Providing time & frequency at scale

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Netnod Internet Exchange

- Internet infrastructure organisation founded in 1997.
- 30 employees.
- 100% owned by a foundation.

Netnod Internet Exchange

- Largest Internet Exchange Point operator in the Nordics (>160 connected networks in Stockholm).
- Manages the i.root-servers.net DNS server carrying the DNS root zone.
- DNS anycast services to ccTLDs, enterprises and partners.
- Time and frequency services.

Netnod's Internet Exchange

- Internet Exchange with $\approx$ 200 ASNs.
- WDM transport throughout the Nordics between IX points.
- Metro access between datacenters.

Netnod's Internet Exchange Presence

Time & frequency @ Netnod I

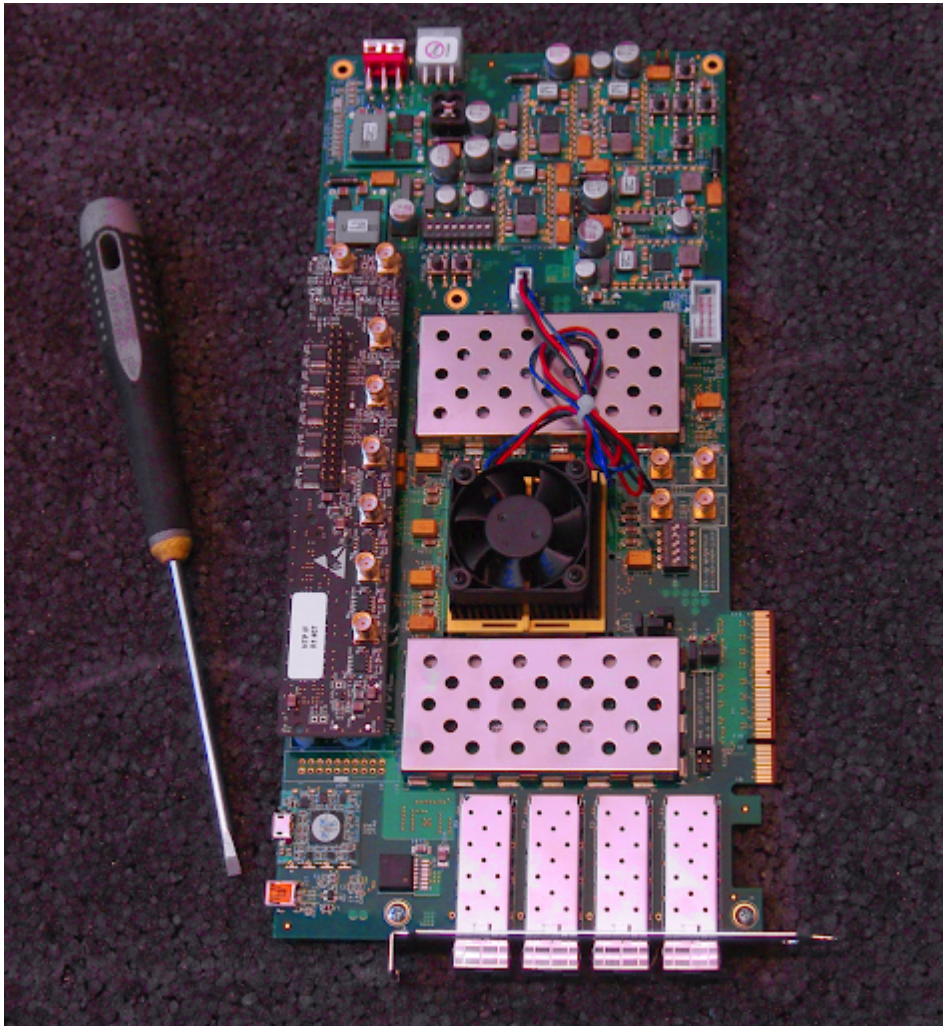
- From 1993 Peter Löthberg provided NTP to the public from an atomic clock.
- Since at least 2003 Netnod has provided NTP services.
- Under contract with Swedish Post and Telecom Authority (PTS).

Time & frequency @ Netnod II

- 4 sites. Working on #5.
- Cesium clocks, 2x at each site.
- Local time scales traceable to UTC (SP) within $\pm$ 250 ns.
- NTP servers in hardware!
- PTP on request.
- Operational in this setup since 2015.
- `https://www.netnod.se/ntp/`


CBL: 222, Delay: 6,21 ns
CBL: 208, Delay: 6,17 ns
CBL: 221, Delay: 6,21 ns

Xilinx VC709



NTP Server

- Full wirespeed (4 x 10 GigE) NTP at once.
- DoS protection.
- Clock inputs (PPS + 10 MHz) x 2, connected to both local timescales.
- Automatic failover to second clock if primary fails.

Verilog NTP server

https://github.com/Netnod/FPGA_NTP_SERVER

NTP server addresses

Anycast address: `ntp.se`

Malmö:

- `mmo1.ntp.se`
- `mmo2.ntp.se`

Göteborg:

- `gbg1.ntp.se`
- `gbg2.ntp.se`

Stockholm:

- `sth1.ntp.se`
- `sth2.ntp.se`

Sundsvall:

- `svl1.ntp.se`
- `svl2.ntp.se`

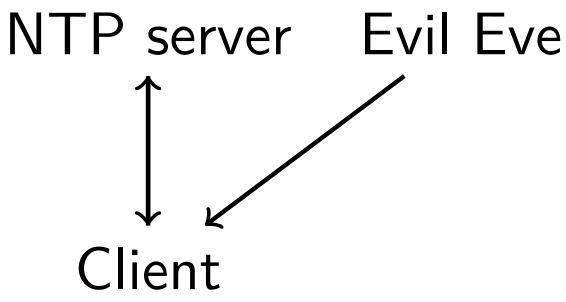
PTP

- PTP available on request.
- Delivered over dedicated fibre.

NTP protocol

- Oldest protocol still in use on the Internet?
- Does anyone remember PDP-11 Fuzzballs?
- Insecure.

Spoofing



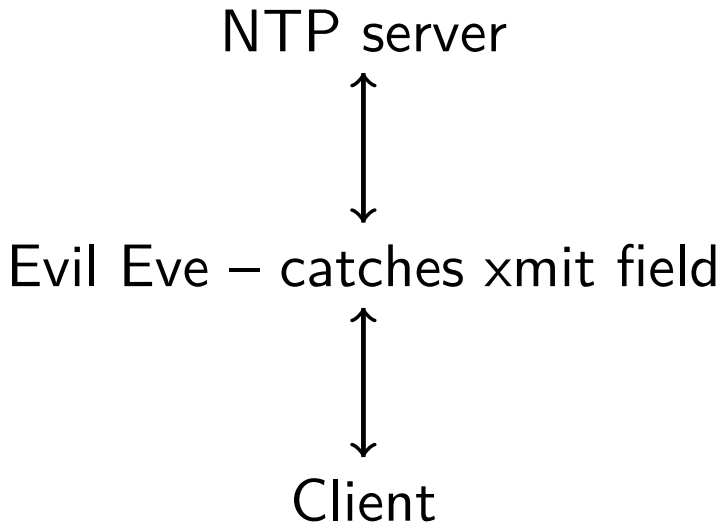
- UDP-based.
- No source identification other than IP address.
- If you can spoof the source, you can lie about time!

Spoof protection

- NTP `xmit` field — timestamp of sending program.
- On a client, this was originally used for sending what the client thought the time was.
- On modern clients, a spoof protection. 8 random bytes.
- The server simply copies the `xmit` field to the origin time (`org`) field.
- Client verifies that received `org` = sent `xmit`.

Eve – the woman in the middle

Still open for (wo)man in the middle attacks.



But NTP supports signatures!

- Symmetric keys only.
- Similar to TSIG in DNS.
- Needs a different key per consumer.
- Can't publish keys – defeats purpose.
- We support symmetric NTP signatures in the FPGA server for specific customers.

Network Time Security (NTS)

- Network Time Security (NTS) in IETF NTP working group.
- Netnod has been a large part of the standards work.
- `https://datatracker.ietf.org/doc/draft-ietf-ntp-using-nts-for-ntp/`
- "WG state: Submitted to IESG for Publication"

NTS Protocol

- Really two protocols: NTS-KE & NTP
- NTS-KE: Key exchange over TLS 1.3.
- NTP extended with Extension Fields for NTS specific data, signatures, et c...

Netnod's NTS server

Proof-of-concept server running at:
`nts.ntp.se:4443`

NTS implementations

Netnod is supporting three implementations:

- A Go client with NTP and NTS-KE packages.
- A Python client and server with NTP and NTS-KE modules.
- A Verilog implementation of the NTP extensions.

There are a few other implementations...

Go implementation

- Implemented by myself and friends on some (remote) IETF hackathons.
- Client: `https://gitlab.com/hacklunch/ntsclient/`
- NTS-KE protocol: `https://gitlab.com/hacklunch/ntske`
- NTP with NTS extension fields: `https://gitlab.com/hacklunch/ntp`
- Netnod sponsored with pizza and beer.

Python PoC server and client

- Consultant Christer “wingel” Weinigel (`http://weinigel.se/`).
- `https://github.com/Netnod/nts-poc-python`

Verilog NTS

- Consultants Joachim Strömbergson and Peter Magnusson from Assured (`https://assured/`).
- Code not yet available.

NTS-KE – the key exchange

- Establish NTP server to talk to.
- Establish algorithm.
- Establish session keys: C2S & S2C
- Get initial session cookies.

NTP Extension Fields for client

- Cookie.
- Placeholder asking for more cookies.
- Signature with C2S key.

NTP Extension Fields for server

- Signature with S2C key.
- Maybe new cookie for client's later use (if client asked for it).
- Fields can be encrypted optionally.

Cookies

- Keeps most of the server's state in cookies.
- Exact content of cookies are known only to server.
- Session keys are in cookies, everything the server needs to verify client and sign the NTP packet.

IETF NTP working group

https://datatracker.ietf.org/wg/ntp/about/

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