Planes will crash!
Things that leap seconds didn't, and did, cause

Steve Allen

UCO/Lick Observatory

1970 IAU Comm. 31 Report

Only the first item of the two documents (abolition of offset) found nearly unanimous consent while for the others discussions are still open. According to the authoritative intervention of D. H. Sadler and G. M. Winkler, who examined thoroughly the serious dissensions between those concerned with standard frequencies and those who request a time system connected with the Earth's rotation (astronomers, geodesists, navigators etc.) and in particular the world-wide collision avoidance system for aircraft (CAS), which cannot admit stepping time adjustments, serious objections can be made as regards the proposals of the two documents; also because said Commissions ignore the needs of a great minority who cannot prescind from the definition of above mentioned U.T.C. and in particular cannot accept differences greater than $\pm 0^{s}.1$. It is stated as a necessity that activities concerning time service should be completely independent of the activities of frequency standards laboratories.

1970 IAU Proceedings

The *President* urged Commission 31 to consider the scope of its activities. The Commissions of URSI, CCDS, and the IAU are, in many cases, attended by the same people, but the discussions are held in very different climates. Commission 31 should ensure that its views are made known to the Directing Board of the BIH.

The Chairman of CCIR IWP VII/I, H. M. Smith, explained that problems arose from the need for two time systems: UT based on the rotation of the Earth and a uniform atomic time scale based on the second. The control of radio time signals is the responsibility of the CCIR, and at Boulder, 1968, a Working Party had been set up to look into the problem of improving the system for radio time signals which would better suit the needs of users of both UT and AT. The Working Party had proposed that the signals should be emitted without offset, but that there should be steps of 1 second to keep the signals in general agreement with UT and that this system should commence on 1.1.72. The Working Party sought the views of Commission 31 on details of implementation.

In reporting informally on the draft recommendations, J. Terrien stressed that the CCDS had still to report to the CIPM. He added that although the IAU had no power to change the recommendations he would note any views expressed by Commission 31 and report them at the October meeting of the CIPM.

1970 IAU Proceedings

The *President* reported that unfortunately the IAU had received no official communication from the CCIR of the recommendations and resolutions made at New Delhi. *D. H. Sadler* expressed amazement since a CCIR resolution stated specifically that the IAU should be informed. After further discussion *H. M. Smith* said that although the Commission could not comment on documents which had not been received he would like views on the six points he had raised in an earlier meeting.

The *President* proposed that the discussion on reaction to the CCIR's recommendations be dropped and that the Commission proceed to hold a free discussion giving their own views and this was agreed. The President then read out a draft of the resolution on time signal emissions which had been prepared by the Organizing Committee. After clarification of a few points the meeting adjourned.

Third Session

The *President* reopened discussion on the draft Resolution by remarking on the need to reach an acceptable compromise. The following points were made:

1972, Terrien in *Metrologia*

I now come to measurements and *standards of time*. BIPM, as you know, does no experimental work on the measurement of time or frequency. Nevertheless my staff and I consider that we must keep abreast of every aspect of this subject. That is why I am a member of Commission 31 (Time) of the International Astronomical Union, am always invited to the General Assembly of the International Radio Scientific Union, and am well acquainted with whatever is discussed by the International Radio Consultative Committee of the International Telecommunications Union. I have several times visited laboratories where atomic frequency standards, of the caesium beam or hydrogen maser type, have been built. And I believe this activity has been profitable, for in the last few years regrettable misunderstandings, especially between astronomers and physicists, have crept into discussions on time and frequency. Naturally all those competent to do so have tried to remove such misunderstandings, and I have done my good share.

1978 CCIR

2. Consideration of Study Group 7 documents (Docs. 7/1000 to 7/1042)

Docs. 7/1000 to 7/1002

2.1 The *Chairman of Study Group 7*, introducing his Report (Doc. 7/1001), stressed the most important aspects of the Study Group's work during the last Study Period. In particular, he drew attention to the recommended adoption of Coordinated Universal Time (UTC) as the basis for civil time, the results achieved in respect of time and frequency generators, and problems encountered in respect of mutual interference in the bands allocated for the time and frequency services.

Coordinated Universal Time (UTC)

UTC was introduced by Recommendation 460 in 1972 for the purpose of time-signal emissions of standard-frequency and time-signal transmitters. In 1975 the General Conference of Weights and Measures recommended UTC as the basis of civil time. Some countries have already introduced new time laws in which legal time is no longer based on mean solar time of the Greenwich meridian, Universal Time (UT), but on UTC. Though UT and UTC differ by less than 1 s, for precise time measurements, their qualities differ considerably. UTC is defined and at many places immediately available with an uncertainty of less than 1 µs. In contrast, UT is uncertain by several ms. The scale unit of UTC is the SI second which is the legal time unit in many countries. Since only UTC time signals and corresponding standard frequencies are distributed, the UTC time scale is the general reference for civil time as well as for all international services. Greenwich Mean Time (GMT), though not precisely defined, corresponds nearly to UT. In the new Recommendation 535, it is recommended that the term GMT in the Radio Regulations be replaced by UTC. It is also recommended that UTC should be used in all official documents of the International Telecommunication Union. According to Recommendation 736 the designation UTC is to be used in all languages.

