Time Keeping and NTP

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7pm, February 10 2004

- NTP is the Network Time Protocol.
- One of many protocols for synchronising the time.
- Aims to synchronise time (and frequency) to a reference source.
- Doesn't just aim to get a group's clocks reading the same!

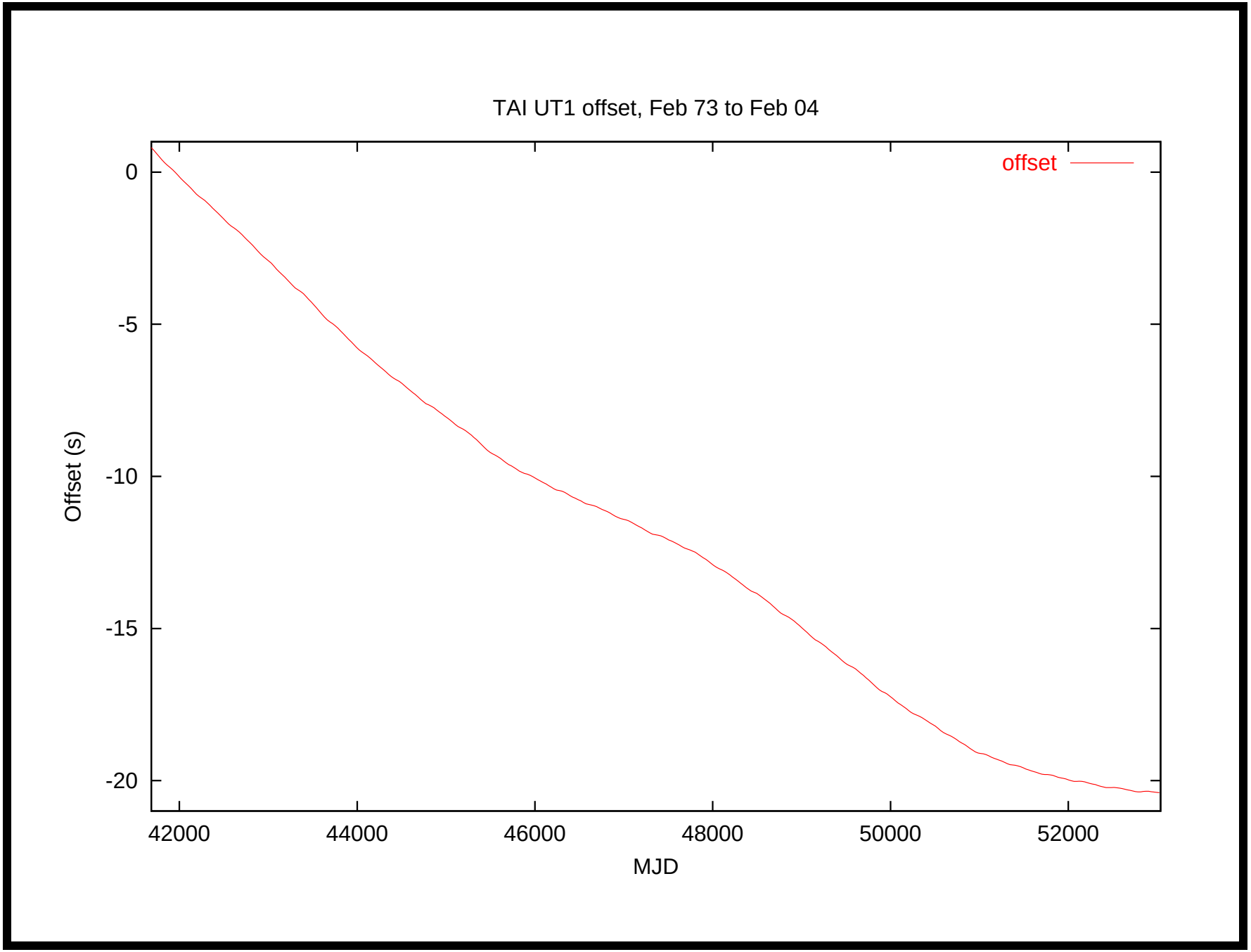
