Say Kids, What Time Is It?

David Malone

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1

Time

What is time all about?

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.

For scientists that's usually as far as it goes, but what do *ordinary* people make of time?

It's that incredibly useful stuff
that we all use to stop every
thing happening at once.
— Jeff Rosson

Mostly time is used for ordering our
lives, not measuring how long has
passed between events.

I want to look at this while avoiding the
profound issues.

If a job application must be in by 5pm,
how do you know when that is?

3

Time In Ireland

1880 GMT in England, DMT in Ireland

1916 assimilated with GB

1925 Western-European Time

(minister of justice)

1968 Standard Time (GMT+1)

1971 Changed mind

1986 Order giving effect

to EEC directive

1997 EU directive currently

in force

All in terms of GMT. What is GMT?

4

GMT

Greenwich Mean Time: Mean solar time at the Greenwich Meridian.

Note the word solar — days are related to the sun!

GMT used to be measured from noon (00:00GMT) to noon. In 1925 they moved to starting the clock at mid-night.

Universal Times

Sidereal Time is measured against a point in the sky, the catalog equinox. You can find out the local sidereal time by measuring where a star is in the sky and then looking it up in a catalog. The sun isn't important here.

Universal Time is calculated from sidereal time using a formula.

$$86636.55536790872 + 5.098097 \times 10^{-6}T$$
$$+5.09 \times 10^{-10}T^2$$

(A day is usually 86400 long).

TAI and UTC

International Atomic Time has been available since 1955 officially since 1972). Uses SI second.

Problem is that UT seconds and SI seconds are different.

Coordinated Universal Time is a compromise. It ticks once per SI second, in sync with TAI.

If UTC is more than one second from UT1 then a leap second is introduced.

7

Years

Days are kept in sync with sunrise.
Years are kept in sync with seasons.

The time of year: angle between
earth's axis and the line from the
earth to the sun.

NB: seasons nothing to do with distance
to sun. Earth is at it's closest about 2nd
January.

Current aim of our calendar: Keep the
vernial equinox near 21st March.

The length of the year isn't a whole
number of days (365.24219), which
causes complications.

When	Calendar	Length
????	old roman	£££
45BC	Julian	365.25
1582AD	Gregorian	365.2425

It's hard to get the length right when
you can't write it down.

Counting Years

We now count years from the (supposed) birth of Christ.

Dionysius Exiguus (AD 523) was asked to produce table of Easter Dates.

Unfortunately, Herod died in 4BC, so Dionysius probably got it wrong.

BC dating came somewhat later, along with the missing year zero.

Before that dates were counted since the founding of Rome. 1AD = 754AUC (ab urbe condita).

Hours, Minutes and Seconds

Pretty arbitrary divisions of a day. They arise by dividing things into 12 and 60.

Weeks and Months

7 day week is very old. Used by Romans and Jews (independently?).

English	French	Planet
Monday	lundi	Moon
Tuesday	mardi	Mars
Wednesday	mercredi	Mercury
Thursday	jeudi	Jupiter
Friday	vendredi	Venus
Saturday	samedi	Saturn
Sunday	dimanche	(Sun)

Months were probably supposed to keep in sync with the moon (29.5305889 days). Some other calendars are much better in this respect.

12

Easter

Easter Sunday is the first Sunday after the first full moon after vernal equinox.

But which full moon and which equinox?

$$
\begin{aligned}
G &= Y \mod 19 \\
C &= \frac{Y}{100} \\
H &= (C - \frac{C}{4} - \frac{8*C+13}{25} + 19*G + 15) \mod 30 \\
I &= H - \frac{H}{28} * (1 - \frac{H}{28} * \frac{29}{H+1} * \frac{21-G}{11}) \\
J &= (Y + \frac{Y}{4} + I + 2 - C + \frac{C}{4}) \mod 7 \\
L &= I - J \\
\text{Month} &= 3 + \frac{L+40}{44} \\
\text{Day} &= L + 28 - 31 * \frac{\text{EasterMonth}}{4}
\end{aligned}
$$

G is the Golden Number, H is Epact.

Julian Day Number

Another way of counting days avoiding BC/AD problems. It is a cycle of 7980 years.

JD 0 designates the 24 hours from noon UTC on 1 January 4713 BC to noon UTC on 2 January 4713 BC.

Today is Julian Day 2452018.5 or MJD 52018.

Why start then? Why 7980 years?

A combination of Indiction, Golden Number and Solar Number (15*19*28=7980).

14

Friday the Thirteenth

Solar Number counts what part of the 28 year year/weekday cycle we are in for the Julian Calendar.

$$\text{lcm}(365 * 4 + 1, 7) = 28 \text{years}$$

What about the Gregorian Calendar?

$$\text{lcm}(365 * 400 + 97, 7) = 400 \text{years}$$

So there is room for bias!