Review of the work

...important in connection with synchronous digital

In contrast to earlier Study Periods, no contributions concerning the definition and designation of time scales and relevant problems have been submitted. This shows that the fundamental problems on time and frequency are sufficiently solved.

Some of the important work was done in the three Interim Working Parties.

Interim Working Party 7/1 has successfully accomplished its work on the implementation of the UTC system.

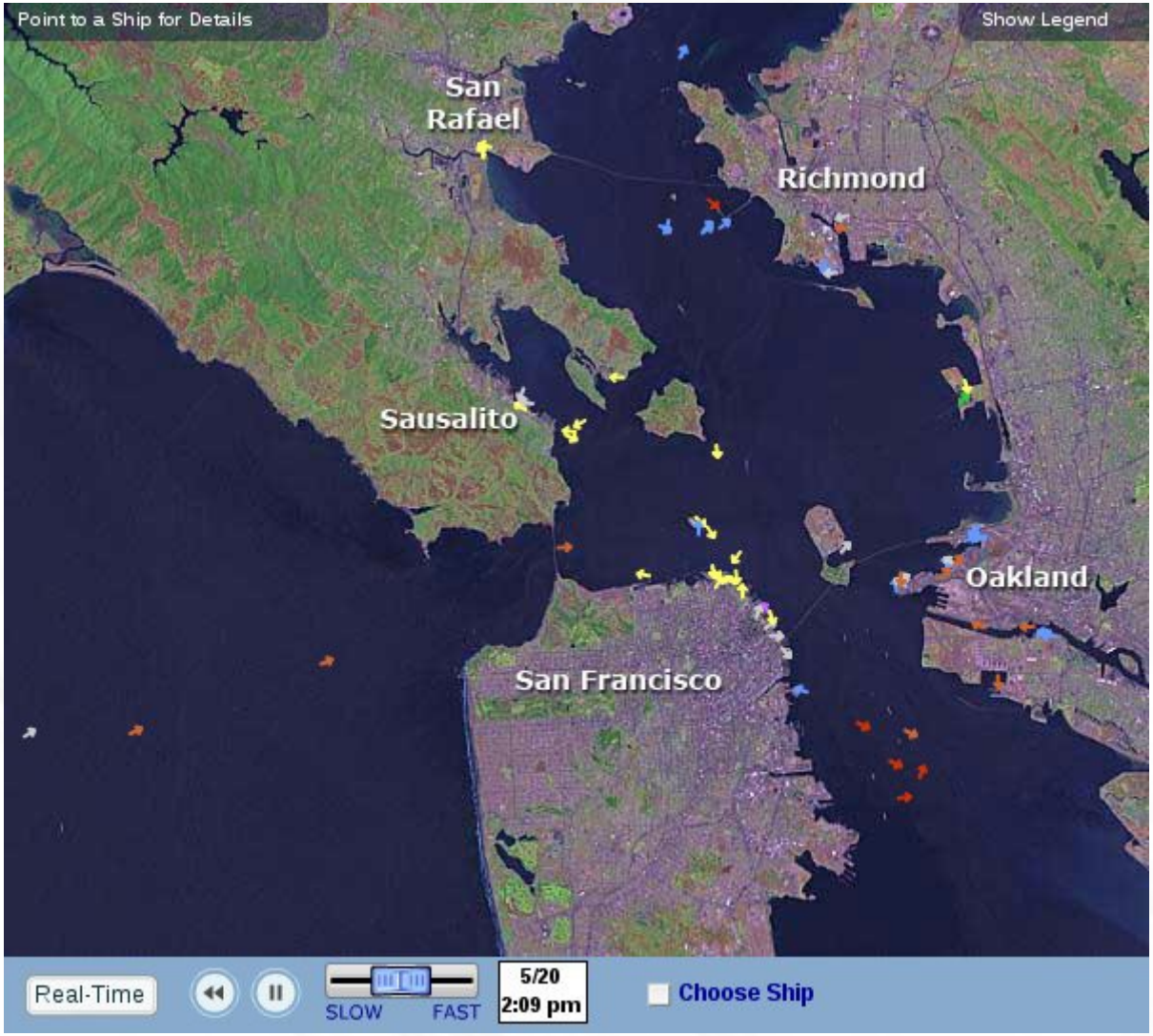
Interim Working Party 7/2 has prepared a glossary containing more than sixty terms and definitions used in the standard frequency and time signal service.

