours behind London depending on time of year (L.A. rules, from `/etc/localtime`)

**"--utc" different meanings to date & hwclock**

<table>
<thead>
<tr>
<th></th>
<th>date --utc¹</th>
<th>hwclock --utc²</th>
</tr>
</thead>
<tbody>
<tr>
<td>base clock is:</td>
<td>the system clock</td>
<td>the hardware clock</td>
</tr>
<tr>
<td>base clock keeps:</td>
<td>the local time (always)</td>
<td>the utc time</td>
</tr>
<tr>
<td>to be displayed:</td>
<td>utc time</td>
<td>local time (always)</td>
</tr>
</tbody>
</table>

¹tells date which time to display, namely the utc time

²tells hwclock which way to interpret the base clock (time to display is implicit, given, always local)
---UTC--- different meanings to date & hwclock

How do date & hwclock know which timezone to use?

- according to /etc/localtime file
- society’s rules
  - many zones
  - a UTC-offset ruleset for each
- /usr/share/zoneinfo/ holds a file containing each ruleset
- /etc/localtime is set to one of them, by
  - being a copy of it or
  - being a link to it
Local time rules are jurisdiction-specific, arbitrary, and particular...

Timezone definition files

...please choose one
...and put it in /etc/localtime
Setting your timezone

Before

After

scripted on boot, in /etc/rc.d/rc.sysinit
(if UTC=false in /etc/sysconfig/clock)
**hwclock --systohc --localtime**

**BEFORE**

- Hardware clock
- System clock

**AFTER**

- hwclock --systohc

scripted on shutdown, in /etc/rc.d/init.d/halt

(if UTC=false in /etc/sysconfig/clock)

---

**hwclock --hctosys --utc**

**BEFORE**

- Hardware clock
- System clock

**AFTER**

- hwclock --hctosys

adjusts system clock to 7 hours behind hardware clock

scripted on boot, in /etc/rc.d/rc.sysinit

(if UTC=true in /etc/sysconfig/clock)
**hwclock** --systohc --utc

--- BEFORE ---

**hwclock** --systohc

--- AFTER ---

scripted on shutdown, in /etc/rc.d/init.d/halt
(if UTC=true in /etc/sysconfig/clock)

--- Two reference files ---

- /etc/sysconfig/clock
  - used by startup/shutdown scripts
  - commands don’t use it
- /etc/adjtime
  - used by hwclock
/etc/sysconfig/clock

- UTC=true, yes
  - inserts --utc" option in hwclock call in boot/shutdown scripts
- UTC=no, false
  - inserts --localtime" option in hwclock call in boot/shutdown scripts

/zone=“filename”

determines which zonefile from /usr/share/zoneinfo to copy to /etc/localtime. Examples:

ZONE=“US/Eastern”
ZONE=“America/Los_Angeles”
/etc/adjtime

How to read the hardware clock

- hwclock --show --localtime

Because
hwclock’s job is to print the local time
--localtime says “assume hardware clock’s time is local time”
so --localtime means effectively print hardware clock time with no adjustments
Setting the hardware clock

```bash
[root@CHANG ~]# hwclock --test --debug --systime --localtime
Hardware clock is in LOCAL time
Assuming hardware clock is set in local time
Setting Hardware Clock to 13:25:15 - 96182730 seconds since 1969

[root@CHANG ~]# hwclock --test --debug --systime --utc
Hardware clock is in LOCAL time
Assuming hardware clock is set in UTC time
Setting Hardware Clock to 20:25:15 - 96182730 seconds since 1969
```
Network time protocol

- sets the system time
- not the hardware time
- implemented by ntpd
- ntpd is both client and server
  - configuration for particular IPs specifies which roles to play against them
  - in ntpd.conf
- runs on port 123 (both ends)

Configuring ntpd

- extensive options, but you only need a few
- finding config documentation
  - on ntp project page
  - recently embodied in man (5) pages
    - ntp.conf, ntp_acc, ntp_auth, ntp_clock, ntp_misc, ntp_mon
- “server” “restrict”
Configuring ntpd

Configuring Your Server or Client

...A working configuration file might look like…:

```
# peer configuration for host whimsy
# (expected to operate at stratum 2)
server rackety.udel.edu
server umd1.umd.edu
server lilben.tn.cornell.edu

# driftfile /etc/ntp.drift
```

...When configured using the server keyword, this host can receive synchronization from any of the listed servers, but can never provide synchronization to them. Unless restricted..., this host can provide synchronization to dependent clients, which do not have to be listed in the configuration file. Associations maintained for these clients are transitory and result in no persistent state in the host.


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Two main keywords

- **server address [options ...]**
  
  ...this command normally mobilizes a persistent client mode association with the specified remote server or local reference clock.... In client mode the client clock can synchronize to the remote server or local reference clock, but the remote server can never be synchronized to the client clock.

  ntp.conf man page

- **restrict address [mask mask] [flag][...]**

  Clients can be denied service because they are explicitly included in the restrict list created by the restrict command....

  ...flag always restricts access, i.e., an entry with no flag indicates that free access to the server is to be given, ...more restrictive flags will often make less restrictive ones redundant.

  ntp_acc man page
“restrict 127.0.0.1”

- apparent meaning
  - 127.0.0.1 is to be restricted
- actual meaning
  - place listed restrictions on 127.0.0.1
  - but none are listed
  - so means “127.0.0.1 is to be not restricted”

Finding time servers
Performing initial synchronization

- ntp won’t update systems with wildly wrong times
- set approximate time before running ntpd
- by running ntpd –q
  (quits as soon as it first sets time)
- then start ntpd for continuous, server operation

Local relay servers for ntp

from: Managing Accurate Date and Time, Avi Alkalay
http://www.tldp.org/HOWTO/TimePrecision-HOWTO/
Server stratum

- stratum 1, primary reference (gets time from calibrated clock device)
- strata 2-255, secondary reference (gets time via NTP)

Windows client

double click
ntp protocol
header structure

---

ntp protocol message format

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**ntp protocol message format**

<table>
<thead>
<tr>
<th>Flag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x24</td>
<td>Flags: Leap Indicator: no warning (0) 0..100: Version number: NTP version 4 (4) 100: Mode: server (0) Peer Clock Status: secondary reference (2) Peer Polling Interval: 8 (64 sec) Peer Clock Precision: 0.000000 sec Root Delay: 0.0002 sec Clock Dispersion: 0.0185 sec Reference Clock ID: TIME6-Scup1-SE Reference Clock Update Time: Jun 1, 2006 00:24:26.8829 UTC Origin Time Stamp: Jun 1, 2006 00:24:22.2287 UTC Receive Time Stamp: Jun 1, 2006 00:24:18.7524 UTC Transmit Time Stamp: Jun 1, 2006 00:24:18.7524 UTC</td>
</tr>
</tbody>
</table>

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**Info**

- [www.ntp.org](http://www.ntp.org)
- [extensive documentation by originator David Mills](http://www.eeics.udel.edu/~mills/ntp/html/index.html)