How Sweden built a world-leading time network

Karin Ahl, Interim CEO, Netnod

National distribution of Swedish time

- Reasons and requirements for a national time distribution network
- Infrastructure we use to ensure security, accuracy and redundancy
- Network Time Security (NTS)
- Main players: PTS, RISE and Netnod

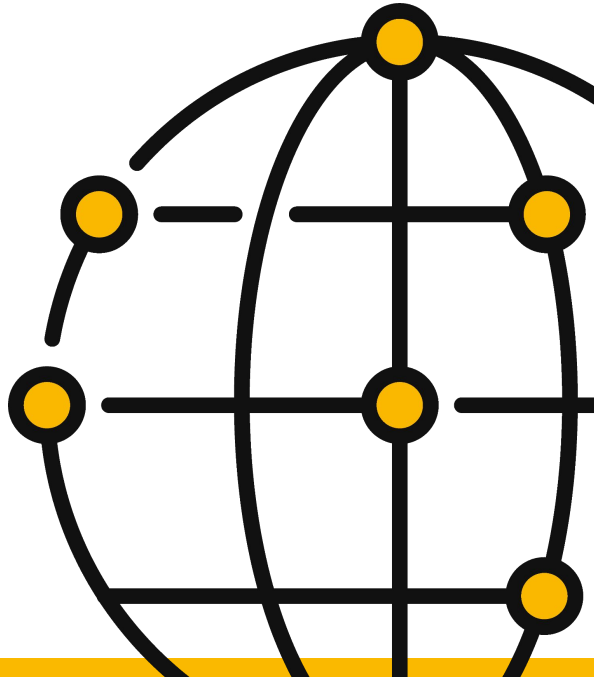
Netnod background

A neutral organisation with more than 25 years working at the core of the Internet

- Operates the largest **Internet Exchange (IX)** in the Nordics
- Manages I-root, one of world's 13 root name **DNS** servers
- Provides **DNS services** to enterprises and some of the largest Top Level Domains in the world
- Develops **Time services** with the highest levels of accuracy and security

Netnod: working for the good of the Internet

- Netnod is a neutral organisation formed and fully owned by the non-profit Stiftelsen för Telematikens Utveckling (TU-Stiftelsen).
- We are focused on contributing to the development of the Internet by:
    - providing rock solid, best-in-class services at the core of the Internet
    - ensuring full redundancy and the highest level of service availability
    - playing a role in standards and governance activities important for Netnod’s services and customers



We always know what time it is

The reasons and requirements for a national time distribution network

Why a national time distribution system?

- Citizens and critical community services are dependent on the availability of electronic communications
- Electronic communications have a dependency on correct time and frequency
- Time and frequency distributed by GNSS can be easily spoofed or interrupted

Given these factors we identified a public need which was not delivered by the market

GNSS - good, cheap but easily compromised

GPS - GLONASS - Galileo - BeiDou

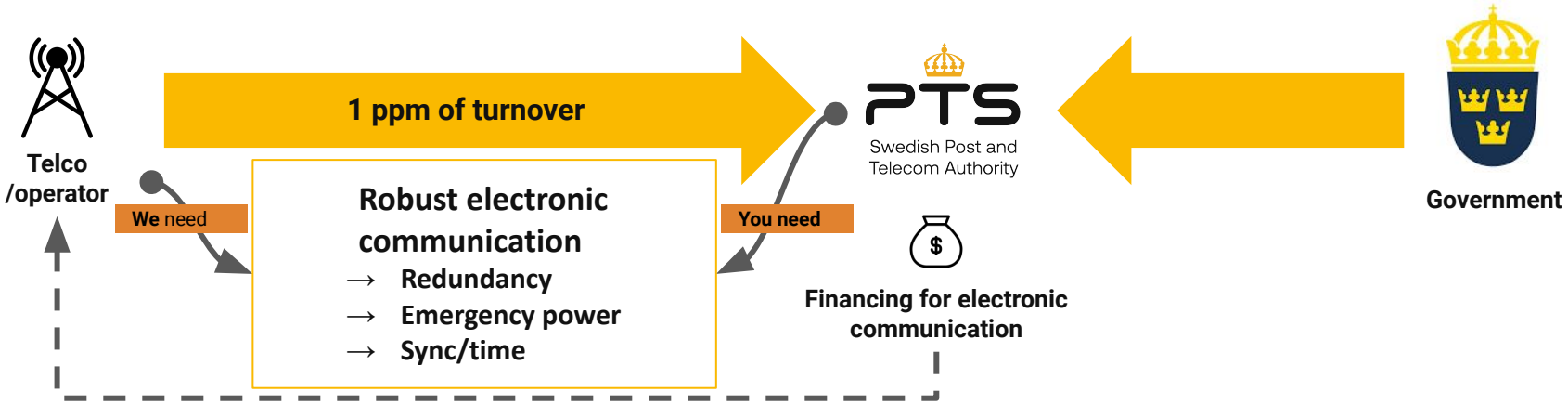
- Common even in critical infrastructure
- Easy to disrupt with cheap equipment (jamming)
- Easy to “fake the time” (spoofing)
- Not available all the time:
  - signal interference
  - outdated equipment and infrastructure problems
  - sabotage - “not peacetime”

€10 GNSS receiver
€250 software based radio that can be used to manipulate the receiver

A national time distribution system

- A system without GNSS dependency which, from a national perspective, can guarantee robust and secure time
- The system must be robust and available throughout the country
- The services delivered from the system must be affordable for operators of networks so that the price is not a barrier for use of the services
- The government must have visibility and direct input regarding the infrastructure, which means it must be located in, and operated from, Sweden