Interim Working Party 7/3 has presented a final Report on the proposed reduction of mutual interference between standard frequency and time signal emissions in bands 6 and 7.

On the basis of the results achieved, Study Group 7 decided to abolish the three Working Parties; the remaining work could be accomplished by the Study Group itself.

What is a leap second like?

2005 leap second



http://www.boatingsf.com/ships-on-SF-bay/central-san-francisco-bay

2005 leap second

Automated Identification System (AIS)

Document Id	Version	Date
PT-05-0078	A	2005-09-09

Saab TransponderTech AB

Issued by	Approved by
Mikael Pettersson	Gunnar Mangs

Timing problem in the R3 and R4 Transponder

A problem with the UTC time has recently occurred in our R3 and R4 transponder products. This causes a functional problem in our transponders which will remain until the end of 2005. The problem can be removed with a software upgrade that is available through our Service Network.

1.1 Background

UTC time is used as the time base in the AIS system. A leap second will be introduced in UTC time at midnight, 31st December 2005. Announcement on the upcoming change in UTC has been broadcast in the GPS system since early July this year.

Also, something at Google ...

Media Alert

Date: December 5th, 2005
From: ACR Electronics, Inc.
Re: Re-synchronization of AIS systems due to Leap Second Phenomenon
Contact: John Bell/PRCoordinator ACR Electronics, Inc.
Email: prseitz@bellsouth.net
Tel: 954-970-3394

According the Time and Frequency Division at the U.S. National Institution of Standards and Technology an extra second will be added to 2005 to make up for the slowing down of the Earth's rotation.

The once common "leap second" is the first in seven years and reflects the unpredictable nature of the planet's behavior. For the first time since 1998, the International Earth Rotation and Reference Systems Service in Paris will sneak in an extra second at the end of the year to get time back in synch with the atomic clock, which is unwavering in its measurement of time on earth.

ACR Electronics, a global manufacturer of two Automatic Identification Systems (AIS) brands-- The GlobalWatch™ and GlobalWatch$_2$™-- is alerting customers that the additional second will affect the performance of their on-board AIS systems, unless a manual re-synchronization takes place between January 1 and January 2. The "leap second" will affect all AIS systems and manufacturers such as ACR are proactively notifying users around the world.

The Coordinated Universal Time (UTC) kept by the atomic clock is used as the time-base for all AIS systems. Unless re-synchronized the GPS-signal received by the transponder could fail to identify targets on the AIS display.

ACR, in addition to emails to dealers and unit owners, has posted a detailed technical bulletin on its website at www.acrelectronics.com offering two simple options for manual re-synchronization.

2008 leap second

Linux kernel deadlock https://lkml.org/lkml/2009/1/5/562

- "Linas Vepstas"
  - Diego Calleja
    - Robert Hancock
      - David Newall
        - "Ben Goodger"
        - Chris Adams
      - "Linas Vepstas"
    - "Ben Goodger"
    - Chris Adams
      - "Duane Griffin"
        - "Linas Vepstas"
        - Chris Adams
          - "Duane Griffin"
        - **"john stultz-lkml"**
        - Chris Adams
        - "Linas Vepstas"
    - "Linas Vepstas"
      - "Ben Goodger"
      - "Duane Griffin"
        - "Ben Goodger"
      - "Jeffrey J. Kosowsky"

Google Search ○Web ◉lkml.org

Date Mon, 5 Jan 2009 18:21:36 -0800

From "john stultz-lkml" <>

Subject Re: Bug: Status/Summary of slashdot leap-second crash on new years 2008-2009