Time and Frequency

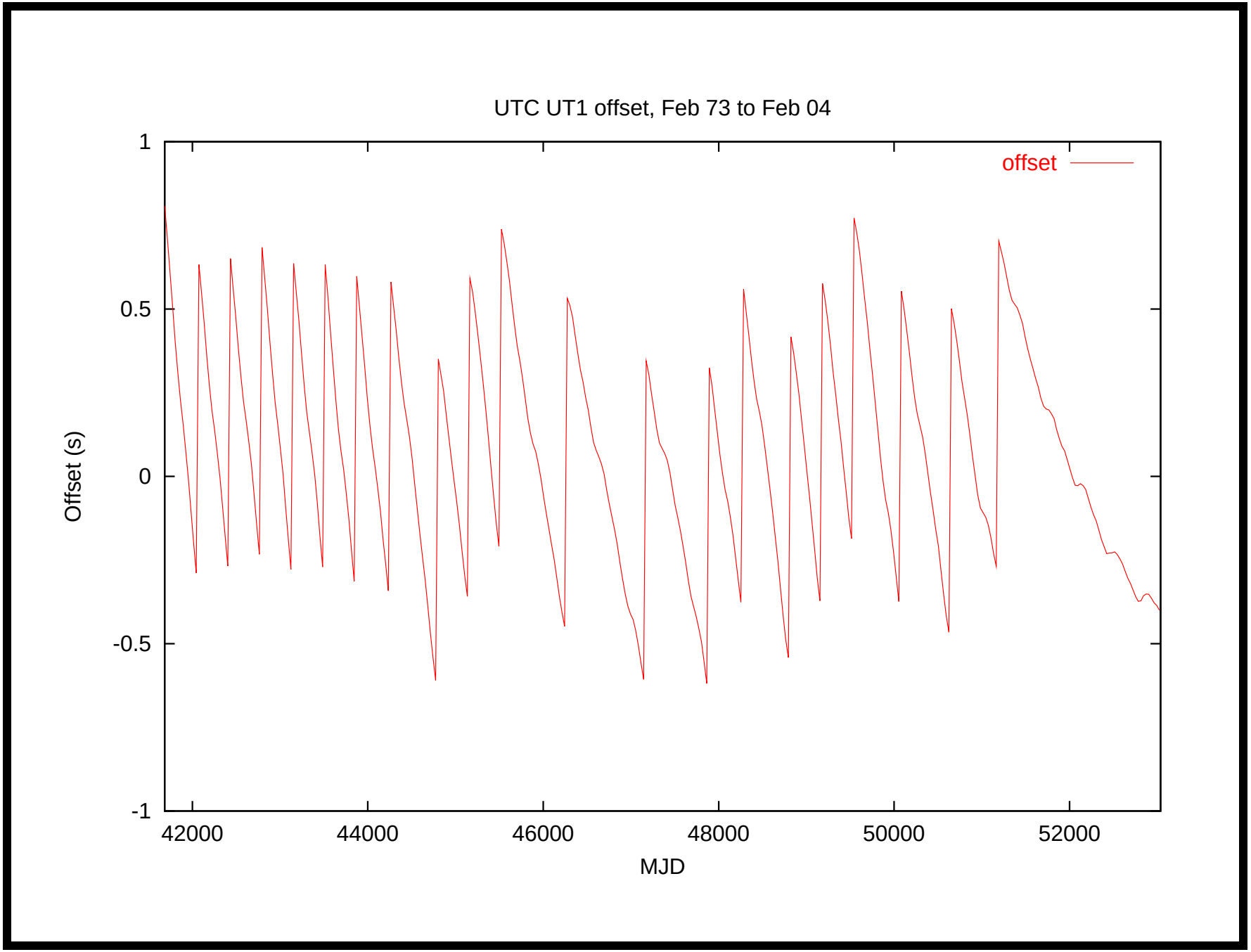
second: In the International System of Units (SI), the time interval equal to 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom.

TAI: A clock that ticks once per SI second (1955, 1972).

UT1: The angle that the earth points relative to background stars.