Robust financing



NET NOD

We always know what time it is

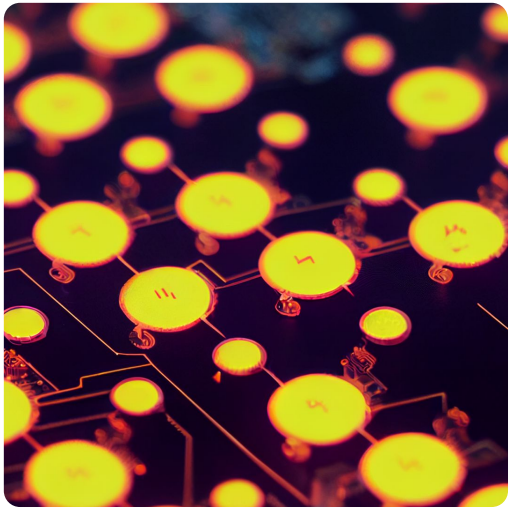
Outline of infrastructure

Netnod’s clock nodes - accurate and secure time

- Dual nodes with all critical equipment duplicated for redundancy (2x caesium clocks)
- Dedicated battery backup for all time components
- NTP/NTS servers use a custom-built FPGA-based hardware implementation

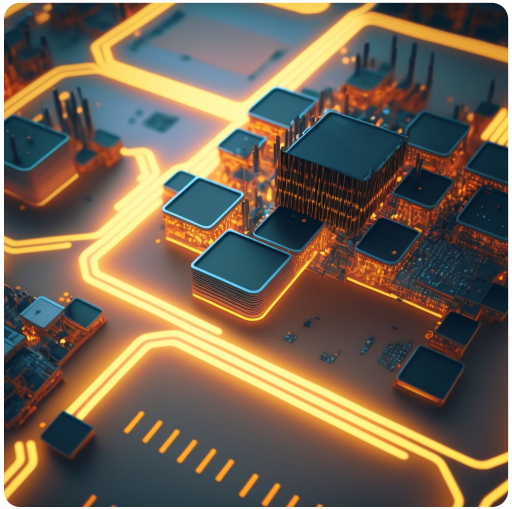
Swedish distributed time service

- 6 time nodes placed in secure bunkers throughout Sweden (Stratum-1 time servers)
- Time traceable to UTC
- Free and commercial service with SLA
- Operated by Netnod, monitored by RISE and financed by PTS



NTP service

Connect for free to one of the most advanced and secure NTP services available which also includes...

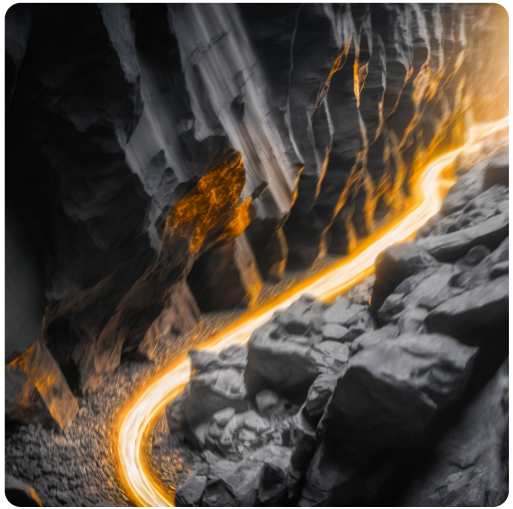


NTS service

Connect for free to ensure you are receiving secure and accurate time from a trusted source

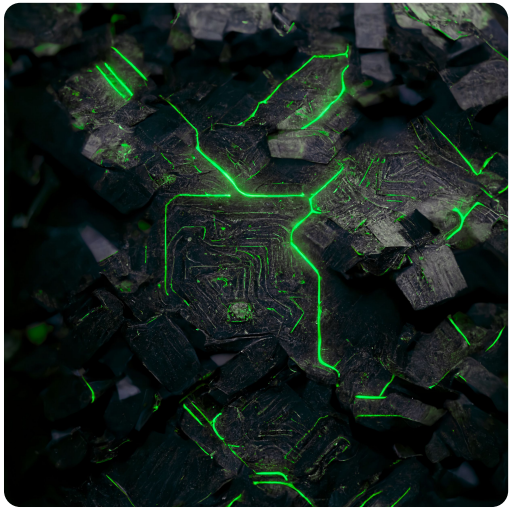
Netnod PTP

Ensure your network the highest level accuracy with the most robust, reliable and accurate source of time available without running your own atomic clock.



Netnod Time Direct

Get the most accurate and reliable time available over an IX port with a fully-managed, secure time service that guarantees 30µs accuracy from UTC.

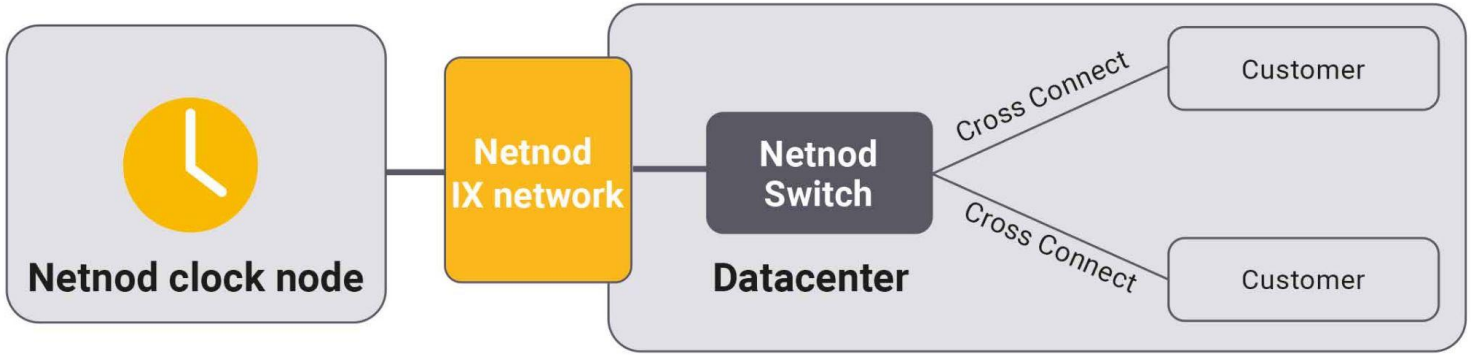


Netnod Time Remote

Get accurate and reliable time securely delivered wherever you are located in Sweden with a guaranteed accuracy of 1ms from UTC.