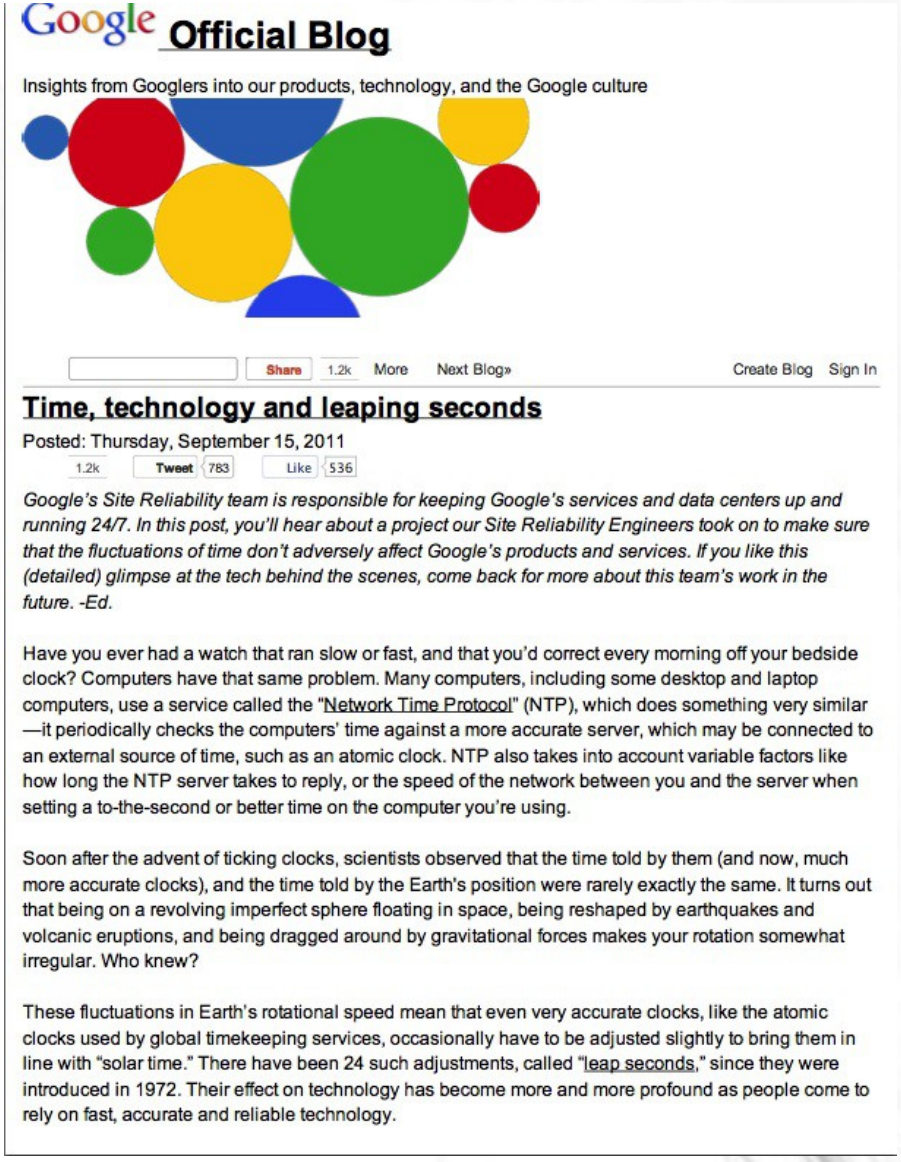
0

```
On Fri, Jan 2, 2009 at 4:21 PM, Chris Adams <cmadams@hiwaay.net> wrote:
> Once upon a time, Linas Vepstas <linasvepstas@gmail.com> said:
>> Below follows a summary of the reported crashes. I'm ignoring the
>> zillions of "mine didn't crash" reports, or the "you're a paranoid
>> conspiracy theorist, its random chance" reports.
>
> I have reproduced this and got a stack trace (this is with Fedora 8 and
> kernel kernel-2.6.26.6-49.fc8.x86_64):
>
[snip]
> Basically (to my untrained eye), the leap second code is called from the
> timer interrupt handler, which holds xtime_lock.  The leap second code
> does a printk to notify about the leap second.  The printk code tries to
> wake up klogd (I assume to prioritize kernel messages), and (under some
> conditions), the scheduler attempts to get the current time, which tries
> to get xtime_lock => deadlock.

This analysis looks correct to me.

Grrrr. This has bit us a few times since the "no printk while holding
the xtime lock" restriction was added.
Thomas: Do you think this warrents adding a check to the printk path
to make sure the xtime lock isn't held? This way we can at least get a
warning when someone accidentally adds a printk or calls a function
that does while holding the xtime_lock.

thanks
-john
```

Meanwhile, at Google ...

Google “leap smear”

googleblog.blogspot.com/2011/09/time-technology-and-leaping-seconds.html



Google Official Blog

Insights from Googlers into our products, technology, and the Google culture

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Time, technology and leaping seconds

Posted: Thursday, September 15, 2011

1.2k Tweet 783 Like 536

Google's Site Reliability team is responsible for keeping Google's services and data centers up and running 24/7. In this post, you'll hear about a project our Site Reliability Engineers took on to make sure that the fluctuations of time don't adversely affect Google's products and services. If you like this (detailed) glimpse at the tech behind the scenes, come back for more about this team's work in the future. -Ed.

Have you ever had a watch that ran slow or fast, and that you'd correct every morning off your bedside clock? Computers have that same problem. Many computers, including some desktop and laptop computers, use a service called the "Network Time Protocol" (NTP), which does something very similar —it periodically checks the computers' time against a more accurate server, which may be connected to an external source of time, such as an atomic clock. NTP also takes into account variable factors like how long the NTP server takes to reply, or the speed of the network between you and the server when setting a to-the-second or better time on the computer you're using.

