Timekeeping System Implementations: Options for the *Pontifex Maximus*
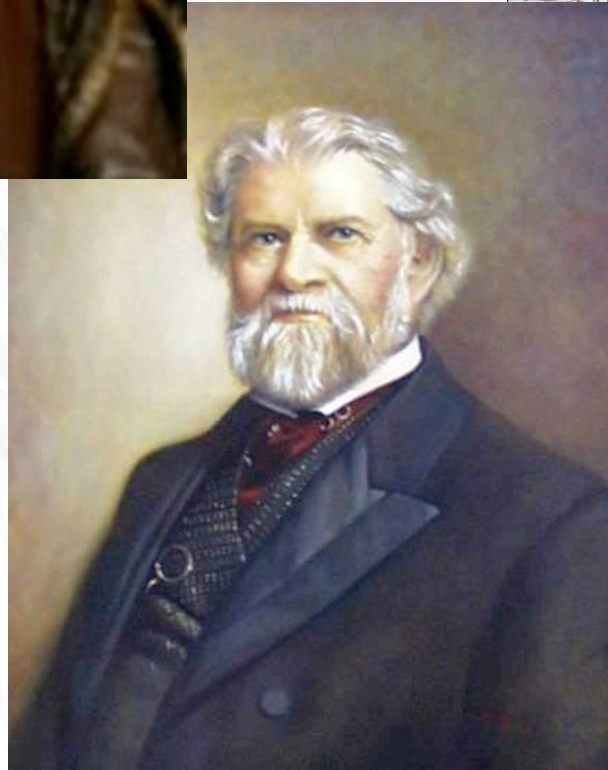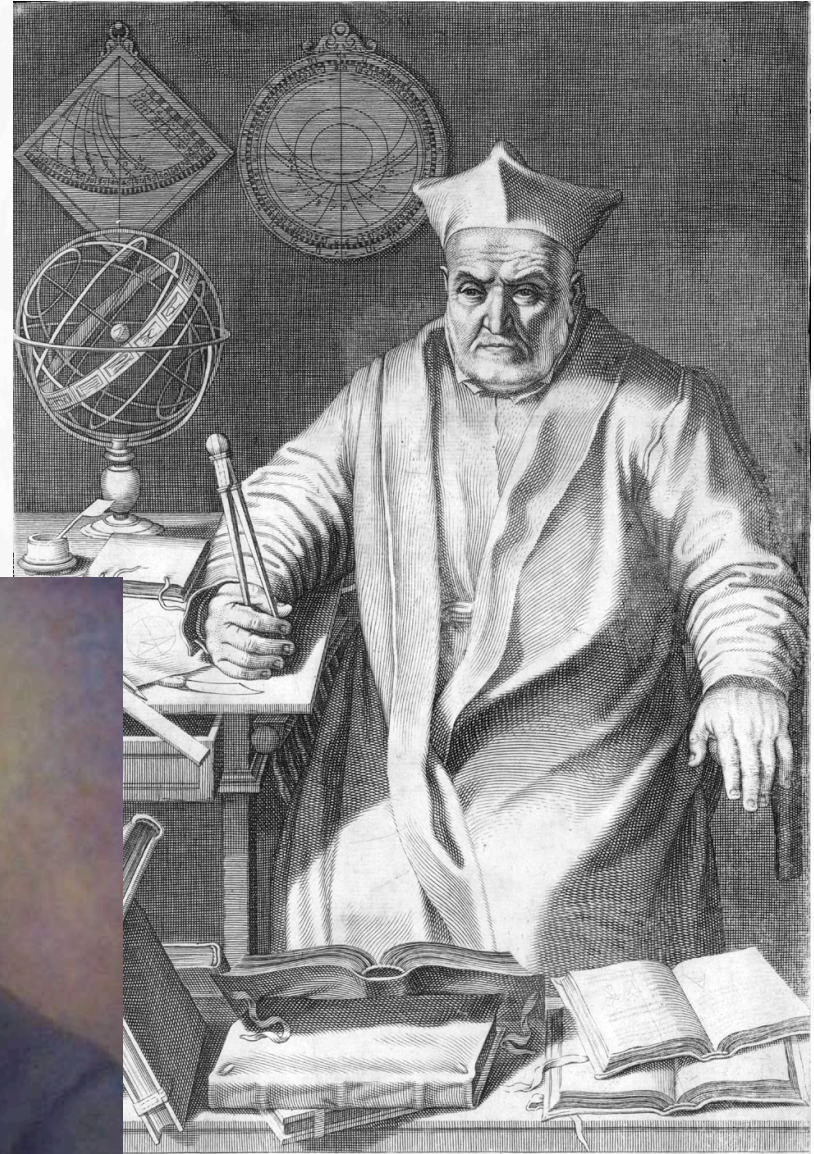
Steve Allen