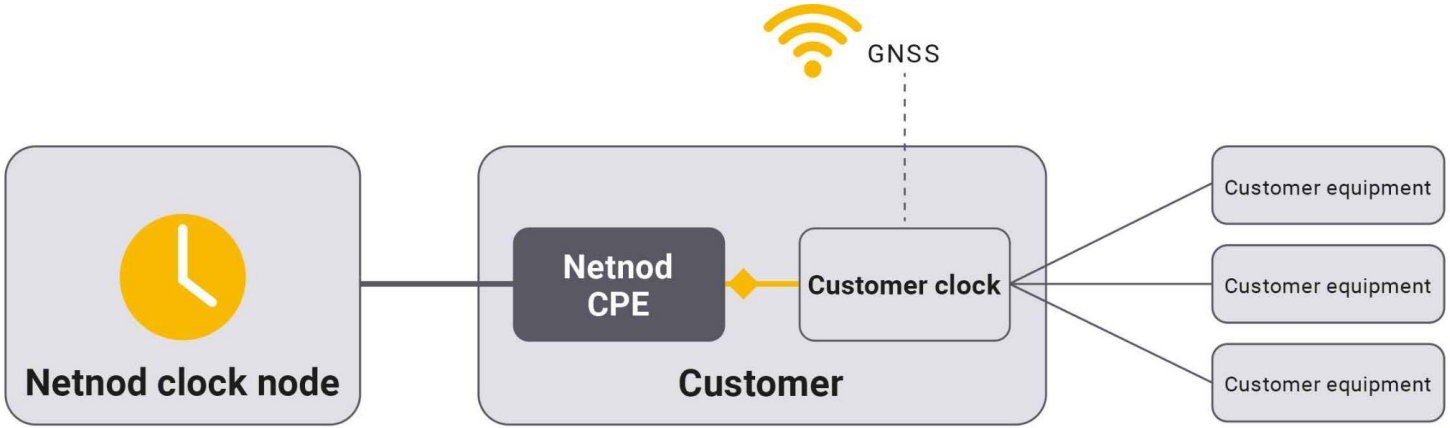
Netnod Time Direct - time-as-a-service

- A fully managed time service with SLA that guarantees 30µs accuracy from UTC
- Delivered over cross-connect or IX port
- Immediate provisioning and easy integration with current setup



Netnod Time Remote - time-as-a-service

- Fibre connection from Netnod's central clock nodes to locally placed equipment (CPE) from Netnod
- The CPE's clock is set by Netnod's central clocks
- The CPE delivers high precision, stable time: within 1ms of UTC
- Client clocks can be set from the CPE



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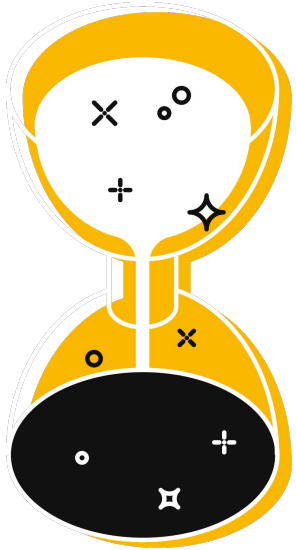
We always know what time it is

Network Time Security

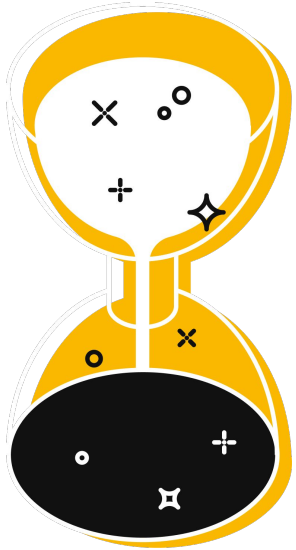
NTP is vulnerable

- No security
  - Plain text, vulnerable to man-in-the-middle attacks
  - Time is important
    - TLS, HTTPS, SMTPS, IMAPS, POP3S
    - DNSSEC
    - Timestamps on logs and transactions
- Actually: no scalable security
  - Authentication using a shared secret and MD5/SHA1
    - Limited number of shared keys (16 bits)
    - Key distribution is hard
  - Autokey never caught on