Soon after the advent of ticking clocks, scientists observed that the time told by them (and now, much more accurate clocks), and the time told by the Earth's position were rarely exactly the same. It turns out that being on a revolving imperfect sphere floating in space, being reshaped by earthquakes and volcanic eruptions, and being dragged around by gravitational forces makes your rotation somewhat irregular. Who knew?

These fluctuations in Earth's rotational speed mean that even very accurate clocks, like the atomic clocks used by global timekeeping services, occasionally have to be adjusted slightly to bring them in line with "solar time." There have been 24 such adjustments, called "leap seconds," since they were introduced in 1972. Their effect on technology has become more and more profound as people come to rely on fast, accurate and reliable technology.

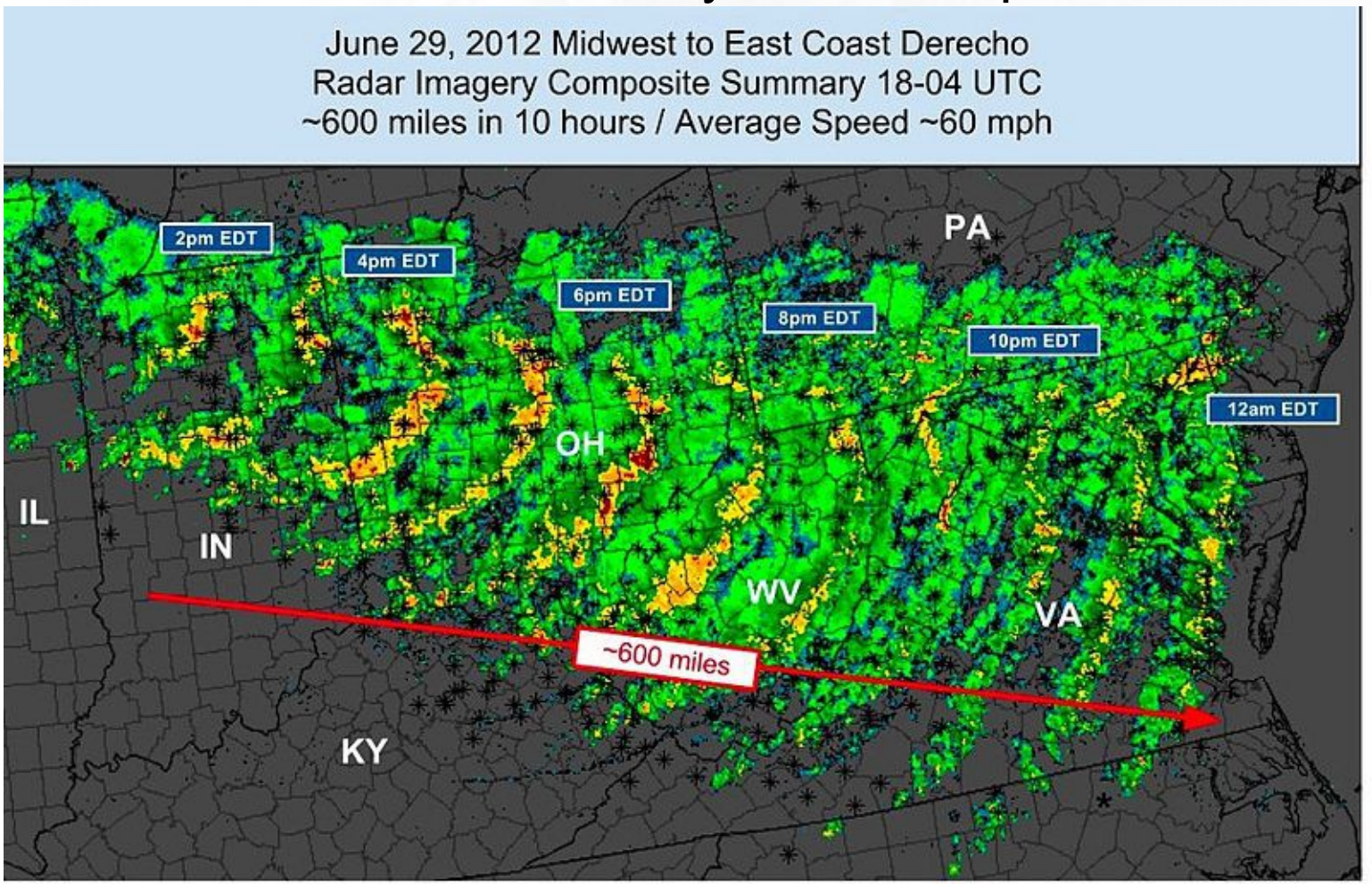
Google is among the few agencies on the planet capable of defining and distributing its own global time scale.

The leap smear is a “lie”

Cloud applications are generally not real-time systems.

