12Ghosts Synchronize

Synchronize Time over the Internet

Synchronize your PC time over the Internet with an atomic clock.

Command Line Parameters

12-Synchronize also supports the following command line options:

/once	Synchronize once and then stop. Otherwise 12-Sync will stay in memory, showing a tray icon, and sync in the selected intervall.
/s	Like all 12Ghosts, start silently and move into the taskbar tray.

Time and Frequency Dissemination

In order that atomic and civil time can be coordinated throughout the world, national administrations operate primary time and frequency standards and coordinate them cooperatively by observing various radio broadcasts and through occasional use of portable atomic clocks. Most seafaring nations of the world operate some sort of broadcast time service for the purpose of calibrating chronographs, which are used in conjunction with ephemeris data to determine navigational position. In many countries the service is primitive and limited to seconds-pips broadcast by marine communication stations at certain hours. For instance, a chronograph error of one second represents a longitudinal position error of about 0.23 nautical mile at the Equator.

The U.S. National Institute of Standards and Technology (NIST - formerly National Bureau of Standards) operates three radio services for the dissemination of primary time and frequency information. One of these uses high-frequency (HF or CCIR band 7) transmissions on frequencies of 2.5, 5, 10, 15 and 20 MHz from Fort Collins, CO (WWV), and Kauai, HI (WWVH). Signal propagation is usually by reflection from the upper ionospheric layers, which vary in height and composition throughout the day and season and result in unpredictable delay variations at the receiver. The timecode is transmitted over a 60-second interval at a data rate of 1 bps using a 100-Hz subcarrier on the broadcast signal. The timecode information includes UTC time-day information, but does not currently include year or leap-second warning. While these transmissions and those of Canada from Ottawa, Ontario (CHU), and other countries can be received over large areas in the western hemisphere, reliable frequency comparisons can be made only to the order of 10-7 and time accuracies are limited to the order of a millisecond.

A second service operated by NIST uses low-frequency (LF or CCIR band 5) transmissions on 60 kHz from Boulder, CO (WWVB), and can be received over the continental U.S. and adjacent coastal areas. Signal propagation is via the lower ionospheric layers, which are relatively stable and have predictable diurnal variations in height. The timecode is transmitted over a 60-second interval at a rate of 1 pps using periodic reductions in carrier power. With appropriate receiving and averaging techniques and corrections for diurnal and seasonal propagation effects, frequency comparisons to within 10-11 are possible and time accuracies of from a few to 50 microseconds can be obtained. Some countries in western Europe operate similar services which use transmissions on 60 kHz from Rugby, U.K. (MSF), and on 77.5 kHz from Mainflingen, West Germany (DCF77). The timecode information includes UTC time-day-year information and leap-second warning.

The third service operated by NIST uses ultra-high frequency (UHF or CCIR band 9) transmissions on about 468 MHz from the Geosynchronous Orbit Environmental Satellites (GOES), three of which cover the western hemisphere. The timecode is interleaved with messages used to interrogate remote sensors and consists of 60 4-bit binary-coded decimal words transmitted over an interval of 30 seconds. The timecode information includes UTC time-day-year information and leap-second warning.

The U.S. Department of Defense has developed the Global Positioning System (GPS) for worldwide precision navigation. This system provides 24-hour worldwide coverage using a constellation of 24 satellites in 12-hour orbits. For time-transfer applications GPS has a potential accuracy in the order of a few nanoseconds; however, various considerations of defense policy may limit accuracy to hundreds of nanoseconds. The timecode information includes GPS time and UTC correction.

Calendar Systems

The calendar systems used in the ancient world reflect the agricultural, political and ritual needs characteristic of the societies in which they flourished. Astronomical observations to establish the winter and summer solstices were in use three to four millennia ago. By the 14th century BC the Shang Chinese had established the solar year as 365.25 days and the lunar month as 29.5 days. The lunisolar calendar, in which the ritual month is based on the Moon and the agricultural year on the Sun, was used throughout the ancient Near East (except Egypt) and Greece from the third millennium BC. Early calendars used either thirteen lunar months of 28 days or twelve alternating lunar months of 29 and 30 days and haphazard means to reconcile the 354/364-day lunar year with the 365-day vague solar year.

The ancient Egyptian lunisolar calendar had twelve 30-day lunar months, but was guided by the seasonal appearance of the star Sirius (Sothis). In order to reconcile this calendar with the solar year, a civil calendar was invented by adding five intercalary days for a total of 365 days. However, in time it was observed that the civil year was about one-fourth day shorter than the actual solar year and thus would precess relative to it over a 1460-year cycle called the Sothic cycle. Along with the Shang Chinese, the ancient Egyptians had thus established the solar year at 365.25 days, or within about 11 minutes of the present measured value. In 432 BC, about a century after the Chinese had done so, the Greek astronomer Meton calculated there were 110 lunar months of 29 days and 125 lunar months of 30 days for a total of 235 lunar months in 6940 solar days, or just over 19 years. The 19-year cycle, called the Metonic cycle, established the lunar month at 29.532 solar days, or within about two minutes of the present measured value.

