Network Time Protocol

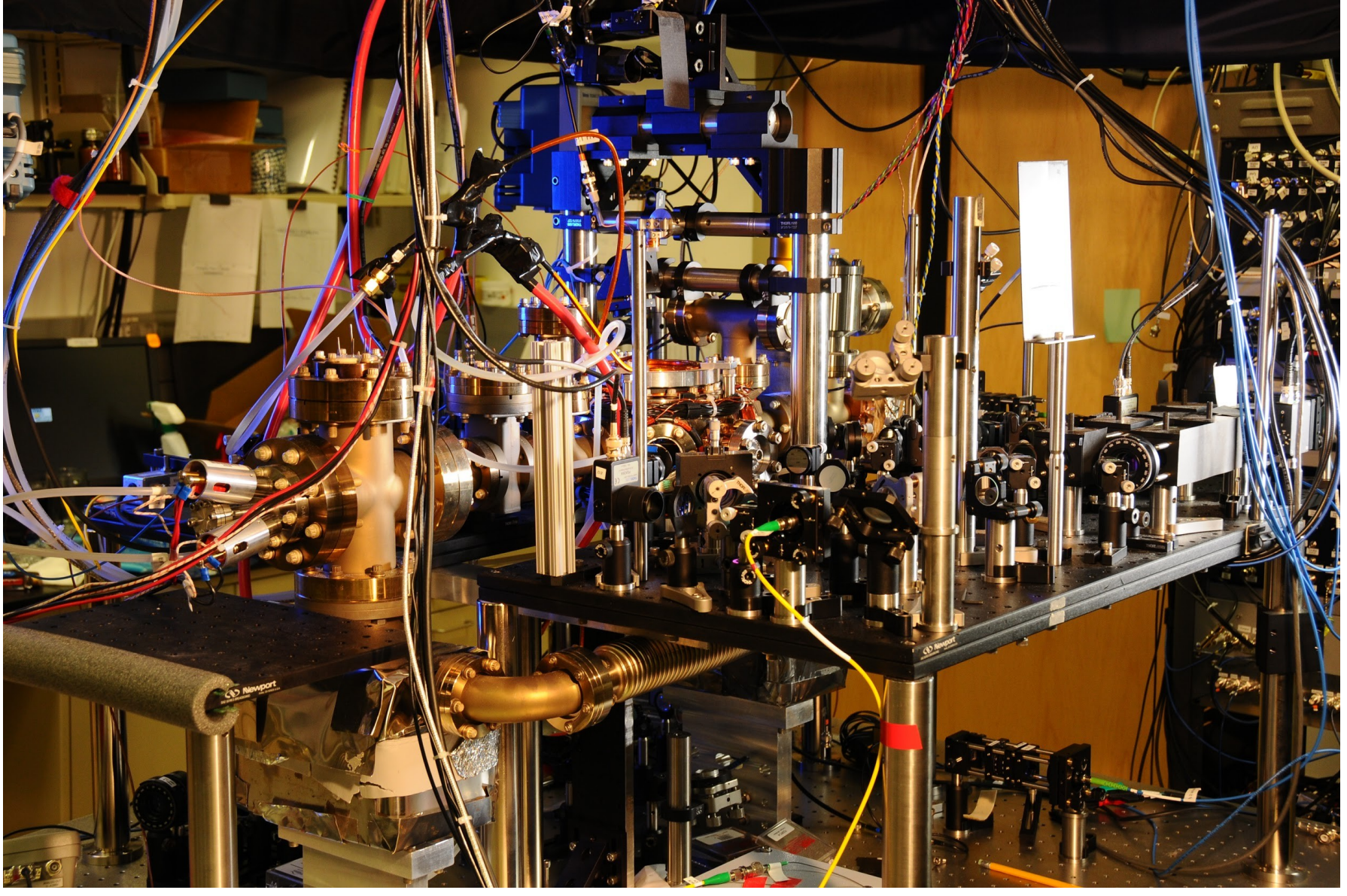
Linux System Administration
Spring 2026

The need for NTP

- Systems need to agree on the time
  - Time stamps on files
    - Critical for networked file systems
  - Time stamps in logs
    - Critical for debugging distributed problems
  - Time stamps on transactions
    - Critical for trading, banking, etc
- Common time is good, absolute time is best

