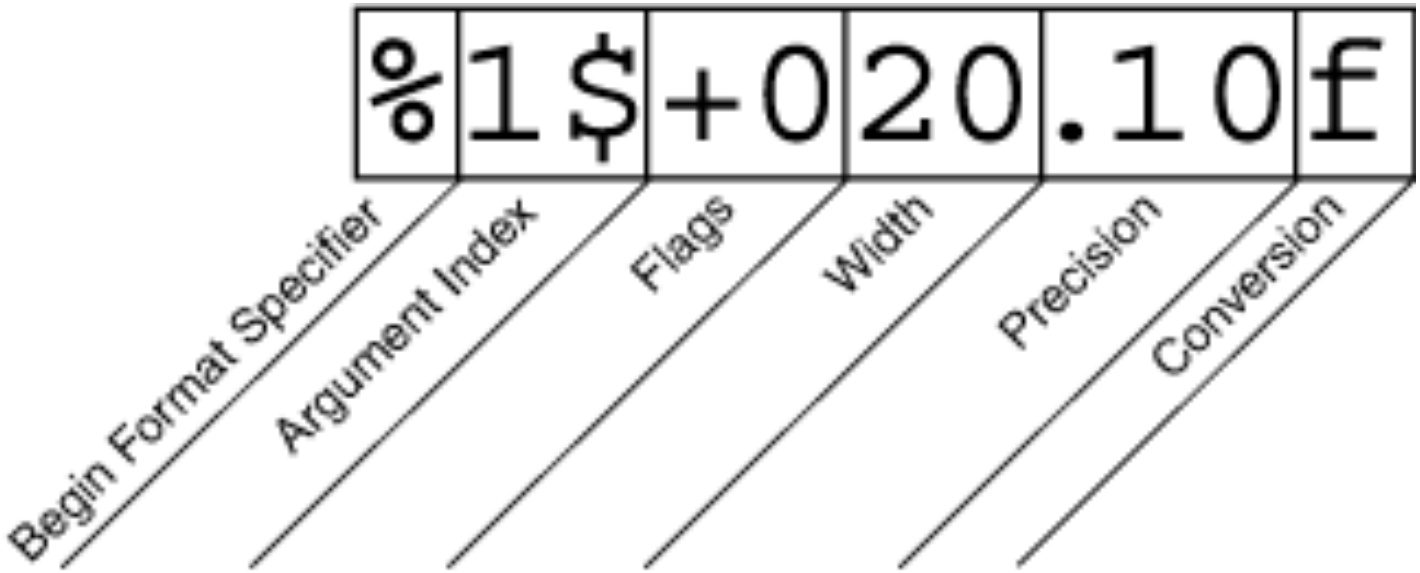
Example

```
import java.util.*;

public class Launcher {

    public static void main(String[] args) {

        // Example 1: Write formatted data to System.out.
        // Local time: 18:23:20

        System.out.format("Local time: %tT %n", Calendar.getInstance());

        // Example 2: Write formatted data to System.err.
        // Unable to open file 'test.txt': Fehler!

        String f = "test.txt";
        Exception e = new Exception("Fehler!");
        System.err.printf("Unable to open file '%2$s': %1$s %n", e.getMessage(), f);

        // Example 3: Format string containing a date.
        // Duke's Birthday: 05 23,1995

        Calendar c = new GregorianCalendar(1995, Calendar.MAY, 23);
        String s = String.format("Duke's Birthday: %1$tm %1$te,%1$tY %n", c);
        System.out.println(s);
    }
}
```

Format String




```
System.out.printf("Hello, %s %n", "World!");

double d = 12345;
System.out.format("Aktueller Wert: %.3f %n", d);
// precision 3; conversion f = float; n = newline
```

Date Format

https://de.wikipedia.org/wiki/Datumsformat

Vollständige Darstellung		
20030107	YYYYMMDD	Basisformat
2003-01-07	YYYY-MM-DD	Erweitertes Format (Mittelstrich als Trennzeichen)
Geringere Genauigkeit		
Ein bestimmter Monat		
2003-01	YYYY-MM	Basisformat (Mittelstrich als Trennzeichen)
Ein bestimmtes Jahr		
2003	YYYY	Basisformat