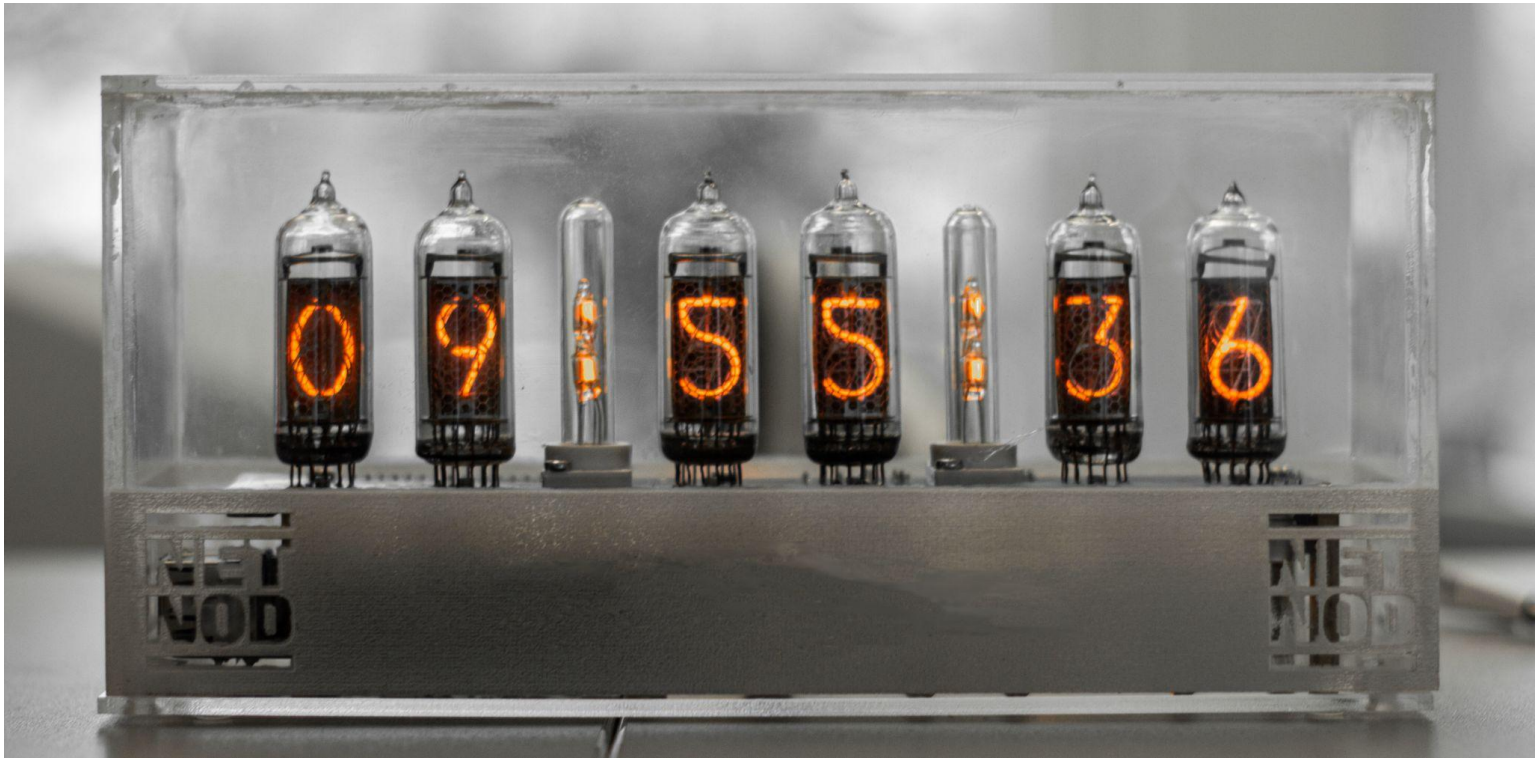


What is NTS?

- NTP with security
  - Adds authentication and encryption to NTP
  - Scales to an unlimited number of clients
  - Netnod got involved as co-authors in IETF draft process during 2018
  - Published as RFC 8915 in September 2020



nts.netnod.se

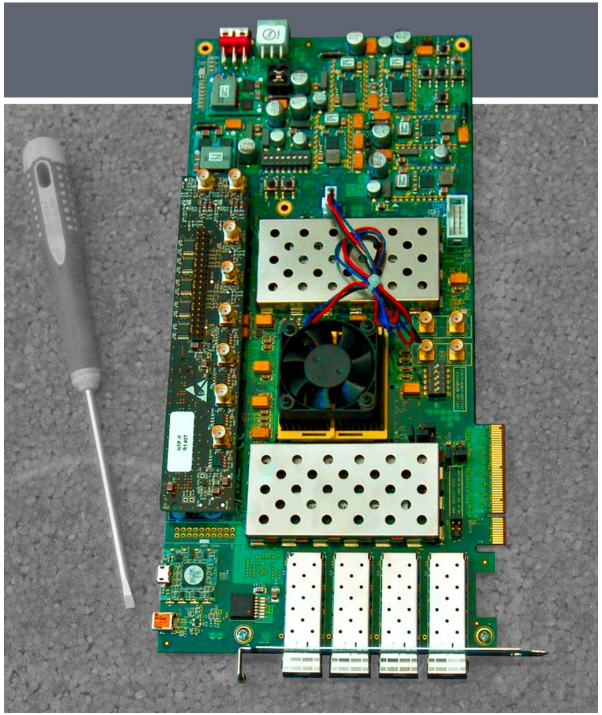


NTS sites

- We operate 6 nodes with Stratum-1 NTS servers
  - Luleå
  - Sundsvall
  - Stockholm x2
  - Gothenburg
  - Malmö/Copenhagen

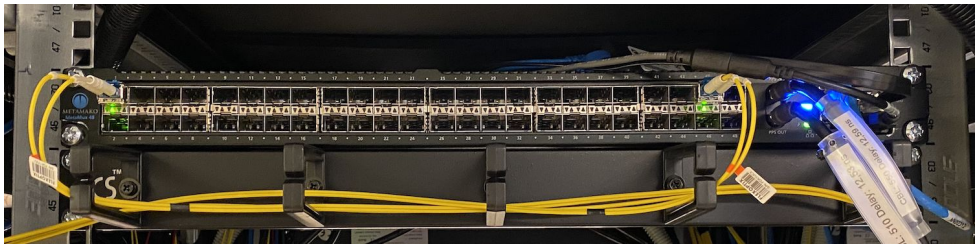
Hardware NTP server in FPGA

- Public Internet service
- 4 x 10 Gb/s full wire speed
- IPv4 and IPv6
- Secure - NTP traffic stays in the FPGA
- Standard FPGA board, with custom interface for time input and output (1 PPS & 10 MHz)
- Open source FPGA code