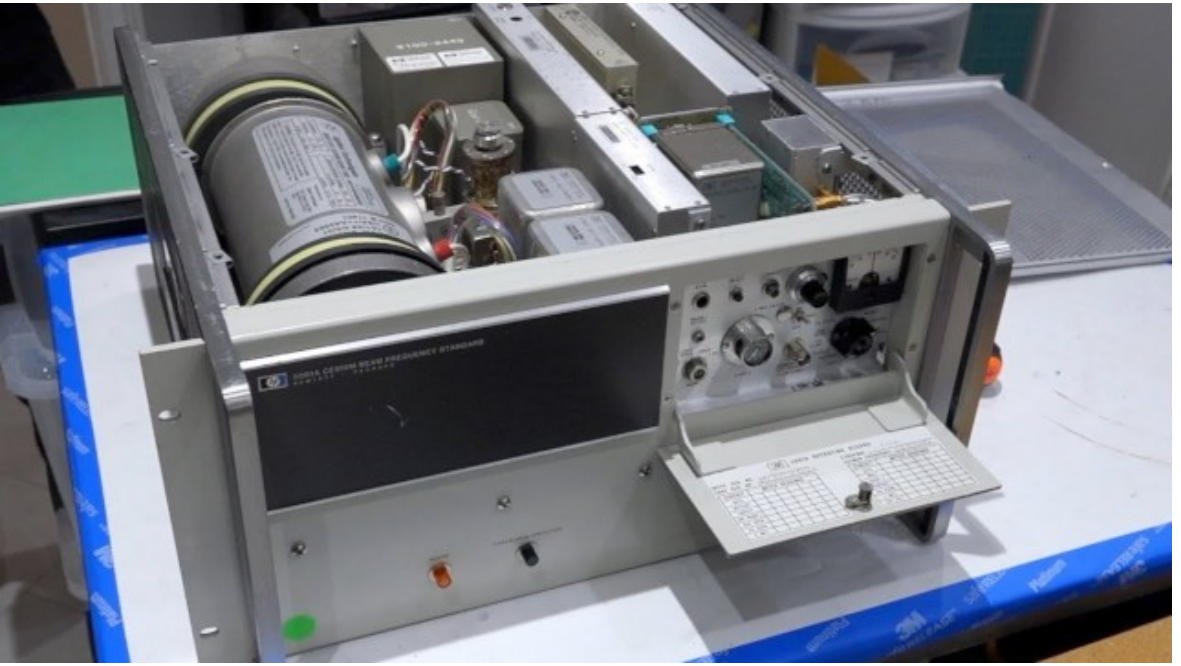
Time Strata

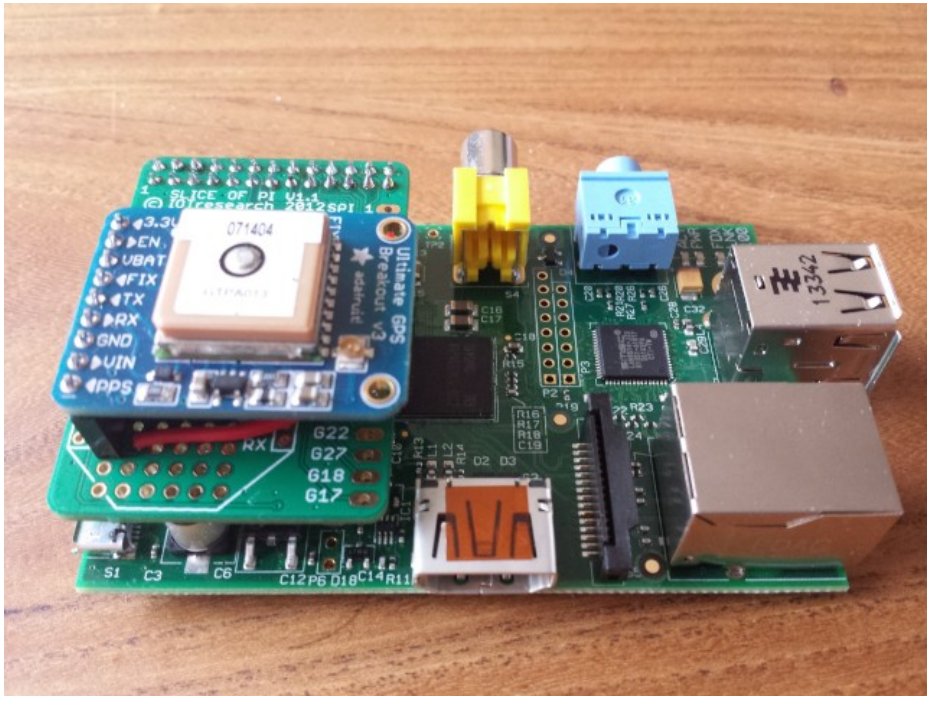
- 0: atomic clocks (also GPS/GNSS)
- 1: Computers slaved to Startum 0 clocks
- 2: Computers network synced to Stratum 1
- 3-15: Computers network synced to higher strata