Time Format

```
Y: Year (may be negative or zero)
   YYYY (may be extended)
M: Month
   MM: 01…12
w: Week
   ww: week of year 01…53
D: Day
   D: day of week 1…7 (0≙7), Monday = 1 to Sunday = 7
   DD: day of month 01…31
   DDD: day of year 001…366
h: hour
   hh: 00…23 (00≙24; 24 in 24:00:00 as ending time)
m: minute
   mm: 00…59 (00≙60)
s: second
   ss: 00…59 (00≙60; 60 as leap second)
f = decimal fraction, usually of a second
```

Format	Beispiel
JJJJ-MM-TT	2004-07-11
JJJJMMTT	20040711
JJJJ-MM	2004-07
JJJJ	2004
JJJJ-Www	2004-W28
JJJJWww	2004W28
JJJJ-Www-T	2004-W28-7
JJJJWwwT	2004W287
JJJJ-TTT	2004-193
JJJJTTT	2004193

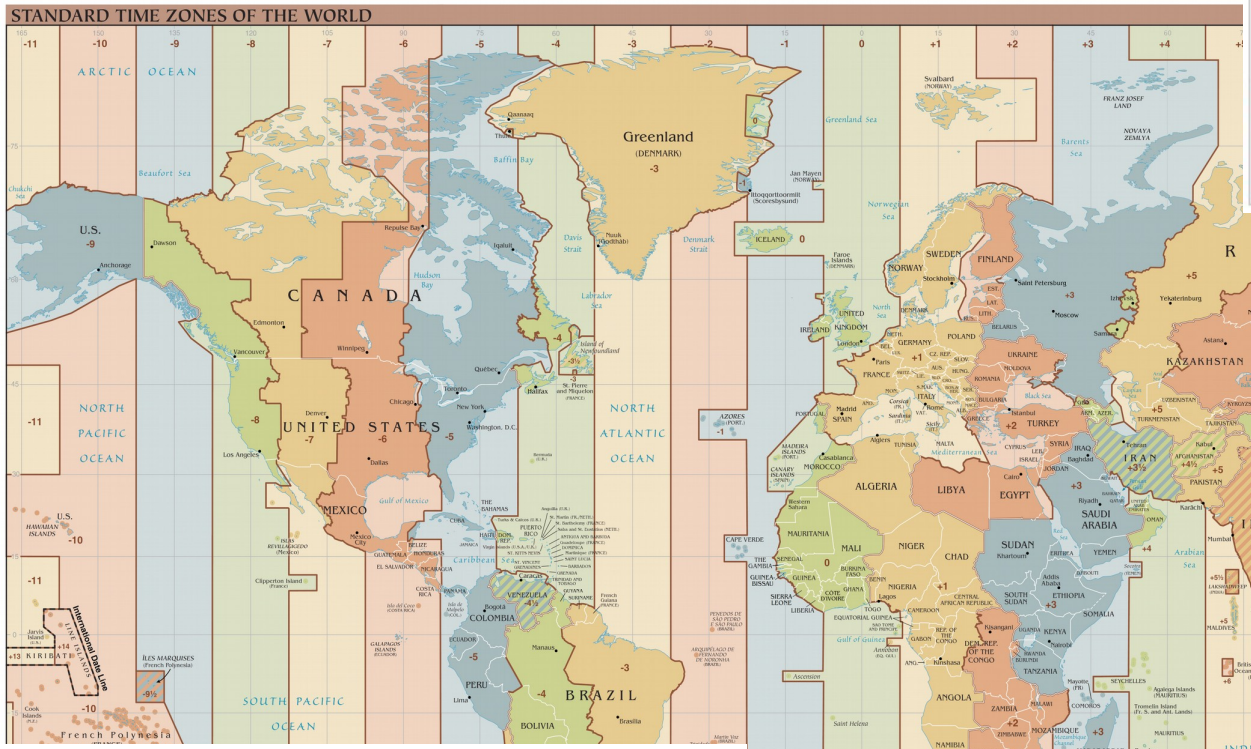
Format	Beispiel
hh:mm:ss	16:43:16
hhmmss	164316
hh:mm	16:43
hhmm	1643
hh	16
hh:mm:ss,f	16:43:16,2345

https://de.wikipedia.org/wiki/ISO_8601

Duration (old: Period)

```
2005-08-09T18:31:42P3Y6M4DT12H30M17S
3 Jahre, 6 Monate, 4 Tage, 12 Stunden, 30 Minuten, 17 Sekunden ab dem 9. August 2005
kurz nach halb sieben abends

P3Y6M4DT12H30M17S
die gleiche Zeitspanne wie oben, allerdings ohne ein bestimmtes Startdatum

P1D
bis morgen zur jetzigen Uhrzeit

PT24H
bis in 24 Stunden ab jetzt
weicht im Falle einer Zeitumstellung vom vorherigen Beispiel ab

2005-08-09P14W
die 14 Wochen beginnend ab dem 9. August 2005

2005-08-09/2005-08-30
vom 9. zum 30. August 2005

2005-08-09—2005-08-30
vom 9. zum 30. August 2005

2005-08-09/30
vom 9. bis 30. August 2005
```

