

Tamme Dittrich

What time is it?

An introduction to network
based time synchronization



What to expect today?

Topics:

- Applications
- Methods
- NTP and NTS
- PTP

Who am I?

Tamme Dittrich

- Embedded software engineer @ Tweede golf
 - Soft- and Firmware in Rust
 - Rust trainer
- Worked on
 - [ntpd-rs](#)
 - [statime](#)



Applications

●
TLS Certificates
(Minutes)

●
Oven Clocks
(Seconds)

●
Ordering Logs
(Milliseconds)

Applications

●
Differential Line Protection
(1 μ s)

●
5G Tx
(100 ns)

●
Physics Experiments
(<1ns)

Methods



GNSS



Radio
(DCF77)



Network

Protocols

●
NTP
(with NTS)

●
PTP
(IEEE 1588)

●
Roughtime
Draft

●
Raytime
Draft

Network Time Protocol (NTP)

History:

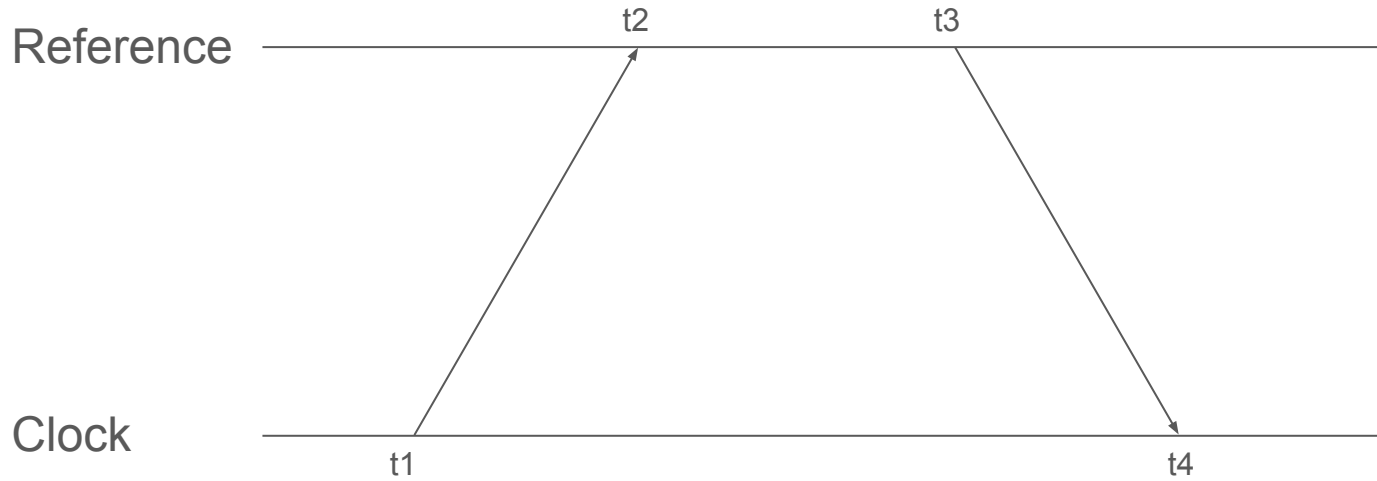
- v1 RFC 778 from 1981
- v4 RFC 5905 from 2010
- v5 [Draft](#)

Base Facts:

- UDP Port 123
- 48 bytes header
- Multiple Modes
- (Usually) no authentication

RIOT has [SNTP support](#)