UTC: Half way house between TAI and UTC.


TAI UT1 offset, Feb 73 to Feb 04
offset
0
-5
-10
-15
-20
Offset (s)
42000
44000
46000
48000
50000
52000
MJD


UTC UT1 offset, Feb 73 to Feb 04
offset
Offset (s)
1
0.5
0
-0.5
-1
42000
44000
46000
48000
50000
52000
MJD

NTP Structure

- The ultimate source of time is a reference clock.
- NTP speakers synced to a refclock are at stratum 1.
- NTP speakers exchange UDP packets and calculate delay and offset.
- If you get time from a stratum n NTP speaker, then you're at stratum $n + 1$.
- Stratum 16 is unsynchronised.

- Packet exchanges happen at automatically tuned intervals (64–1024s).
- There's a broadcast mode (less accurate, but less traffic).
- There's a simple version of NTP for leaf nodes.

/etc/ntp.conf

```
server ntp.maths.tcd.ie
server ntp.tcd.ie
server ntp.cs.tcd.ie
peer salmon.maths.tcd.ie

enable monitor
disable auth
driftfile /etc/ntp.drift
```

Quirks

- ntpd takes a while to get going.
- ntpd hates stepping the clock.
- If out by more than 1000s need ntpdate or -g flag.

NTP algorithms

1. 8 delay/offset pairs for each source.
2. Calculate smallest interval for each source.
3. Intersect intervals and find majority clique.
4. Discard ‘falsetickers’.
5. Cluster by discarding outliers (high RMS) until small number remain.

Watching ntpd

```
> ntpq -p
     remote           refid      st t when poll reach   delay   offset  jitter
==============================================================================
*lanczos.maths.t tt25.ripe.net    2 u   60 1024  377    0.362    8.627   1.047
+ns1.tcd.ie      lanczos.maths.t  2 u   86 1024  377    0.648    5.316   0.291
+burke.cs.tcd.ie ntp0-rz.rrze.un  2 u  102 1024  377    0.693    7.884   0.905
-salmon.maths.tc lanczos.maths.t  2 u  381 1024  337    0.345    4.344   0.846
```

' ' reject, 'x' falsetick, '.' excess (> 10), '-' outlier,
'+' candidate, '#' select (> 6), '*' used, 'o' used (PPS).

`when` and `poll` in seconds.

`delay`, `offset`, `jitter` in ms.

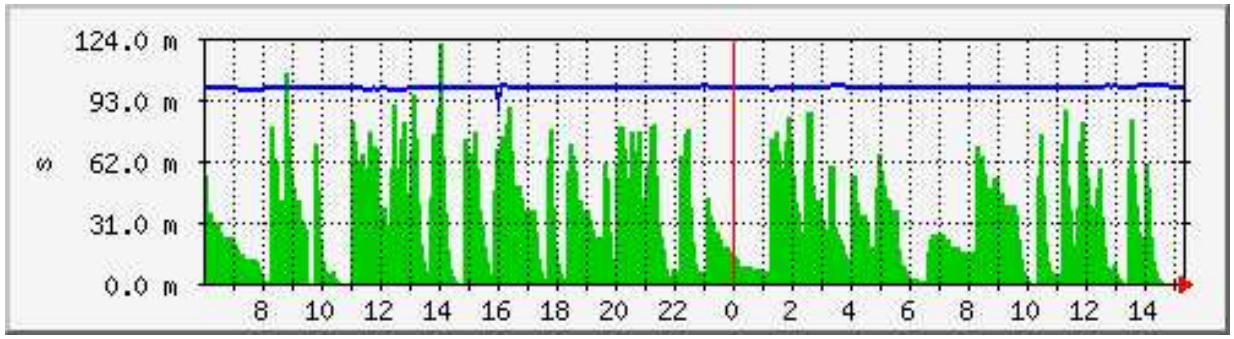
`reach` is an octal list of bits.

$337_8 = 11011111_2$ sixth last packet missed.