2012 leap second

derecho occurred 1 day before leap second



Over 500 preliminary thunderstorm wind reports indicated by *
Peak wind gusts 80-100mph. Millions w/o power.

Summary Map by G. Carbin
NWS/Storm Prediction Center

2012 leap second

Some Linux systems without a kernel patch from March crashed all day before the leap if they ran NTP.
https://lkml.org/lkml/2012/3/15/616
Heavily loaded systems were more likely to crash.
http://serverfault.com/questions/403732/anyone-else-experiencing-high-rates-of-linux-server-crashes-during-a-leap-second
http://blog.fastmail.fm/2012/07/03/a-story-of-leaping-seconds/

Some Linux systems running old unpatched kernels (re)experienced the 2008 deadlock bug.

Large amounts of speculation and misinformation
Leap second did not crash Pirate Bay
http://torrentfreak.com/leap-second-did-not-crash-the-pirate-bay-120701/
Nor fark
http://www.fark.com/comments/blog284

Some Linux systems running fully patched kernels experienced the 2012 livelock bug.
Qantas reservation system Amadeus
and many other sites, not all reported in the media.

2012 leap second

Linux kernel livelock https://lkml.org/lkml/2012/7/1/19

- *Jan Engelhardt*
- *Markus Trippelsdorf*
- **john stultz**
- *Ben Blum*
- *John Stultz*

Google Search Web lkml.org

Date Sun, 1 Jul 2012 01:16:13 -0700

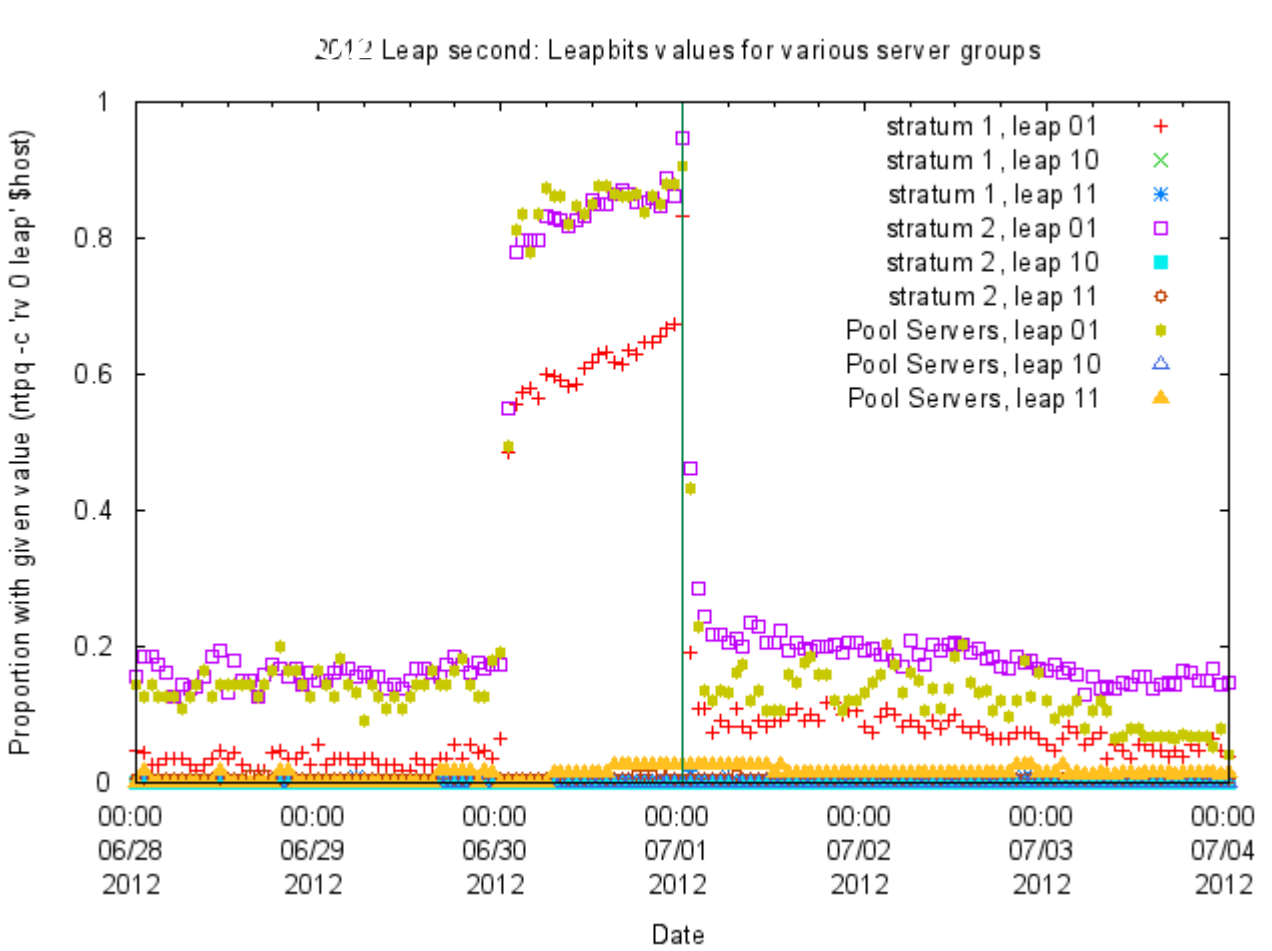
Subject Re: Leap second insertion causes futex to repeatedly timeout