UCO/Lick Observatory

Civil actors

Astronomical actors

Yes, really, actors

Civil time dramas had been *two-handers*
Everybody else had been audience

Then things got complicated

Who?

- IAU
- BIH
- CCDS
- CGPM
- CCIR
- IUGG
- URSI
- IERS
- ITU-R

What?

- GMT
- UT
- ET
- UT0,1,2
- AT
- coordinated
- TAI
- UTC
- GPS

How?

- Computers

Computer standards(?)

- ANSI C and POSIX 1997 had "double leap second"

- NTP specifies UTC but discounts leap seconds

- POSIX specifies UTC but discounts leap seconds

- Specifications demand POSIX and real-time systems

- IBM S/390 and z/OS implement LSO, nobody uses it

- C99 and POSIX 2004 remove "double leap second"

- POSIX unclearly apologizes about lack of consensus

- Microsoft refuses to address the issues

- Vendor manuals include broken regurgitations of TF.460

Leap second experiments

- IBM hacked Linux kernels to have z/OS-like LSO

- Result: not POSIX-conformant

- Google hacked NTP servers to stretch time

- Result: POSIX-conformant, but not real-time

- POSIX is not the only player, but it represents others

- There is an underlying problem insoluble via any kernel

Actor?
What I really want to do is direct

Time zones and daylight time the `tz` database

- Arthur David Olson at NIH

- Paul Eggert at UCLA

- a worldwide community of contributors and testers

- completely unauthoritative, but used by most OS

- does not involve the kernel, only user code

- current version is `tzcode2011i` and `tzdata2011k`

- includes `leapseconds` file and code

- most vendors provide updates along with OS patches

RFC 5545: iCalendar

- IETF standard for scheduling and sharing events

- Calendaring and Scheduling Consortium CALCONNECT

- hoping for `tz` database patches is not good enough

- reactivated TIMEZONE Technical Committee

- tasked to create timezone registry and API for a service

- submitted Internet Draft proposing IANA do `tz` database

- recent discussions about including `leapseconds` file

Reinterpreting POSIX

What does a POSIX kernel really want?

- not to know anything about astrometry

- not to know anything about geophysics

- a self-consistent way to be real-time

- 86400 seconds in a "day"

Reinterpreting POSIX

What does POSIX not need?

Knowing nothing about astrometry or geophysics, POSIX is oblivious to the meaning of "day".

POSIX is mistaken when it says it wants UTC.

The practical evolution of systems and hardware means that POSIX really wants the time scale which is internationally approved for use in radio broadcasts. The POSIX systems have no concept of what name humans use for that time scale.

A POSIX-conformant way to retain leap seconds in UTC

POSIX demands that it be possible to format local civil time with offets of arbitrary seconds from the underlying `time_t`

The `tz` database provides code to handle leap seconds

GPS-based NTP servers from Meinberg and Symmetricom can be configured to provide GPS system time instead of UTC.

The combination of these allows demonstration of a compromise the ITU-R could enable.