Hardware NTP with NTS server in FPGA

- NTP with Network Time Security
- RFC 8915
- Public Internet service
- Our implementation runs in a commercial vendor’s box (white box), many other variants possible
- Open source FPGA code

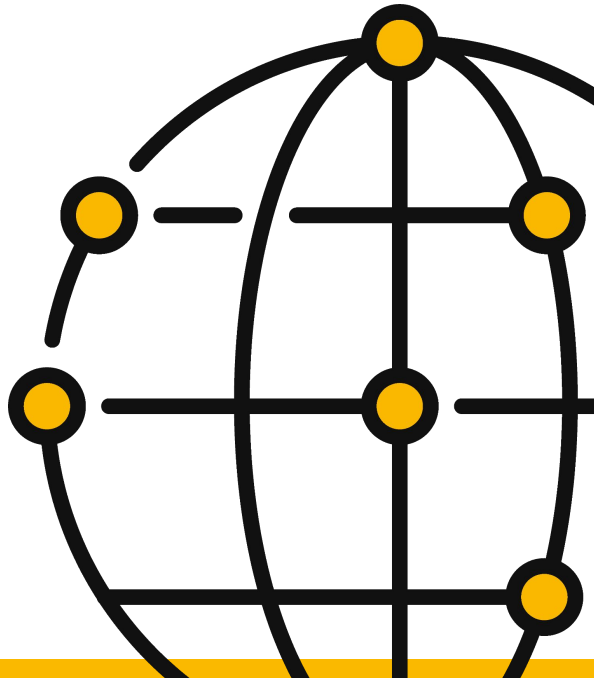


How to connect to NTS

- Most LINUX distributions allow you to run Chrony or NTPsec which supports NTS
- Install Chrony/NTPsec or similar as NTP client
- Configure NTS [point at Netnod's NTS servers]
- Verify

Full how to available here:

https://www.netnod.se/netnod-time/how-to-use-nts

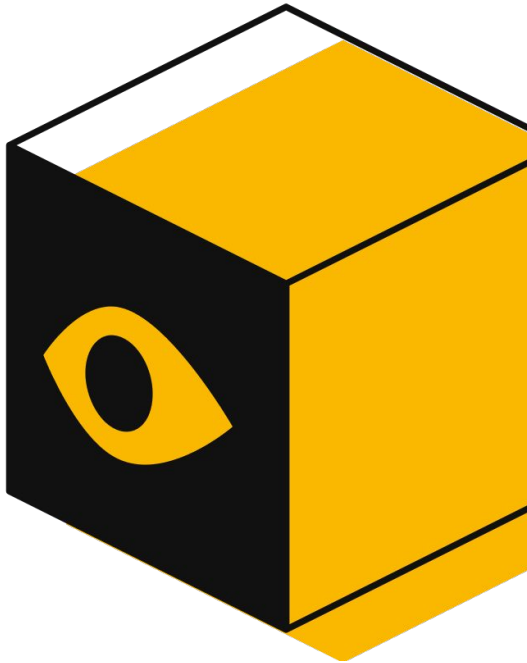


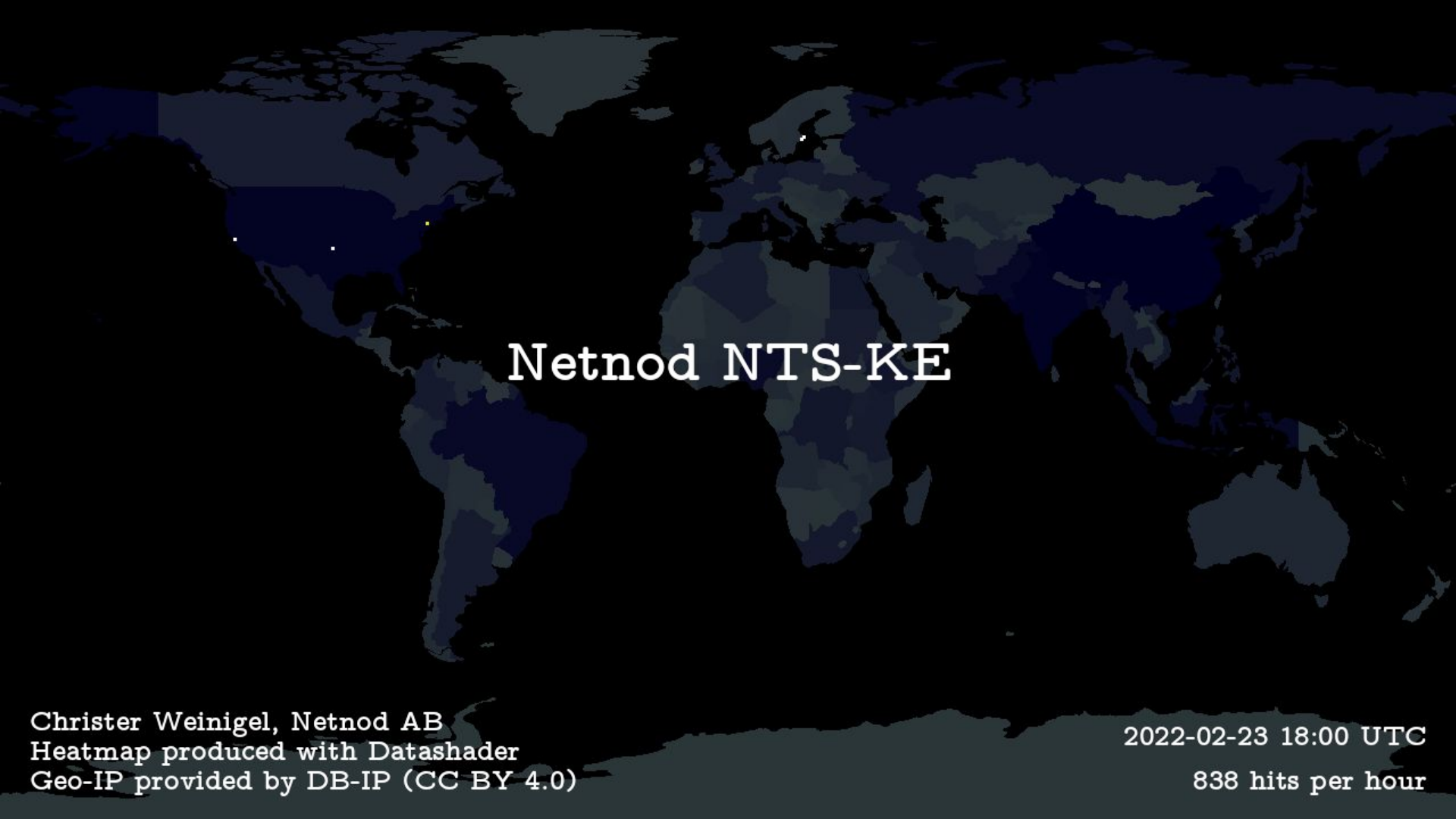
References

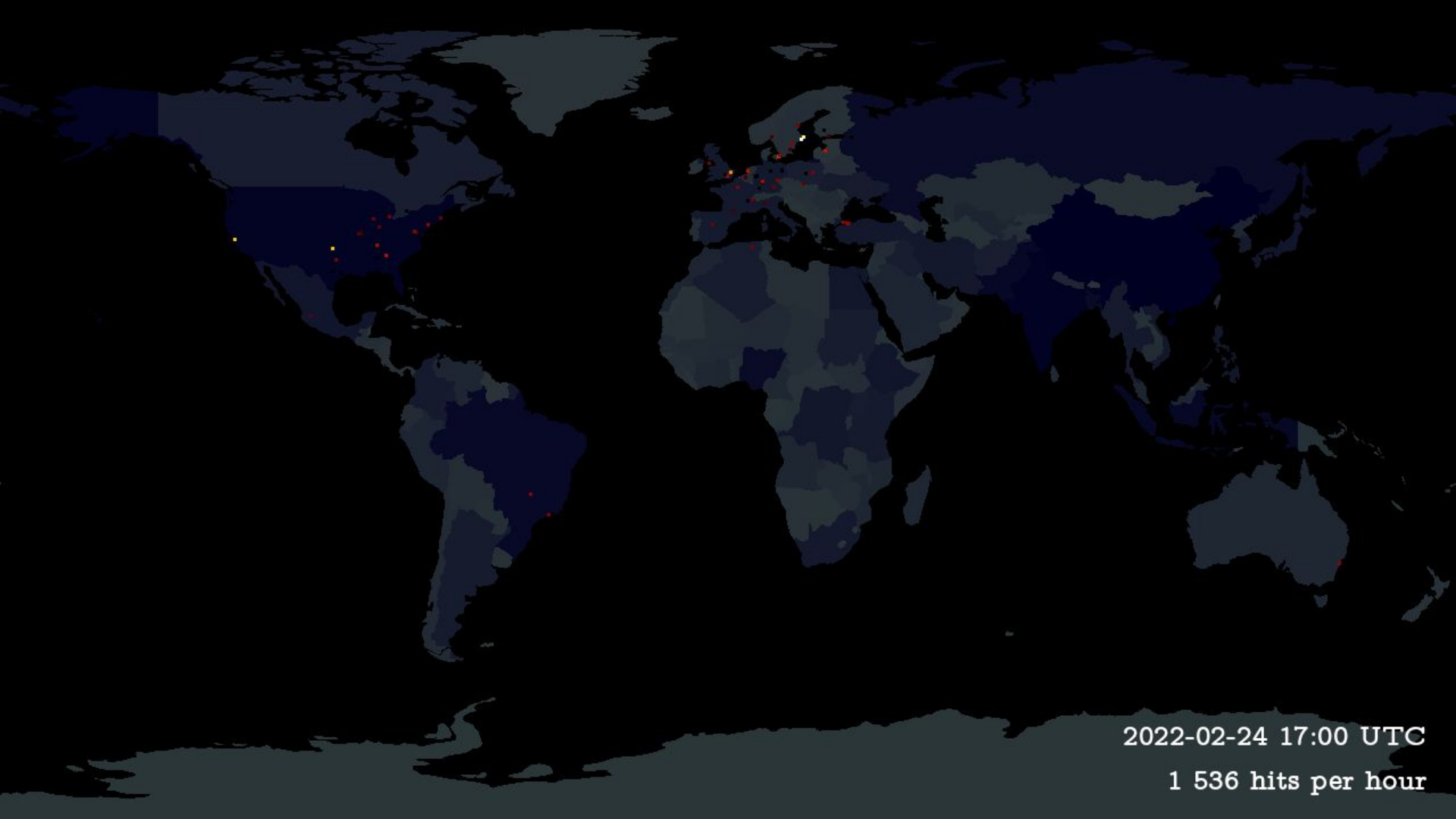
- AXIS Communications - Q&A on NTS deployment
- NTS white papers
  - How does NTS work and why is it important?
  - How we developed the world's first hardware implementation of Network Time Security
- Best practice for connecting to NTP servers
- How to set up an NTS client
- List of Netnod time services