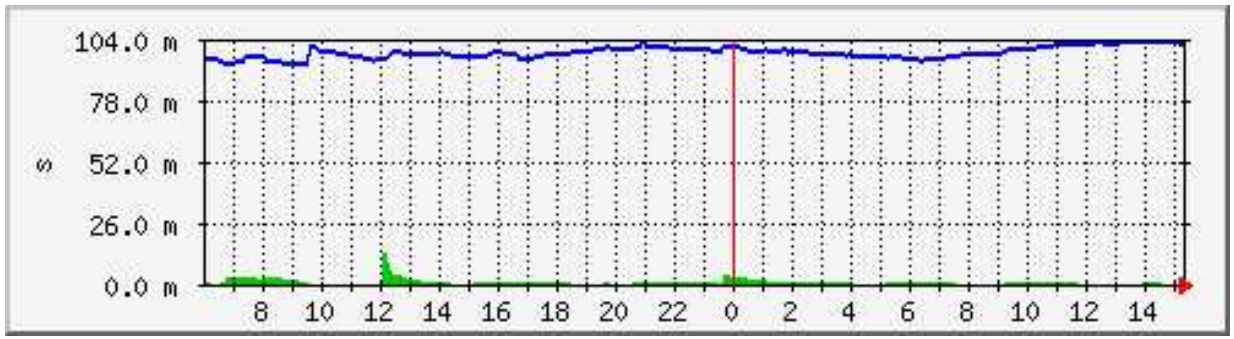
```
> ntpdc -nc monlist ntp.maths.tcd.ie
remote address          port local address      count m ver code avglen   first
===============================================================================
134.226.81.10           2122 134.226.81.3           1 7 2      0      0       0
217.45.250.124         52296 134.226.81.3           7 3 3      0     32     231
195.194.86.93           4551 134.226.81.3           2 3 3      0     30      30
195.209.63.99            123 134.226.81.3           1 3 4      0      0       0
213.79.36.118           3967 134.226.81.3        3532 3 3      0     29  105244
80.37.234.108          15469 134.226.81.3           1 3 3      0      0       0
217.67.143.122          6190 134.226.81.3           1 3 1      0      0       1
217.40.115.53          62423 134.226.81.3          10 3 3      0     64     602
202.224.209.22           123 134.226.81.3           2 3 1      0      1       2
213.168.35.2           62812 134.226.81.3          35 3 3      0     65    2239
> ntpdc -nc sysinfo ntp.maths.tcd.ie
system peer:          127.127.20.0
system peer mode:     client
leap indicator:       00
stratum:              1
precision:            -19
root distance:        0.00000 s
root dispersion:      0.00267 s
reference ID:         [GPS]
reference time:       c3d0cc9e.56f0c282  Sun, Feb  8 2004 14:56:30.339
system flags:         monitor ntp kernel stats
jitter:               0.000153 s
stability:            0.002 ppm
broadcastdelay:       0.003998 s
authdelay:            0.000003 s
```

Offset and jitter

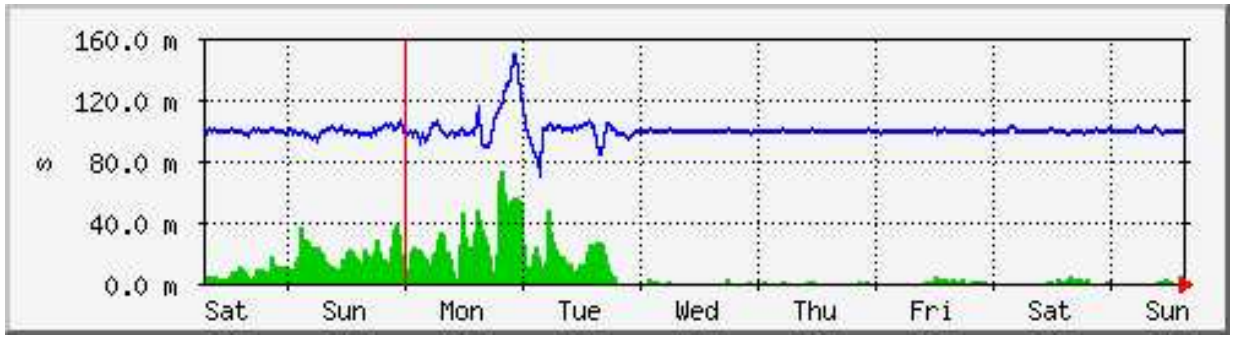
NTP server:



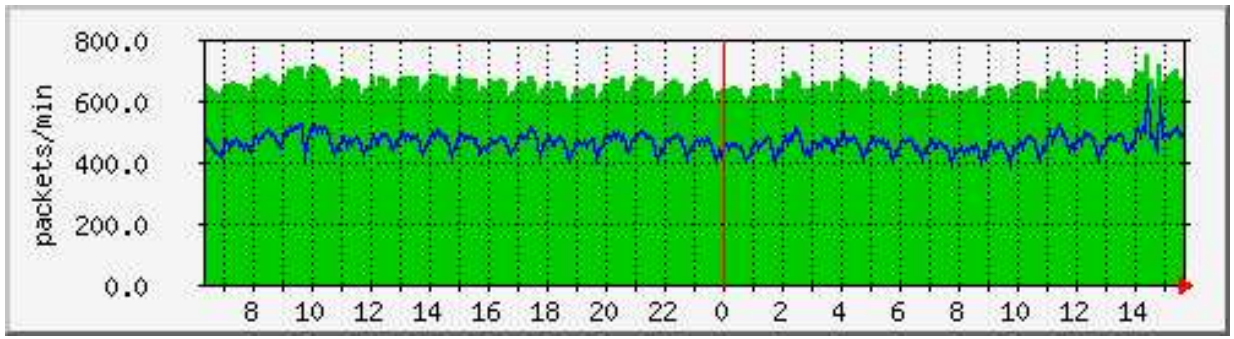
NTP client:



Problem:



Load:



Common issues

- Asymmetric delay causes an offset (particularly if common to a majority of sources). `burst`, `iburst`, `prefer` and `tinker huffpuff` may help, depending on situation.
- No connectivity eventually leaves entire network unsynchronised (particularly after power failure). To keep things going you can create a fake local refclock, `fudge`d to stratum 14 or 15.
- DNS: ntpd talks to the first IP address returned to a hostname, regardless of if it replies or not. Names are not relooked-up!

Reconfiguration

```
> cat /etc/ntp.conf
peer yipyip.home.dwmalone.net burst
keys /etc/ntp.keys
trustedkey 1 # enable this key
requestkey 1 # ntpdc key
controlkey 1 # ntpq key
> cat /etc/ntp.keys
1       M       crappassword
> ntpdc
ntpdc> keyid 1
ntpdc> passwd
MD5 Password:
ntpdc> addpeer 134.228.81.11
done!
ntpdc> peers
     remote           local      st poll reach  delay   offset    disp
==============================================================================
+yipyip.home     10.0.0.1         2   64    1 0.00044  0.002701 7.93750
+134.228.81.11   10.0.0.1        16   64    0 0.00000  0.000000 0.00000
```

Similar authentication can be applied to `peer` and `server`. NTP also supports public key based schemes.

Restrictions

You can also place restrictions on queries are accepted from what addresses.

```
restrict default ignore
restrict 134.226.81.3 noquery
restrict 10.0.0.0 mask 255.255.0.0 nomodify
restrict 127.0.0.1
```

Can also rate limit, nopeer, kiss-o'-death ...

Reference Clocks

Reference clocks are typically GPS units, radio receivers, modems, . . . Treated as magic IP addresses in config file:

```
# GPS NMEA with PPS
server 127.127.20.0 prefer
fudge 127.127.20.0 stratum 0
fudge 127.127.20.0 time1 -1.0

# Local clock
server 127.127.1.1
fudge 127.127.1.1 stratum 14

# SHM driver
server 127.127.28.0 minpoll 5
fudge 127.127.28.0 stratum 1
```

