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2015 - The Year of the Leap Second

February 2015
Version 2

There is a reason that there will be no space launches on June 30 or July 1, 2015. Scientists do not want to risk a computer malfunction due to a leap second being added at midnight.



What is a Leap Second?

Our day is one rotation of the Earth about its axis. We call this a *solar day*. We break the day up into 24 hours, with 60 minutes per hour and 60 seconds per minute. Therefore, there are 86,400 seconds in a day (24 x 60 x 60). Each second is timed very accurately with an atomic clock, which counts 9,192,631,770 periods of radiation emitted by a cesium-133 atom to time one second. This timing is used to determine Coordinated Universal Time (UTC).

However, the rate of the Earth's rotation is slowing down. The solar day is getting longer. To account for this, one second is added on occasion to the UTC time to synchronize it with the solar day. This is the leap second.

At the current rate of deceleration, the Earth's rotation is slowing down about 2 milliseconds per day or about one minute every 60 to 90 years. In the past 40 years or so, 25 leap seconds have been added to our clocks to keep them synchronized with the solar day.

The major cause of the Earth's deceleration is believed to be the result of tidal action. However, the rotation also is guided by a fundamental law of physics – the conservation of angular momentum. Just like a spinning skater who brings her arms in to spin faster, the Earth will rotate faster if its mass becomes more concentrated toward its center. Likewise, it will spin slower if its mass becomes more distributed away from its center. Earthquakes tend to push tectonic plates upwards or downwards, thus slowing or speeding the rotation. However, melting ice caps move water off the ice caps into the oceans and lead to a more rapid rotation.

Leap seconds were introduced in 1972. However, leap seconds do not occur with regular frequency. They cannot be predicted because of irregularities in the Earth's rotation. Nine leap seconds were added in the eight years from 1972 to 1979. No leap seconds were added in the seven years from 1999 to 2005. The last leap second was added on June 30, 2012. The next leap second will be added on June 30, 2015.

Leap seconds are generally announced six months in advance to give everyone time to prepare. They always occur at midnight UTC time (Greenwich Mean Time) on the last day of a month. Since 1972, these months have always been June or December. Also since 1972, there have been no negative leap seconds. The Earth's rotation seems to be slowing down continuously.

The Form of the Time Change

Not all systems handle the time change in the same way. For a positive leap second, some clocks will add an additional second and will count as follows:

23:59:59 23:59:60 00:00:00

Others will repeat the last second (Unix does this):

23:59:59 23:59:59 00:00:00

Still others will freeze the last second (NTP, the Network Time Protocol, does this):

23:59:59 00:00:00

If a negative leap second is required, the last second is deleted:

23:59:58 00:00:00

The Last Leap Second Caused Major IT Problems

From 1999 to 2005, there were no leap seconds. Cloud services and multiprocessors came into existence during this time. Many facilities were implemented by software programmers who didn't even know that leap seconds existed. The programmers were incapable of allowing for the fact that the addition of a leap second makes the time appear to go backward.

The leap second is problematic in many cases in computing:

- The exact time between two UTC past dates cannot be accurately computed without taking into account leap seconds.
- The exact time between two UTC dates more than six months in the future cannot be accurately computed because it is unknown how many leap seconds, either positive or negative, will be inserted during this time period.
- Compute actions driven by a timer may get confused if they are triggered twice in two seconds, or they may not be triggered at all if a negative leap second occurs.

The 2012 leap second caused a myriad of problems, mainly with systems locking up and needing rebooting. Most sites running Linux had problems, as did those running Solaris. Web sites suffering Linux problems included LinkedIn, Reddit, Mozilla, Yelp, Gawker, and StumbleDown.

Java also had its problems. Reddit suffered an outage with its database, Apache Cassandra. Mozilla had a problem with Hadoop, as did Gawker with its Tomcat server. Cassandra, Hadoop, and Tomcat are all built with Java.

Older Motorola GPS receivers had a software bug that caused the receiver to revert to the previous day if a leap second had not occurred in 256 weeks. This bug hit on November 28, 2003. November 28th was repeated.

NTP includes a leap-second flag in its packets. The flag informs servers that a leap second is imminent. However, researchers have reported that not all of the NTP servers correctly set their flags, causing them to provide the wrong time for up to a day after the leap second was added. Security firms have suggested that hackers were able to exploit this vulnerability.

The Status of Linux

The 2012 Bug

Perhaps the issue of most concern is whether Linux is now prepared for this year's leap second. Linus Torvalds, the creator of Linux, commiserates that:

“Almost every time we have a leap second, we find something. It's really annoying, because it's a classic case of code that is basically never run and thus not tested by users under their normal conditions.”

The 2012 problem was traced to a bug in the Linux subsystem, hrtimer. Hrtimer is used when the system is “sleeping,” waiting for the operating system (OS) to complete some other task. In some cases, hrtimer sets an alarm for the sleeping applications. The alarm will go off if the OS is taking too much time with its other work. When the leap second hit, the hrtimers were suddenly a second ahead of the OS. They started generating alarms, waking up countless sleeping applications at once and overloading the machines' CPUs.

The State of Readiness for Red Hat Enterprise Linux

Red Hat has posted information on its Customer Portal concerning the readiness of its Red Hat Enterprise Linux (RHEL) operating system (<https://access.redhat.com/articles/15145>). It states in a January 10, 2015, blog posting that “Red Hat is aware of the upcoming June 30, 2015 leap second and is working to address it.”

Red Hat offers the following suggestions. If a system is running NTP on any platform but an IA-64 architecture, RHEL should be upgraded to Version 7. Version 6 may work, but there is a chance that the leap second could lead to high CPU usage.

If a system is not running NTP or is running on an IA-64 architecture, the Linux operating system will not correct for the leap second. The system clock should be reset after the leap second occurs.

Workarounds

It appears that Linux and Java have been patched to correct for the upcoming leap second. However, systems should be carefully monitored as midnight of June 30th approaches, just in case.

In 2011, Google came up with a unique way to handle leap seconds, a method that could be adopted by others. On the day on which the leap second is to be added, Google periodically adds one millisecond to its clocks. This means that it adds one millisecond every 86 seconds or so, there being 86,400 seconds in the day. Thus, when leap-second time arrives, Google's clocks are already in synchronism. This strategy worked fine for Google for the 2012 leap second. Google dubs this method *leap smear*.

Summary

The leap second is such an erratic and infrequent occurrence that it is likely that many systems have not been built to account for it. Those that have may not have been thoroughly tested for the condition. This is the rationale for everyone to monitor their systems carefully as the leap second approaches at midnight on June 30th.

With the Earth slowing down, do we have to worry about its rotation stopping? Probably not. At its current deceleration, it will take about 2.6 billion years to stop, if it stops at all.

Acknowledgements

Our thanks to the International Occultation Timing Association members for comments on this article.

Material for this article was taken from the following sources:

[Leap Second Bug Wreaks Havoc Across Web](#), *Wired*; 2012.

[The Inside Story of the Extra Second That Crashed the Web](#), *Wired*; 2012.

[Computer chaos feared over 2015's leap second](#), *USA Today*; January 9, 2015.

[No, the Linux leap second bug WON'T crash the web](#), *The Register*; January 9, 2015.

[Leap Seconds in Red Hat Enterprise Linux](#), *Red Hat Customer Portal*; January 14, 2015.

[Leap Second](#), *Wikipedia*.