Time Zone



Date and time (current at page generation) expressed according to ISO 8601:

Date:	**2015-05-06**
Combined date and time in UTC:	**2015-05-06T15:43:54+00:00** **2015-05-06T15:43:54Z**
Week:	**2015-W19**
Date with week number:	**2015-W19-3**
Ordinal date:	**2015-126**

https://en.wikipedia.org/wiki/ISO_8601
https://de.wikipedia.org/wiki/Zeitzone

Calendar Systems

https://de.wikipedia.org/wiki/Gregorianischer_Kalender
https://www.fourmilab.ch/documents/calendar/

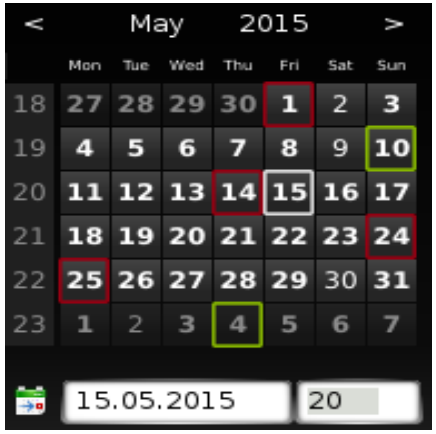
Religious Holidays

- Christian: liturgical year with Easter and Christmas
- Orthodox Christian: patronal feast day or name day
- Islam: Eid ul-Fitr and Eid al-Adha
- Hindus (Jains and Sikhs): Diwali (Festival of Light)
- Japanese: different faiths and beliefs
- Celtic, Norse, Neopagan: Wheel of the Year
- Bahá'í Faith: Bahá'í calendar
- Jews: Spring Feasts and Fall Feasts

Calculation of Easter, Day of Week, Calendar Week

Sonntag	Montag	Dienstag	Mittwoch	Donnerstag	Freitag	Samstag
☉	☽	♂	☿	♃	♀	♄
Sonne	Mond	Mars	Merkur	Jupiter	Venus	Saturn

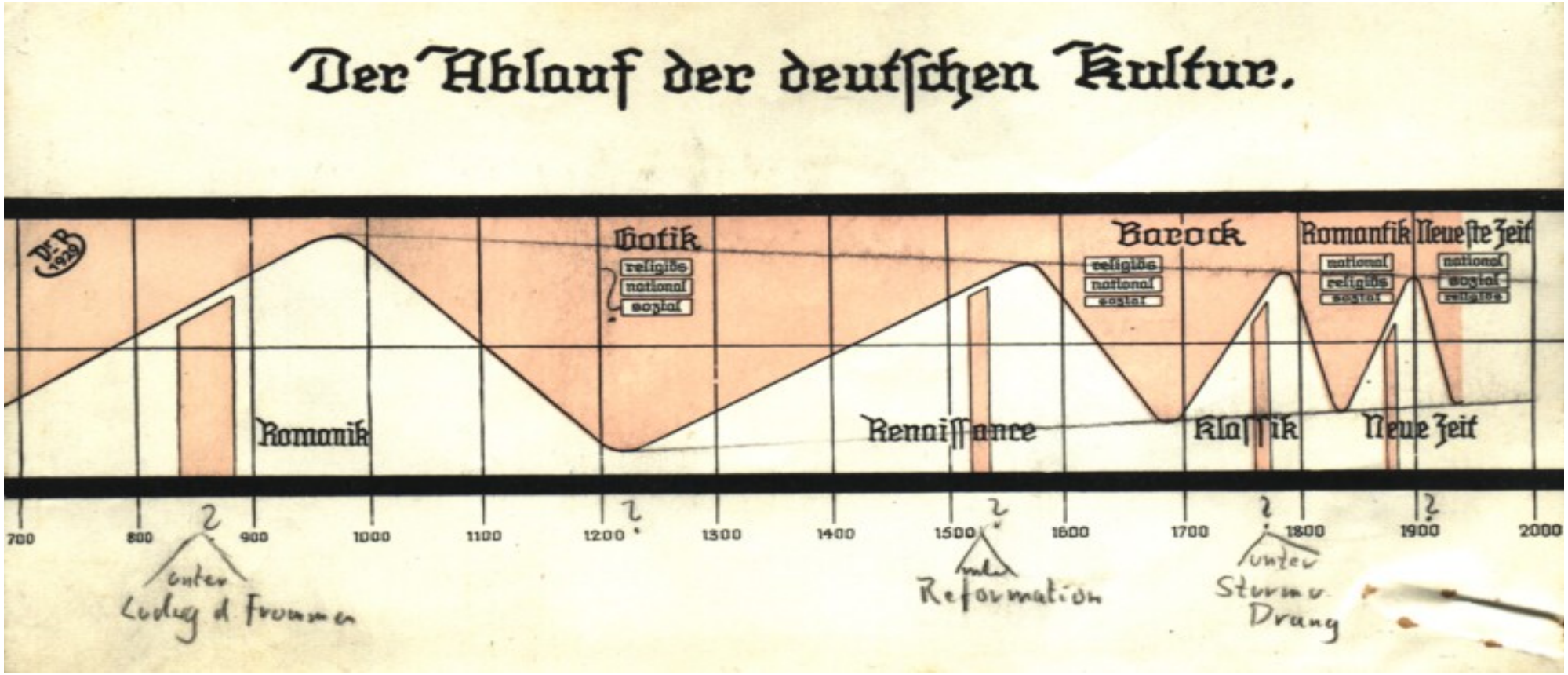
https://de.wikipedia.org/wiki/Wochentag
https://de.wikipedia.org/wiki/Gau%C3%9Fsche_Wochentagsformel



https://de.wikipedia.org/wiki/Woche#Kalenderwoche

https://de.wikipedia.org/wiki/Computus_%28Osterrechnung%29
https://de.wikipedia.org/wiki/Gau%C3%9Fsche_Osterformel

Calendar Epoch and Era



https://de.wikipedia.org/wiki/Epoche_%28Literatur%29
Dr. E. Brenner, Deutsche Literaturgeschichte, 13. Auflage, 122–131. Tsd. Mit einer farbigen Beilage (Wunsiedel/Wels/Zürich, 1952)

Julian Date (JD)

Name	Epoch	Calculation	Current value	Notes
Julian Date	12h Jan 1, 4713 BC		**2457160.81042**	
Reduced JD	12h Nov 16, 1858	JD − 2400000	**57160.81042**	[6][7]
Modified JD	0h Nov 17, 1858	JD − 2400000.5	**57160.31042**	Introduced by SAO in 1957
Truncated JD	0h May 24, 1968	floor (JD − 2440000.5)	**17160**	Introduced by NASA in 1979
Dublin JD	12h Dec 31, 1899	JD − 2415020	**42140.81042**	Introduced by the IAU in 1955
Lilian date	Oct 15, 1582[8]	floor (JD − 2299159.5)	**158001**	Count of days of the Gregorian calendar
Rata Die	Jan 1, 1[8] proleptic Gregorian calendar	floor (JD − 1721424.5)	**735736**	Count of days of the Common Era
Unix Time	0h Jan 1, 1970	(JD − 2440587.5) × 86400	**1431934028**	Count of seconds[9]
Mars Sol Date	12h Dec 29, 1873	(JD − 2405522)/1.02749	**50257.17778**	Count of Martian days

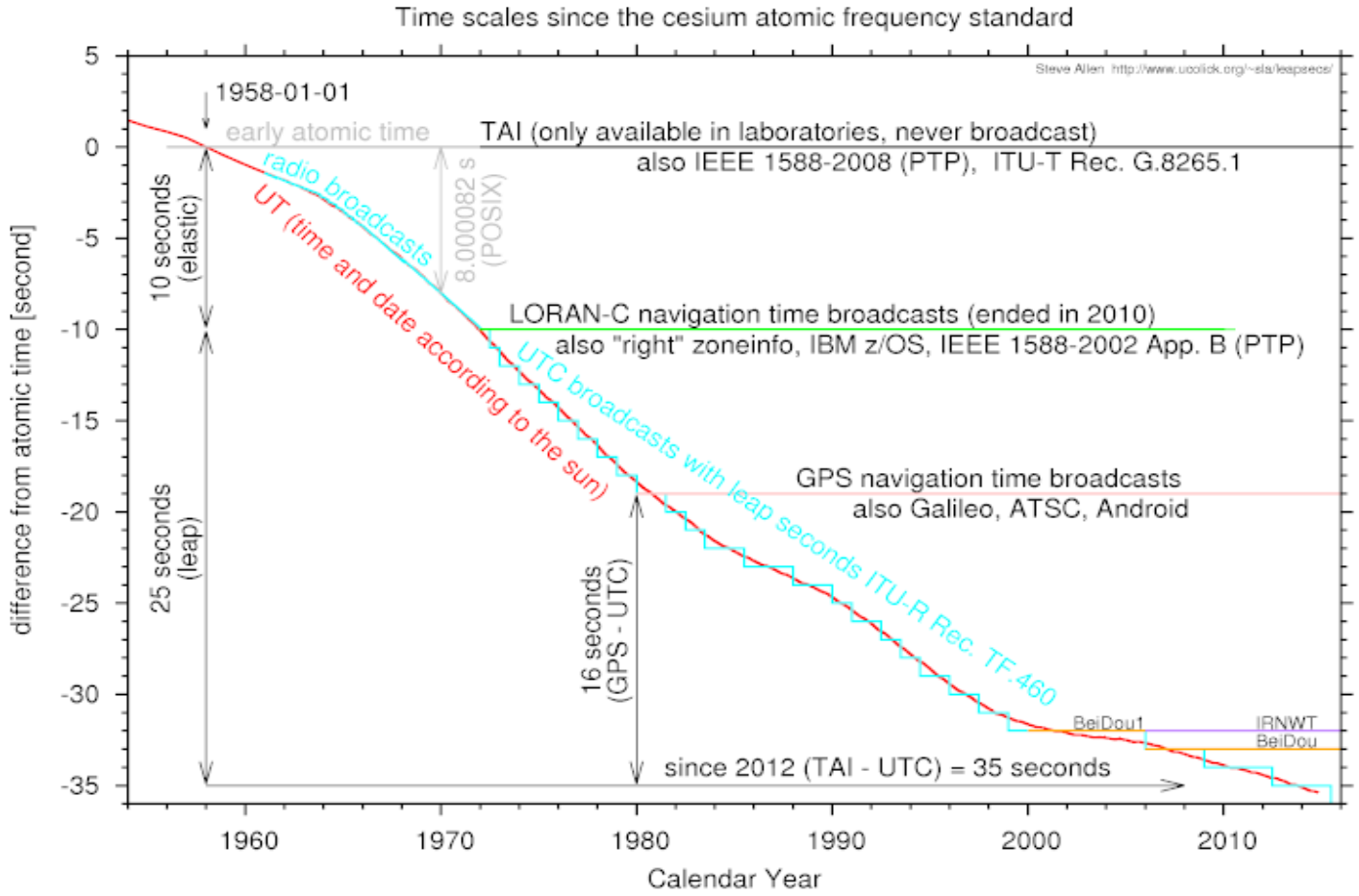
Artikelserie von Heinz Zemanek in "Elektronische Rechenanlagen" 6/78, 4/79 und 6/79
Jean Meeus: Astronomische Algorithmen, Barth, 1992, ISBN 3-335-00318-7
http://www.netzmafia.de/skripten/programmieren/ad11.html#8.2
https://de.wikipedia.org/wiki/Julianisches_Datum
https://en.wikipedia.org/wiki/Julian_day

Time Scale based on Time Unit

<table>
<tr><td colspan="3">Zeit / Uhrzeit
(Sekunde)</td></tr>
<tr><td rowspan="2">Atomzeitskala
(SI-Sekunde)</td><td colspan="2">Astronomische Zeitskala</td></tr>
<tr><td>Sonnenzeit
(Sonnensekunde)</td><td>Umlaufzeit
(Ephemeridensekunde)</td></tr>
<tr><td>Atomzeit (TA)</td><td>Mittlere Sonnenzeit (Ortszeit)</td><td rowspan="3"></td></tr>
<tr><td>Internationale Atomzeit (TAI)</td><td>Universelle Sonnenzeit (UT1)</td></tr>
<tr><td colspan="2">Weltzeit (UT)
Koordinierte Weltzeit (UTC)</td></tr>
</table>

https://de.wikipedia.org/wiki/Atomzeit
Dieter Egger. Astronomie und Java. Objekte der Astronomie. TU München, 2001
http://www.astro-toolbox.com/

Leap Second




```
+1972-06-30
+1972-12-31
+1973-12-31
+1974-12-31
+1975-12-31
+1976-12-31
+1977-12-31
+1978-12-31
+1979-12-31
+1981-06-30
+1982-06-30
+1983-06-30
+1985-06-30
+1987-12-31
+1989-12-31
+1990-12-31
+1992-06-30
+1993-06-30
+1994-06-30
+1995-12-31
+1997-06-30
+1998-12-31
+2005-12-31
+2008-12-31
+2012-06-30
```

Steve Allen. UCO/Lick Observatory. University of California. Santa Cruz, 2015
http://www.ucolick.org/~sla/leapsecs/timescales.html
http://cr.yp.to/libtai/leapsecs.txt

Platform Issues

- Backward counting in proleptic calendar unreliable
- Leap years regularly only since 4 CE
- Definition prior to telescope/GMT/UTC
- Precision ns nonsense since SI second did not exist
- Year 1900 mistakenly taken as leap year
- Start of counting on January 1st with 1 instead of 0
- Inconsistency due to mix of atomic and solar second

```
http://www.ucolick.org/~sla/leapsecs/timescales.html
http://www.ucolick.org/~sla/leapsecs/epochtime.html
https://de.wikipedia.org/wiki/Julianisches_Datum#Weitere_julianische_Daten
http://www.joda.org/joda-time/apidocs/org/joda/time/DateTime.html
```

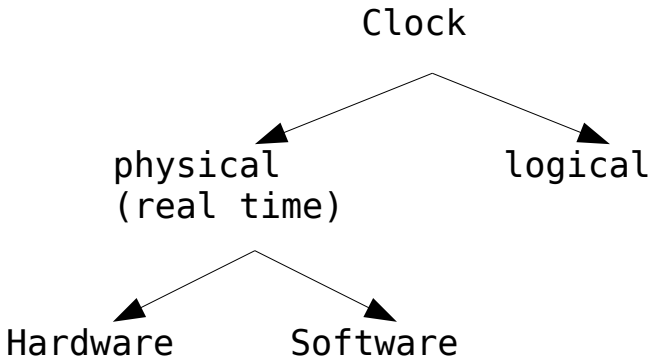
POSIX/UNIX/NTP Time Inconsistency

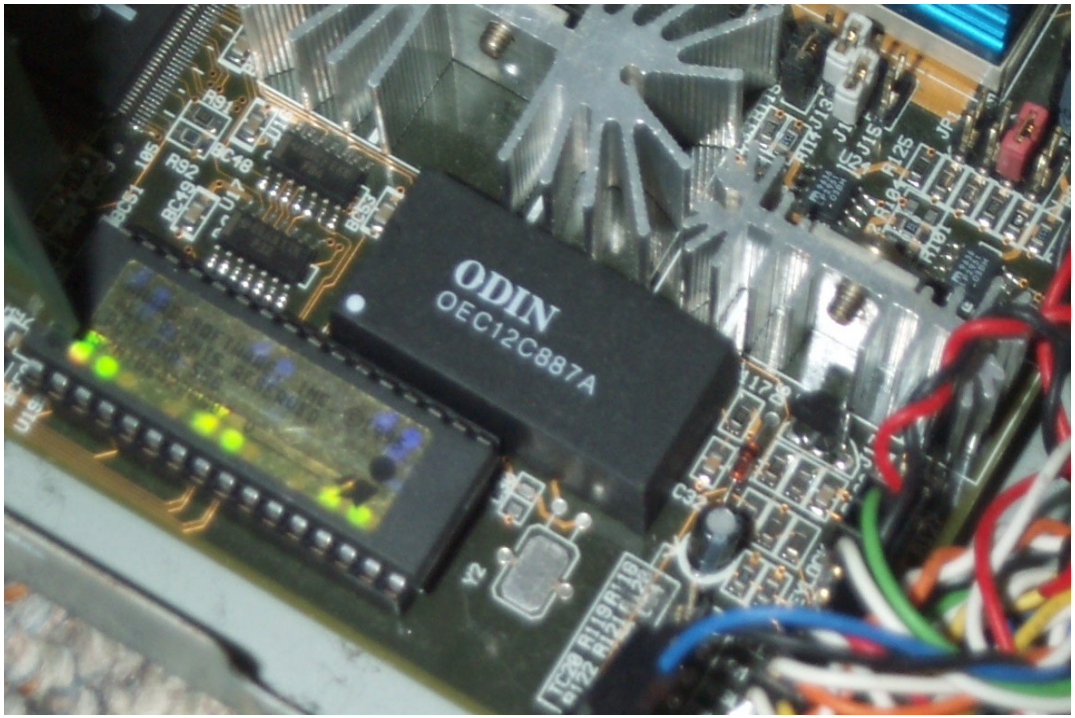
- De-facto standard in computing due to wide usage
- Easy representation (integer) and calculation (subtraction)
- Fuzzy definition of epoch 1970, since UTC only since 1972
- Ignorance of leap seconds, also in conversion UTC-UNIX
- Overflow if signed integer in year 2038

/usr/share/zoneinfo/
/etc/localtime
/etc/timezone

http://www.ucolick.org/~sla/leapsecs/timescales.html
https://de.wikipedia.org/wiki/Unixzeit

Real Time Clock (RTC)

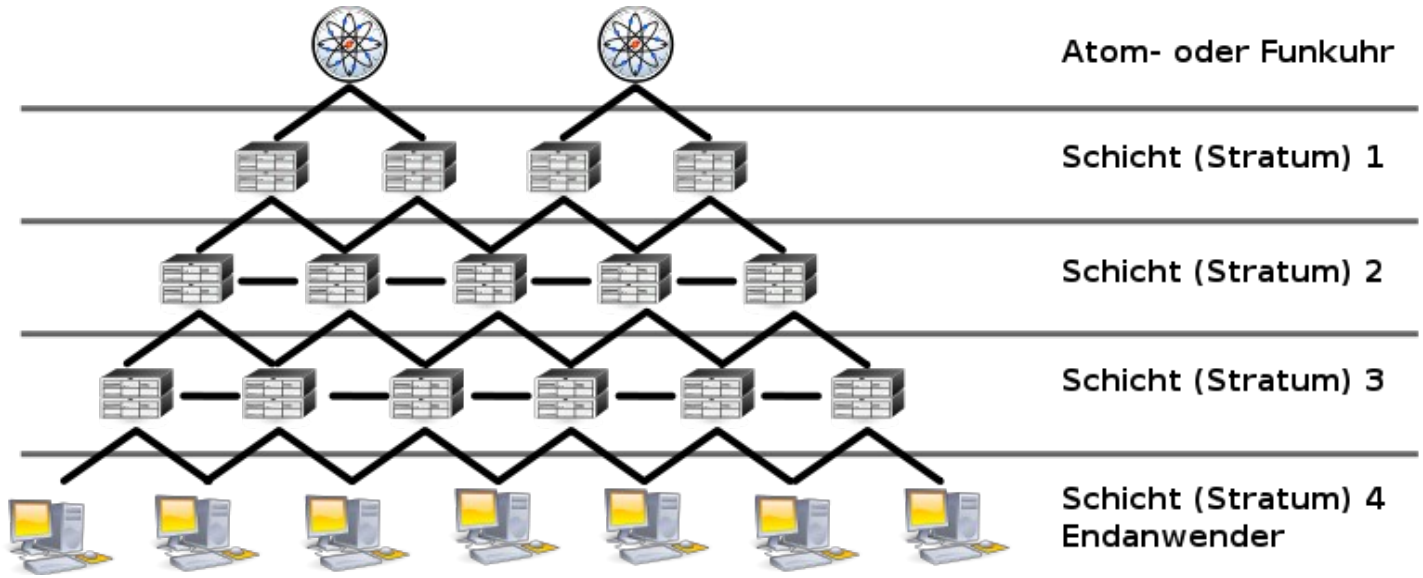




RTC produced by ODIN on PC Mainboard
https://de.wikipedia.org/wiki/Echtzeituhr

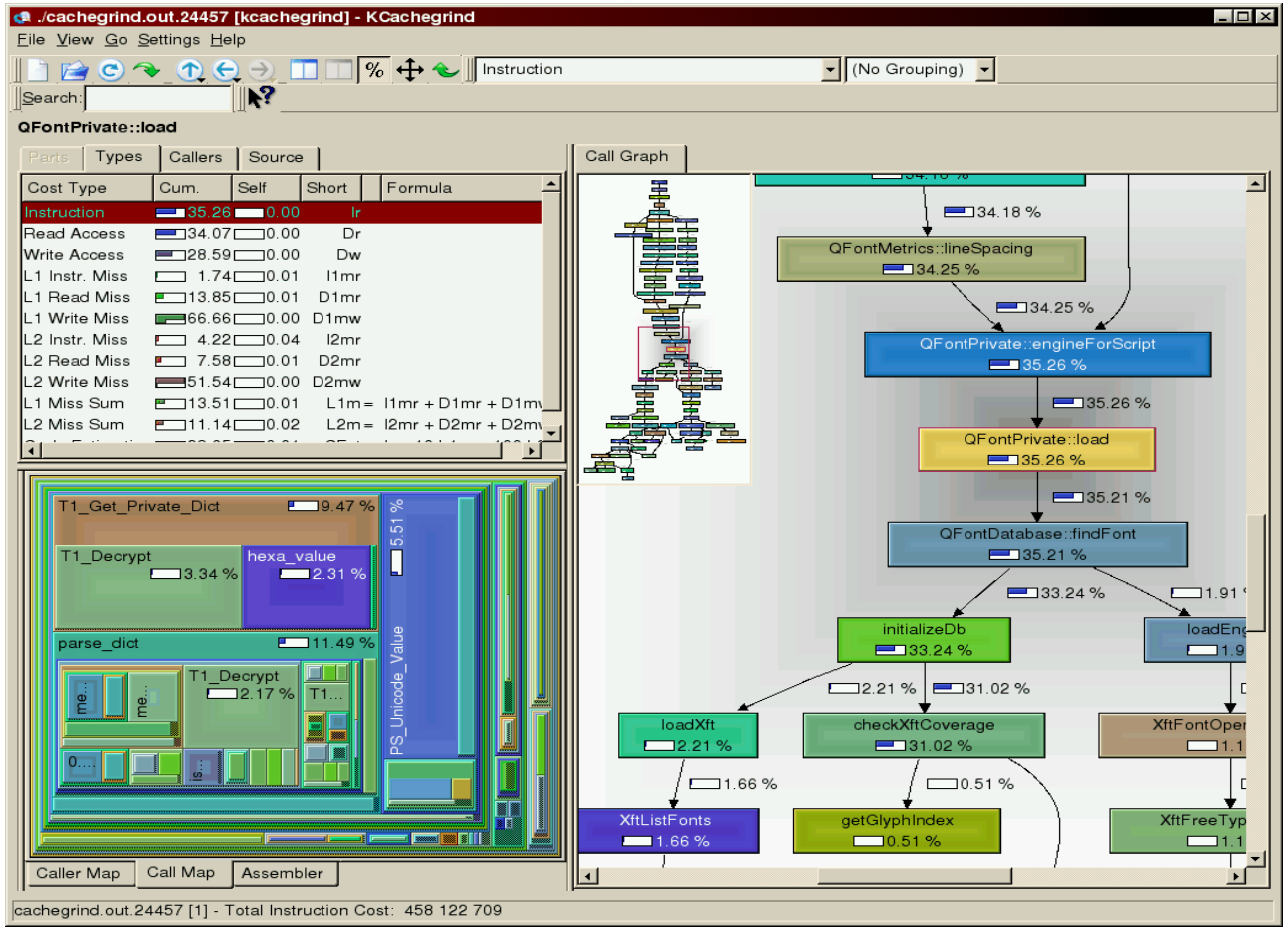
Network Time Protocol (NTP)

Anwendung	NTP				
Transport	UDP				
Internet	IP (IPv4, IPv6)				
Netzzugang	Ethernet	Token Bus	Token Ring	FDDI	...



https://de.wikipedia.org/wiki/Network_Time_Protocol

Processor Time



Profiling tool Callgrind and profile data visualization KCachegrind (call graph viewer)
http://kcachegrind.sourceforge.net/

clock_t clock(void)
clock_t times(struct tms *buffer)

https://www.gnu.org/software/libc/manual/html_mono/libc.html#toc-Date-and-Time-1

Summary

- Different datetime formats around the world (use ISO)
- Calendar history and systems (modern Gregorian)
- Calculation of religious holiday, weekday, calendar week
- Calendar epoch (start) and era (span)
- Julian date (day and fraction)
- Time scale based on time unit (solar, dynamic, atomic)
- Platform Issues (JD for calendar, high resolution real-time)
- RTC, BIOS, NTP server, processor time