Newport
Newport

Time Sources (PPS or Frequency)

- sub microsecond
  - Caesium clocks
  - GPS (USA)
  - Galileo (Europe)
  - GLONASS (Russia)
  - BeiDou (China)
- sub millisecond
  - Rubidium clock
  - WWV (USA)
  - DCF (Europe)
  - JJY (Japan)
  - Cellular




Ultimate GPS Breakout v3
VBAT
FIX
TX
RX
GND
VIN
PPS
G22
G27
G18
G17


MEINBERG
LANTIME M200
GPS:NORMAL OPERATION THU, 28.05.2009
NTP:Offset: PPS: -5us UTC 07:23:25
F1
F2
OK
ESC
Ref. Time
Time Service
Network
Alarm

Temperature Sensitivity

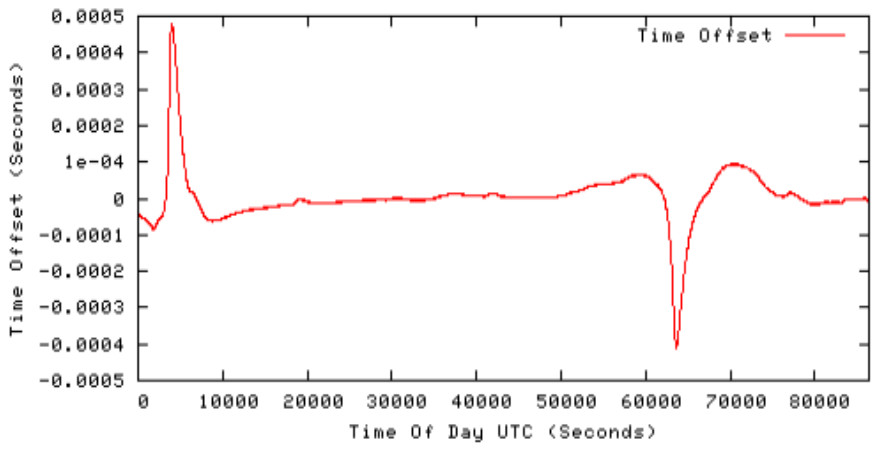
NTP Status:

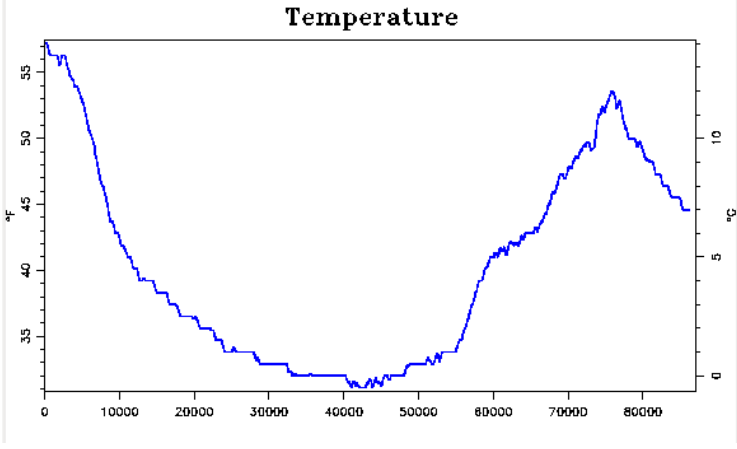
Status	In Sync
Stratum	1
Selected Reference	.GPS.
Delay	0.000 mS
Offset	0.048 mS
Jitter	0.002 mS

Offset Graph:

04/11/2023 | Refresh Graph

(•) Time Offset ( ) Frequency Offset ( ) RMS Jitter





NTP Reference Status:

Sync	Host	Ref ID	Stratum	Mode	Type	Auth Status	Last (Sec)	Poll Interval (Sec)	Reach	Delay (mS)	Offset (mS)	Jitter (mS)
*	Spectracom	.GPS.	0	Client	local	none	10	16	377	0.000	0.117	0.002