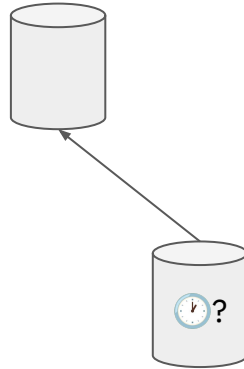
Principle of Operation



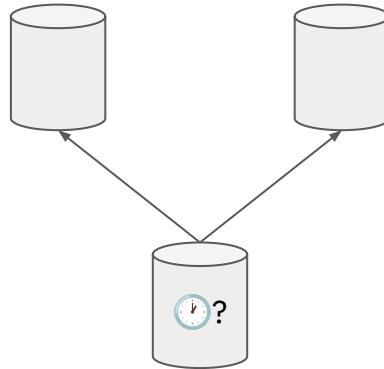
Time sources



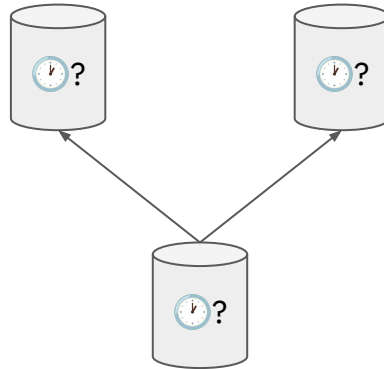
Time sources



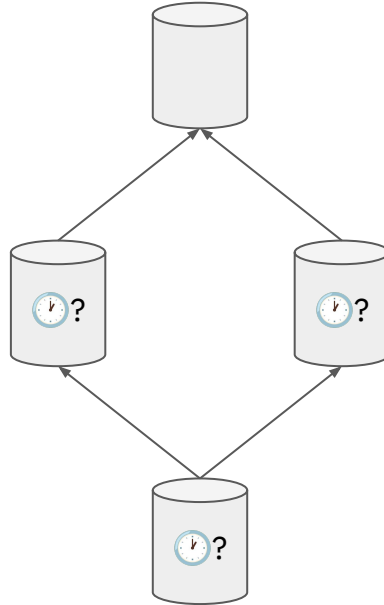
Time sources



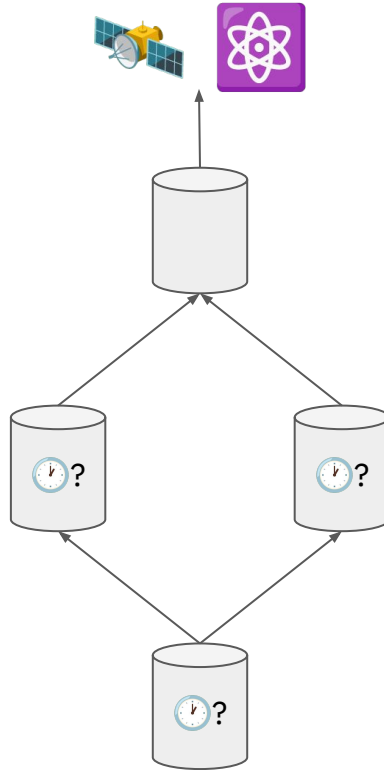
Time sources



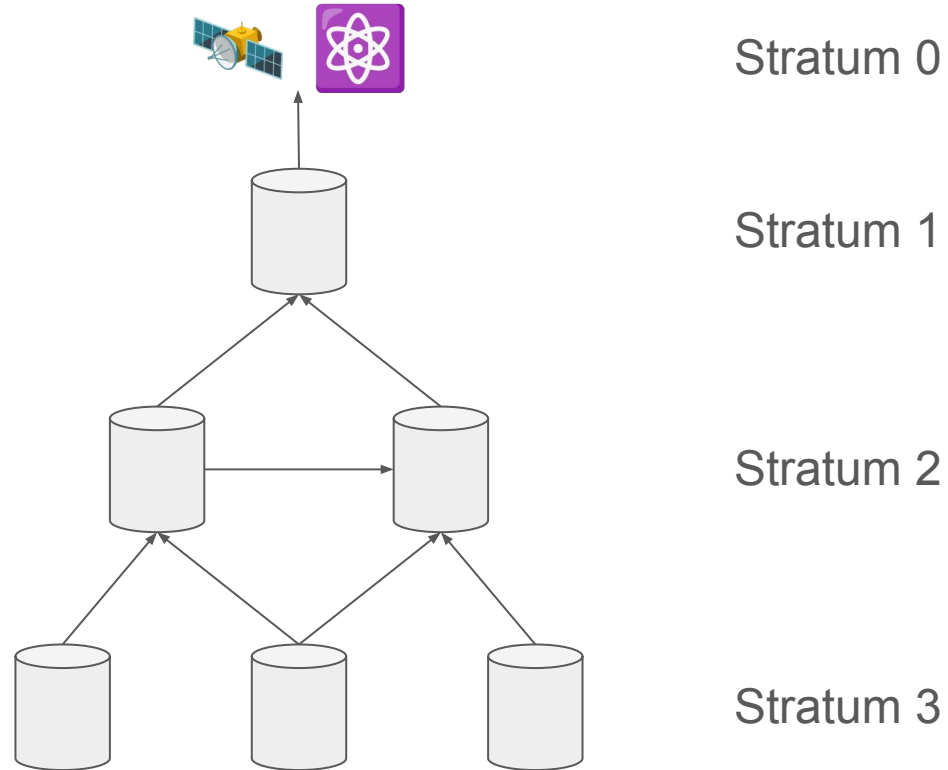
Time sources



Time sources



Time sources



Time stamps

1900-01-01T00:00:00Z 0x 00 00 00 00 . 00 00 00 00

Time stamps

1900-01-01T00:00:00Z 0x 00 00 00 00 . 00 00 00 00

2024-09-06T11:30:00Z 0x EA 85 66 38 . 00 00 00 00

Time stamps

1900-01-01T00:00:00Z 0x 00 00 00 00 . 00 00 00 00

2024-09-06T11:30:00Z 0x EA 85 66 38 . 00 00 00 00

2036-02-07T06:28:16Z 0x FF FF FF FF . FF FF FF FF

Time stamps

1900-01-01T00:00:00Z 0x 00 00 00 00 . 00 00 00 00

2024-09-06T11:30:00Z 0x EA 85 66 38 . 00 00 00 00

2036-02-07T06:28:16Z 0x FF FF FF FF . FF FF FF FF

2036-02-07T06:28:17Z 0x 00 00 00 01 . 00 00 00 00

Network Time Security (NTS)

- RFC 8915 from 2020
 - ntpd-rs
 - Chrony >4.0
 - NTPsec >1.2.0
- Two phases
 - NTS-KE (via TCP and TLS)
 - NTP extensions (via UDP)
- Problem: Bootstrapping

ntpd-rs

- NTS support
- NTPv5 draft
- [Used by LetsEncrypt](#)
- [Kalman Filter](#)

Precision Time Protocol (PTP)

- IEEE 1588
- HW Timestamping
- 48+32 bit timestamps
- Path correction

PTP developments

- White Rabbit (Special HW)
- Draft: [NTS4PTP](#)

PTP Software

- Parts
 - BMCA: Best Master Clock Algorithm
 - Clock Steering (HAL)
 - Network Stack (Timestamps)
- Implementations
 - Linux PTP
 - statime

RIOT has a [PTP clock HAL](#)

Statime

- Binary + Library
- Sans-IO & no_std
- Kalman Filter
- Runs on STM32

Not Covered Here



Time Zones



Leap Seconds



UTC vs TAI vs UT1 vs GPS



Reference Frames

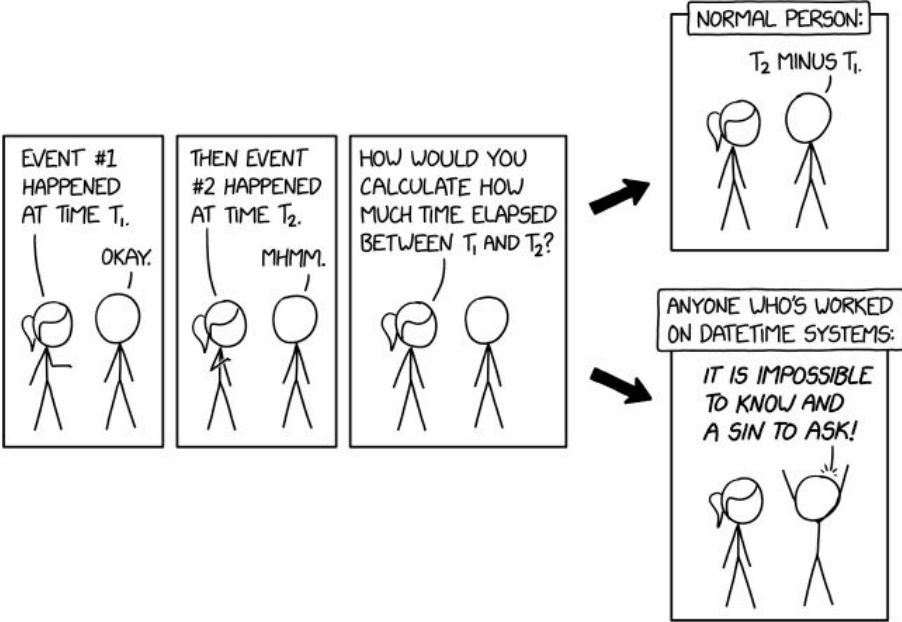
Not Covered Here

Time Zones

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Reference Frames



[XKCD 2867 "DateTime"](#) by xkcd.com / [CC BY-NC 2.5](#)

Takeaways



Time is
important



Sync your
clocks



Use NTS

Thanks

Getting the code

<https://github.com/pendulum-project>

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