The Roman republican calendar was based on a lunar year and by 50 BC was eight weeks out of step with the solar year. Julius Caesar invited the Alexandrian astronomer Sosigenes to redesign the calendar, which led to the adoption in 46 BC of the Julian calendar. This calendar is based on a year of 365 days with an intercalary day inserted every four years. However, for the first 36 years an intercalary day was mistakenly inserted every three years instead of every four. The result was 12 intercalary days instead of nine, and a series of corrections that was not complete until 8 AD.

The seven-day Sumerian week was introduced only in the fourth century AD by Emperor Constantine I. During the Roman era a 15-year census cycle, called the Indiction cycle, was instituted for taxation purposes. The sequence of day-names for consecutive occurrences of a particular day of the year does not recur for 28 years, called the solar cycle. Thus, the least common multiple of the 28-year solar cycle, 19-year Metonic cycle and 15-year Indiction cycle results in a grand 7980-year supercycle called the Julian Era, which began in 4713 BC. A particular combination of the day of the week, day of the year, phase of the Moon and round of the census will recur beginning in 3268 AD.

By 1545 the discrepancy in the Julian year relative to the solar year had accumulated to ten days. In 1582, following suggestions by the astronomers Christopher Clavius and Luigi Lilio, Pope Gregory XIII issued a papal bull which decreed, among other things, that the solar year would consist of 365.2422 days. In order to more closely approximate the new value, only those centennial years divisible by 400 would be leap years, while the remaining centennial years would not, making the actual value 365.2425, or within about 26 seconds of the current measured value. Since the beginning of the Common Era and prior to 1990 there were 474 intercalary days inserted in the Julian calendar, but 14 of these were removed in the Gregorian calendar. While the Gregorian calendar is in use throughout most of the world today, some countries did not adopt it until early in the twentieth century.

While it remains a fascinating field for time historians, the above narrative provides conclusive evidence that conjugating calendar dates of significant events and assigning NTP timestamps to them is approximate at best. In principle, reliable dating of such events requires only an accurate count of the days relative to some globally alarming event, such as a comet passage or supernova explosion; however, only historically persistent and politically stable societies, such as the ancient Chinese and Egyptian, and especially the classic Maya, possessed the means and will to do so.

The Modified Julian Day System

In order to measure the span of the universe or the decay of the proton, it is necessary to have a standard day-numbering plan. Accordingly, the International Astronomical Union has adopted the use of the standard second and Julian Day Number (JDN) to date cosmological events and related phenomena. The standard day consists of 86,400 standard seconds, where time is expressed as a fraction of the whole day, and the standard year consists of 365.25 standard days.

In the scheme devised in 1583 by the French scholar Joseph Julius Scaliger and named after his father, Julius Caesar Scaliger, JDN 0.0 corresponds to 12h (noon) on the first day of the Julian Era, 1 January 4713 BC. The years prior to the Common Era (BC) are reckoned according to the Julian calendar, while the years of the Common Era (AD) are reckoned according to the Gregorian calendar. Since 1 January 1 AD in the Gregorian calendar corresponds to 3 January 1 in the Julian calendar, JDN 1,721,426.0 corresponds to 12h on the first day of the Common Era, 1 January 1 AD. The Modified Julian Date (MJD), which is sometimes used to represent dates near our own era in conventional time and with fewer digits, is defined as MJD = JD <196> 2,400,000.5. Following the convention that our century began at 0h on 1 January 1900, at which time the tropical year was already 12h old, that eclectic instant corresponds to MJD 15,020.0. Thus, the Julian timescale ticks in standard (atomic) 365.25-day centuries and was set to a given value at the approximate epoch of a cosmic event which apparently synchronized the entire human community, the origin of the Common Era.

Determination of Frequency

For many years the most important use of time and frequency information was for worldwide navigation and space science, which depend on astronomical observations of the Sun, Moon and stars. Sidereal time is based on the transit of stars across the celestial meridian of an observer. The mean sidereal day is 23 hours, 56 minutes and 4.09 seconds, but varies about 30 ms throughout the year due to polar wandering and orbit variations. Ephemeris time is based on tables with which a standard time interval such as the tropical year - one complete revolution of the Earth around the Sun - can be determined through observations of the Sun, Moon and planets. In 1958 the standard second was defined as 1/31,556,925.9747 of the tropical year that began this century. On this scale the tropical year is 365.2421987 days and the lunar month - one complete revolution of the Moon around the Earth - is 29.53059 days; however, the actual tropical year can be determined only to an accuracy of about 50 ms and has been increasing by about 5.3 ms per year.

Of the three heavenly oscillators readily apparent to ancient mariners and astronomers - the Earth rotation about its axis, the Earth revolution around the Sun and the Moon revolution around the Earth - none of the three have the intrinsic stability, relative to modern technology, to serve as a standard reference oscillator. In 1967 the standard second was redefined as 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. Since 1972 the time and frequency standards of the world have been based on International Atomic Time (TAI), which is defined and maintained using multiple cesium-beam oscillators to an accuracy of a few parts in 1013, or better than a microsecond per day. Note that, while this provides an extraordinarily precise timescale, it does not necessarily agree with conventional solar time and may not in fact even be absolutely uniform, unless subtle atomic conspiracies can be ruled out.