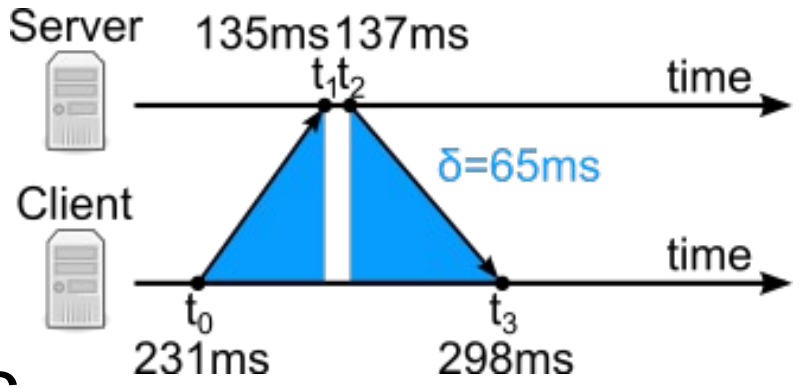
WWV & WWVB Fort Collins CO





NTP Protocol

- 64 bit time stamp (32 bit seconds, 32 bit fraction)
- Estimate network delays
  - Asymmetric network delay
  - dt = $[(t_1-t_0)+(t_2-t_3)] / 2$
- Adjust clock frequency to sync
  - Gradually get clocks in sync
  - Estimate clock drift



Initial clock synchronization

- Hardware clock
- Network request (TCP or UDP)
  - daytime (text string) TCP or UDP port 13
  - time (32 bit UNIX epoch) TCP or UDP port 37
- NTP based
  - ntpdate
  - sntp

chrony (RedHat NTP)

chronyc -N 'sources -a -v'

```
  .-- Source mode  '^' = server, '=' = peer, '#' = local clock.
 / .- Source state '*' = current best, '+' = combined, '-' = not combined,
| /             'x' = may be in error, '~' = too variable, '?' = unusable.
||                                                 .- xxxx [ yyyy ] +/- zzzz
||      Reachability register (octal) -.           |  xxxx = adjusted offset,
||      Log2(Polling interval) --.      |          |  yyyy = measured offset,
||                                \     |          |  zzzz = estimated error.
||                                 |    |           \
MS Name/IP address         Stratum Poll Reach LastRx Last sample
===============================================================================
^- 2.pool.ntp.org                2  10   377   409  -6908us[-6898us] +/-  179ms
^- 2.pool.ntp.org                2  10   377   427   +167us[ +177us] +/-   94ms
^- 2.pool.ntp.org                2  10   377   249    +17us[  +17us] +/-   64ms
^- 2.pool.ntp.org                2  10   377   715  -1280us[-1271us] +/-  114ms
^* 132.163.96.1                  1  10   377   273    -62us[  -53us] +/- 3284us
^+ 132.163.97.1                  1  10   377   239    -98us[  -98us] +/- 5510us
```

/etc/chrony.conf

- Get time from public NTP pool with initial burst
  - `pool 2.pool.ntp.org iburst`
- Get time form specific servers
  - `server time-a-wwv.nist.gov`
  - `server time-a-b.nist.gov`
- Allow requests from subnets
  - `allow 100.64.42.0/24`

systemd-timesyncd

- Default on debian
- Configure with `/etc/systemd/timesyncd.conf`
- Will use values from DHCP
- View status with systemctl

```
systemctl status systemd-timesyncd
systemd-timesyncd.service - Network Time Synchronization
     Loaded: loaded (/lib/systemd/system/systemd-timesyncd.service;
                     enabled; vendor preset: enabled)
     Active: active (running) since Sat 2022-10-29 16:55:25 MDT; 2 days ago
       Docs: man:systemd-timesyncd.service(8)
   Main PID: 436 (systemd-timesyn)
     Status: "Initial synchronization to time server 132.163.96.1:123
             (132.163.96.1)."
      Tasks: 2 (limit: 1132)
```

Other NTP servers

- `ntpd` - the original
  - `xntpd` - NTPv3
- `OpenNTP` - OpenBSD implementation
- `PTP` - Precision Time Protocol
  - sub microsecond precision

Leap Seconds

- 61 or 59 second minutes on 31-Dec 23:59 UTC
  - Skip 23:59:59 (miss a second)
  - Add 23:59:60 (add a second)
- Confuses many systems(including UNIX epoch)
  - step clock to add offset
  - slew or smear clock