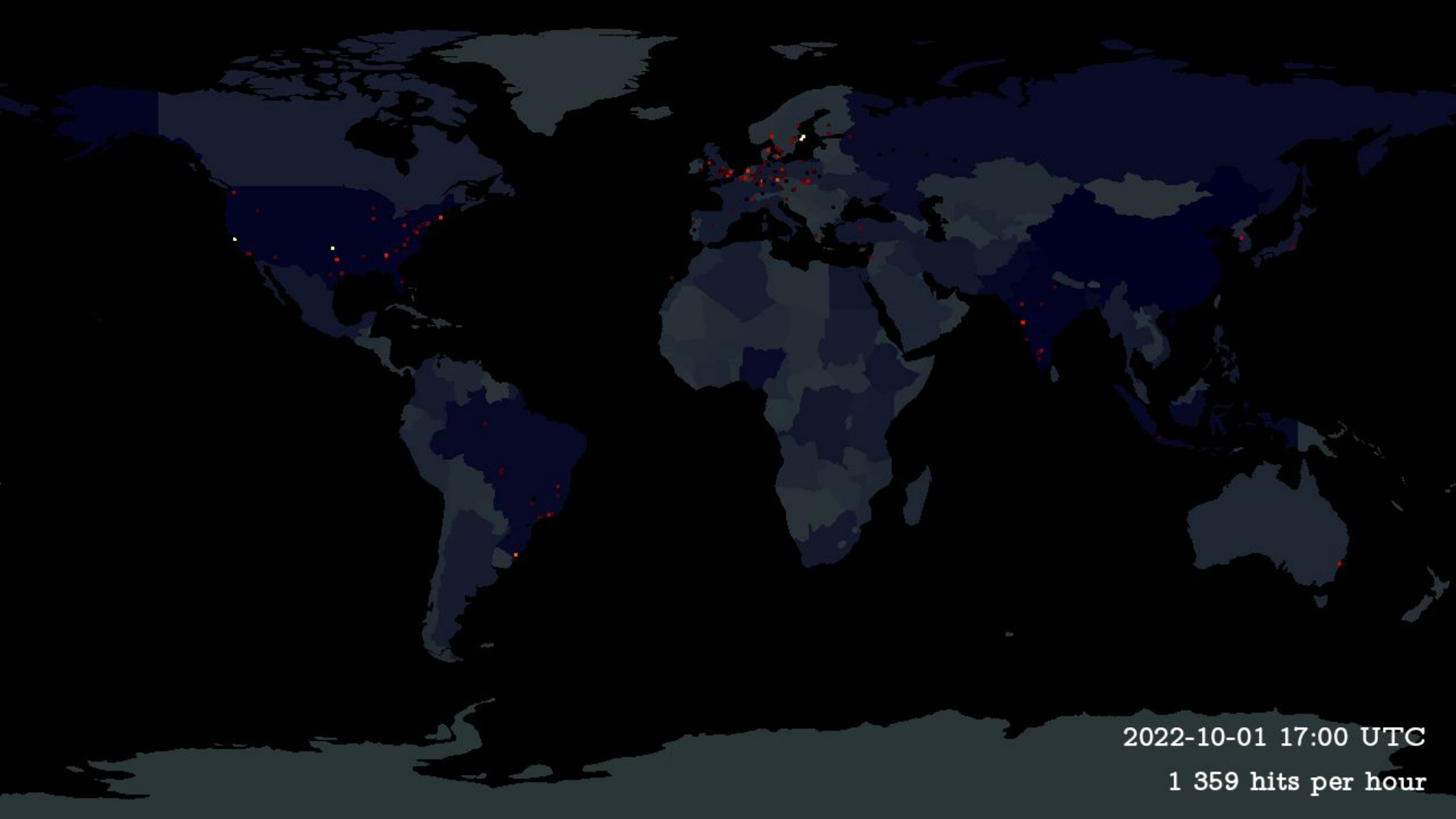
Conclusions

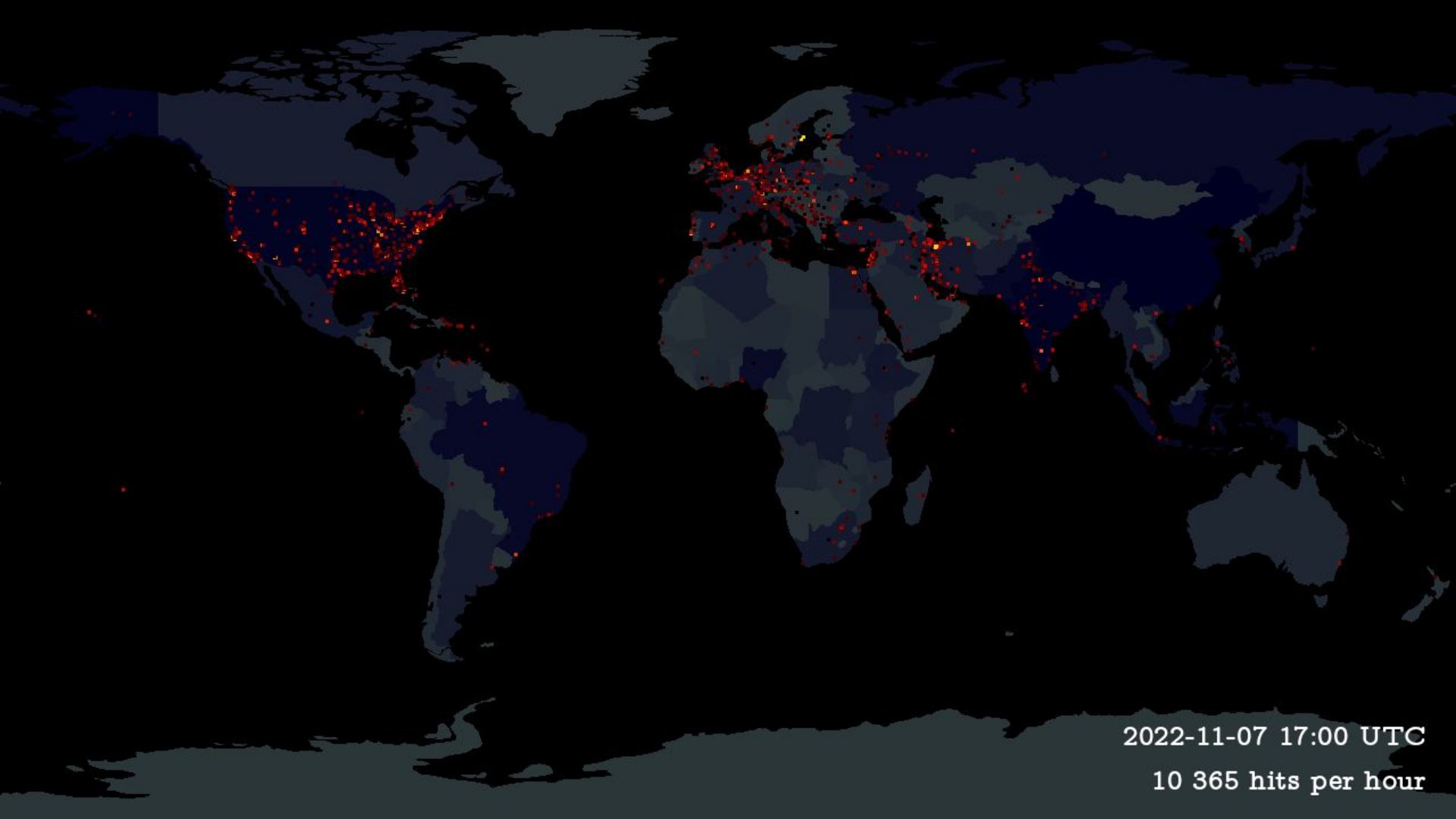
- Developing a national time distribution service is hard!
  - High-level of expertise
  - Investment
  - Cooperation
- Private public cooperation has been a huge success factor
- The customer doesn't always know what they need
- Time distribution requirements/technologies are changing (upcoming challenge: time for IoT devices)
- Use NTS!