16

From john stultz <>

```
On Sat, Jun 30, 2012 at 5:57 PM, Jan Engelhardt <jengelh@inai.de> wrote:
>
> This year's leap second insertion has had the strange effect on at least
> Linux versions 3.4.4 (my end) and 3.5-rc4 (Simon's box, Cc) that certain
> processes use up all CPU power, because of futexes repeatedly timing
> out. This seems to only affect certain processes.
>
> Simon observes - http://s85.org/owXfmLvt - that
> Firefox/Thunderbird/Chrome/Java are affected.
>
> As for me, it affects VirtualBox, mysqld and ksoftirqd. The processes
> continue to run and respond. Most weird: I can stop-start mysqld and the
> issue persists. (I would have expected it to go away because the leap
> second event would then be in the past that mysqld does not know about
> anymore.)
>
>
> Is this a kernel issue? glibc?

Some of the reports that the issue is resolved by calling:
       $ date -s "`date`"
suggests that it might be due to clock_was_set() not being called
after the leap second was added, causing some hrtimer confusion.

Thomas: does that sound about right?

I've got an initial patch to add the clock_was_set() calls where
needed, but so far have not been able to reproduce the issue (tried
firefox and some simpler futex tests).  I'll keep trying and hopefully
have something to send out tomorrow.

Again, my apologies for the trouble.
-john
```

2012-07-31, 2012-08-31 and 2012-12-31 NTP LI (leap indicator) bits roughly 10% to 20% of servers always wrong



http://www.maths.tcd.ie/~dwmalone/time/leap2012/#ntpleapflag

2012-11-19 Giant Leap

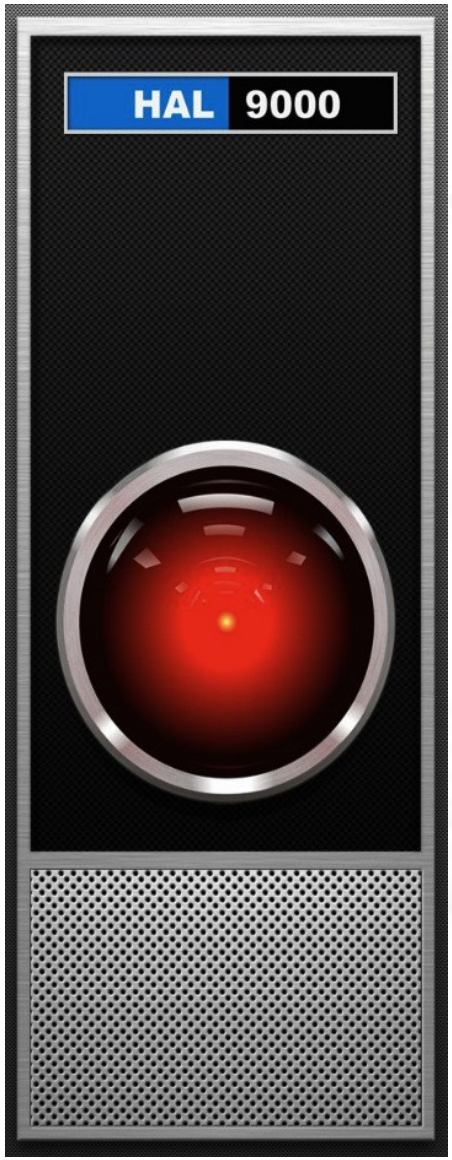
tick.usno.navy.mil and tock.usno.navy.mil NTP servers reported year as 2000

```
Nov 19 14:22:16.062 MST: %SYS-6-CLOCKUPDATE:
 System clock has been updated
 from 14:22:16 MST Mon Nov 19 2012
 to 14:22:16 MST Sun Nov 19 2000,
 configured from NTP by 192.5.41.40.
```

http://mailman.nanog.org/pipermail/nanog/2012-November/053414.html
https://puck.nether.net/pipermail/outages/2012-November/thread.html
See threads “NTP Issues Today” and “Possible NTP attacks?”

Posts reported sites having to reboot all systems.