The hacked `leapseconds` file

# Leap	YEAR	MONTH	DAY	HH:MM:SS	CORR	R/S
Leap	1981	Jun	30	23:59:60	+	S
Leap	1982	Jun	30	23:59:60	+	S
Leap	1983	Jun	30	23:59:60	+	S
Leap	1985	Jun	30	23:59:60	+	S
Leap	1987	Dec	31	23:59:60	+	S
Leap	1989	Dec	31	23:59:60	+	S
Leap	1990	Dec	31	23:59:60	+	S
Leap	1992	Jun	30	23:59:60	+	S
Leap	1993	Jun	30	23:59:60	+	S
Leap	1994	Jun	30	23:59:60	+	S
Leap	1995	Dec	31	23:59:60	+	S
Leap	1997	Jun	30	23:59:60	+	S
Leap	1998	Dec	31	23:59:60	+	S
Leap	2005	Dec	31	23:59:60	+	S
Leap	2008	Dec	31	23:59:60	+	S
Leap	2011	Oct	3	20:51:60	+	S

The `right+gps` demo script

```sh
#! /bin/sh

then='empty'
isofmt='+%Y-%m-%dT%H:%M:%S'
MYTZ=$HOME/tzdir2011k+gps/etc/zoneinfo-leaps/US/Pacific
while true; do
  now=`date "$isofmt"`
  if [ x"$now" != x"$then" ]; then
    right=`TZ=:$MYTZ date "$isofmt"`
    time_t=`date +%s`
    echo "$time_t POSIX $now right+GPS $right"
    then=$now
  fi
  usleep 500000 2>/dev/null || sleep 0.5
done
```

The `right+gps` output

```
1317675120 POSIX 2011-10-03T13:52:00 right+GPS 2011-10-03T13:51:45
1317675121 POSIX 2011-10-03T13:52:01 right+GPS 2011-10-03T13:51:46
1317675122 POSIX 2011-10-03T13:52:02 right+GPS 2011-10-03T13:51:47
1317675123 POSIX 2011-10-03T13:52:03 right+GPS 2011-10-03T13:51:48
1317675124 POSIX 2011-10-03T13:52:04 right+GPS 2011-10-03T13:51:49
1317675125 POSIX 2011-10-03T13:52:05 right+GPS 2011-10-03T13:51:50
1317675126 POSIX 2011-10-03T13:52:06 right+GPS 2011-10-03T13:51:51
1317675127 POSIX 2011-10-03T13:52:07 right+GPS 2011-10-03T13:51:52
1317675128 POSIX 2011-10-03T13:52:08 right+GPS 2011-10-03T13:51:53
1317675129 POSIX 2011-10-03T13:52:09 right+GPS 2011-10-03T13:51:54
1317675130 POSIX 2011-10-03T13:52:10 right+GPS 2011-10-03T13:51:55
1317675131 POSIX 2011-10-03T13:52:11 right+GPS 2011-10-03T13:51:56
1317675132 POSIX 2011-10-03T13:52:12 right+GPS 2011-10-03T13:51:57
1317675133 POSIX 2011-10-03T13:52:13 right+GPS 2011-10-03T13:51:58
1317675134 POSIX 2011-10-03T13:52:14 right+GPS 2011-10-03T13:51:59
1317675135 POSIX 2011-10-03T13:52:15 right+GPS 2011-10-03T13:51:60
1317675136 POSIX 2011-10-03T13:52:16 right+GPS 2011-10-03T13:52:00
1317675137 POSIX 2011-10-03T13:52:17 right+GPS 2011-10-03T13:52:01
1317675138 POSIX 2011-10-03T13:52:18 right+GPS 2011-10-03T13:52:02
1317675139 POSIX 2011-10-03T13:52:19 right+GPS 2011-10-03T13:52:03
1317675140 POSIX 2011-10-03T13:52:20 right+GPS 2011-10-03T13:52:04
1317675141 POSIX 2011-10-03T13:52:21 right+GPS 2011-10-03T13:52:05
```

The effects of `right+gps`

Leap seconds can be handled by code that is already tested, widely-distributed, and in use by POSIX-conformant systems. Any user can test this on any program at any time without special privileges or hardware.

A shift in the representation of time, and the nomenclature used by POSIX systems, allows a compromise which preserves the traditional meaning of time while enabling new technologies. It also enables the rules for the timing of leap seconds to be varied.

Even if the ITU-R does not change the name of the broadcast time scale, this mechanism might be used by jurisdictions which want to insert their own leap seconds to retain mean solar time.

What the outsider sees