Determination of Time and Leap Seconds

The International Bureau of Weights and Measures (IBWM) uses astronomical observations provided by the U.S. Naval Observatory and other observatories to determine UTC. Starting from apparent mean solar time as observed, the UT0 timescale is determined using corrections for Earth orbit and inclination (the Equation of Time, as used by sundials), the UT1 (navigator's) timescale by adding corrections for polar migration and the UT2 timescale by adding corrections for known periodicity variations. While standard frequencies are based on TAI, conventional civil time is based on UT1, which is presently slowing relative to TAI by a fraction of a second per year. When the magnitude of correction approaches 0.7 second, a leap second is inserted or deleted in the TAI timescale on the last day of June or December.

For the most precise coordination and timestamping of events since 1972, it is necessary to know when leap seconds are implemented in UTC and how the seconds are numbered. As specified in CCIR Report 517, which is reproduced in, a leap second is inserted following second 23:59:59 on the last day of June or December and becomes second 23:59:60 of that day. A leap second would be deleted by omitting second 23:59:59 on one of these days, although this has never happened. Published IBWM corrections consist not only of leap seconds, which result in step discontinuities relative to TAI, but 100-ms UT1 adjustments called DUT1, which provide increased accuracy for navigation and space science.

Note that the NTP time column actually shows the epoch following the last second of the day given in the UTC date and MJD columns (except for the first line), which is the precise epoch of insertion. The offset column shows the cumulative seconds offset between the uncoordinated (Julian) timescale and the UTC timescale; that is, the number of seconds to add to the Julian clock in order to maintain nominal agreement with the UTC clock. Finally, note that the epoch of insertion is relative to the timescale immediately prior to that epoch; e.g., the epoch of the 31 December 90 insertion is determined on the timescale in effect following the 31 December 1990 insertion, which means the actual insertion relative to the Julian clock is fourteen seconds later than the apparent time on the UTC timescale.

The UTC timescale thus ticks in standard (atomic) seconds and was set to the value 0h MJD 41,317.0 at the epoch determined by astronomical observation to be 0h on 1 January 1972 according to the Gregorian calendar; that is, the inaugural tick of the UTC Era. In fact, the inaugural tick which synchronized the cosmic oscillators, Julian clock, UTC clock and Gregorian calendar forevermore was displaced about ten seconds from the civil clock then in use, while the GPS clock is ahead of the UTC clock by six seconds in late 1990. Subsequently, the UTC clock has marched backward relative to the Julian timescale exactly one second on scheduled occasions at monumental epoches embedded in the institutional memory of our civilization. Note in passing that leap- second adjustments affect the number of seconds per day and thus the number of seconds per year. Apparently, should we choose to worry about it, the UTC clock, Julian clock and various cosmic clocks will inexorably drift apart with time until rationalized by some future papal bull.

The NTP Timescale and Reckoning with UTC

The NTP timescale is based on the UTC timescale, but not necessarily always coincident with it. At 0h on 1 January 1972 (MJD 41,317.0), the first tick of the UTC Era, the NTP clock was set to 2,272,060,800, representing the number of standard seconds since 0h on 1 January 1900 (MJD 15,020.0). The insertion of leap seconds in UTC and subsequently into NTP does not affect the UTC or NTP oscillator, only the conversion to conventional civil UTC time. However, since the only institutional memory available to NTP are the UTC timecode broadcast services, the NTP timescale is in effect reset to UTC as each timecode is received. Thus, when a leap second is inserted in UTC and subsequently in NTP, knowledge of all previous leap seconds is lost.

Another way to describe this is to say there are as many NTP timescales as historic leap seconds. In effect, a new timescale is established after each new leap second. Thus, all previous leap seconds, not to mention the apparent origin of the timescale itself, lurch backward one second as each new timescale is established. If a clock synchronized to NTP in 1990 was used to establish the UTC epoch of an event that occurred in early 1972 without correction, the event would appear fifteen seconds late relative to UTC. However, NTP primary time servers resolve the epoch using the broadcast timecode, so that the NTP clock is set to the broadcast value on the current timescale. As a result, for the most precise determination of epoch relative to the historic UTC clock, the user must subtract from the apparent NTP epoch a certain offset. This is a feature of almost all present day time-distribution mechanisms.

It is possible that individual systems may use internal data formats other than the NTP timestamp format, which is represented in seconds to a precision of about 200 picoseconds; however, a persuasive argument exists to use a two-part representation, one part for whole days (MJD or some fixed offset from it) and the other for the seconds (or some scaled value, such as milliseconds). This not only facilitates conversion between NTP and conventional civil time, but makes the insertion of leap seconds much easier. All that is required is to change the modulus of the seconds counter, which on overflow increments the day counter. This design insures that continuity of the timescale is assured, even if outside synchronization is lost before, during or after leap-second insertion. Since timestamp data are unaffected, synchronization is assured, even if timestamp data are in flight at the instant and originated before or at that instant. (RFC 1305)