Sunday	687	Monday	685
Tuesday	685	Wednesday	687
Thursday	684	Friday	688
Saturday	684		

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.

EU report covering agriculture, environment, energy, health, leisure, road safety, transport and communications.

Seems to be quite an emotive issue.

Computers and Time

Computers store time in various ways.

Y2K thing was all about ways of storing time.

Unix counts the number of UTC seconds since 1970.

```
 987654321   Thu Apr 19 05:25:21 BST 2001
1000000000   Sun Sep  9 02:46:40 BST 2001
  2^31 - 1   Tue Jan 19 03:14:07 GMT 2038
```

Counting is done in various ways: RTC chips, interrupts or special registers.

Correct dates are important for sharing files, time-stamping events, certain crypto-protocols and charging people.

NTP

The *Network Time Protocol* synchronises a computer to a source of UTC (either another computer or a clock).

Works by building a tree of servers. Stratum 1 are connected directly to a clock, Stratum 2 are synchronised to a Stratum 1 over the network, Stratum 3 are synchronised to a Stratum 2, ...

It works by passing time-stamps back and forth across the network and slewing the clock.

remote	st	poll	delay	offset	disp
=rackety.udel.edu	1	64	0.09657	-0.001534	0.00252
=LOCAL(1)	14	64	0.00000	0.000000	0.00093
+auth1.auth.iol.ie	2	1024	0.01965	0.009256	0.01053
+web1.tcd.ie	2	64	0.00031	-0.004647	0.00198
+orca.ucd.ie	2	64	0.00000	0.000000	0.00000
*GPSNMEA(0)	0	64	0.00000	0.000003	0.00093
+rizzo.esat.net	2	256	0.01189	0.001555	1.00273
=err.ee.ethz.ch	1	64	0.09393	-0.018515	0.00124
+burke.cs.tcd.ie	2	1024	0.00166	-0.001170	0.00867
+salmon.maths.tcd.ie	3	64	0.00040	-0.005916	0.00186

19
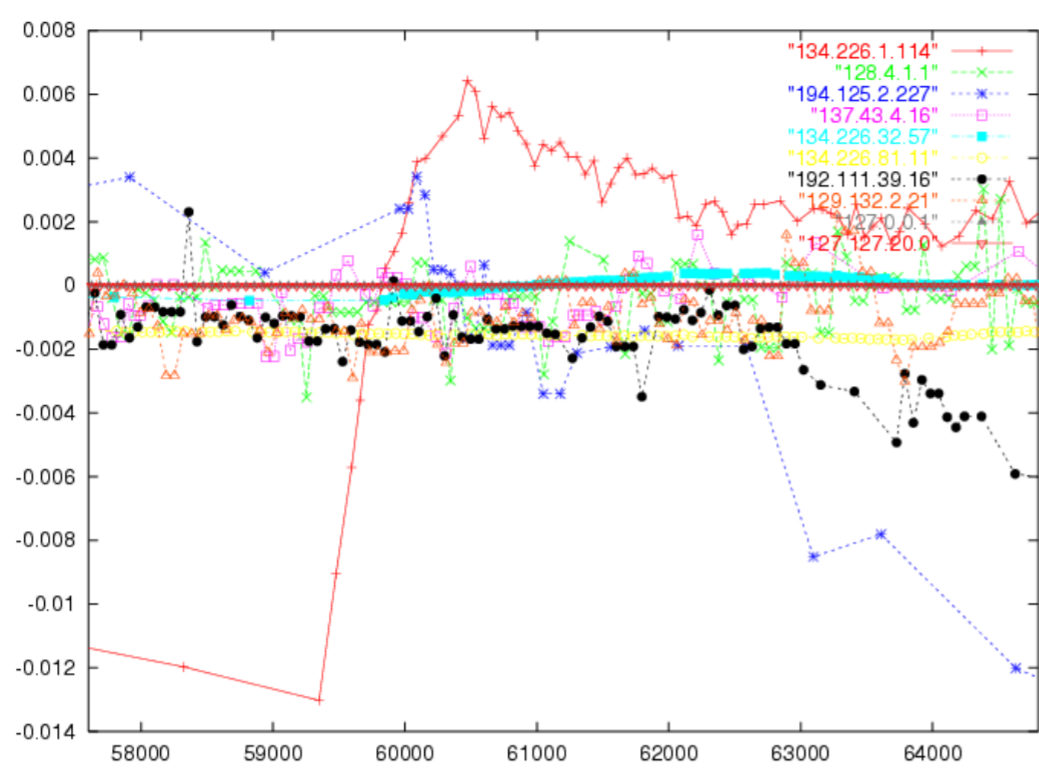
Various ref-clocks are used: Rugby, GPS, Cesium clocks, dialup.

One of the best things about NTP is the jargon: PLL, PPS, jitter, epochs, RTT, PPM, false-tickers, chime-heads.