What the computer is saying



I'm sorry, Dave.
I'm afraid I can't do that.

I think you know what the problem is just as well as I do.

Skip Newhall
Leap Second Party

Masterclock TCD 26
(IRIG-B from Spectracom)

Spectracom Netclock/2 Model 8128
(WWVB)

Symmetricom XLi (GPS)

ESE Display 270U/9
(IRIG-B from XLi)

ESE Model/85 (GPS)

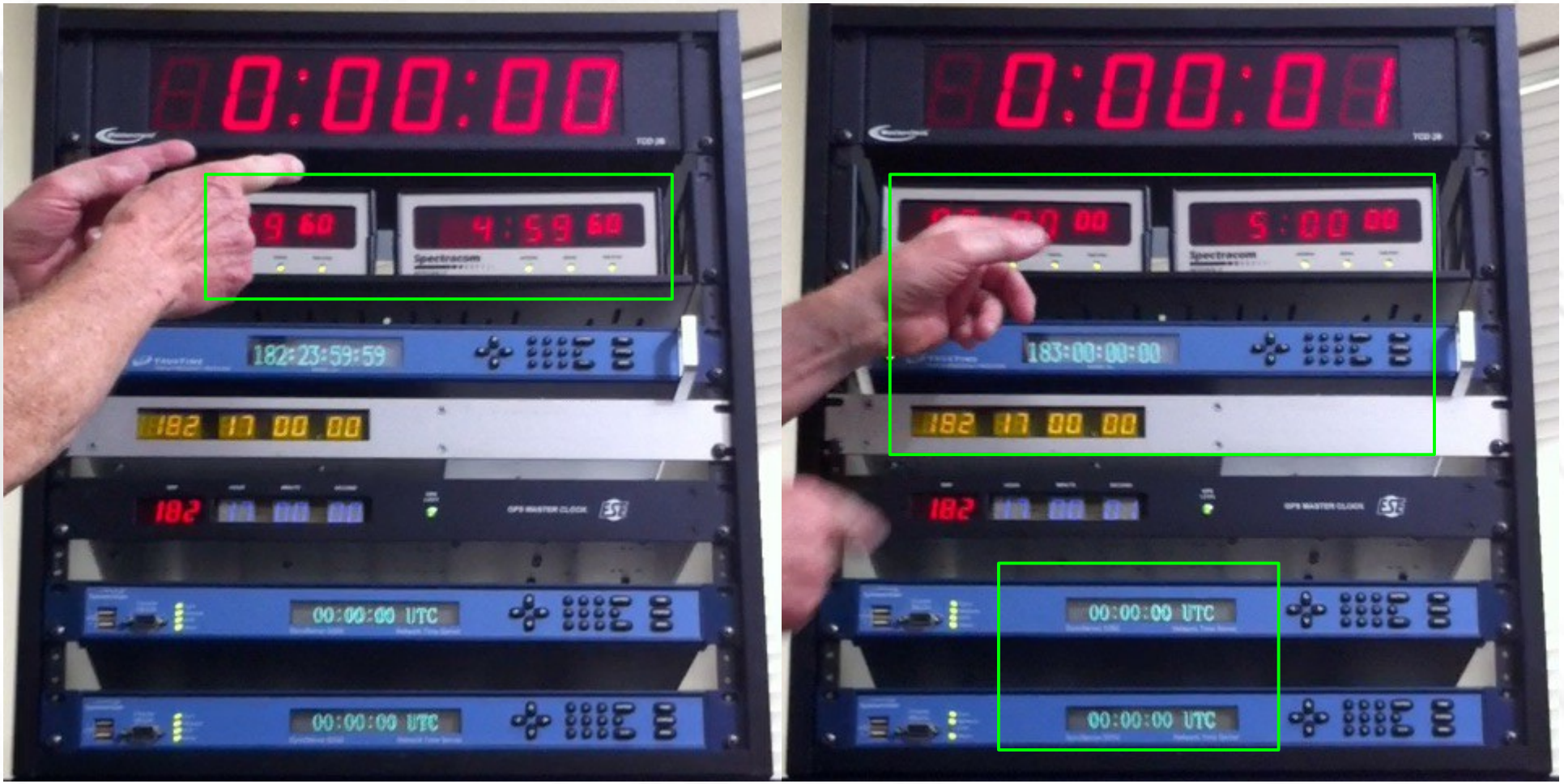
Symmetricom Syncserver S350 (GPS)

Symmetricom Syncserver S250 (GPS)

Leap Second Party

23:59:60

00:00:00



Leap Second Party

00:00:01

00:00:02

2013, DevOps Reactions

Say it with pictures. Describe your feelings about your everyday sysadmin interactions.
http://devopsreactions.tumblr.com/post/38053375865/

“When I realized the leap second problem”