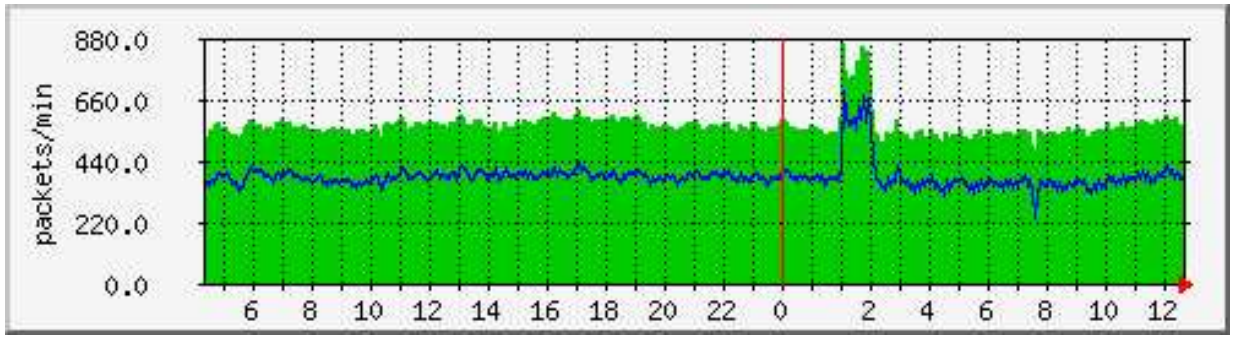
- Commercial NTP servers with built in refclocks are available,
- GPS units with PPS start at about €150,
- Radio receivers can be put together for $<$ €50.
- The serious replace the timecounter or oscillator on their system with something more stable.

See `http://phk.freebsd.dk/soekris/pps/` for a nice setup.
See `http://www.maths.tcd.ie/~dwmalone/time/rugby.html` for details of Ian's Rugby clock.

Daylight Saving

Introduced in 1916 to save energy during the war. Double summer time was used during the second world war.

Now EC uses last Sunday in March/October. Americans use first Sunday of April and last of October.

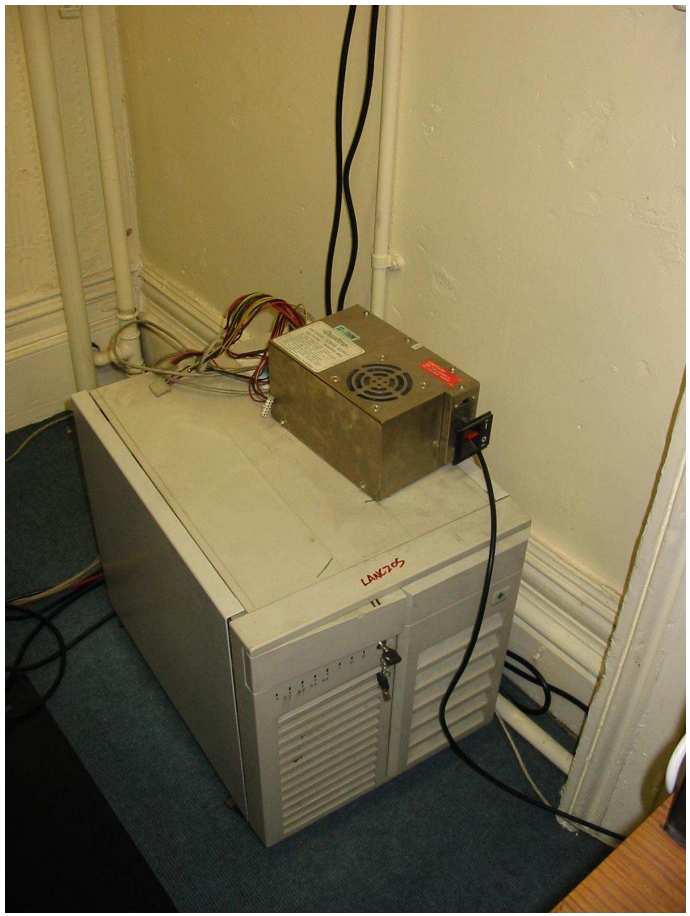


Should have nothing to do with NTP. Similarly for timezones.

Greenwich (0^o):

Dunsink (-6.338^o = 25m 21s):

ntp.maths.tcd.ie:



Rugby radio unit: