Working with Time Zones Inside a Phoenix App

Mike Zornek • March 2020

Big Ner
Ranch

STANDARD TIME ZONES OF THE WORLD

165 150 135 120 105 90 75 60 45 30 15 0 15 30 45 60 75 90 105 120 135 150 165 180
-11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 +1 +2 +3 +4 +5 +6 +7 +8 +9 +10 +11 +12 -12 -11
ARCTIC OCEAN
ARCTIC OCEAN
Chukchi Sea
Beaufort Sea
Baffin Bay
Greenland
(DENMARK)
-3
Qaanaaq
Thule
Jan Mayen
(NORWAY)
Ittoqqortoormiit
(Scoresbysund)
Greenland Sea
Svalbard
(NORWAY)
FRANZ JOSEF LAND
NOVAYA ZEMLYA
SEVERNAYA ZEMLYA
Kara Sea
Barents Sea
Laptev Sea
NEW SIBERIAN ISLANDS
East Siberian Sea
Wrangel Island
Chukchi Sea
U.S.
-9
Anchorage
Dawson
Repulse Bay
Iqaluit
Nuuk
(Godthåb)
Davis Strait
Denmark Strait
ICELAND
0
Norwegian Sea
Faroe Islands
(DENMARK)
Hudson Bay
CANADA
Labrador Sea
Edmonton
Winnipeg
Vancouver
-4
-3½
Island of Newfoundland
Québec
-5
Toronto
St. Pierre and Miquelon
(FRANCE)
-8
Denver
Chicago
New York
Washington, D.C.
UNITED STATES
-7
-6
Los Angeles
Dallas
NORTH PACIFIC OCEAN
-11
NORTH ATLANTIC OCEAN
AZORES
(PORT.)
-1
Bermuda
(U.K.)
Gulf of Mexico
MEXICO
Mexico City
U.S.
HAWAIIAN ISLANDS
-10
ISLAS REVILLAGIGEDO
(Mexico)
Clipperton Island
(France)
THE BAHAMAS
CUBA
HAITI
DOM. REP.
JAMAICA
PUERTO RICO
BELIZE
GUATEMALA
HONDURAS
EL SALVADOR
NICARAGUA
COSTA RICA
PANAMA
Caribbean Sea
Caracas
VENEZUELA
GUYANA
SURINAME
French Guiana
(FRANCE)
Bogotá
COLOMBIA
ECUADOR
GALAPAGOS ISLANDS
(ECUADOR)
Isla del Coco
(COSTA RICA)
PERU
Lima
-5
Manaus
-4
BRAZIL
-3
Brasília
BOLIVIA
PARAGUAY
São Paulo
Rio de Janeiro
CHILE
Santiago
ARGENTINA
Buenos Aires
URUGUAY
-3
Falkland Islands
(Islas Malvinas)
(administered by U.K., claimed by ARGENTINA)
South Georgia and South Sandwich Islands
(administered by U.K., claimed by ARGENTINA)
-3
CABO VERDE
PENEDOS DE SÃO PEDRO E SÃO PAULO
(BRAZIL)
ARQUIPÉLAGO DE FERNANDO DE NORONHA
(BRAZIL)
Trindade
(BRAZIL)
Martin Vaz
(BRAZIL)
Easter Island
(CHILE)
Isla Sala y Gomez
(CHILE)
Pitcairn Islands
(U.K.)
ÎLES GAMBIER
(French Polynesia)
ÎLES MARQUISES
(French Polynesia)
-9½
French Polynesia
(FRANCE)
Cook Islands
(N.Z.)
-10
Jarvis Island
(U.S.)
+14
+13 KIRIBATI
LINE ISLANDS
International Date Line
SOUTH PACIFIC OCEAN
-11
SOUTH ATLANTIC OCEAN
Ascension
Saint Helena
Saint Helena, Ascension, and Tristan da Cunha
(U.K.)
TRISTAN DA CUNHA
Gough Island
Coordinated Universal Time (UTC)
formerly Greenwich Mean Time (GMT)
(number indicates standard time in zone when it is 12 noon, UTC)
Bouvet Island (NORWAY)
IRELAND
UNITED KINGDOM
London
North Sea
NORWAY
SWEDEN
FINLAND
Saint Petersburg
EST.
LAT.
LITH.
RUS.
DENMARK
NETH.
BEL.
LUX.
GERMANY
POLAND
BELARUS
Moscow
+3
CZECHIA
SLOV.
AUS.
HUNG.
UKRAINE
MOLDOVA
ROMANIA
FRANCE
Paris
SWITZ.
+1
ITALY
Rome
Corsica
(FR.)
Sardinia
(IT.)
Sicily
(IT.)
PORTUGAL
SPAIN
Madrid
Gibraltar
(U.K.)
BULGARIA
GREECE
Istanbul
TURKEY
Black Sea
MALTA
CYPRUS
SYRIA
LEB.
ISRAEL
JORDAN
Mediterranean Sea
+2
MADEIRA ISLANDS
(PORT.)
CANARY ISLANDS
(SPAIN)
Casablanca
MOROCCO
Algiers
TUNISIA
ALGERIA
LIBYA
EGYPT
Cairo
Western Sahara
MAURITANIA
MALI
NIGER
CHAD
SUDAN
Khartoum
SENEGAL
THE GAMBIA
GUINEA-BISSAU
GUINEA
SIERRA LEONE
LIBERIA
CÔTE D'IVOIRE
BURKINA FASO
GHANA
TOGO
BENIN
NIGERIA
Lagos
0
+1
CAMEROON
CENTRAL AFRICAN REPUBLIC
SOUTH SUDAN
ETHIOPIA
Addis Ababa
ERITREA
DJIBOUTI
SOMALIA
KENYA
Nairobi
UGANDA
RWANDA
BURUNDI
TANZANIA
EQUATORIAL GUINEA
SAO TOME AND PRINCIPE
GABON
REP. OF THE CONGO
DEM. REP. OF THE CONGO
Kinshasa
Kisangani
Gulf of Guinea
Annobon
(EQ. GUI.)
ANG.
ANGOLA
ZAMBIA
+2
MALAWI
MOZAMBIQUE
ZIMBABWE
NAMIBIA
BOTSWANA
Johannesburg
SWAZILAND
LESOTHO
SOUTH AFRICA
Cape Town
COMOROS
+3
MADAGASCAR
Mozambique Channel
SEYCHELLES
MAURITIUS
Reunion
(FRANCE)
Tromelin Island
Agalega Islands
(MAURITIUS)
PRINCE EDWARD ISLANDS
(SOUTH AFRICA)
ÎLES CROZET
(Fr. S. and Ant. Lands)
French Southern and Antarctic Lands
(FRANCE)
Île Amsterdam
Île Saint-Paul
ÎLES KERGUELEN
Heard Island and McDonald Islands
(AUSTL.)
Red Sea
IRAQ
Baghdad
IRAN
Tehran
+3½
KUWAIT
BAHRAIN
QATAR
U.A.E.
OMAN
Riyadh
SAUDI ARABIA
YEMEN
Socotra
(YEMEN)
Arabian Sea
+4
Samara
Volgograd
+4
Izhevsk
Yekaterinburg
+5
Omsk
Astana
+6
KAZAKHSTAN
UZBEKISTAN
TURKMENISTAN
TAJIKISTAN
KYRGYZSTAN
ARM.
AZER.
GEO.
Caspian Sea
AFGHANISTAN
+4½
Kabul
PAKISTAN
Karachi
+5
New Delhi
NEPAL
+5¾
BHUTAN
BANGLADESH
Kolkata
Dhaka
INDIA
+5½
Mumbai
SRI LANKA
LAKSHADWEEP
(INDIA)
+5
MALDIVES
Bay of Bengal
ANDAMAN ISLANDS
(INDIA)
NICOBAR ISLANDS
(INDIA)
BURMA
+6½
Rangoon
British Indian Ocean Territory
(U.K.)
+6
Cocos (Keeling) Islands
(AUSTL.)
+6½
INDIAN OCEAN
RUSSIA
Novosibirsk
Krasnoyarsk
+7
Irkutsk
+8
MONGOLIA
Urumqi
CHINA
Beijing
Shanghai
Guangzhou
Macau S.A.R.
Hong Kong S.A.R.
Taipei
Taiwan
LAOS
THAILAND
Bangkok
VIETNAM
CAMBODIA
Ho Chi Minh City
South China Sea
PHILIPPINES
Manila
MALAYSIA
Medan
SINGAPORE
BRUNEI
INDONESIA
Jakarta
Makassar
+8
Christmas Island
(AUSTL.)
TIMOR-LESTE
Ashmore and Cartier Islands
(AUSTL.)
Yakutsk
+9
+10
Magadan
+11
+12
Vladivostok
Sakhalin
Sea of Okhotsk
Petropavlovsk-Kamchatskiy
Bering Sea
U.S. -10
ALEUTIAN ISLANDS
KURIL ISLANDS
occupied by the SOVIET UNION in 1945, administered by RUSSIA, claimed by JAPAN
NORTH KOREA
Seoul
SOUTH KOREA
Sea of Japan
JAPAN
Tokyo
+9
RYUKYU ISLANDS
(JAPAN)
Minamitori Shima
(JAPAN)
+9
Philippine Sea
Northern Mariana Islands
(U.S.)
Guam
(U.S.)
+10
PALAU
FEDERATED STATES OF MICRONESIA
MARSHALL ISLANDS
+11
+12
NAURU
PAPUA NEW GUINEA
SOLOMON ISLANDS
Bougainville
(Pap. N. Gui.)
Wake Island
(U.S.)
Midway Islands
(U.S.)
-11
NORTHWESTERN HAWAIIAN ISLANDS
U.S.
-10
Eastward across Date Line subtract 24 hours
Westward across Date Line add 24 hours
Johnston Atoll
(U.S.)
NORTH PACIFIC OCEAN
Howland Island
(U.S.)
Baker Island
(U.S.)
-12
GILBERT ISLANDS
KIRIBATI
PHOENIX ISLANDS
TUVALU
Tokelau
(N.Z.)
Wal. & Fut.
(FR.)
SAMOA
Am. Sam.
(U.S.)
-11
FIJI
+13
TONGA
Niue
(N.Z.)
VANUATU
New Caledonia
(FRANCE)
Coral Sea Islands
(AUSTL.)
Coral Sea
AUSTRALIA
Alice Springs
+9½
Perth
+8¾
Great Australian Bight
Sydney
Melbourne
Tasmania
Tasman Sea
Norfolk Island
(AUSTL.)
Lord Howe Island
(AUSTL.)
+10½
KERMADEC ISLANDS
(N.Z.)
Auckland
NEW ZEALAND
+12¾
CHATHAM ISLANDS
(N.Z.)
International Date Line
Sun 1:00 -11
2:00 -10
3:00 -9
4:00 -8
5:00 -7
6:00 -6
7:00 -5
8:00 -4
9:00 -3
10:00 -2
11:00 -1
Sun 12:00 0
13:00 +1
14:00 +2
15:00 +3
16:00 +4
17:00 +5
18:00 +6
19:00 +7
20:00 +8
21:00 +9
22:00 +10
23:00 +11
Sun 24:00 +12
Sun 00:00 -12
Sun 1:00 -11

Boundary representation is not necessarily authoritative.

Add time zone number to local time to obtain UTC.
Subtract time zone number from UTC to obtain local time.

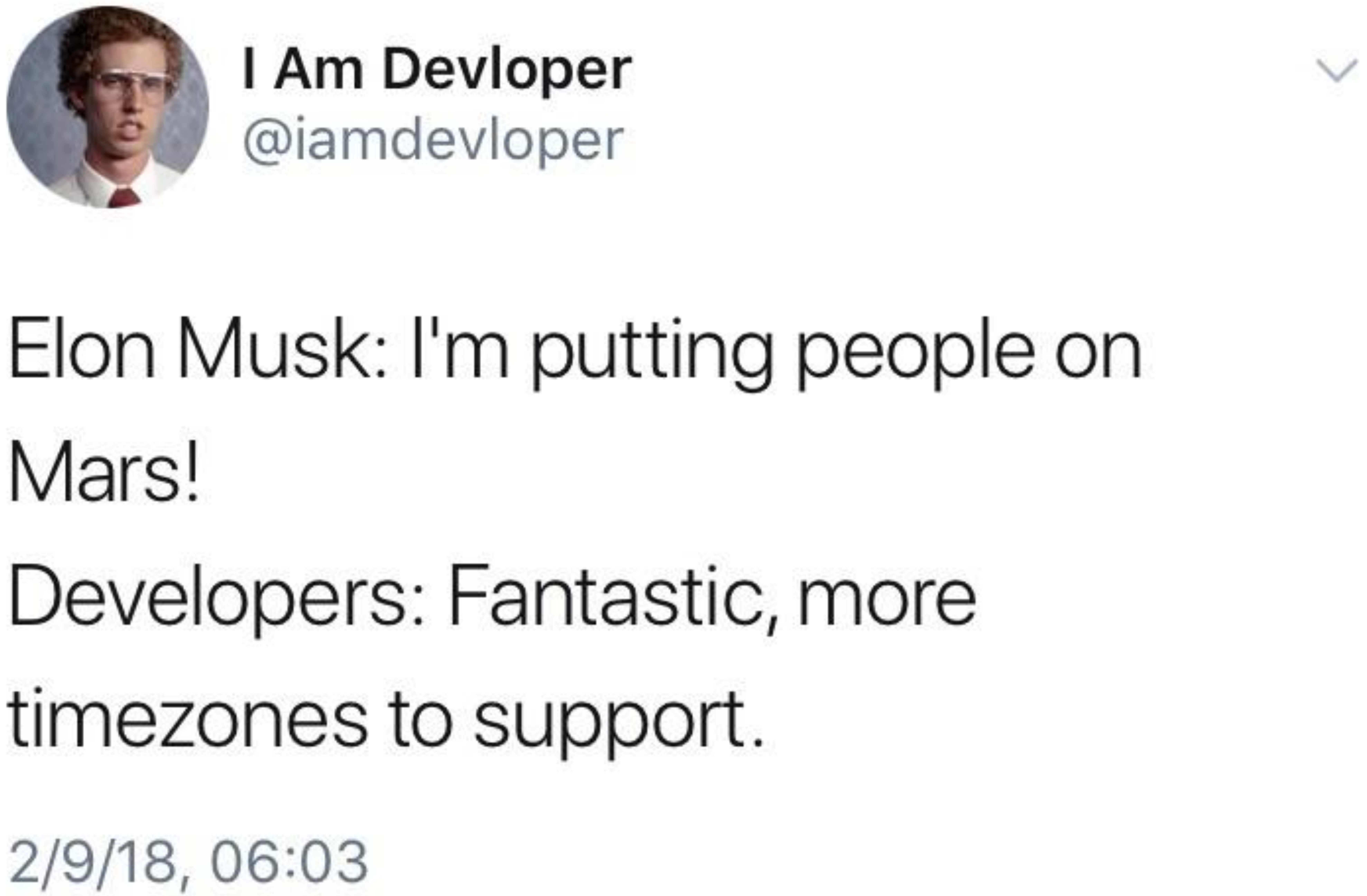
WEST

EAST

Subtract time zone number from local time to obtain UTC.
Add time zone number to UTC to obtain local time.

18-5386 5-18

Terminology



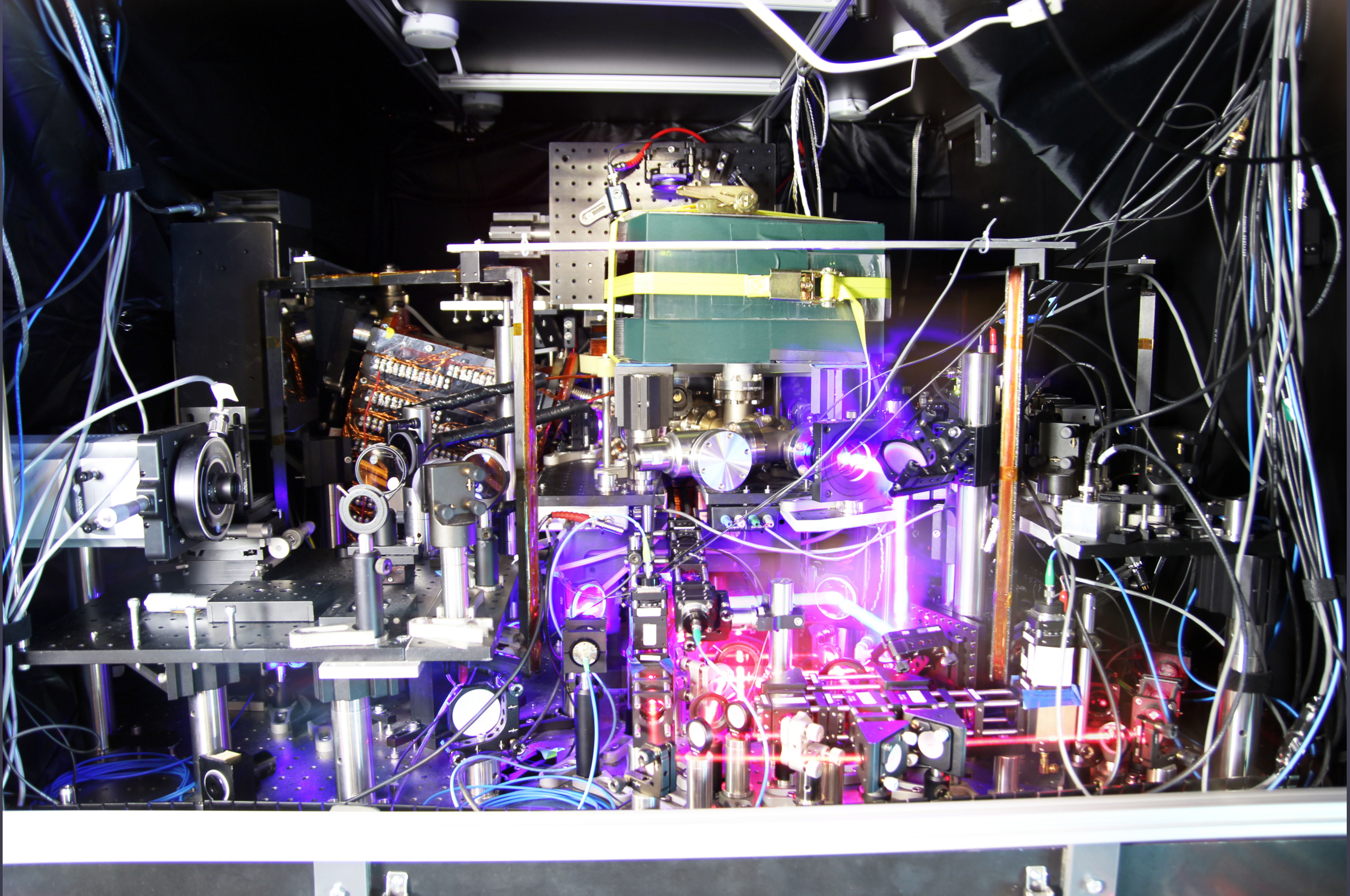
I Am Devloper
@iamdevloper

Elon Musk: I'm putting people on Mars!
Developers: Fantastic, more timezones to support.

2/9/18, 06:03

Layers of Wall Time

International Atomic Time (ITA)

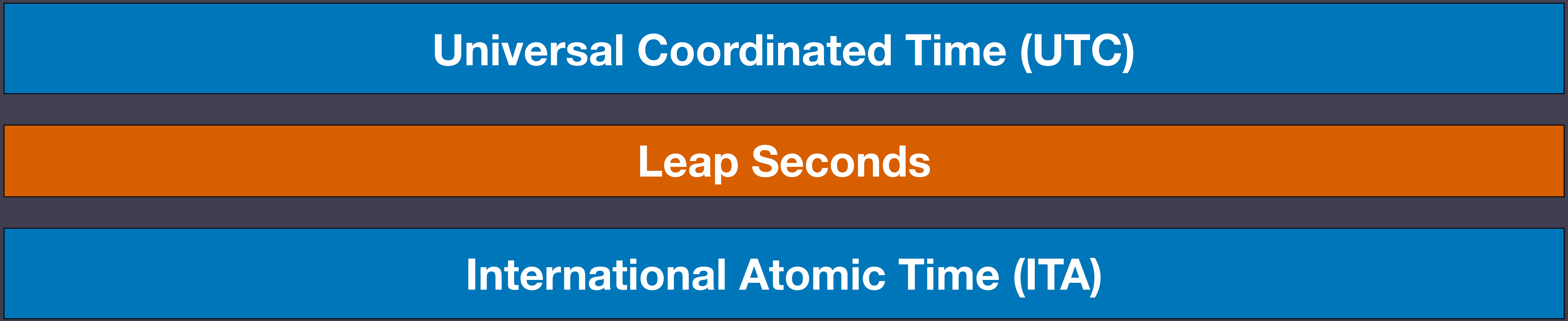

ANDOR

Layers of Wall Time

Universal Coordinated Time (UTC)

International Atomic Time (ITA)

Layers of Wall Time

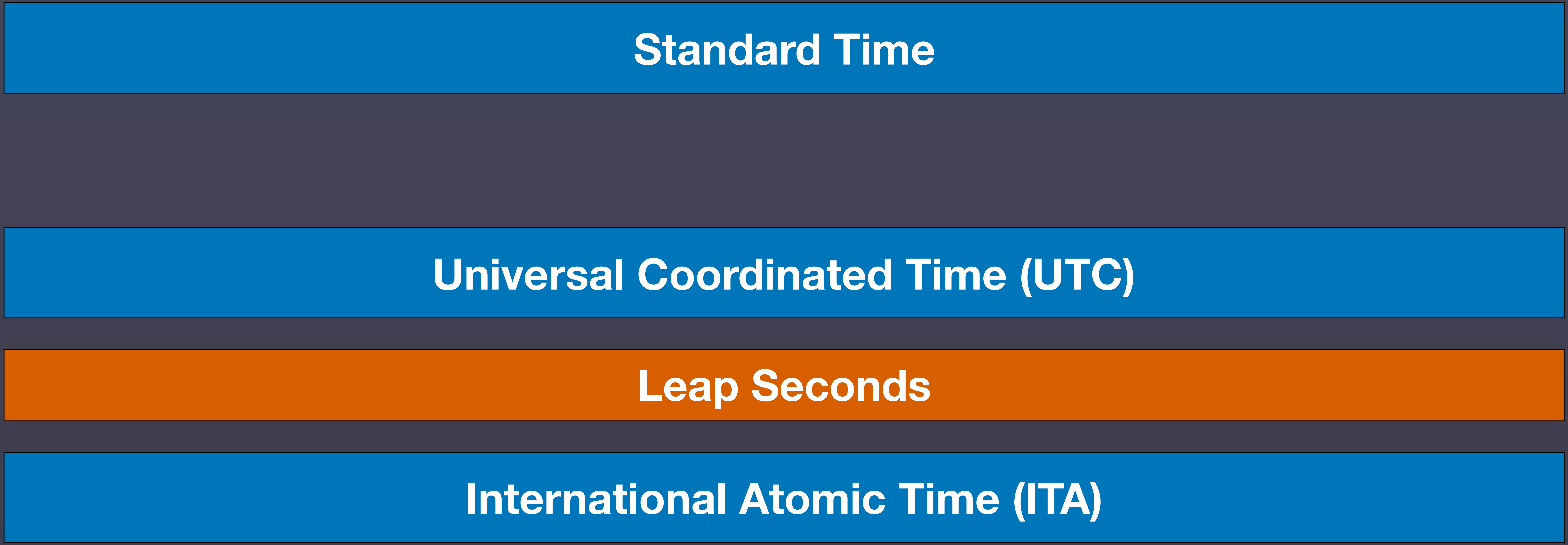


Universal Coordinated Time (UTC)

Leap Seconds

International Atomic Time (ITA)

Layers of Wall Time



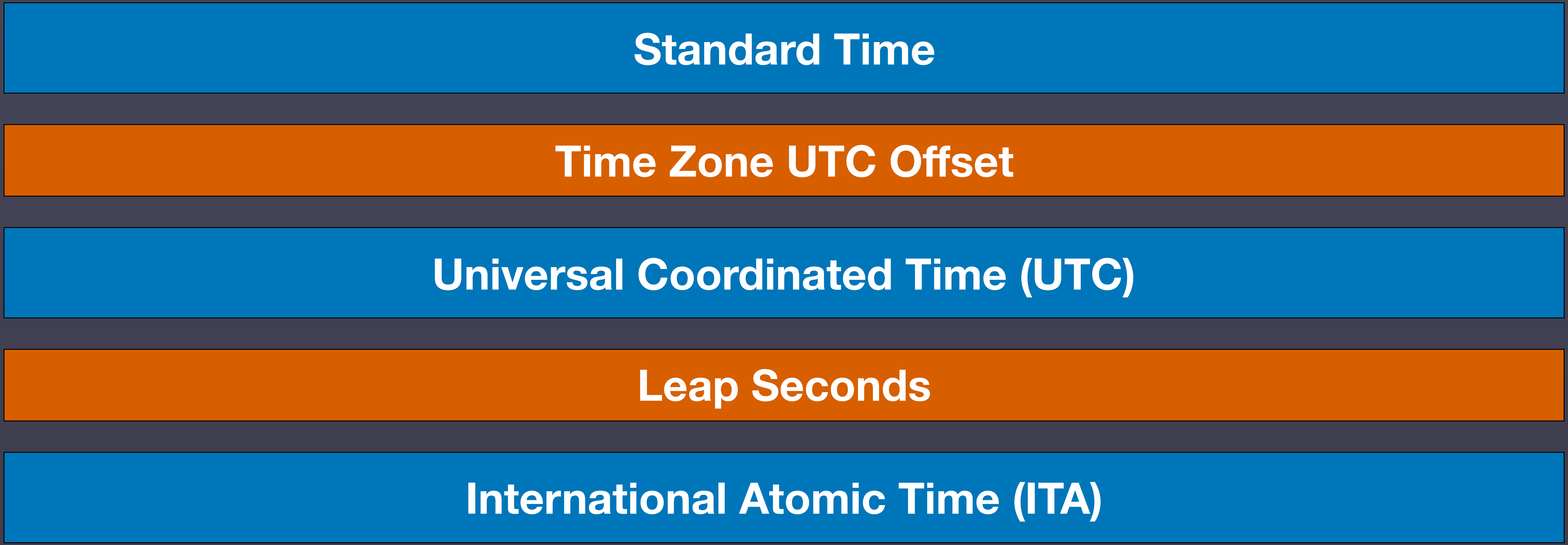
Standard Time

Universal Coordinated Time (UTC)

Leap Seconds

International Atomic Time (ITA)

Layers of Wall Time



Standard Time

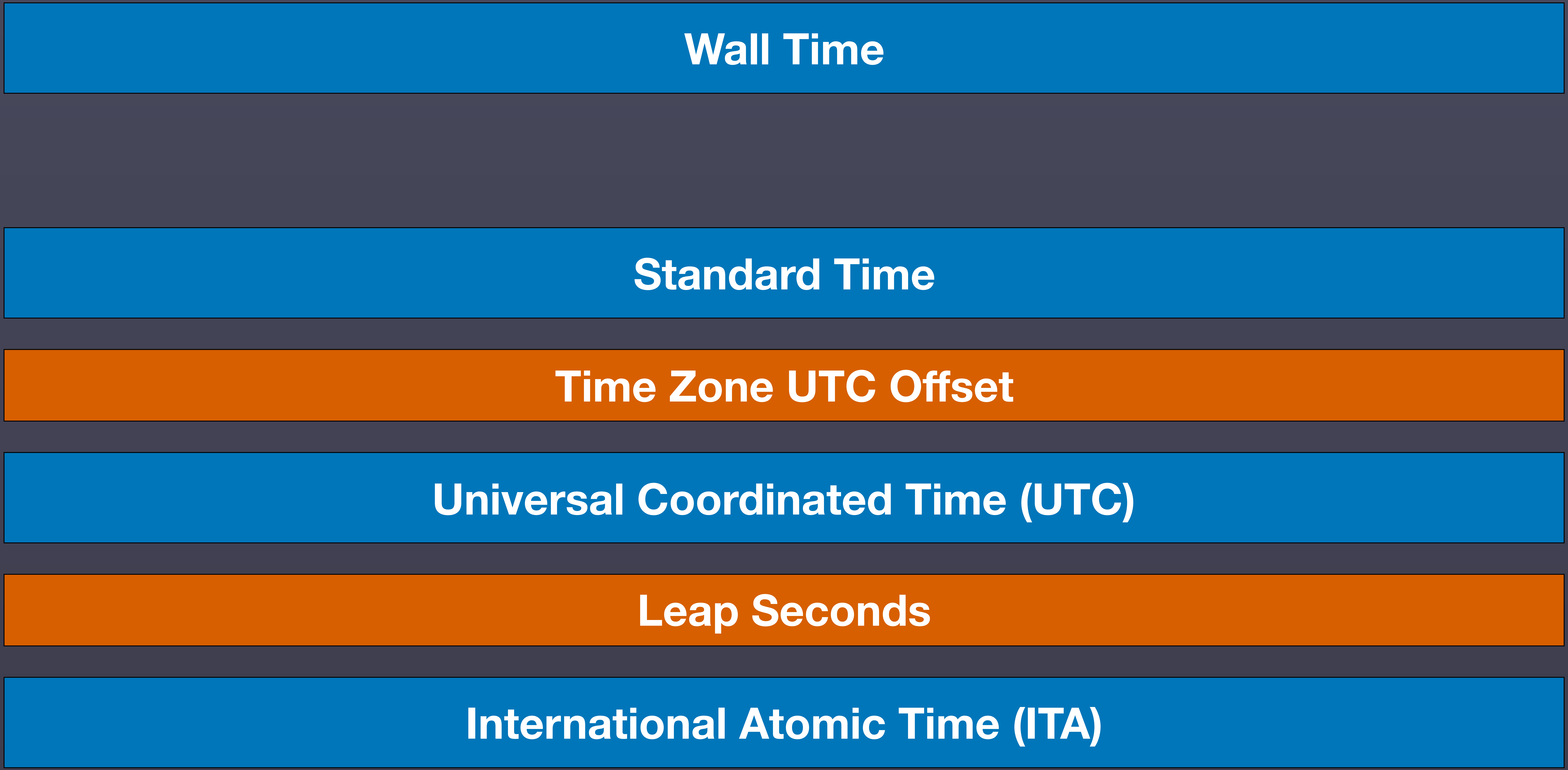
Time Zone UTC Offset

Universal Coordinated Time (UTC)

Leap Seconds

International Atomic Time (ITA)

Layers of Wall Time



Wall Time

Standard Time

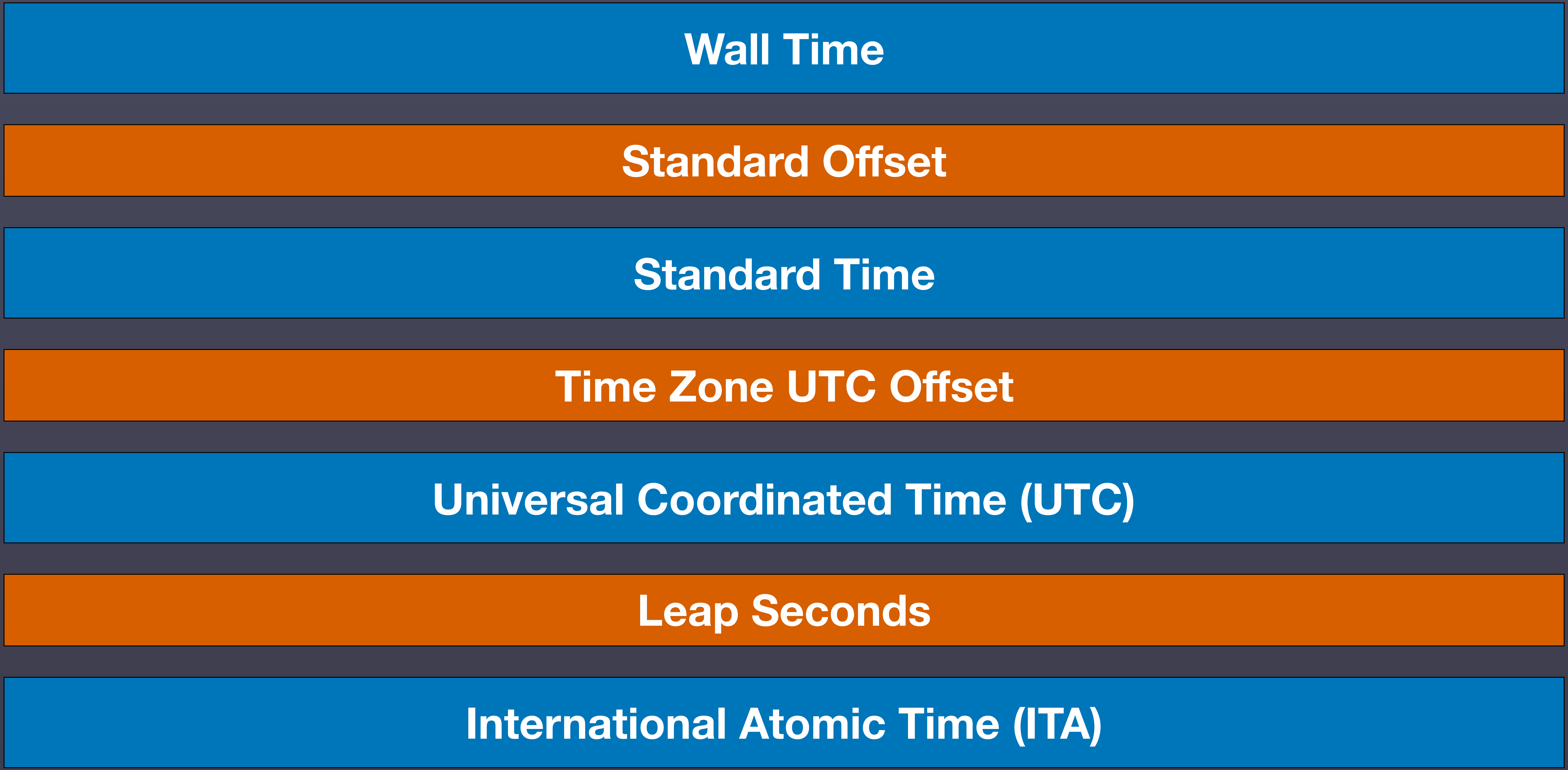
Time Zone UTC Offset

Universal Coordinated Time (UTC)

Leap Seconds

International Atomic Time (ITA)

Layers of Wall Time



Wall Time

Standard Offset

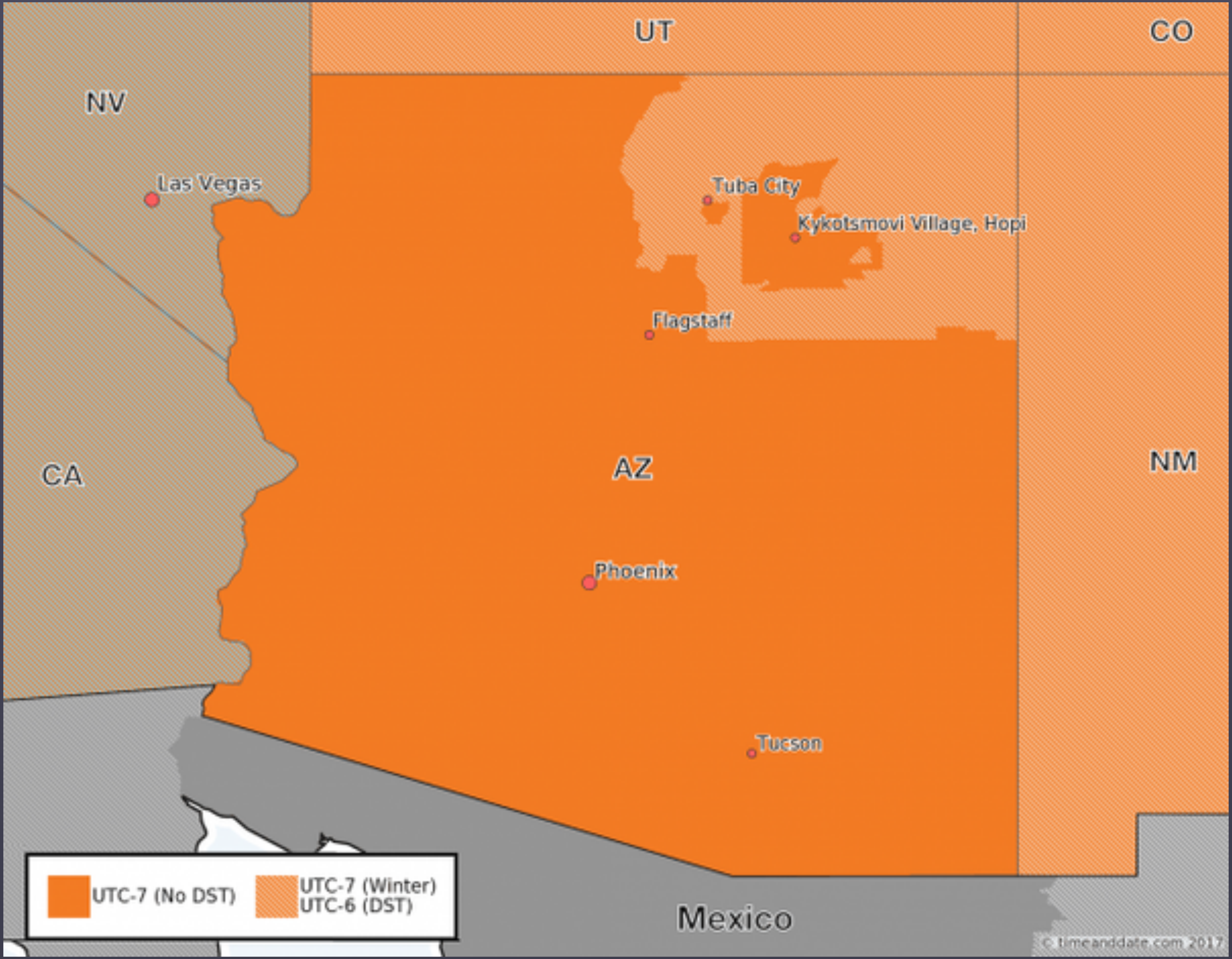
Standard Time

Time Zone UTC Offset

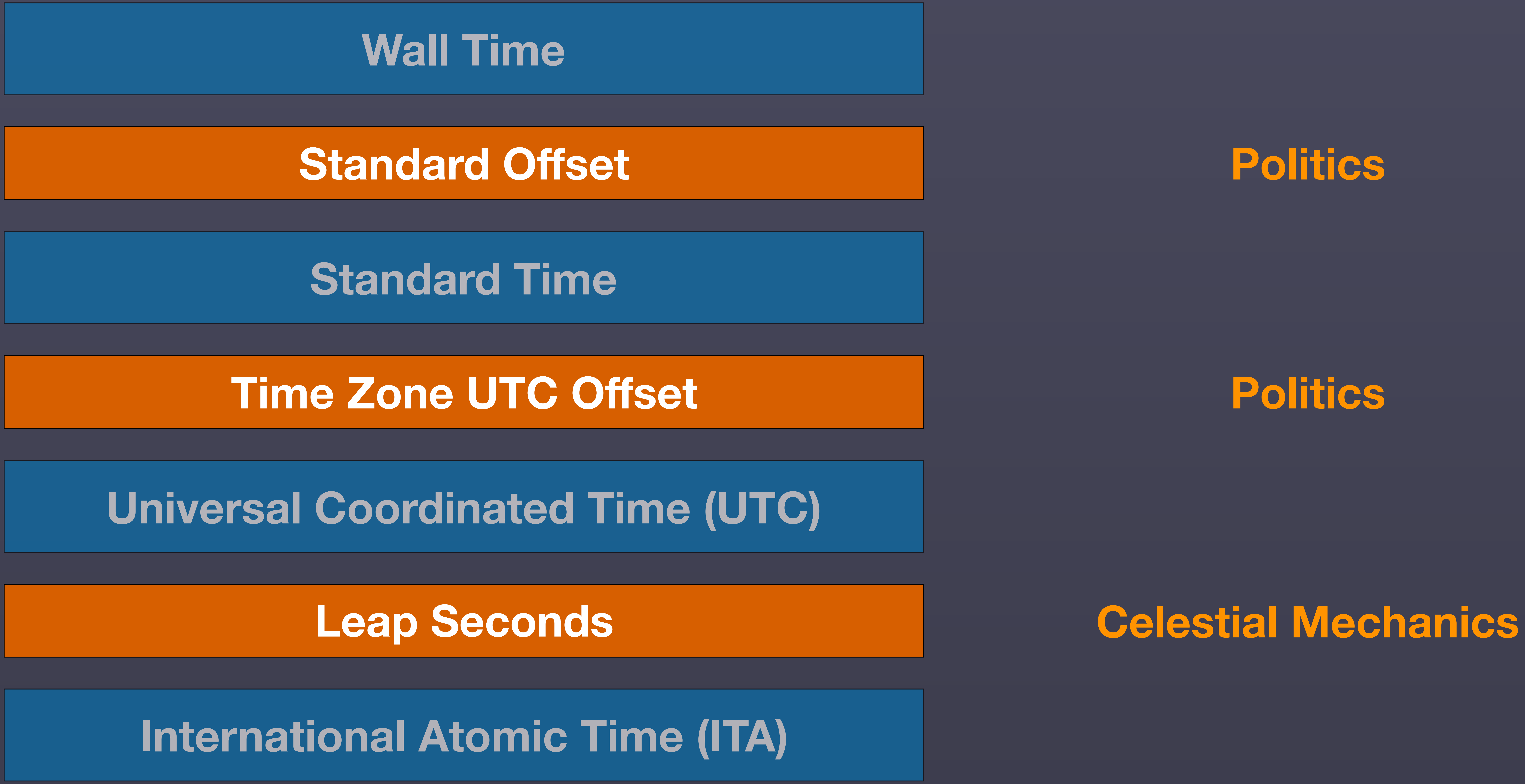
Universal Coordinated Time (UTC)

Leap Seconds

International Atomic Time (ITA)


UT
CO
NV
Las Vegas
Tuba City
Kykotsmovi Village, Hopi
Flagstaff
CA
AZ
NM
Phoenix
Tucson
Mexico
UTC-7 (No DST)
UTC-7 (Winter)
UTC-6 (DST)
© timeanddate.com 2017

Things Change



Wall Time

Standard Offset — Politics

Standard Time

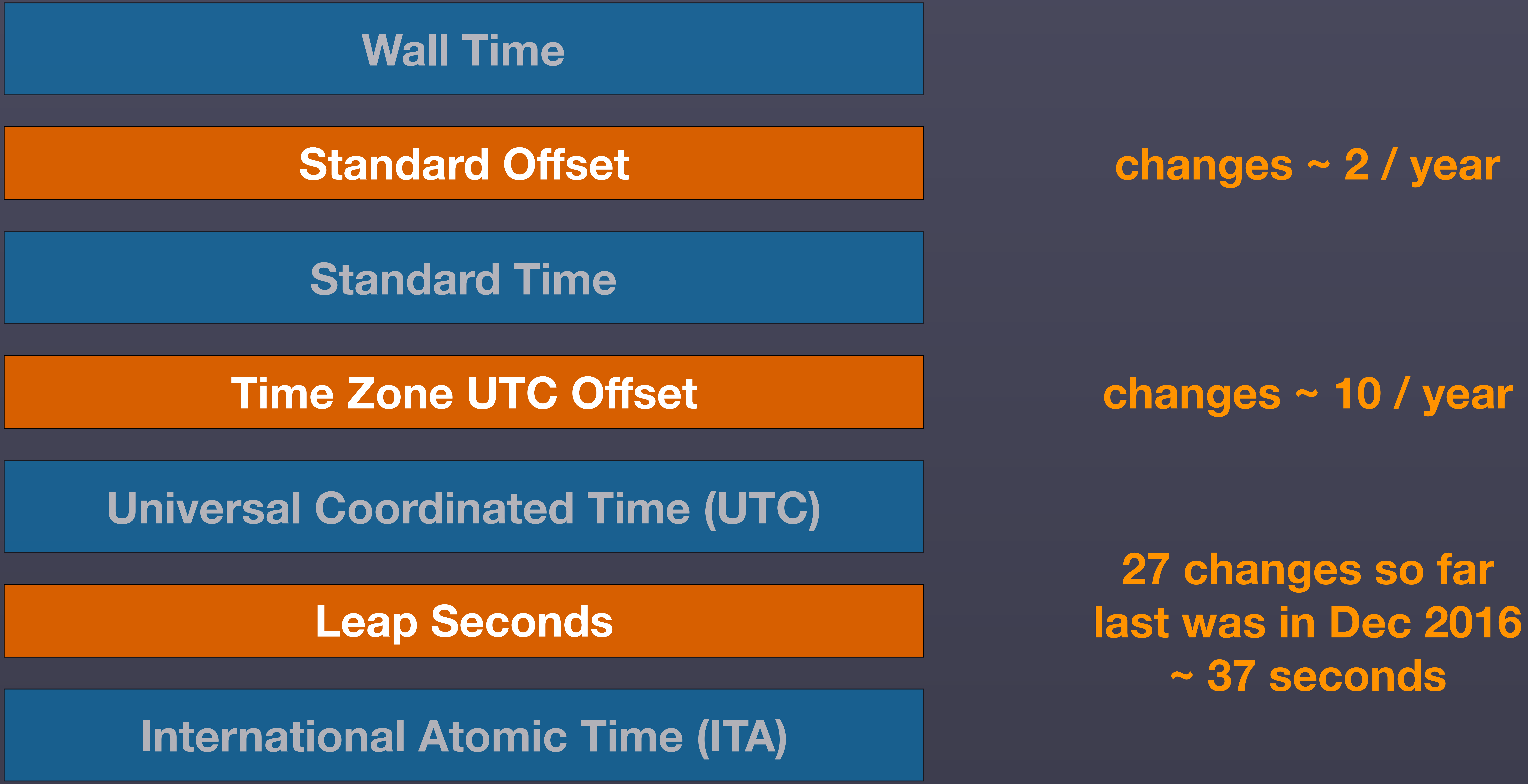
Time Zone UTC Offset — Politics

Universal Coordinated Time (UTC)

Leap Seconds — Celestial Mechanics

International Atomic Time (ITA)

Things Change



Wall Time

Standard Offset

changes ~ 2 / year

Standard Time

Time Zone UTC Offset

changes ~ 10 / year

Universal Coordinated Time (UTC)

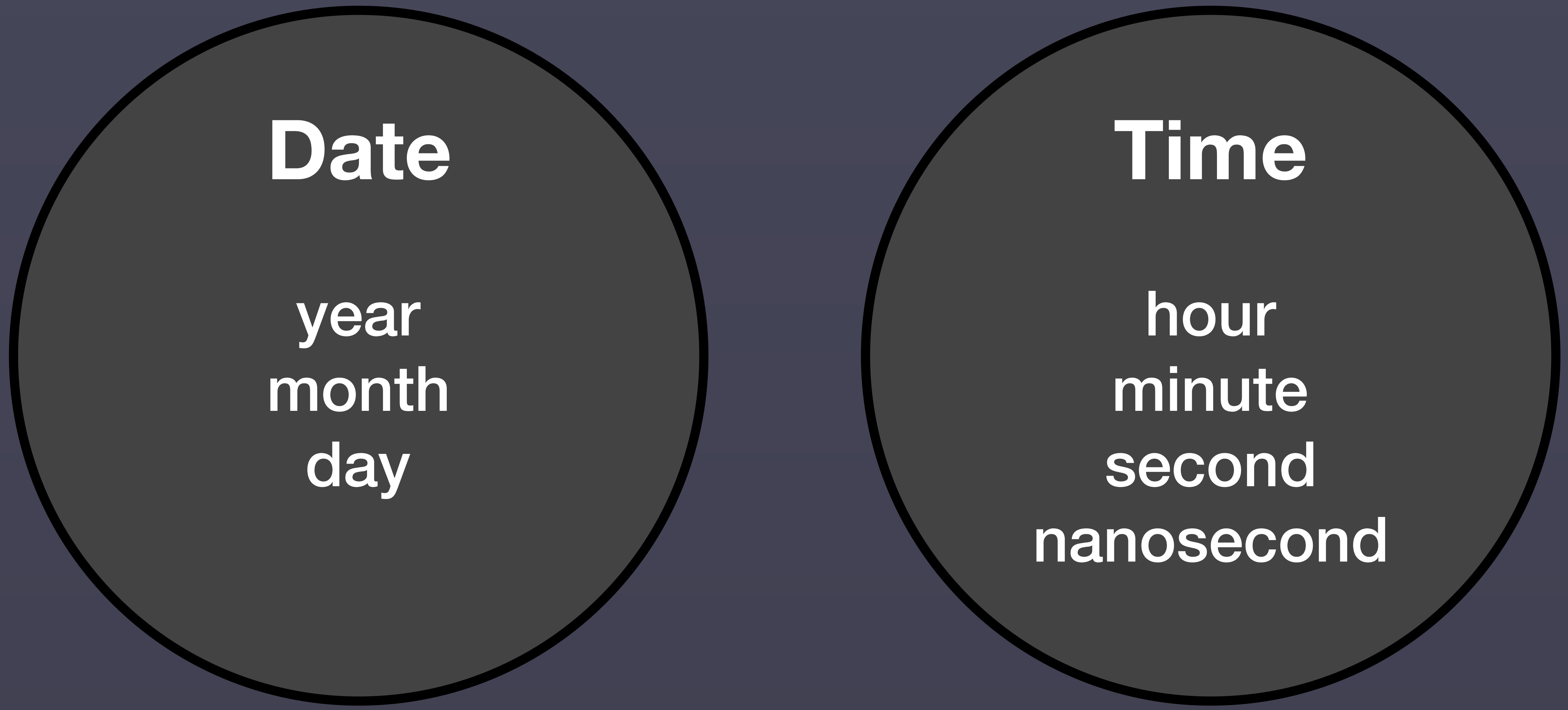
Leap Seconds

27 changes so far
last was in Dec 2016
~ 37 seconds

International Atomic Time (ITA)

"Time Zone"

How Elixir Represents Time

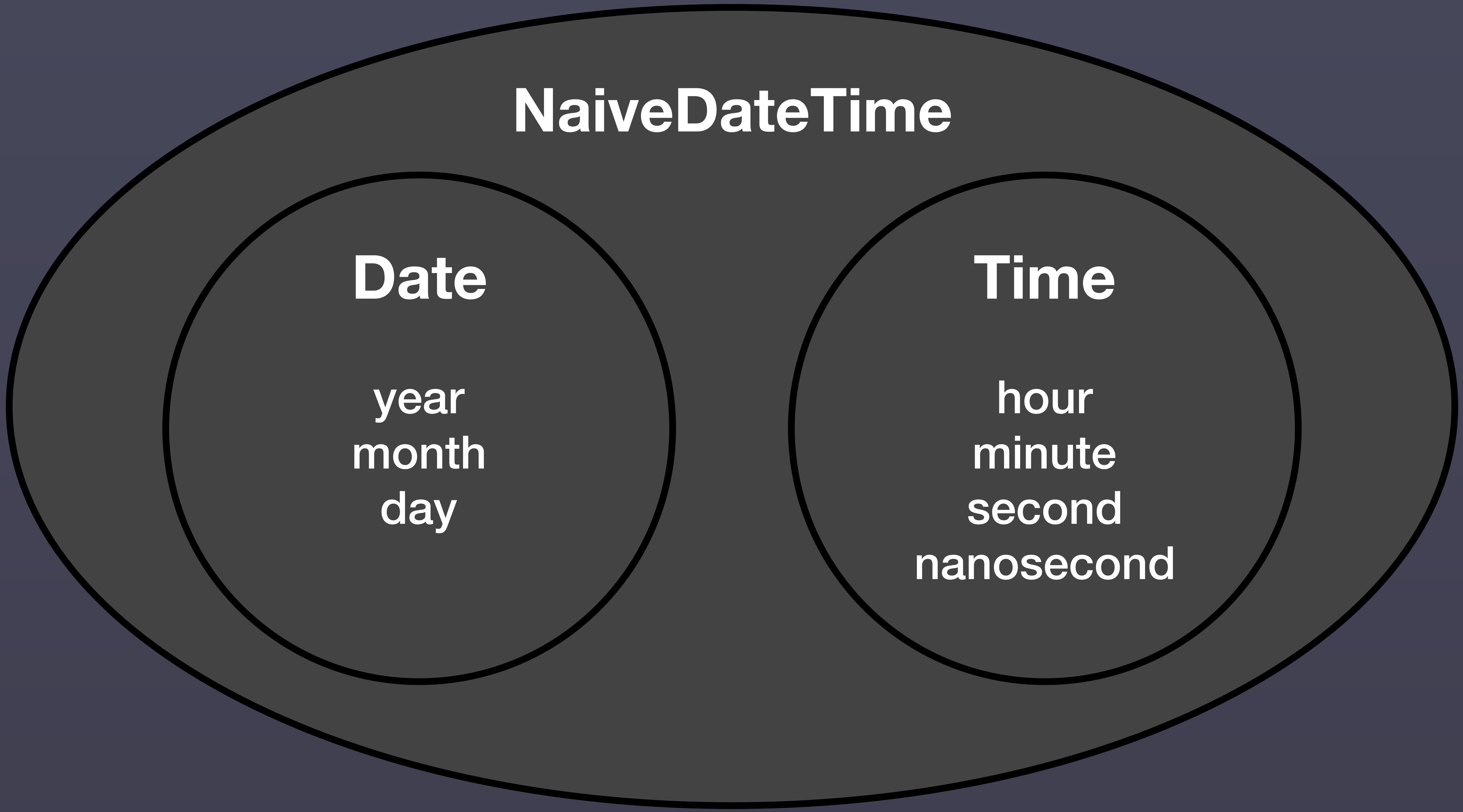


Date

year
month
day

Time

hour
minute
second
nanosecond



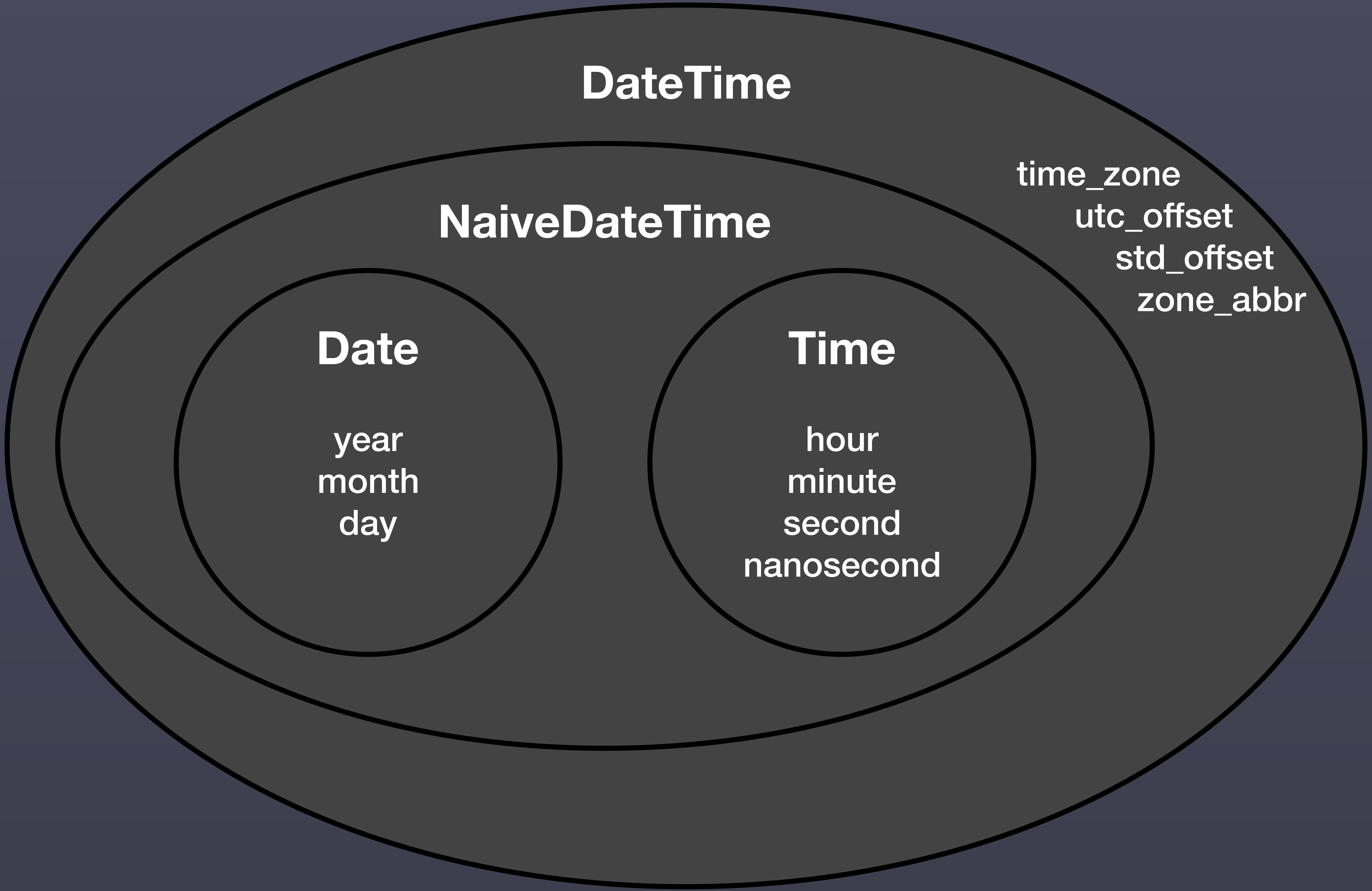
NaiveDateTime

Date

year
month
day

Time

hour
minute
second
nanosecond



DateTime

time_zone
utc_offset
std_offset
zone_abbr

NaiveDateTime

Date

year
month
day

Time

hour
minute
second
nanosecond

Sigils

```
# Date
~D[2019-10-31]

# Time
~T[23:00:07.0]

# NaiveDateTime
~N[2019-10-31 23:00:07]

# DateTime
~U[2019-10-31 19:59:03Z]

iex> DateTime.from_naive(~N[2016-05-24 13:26:08.003], "Etc/UTC")
{:ok, ~U[2016-05-24 13:26:08.003Z]}
```

```
# Past
Enum.sort(collection) # always sorts from lowest to highest
Enum.sort(collection, &>=/2) # alternative, but clunky
Enum.sort(dates, &(Date.compare(&1, &2) != :lt))

# New (Elixir 1.10)
Enum.sort(collection, :asc) # the default
Enum.sort(collection, :desc) # in reverse
Enum.sort(birth_dates, Date)
Enum.sort(birth_dates, {:asc, Date})
Enum.sort(birth_dates, {:desc, Date})
```

TimeZoneDatabase

lau / tzdata
Watch 7
Star 181
Fork 42
Code
Issues 8
Pull requests 1
Actions
Projects 0
Wiki
Security
Insights
Branch: master
New pull request
Create new file
Upload files
Find file
Clone or download

tzdata for Elixir. Born from the Calendar library.

217 commits · 3 branches · 0 packages · 43 releases · 19 contributors · MIT

lau Merge branch 'master' of https://github.com/lau/tzdata ✓ Latest commit de8387b on Jan 27

config	Run Elixir code formatter on mix.exs and config.exs	2 years ago
lib	When comparing HTTP headers, do case-insensitive comparison.	3 months ago
priv/release_ets	Update tzdata release from 2019a to 2019c	3 months ago
test	Use String.to_existing_atom instead of String.to_atom	5 months ago
.formatter.exs	include .formatter.exs	2 years ago
.gitignore	Keep dir needed for automatic update. Ignore remote poll file.	5 years ago
.travis.yml	In Travis CI use Elixir 1.8.1 instead of master	13 months ago
CHANGELOG.md	Update changelog to reflect 2019c release in version 1.0.3	3 months ago
LICENSE	Initial commit of extracted tzdata code as new separate library.	5 years ago

```
defp deps do
  [  {:tzdata, "~> 1.0.3"},  ]
end

config :elixir, :time_zone_database, Tzdata.TimeZoneDatabase

iex> DateTime.now("Europe/Copenhagen")
{:ok, #DateTime<2018-11-30 20:51:59.076524+01:00 CET Europe/Copenhagen>}

# See also
# https://github.com/lau/calendar
# https://github.com/bitwalker/timex
```

mathieuprog / tz
Sponsor
Watch 1
Star 16
Fork 1
Code
Issues 0
Pull requests 0
Actions
Projects 0
Wiki
Security
Insights
Branch: master
New pull request
Create new file
Upload files
Find file
Clone or download

Time zone support for Elixir

elixir elixir-lang timezone time-zone iana tzdata tz

38 commits | 1 branch | 0 packages | 11 releases | 1 contributor | Apache-2.0

mathieuprog Bump version to 0.8.0 Latest commit 390c3ed 7 hours ago

.github	Add FUNDING.yml	19 days ago
lib	Rename env option	21 hours ago
priv/tzdata2019c	Initial commit	21 days ago
test	Add optional automatic updates + major code restructuring	8 days ago
.formatter.exs	Initial commit	21 days ago
.gitignore	Initial commit	21 days ago
LICENSE	Initial commit	21 days ago
README.md	Bump version to 0.8.0	7 hours ago

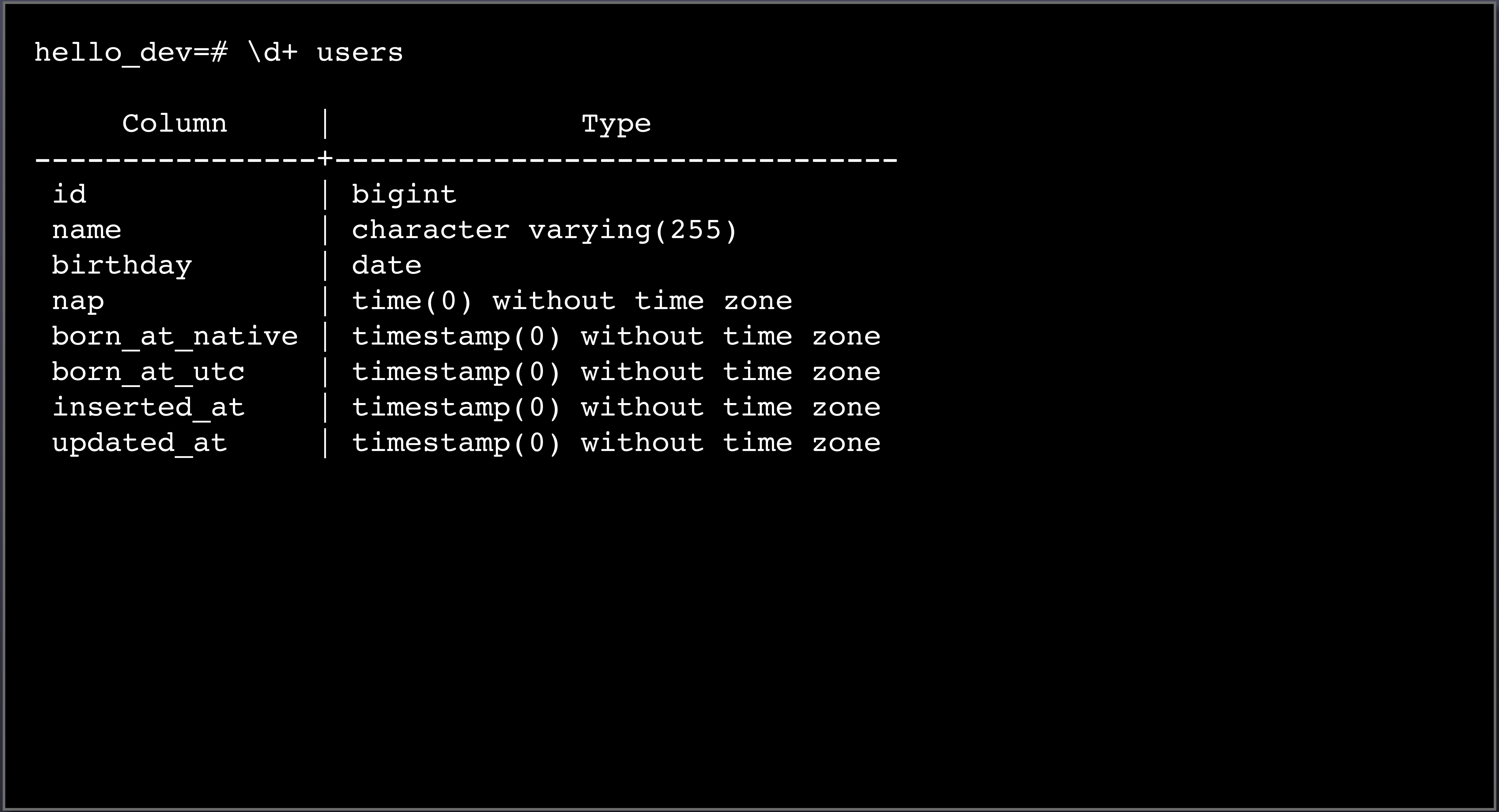
PostgreSQL & Ecto

> “Just, store everything as UTC.”
>
> *–Helpful Forum People*

The Problem

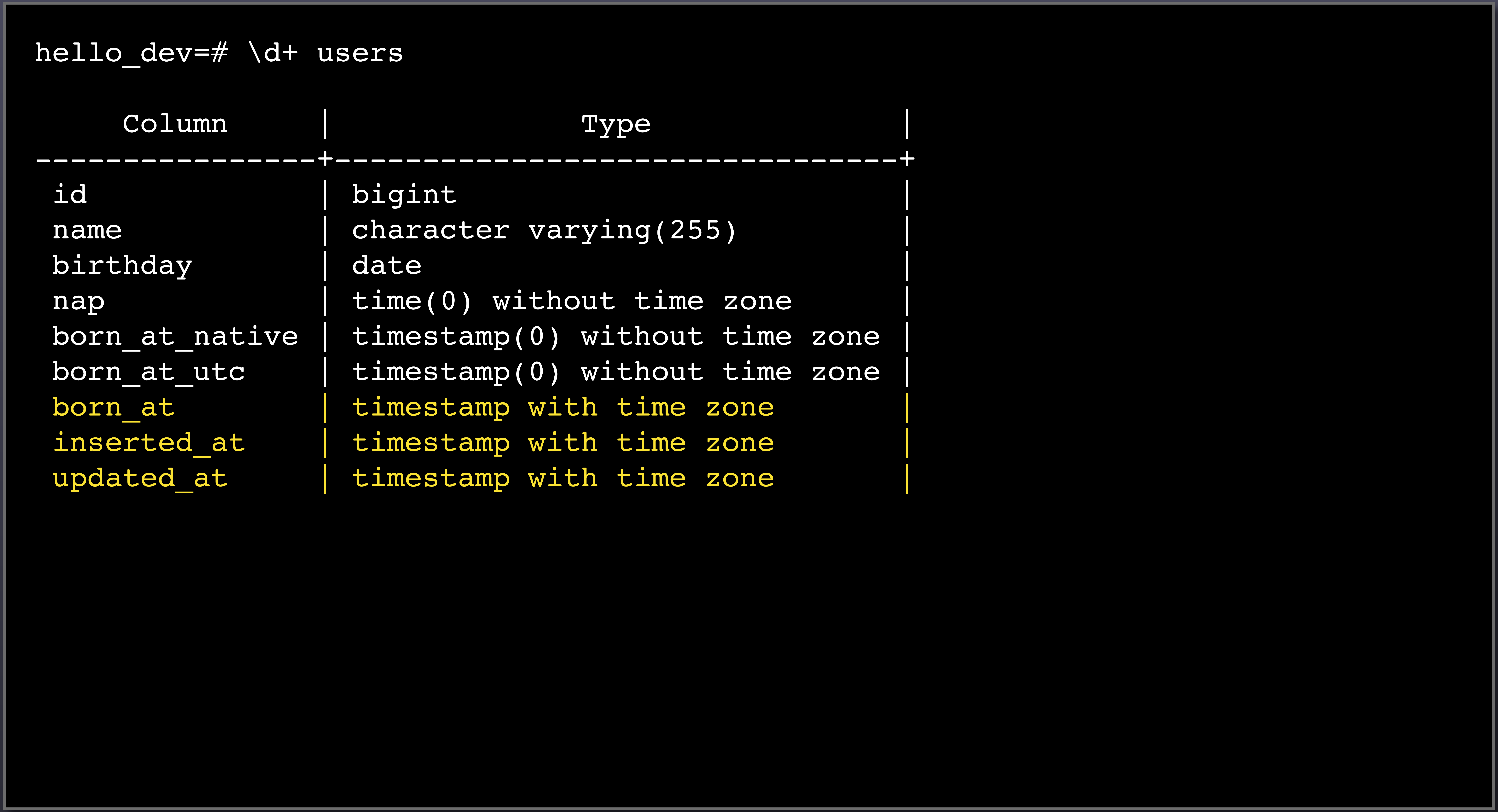
- The default Ecto to Postgres adapter assumes UTC. It's a contract with assumptions.
- Default behavior results in no timezone info actually stored in the database.
- Can cause subtle bugs for users performing date queries from a console connection that will use and apply the user's timezone.

```
schema "users" do
  field :name, :string
  field :birthday, :date
  field :nap, :time
  field :born_at_native, :naive_datetime
  field :born_at_utc, :utc_datetime

  timestamps()
end

def change do
  create table(:users) do
    add :name, :string
    add :birthday, :date
    add :nap, :time
    add :born_at_native, :naive_datetime
    add :born_at_utc, :utc_datetime

    timestamps()
  end
end
```



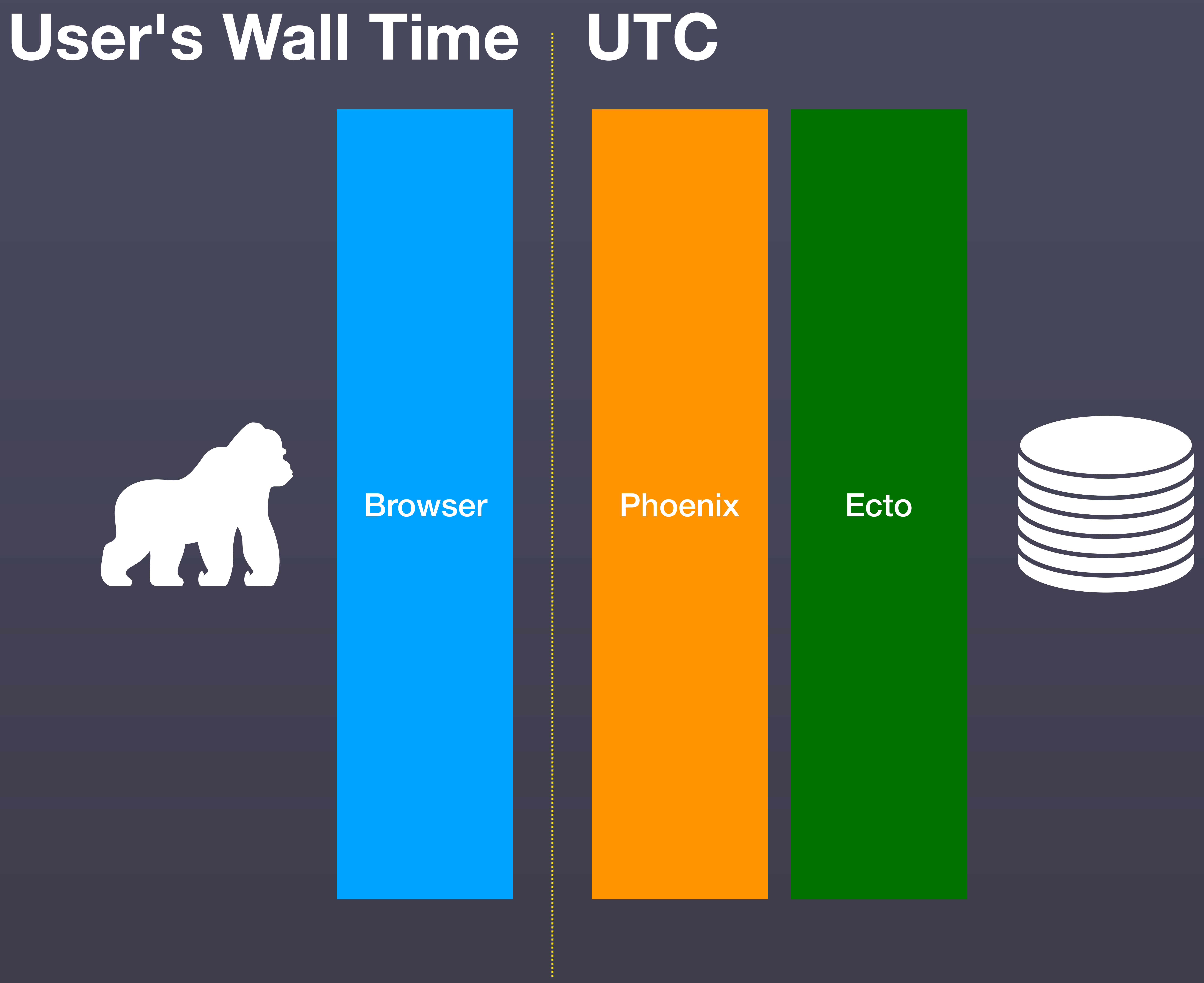
```
hello_dev=# \d+ users

     Column     |                Type
----------------+--------------------------------
 id             | bigint
 name           | character varying(255)
 birthday       | date
 nap            | time(0) without time zone
 born_at_native | timestamp(0) without time zone
 born_at_utc    | timestamp(0) without time zone
 inserted_at    | timestamp(0) without time zone
 updated_at     | timestamp(0) without time zone
```

```
schema "users" do
  field :name, :string
  field :birthday, :date
  field :nap, :time
  field :born_at_native, :naive_datetime
  field :born_at_utc, :utc_datetime
  field :born_at, :utc_datetime
  timestamps(type: :utc_datetime)
end

def change do
  create table(:users) do
    add :name, :string
    add :birthday, :date
    add :nap, :time
    add :born_at_native, :naive_datetime
    add :born_at_utc, :utc_datetime
    add :born_at, :timestamptz
    timestamps(type: :timestamptz)
  end
end
```



```
hello_dev=# \d+ users

     Column     |               Type               |
----------------+----------------------------------+
 id             | bigint                           |
 name           | character varying(255)           |
 birthday       | date                             |
 nap            | time(0) without time zone        |
 born_at_native | timestamp(0) without time zone   |
 born_at_utc    | timestamp(0) without time zone   |
 born_at        | timestamp with time zone         |
 inserted_at    | timestamp with time zone         |
 updated_at     | timestamp with time zone         |
```

Presenting Time in HTML



User's Wall Time

UTC

Browser

Phoenix

Ecto

Web App "Styles"

- **Request <-> Response**
  - Not told the user's timezone via any HTTP header. (hard)
- **Frontend JavaScript App (or using LiveView)**
  - Use JS while rendering the DOM (easy)

Use JavaScript

Detect Timezone via JS and then:

1. Transform DOM on the frontend
    - Have fun testing/debugging dozens of frontends.
2. Report Timezone back to server for future use
    - Would not be able to transform initial pages 😢

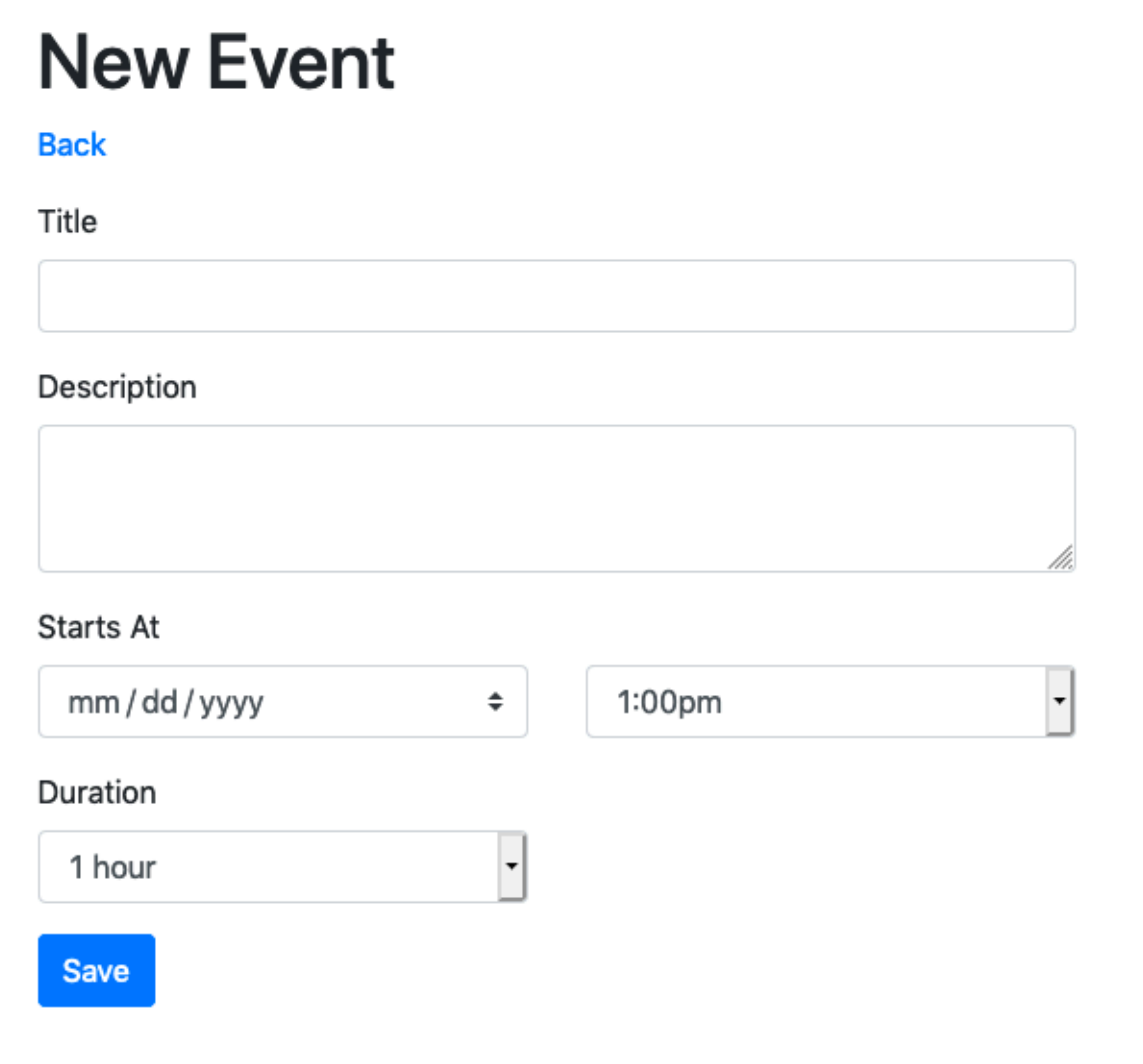
Ask the User

- User sets timezone as part of a registration and we use that from now on (and some site default before).
- Has issues when user is traveling and no longer in New York.
    - If they send a date time in a form while in San Fran, what does that mean?

- Silently set a group time zone upon group creation.
  - Allow group time zone to be edited.
- Use JS to fetch and report the browser timezone to server.
  - Server stores in user's session (req cookies).
- Upon page load, we use in order of availability:
  - User/Browser time zone
  - Group time zone
  - UTC

Accepting Time in HTML

HTML Forms



New Event

Back

Title

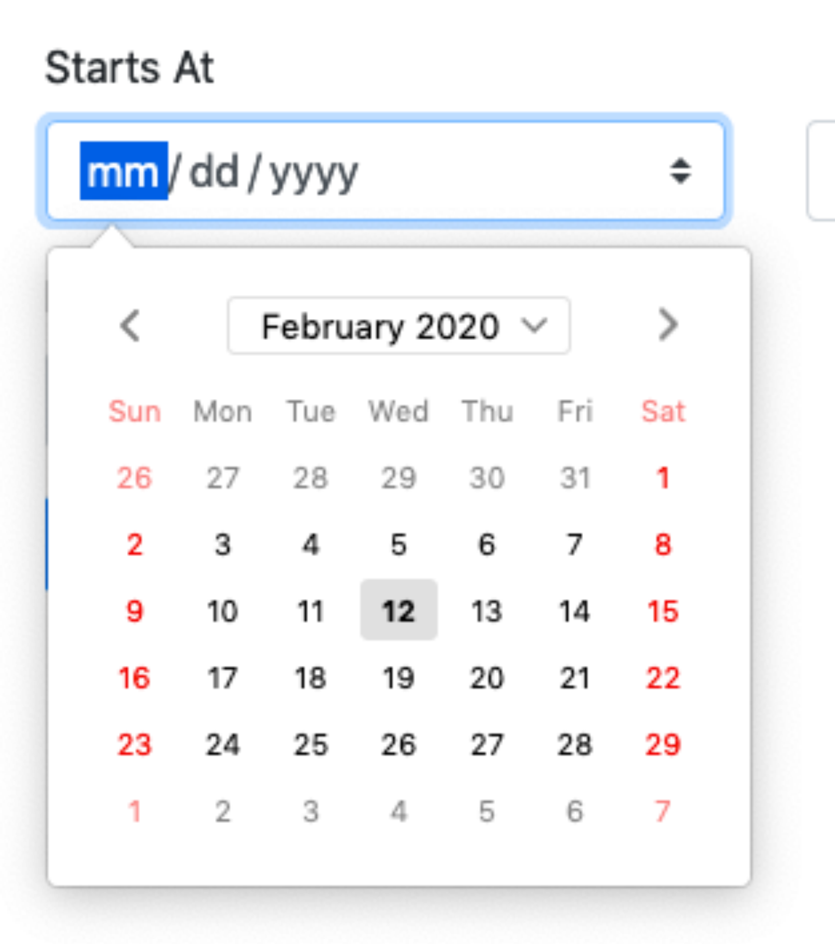
Description

Starts At

mm / dd / yyyy 1:00pm

Duration

1 hour

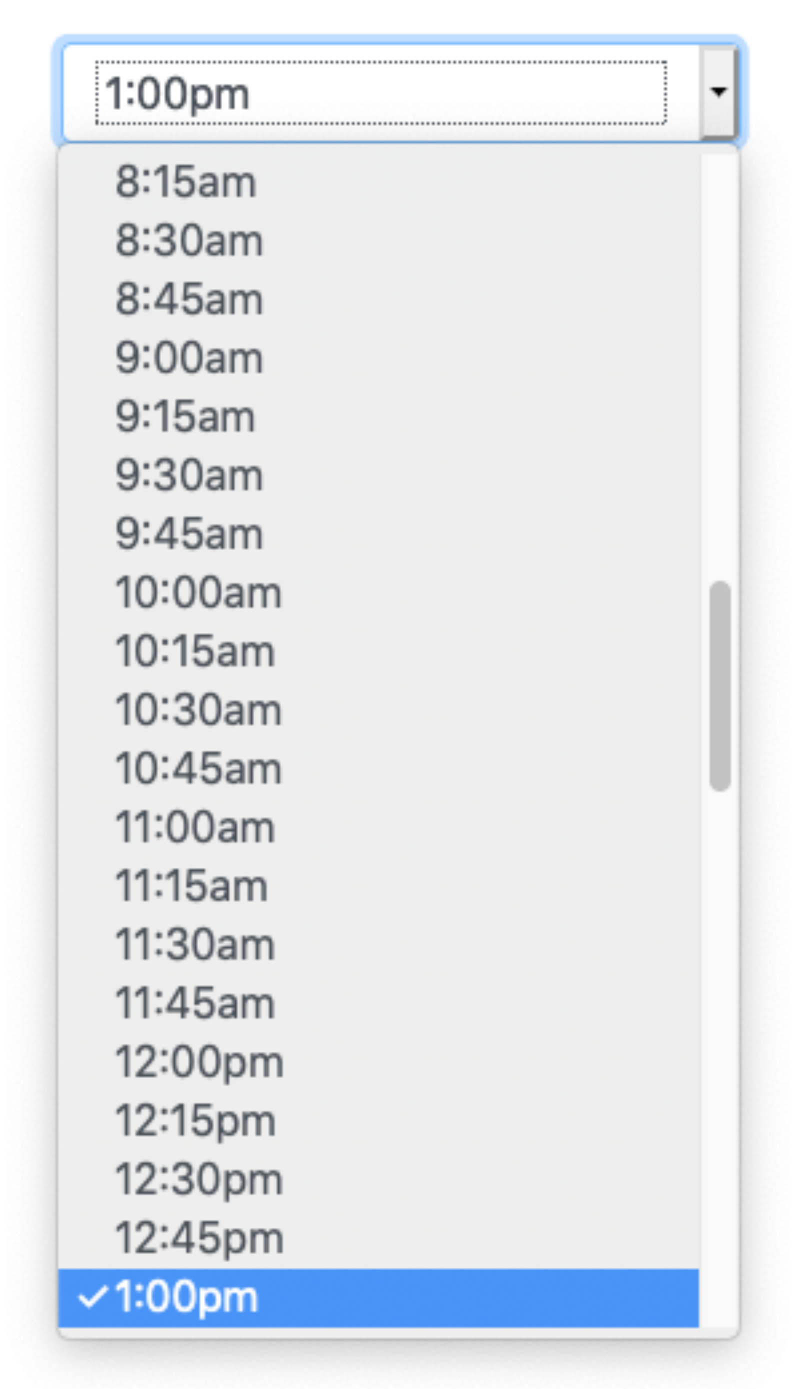


Starts At

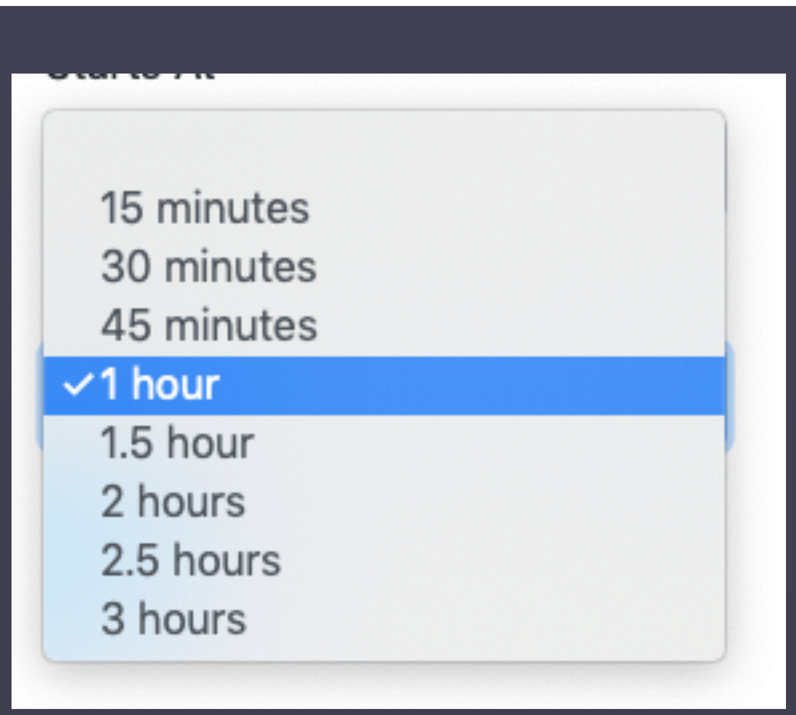
mm / dd / yyyy

February 2020

Sun	Mon	Tue	Wed	Thu	Fri	Sat
26	27	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
1	2	3	4	5	6	7

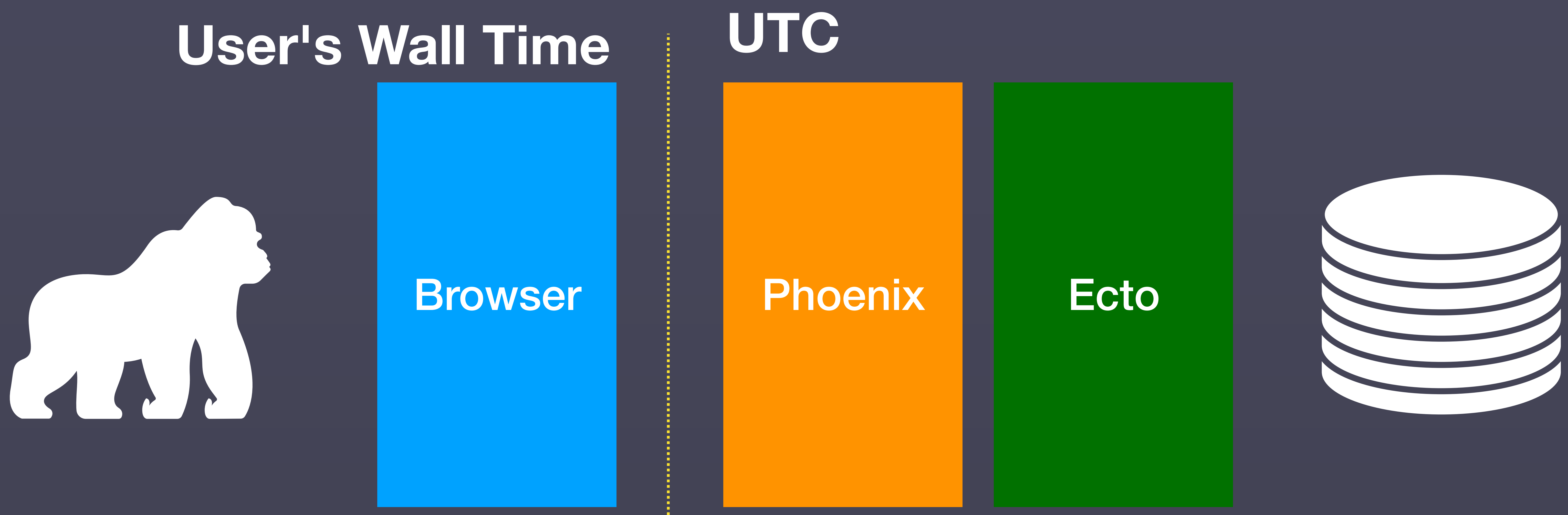


1:00pm



Time Zones Rules are Date-relative

Need to Imply the Form's Time Zone



Feb 12, 2020, 8:30 PM	Eastern Standard Time
July 11, 2020, 5:00 PM	Eastern Daylight Time

```
# Add up the form components to make a NaiveDateTime (no zone)
starts_at_naivedatetime = combined_form_elements()

# Get the user's time zone, "America/New York"
resolved_timezone_name = TimezoneHelper.resolved_timezone(conn, group)

# Find the implied time zone
timezone_for_form = Timex.Timezone.get(resolved_timezone_name, starts_at_naivedatetime)

starts_at_utc =
  starts_at_naivedatetime
    |> Timex.to_datetime(timezone_for_form)
    |> Timex.to_datetime("Etc/UTC")
```

Resources

- **ElixirConf 2019 - Date, Time, and Time Zones in Elixir 1.9 - Lau Taarnskov**
  https://www.youtube.com/watch?v=_E988mvPIzU

- **Date and Time · Elixir School**
  https://elixirschool.com/en/lessons/basics/date-time/

- **GitHub - lau/tzdata: tzdata for Elixir.**
  https://github.com/lau/tzdata

- **GitHub - lau/calendar: date-time and time zone handling in Elixir.**
  https://github.com/lau/calendar

- **GitHub - bitwalker/timex: A complete date/time library for Elixir projects.**
  https://github.com/bitwalker/timex

Mike Zornek

Home Blog Projects For Hire Talks Contact Micro.Blog

I have worked for more than a decade as a self-employed consultant (with a handful of years inside some larger agencies as well). Throughout that time I've helped dozens of companies execute projects on the **Mac, iOS and Web**. I enjoy project variety and the visible personal impact I can make as a consultant.

Let's chat and work on something together!

Services

iOS Development, Mentoring, Teaching

The majority of my projects in recent history have been in helping companies deliver iOS apps, through direct development or helping improve their full time iOS employees through teaching and mentorship. I consider myself to have a strong sense of successful user interface and often times help with crafting the user experience as well as implementing actual code behaviors.

Elixir, Phoenix, Absinthe (GraphQL) Development

I've come to enjoy using Elixir for personal work and have recently started offering Elixir development as a service.

> **What is Elixir?** Elixir is a dynamic, functional language designed for building scalable and maintainable applications. Elixir leverages the Erlang VM, known for running low-latency, distributed and fault-tolerant systems.