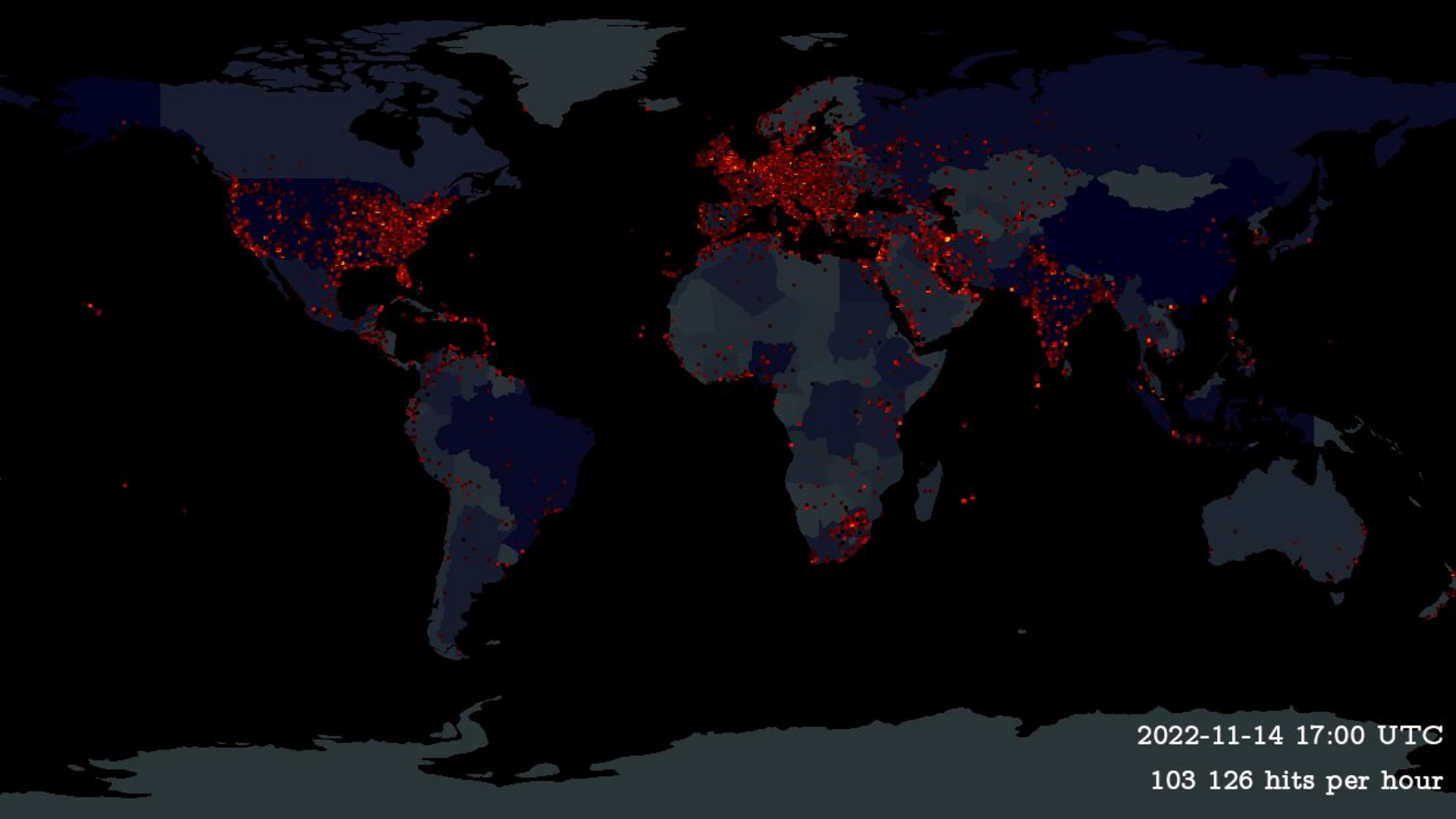


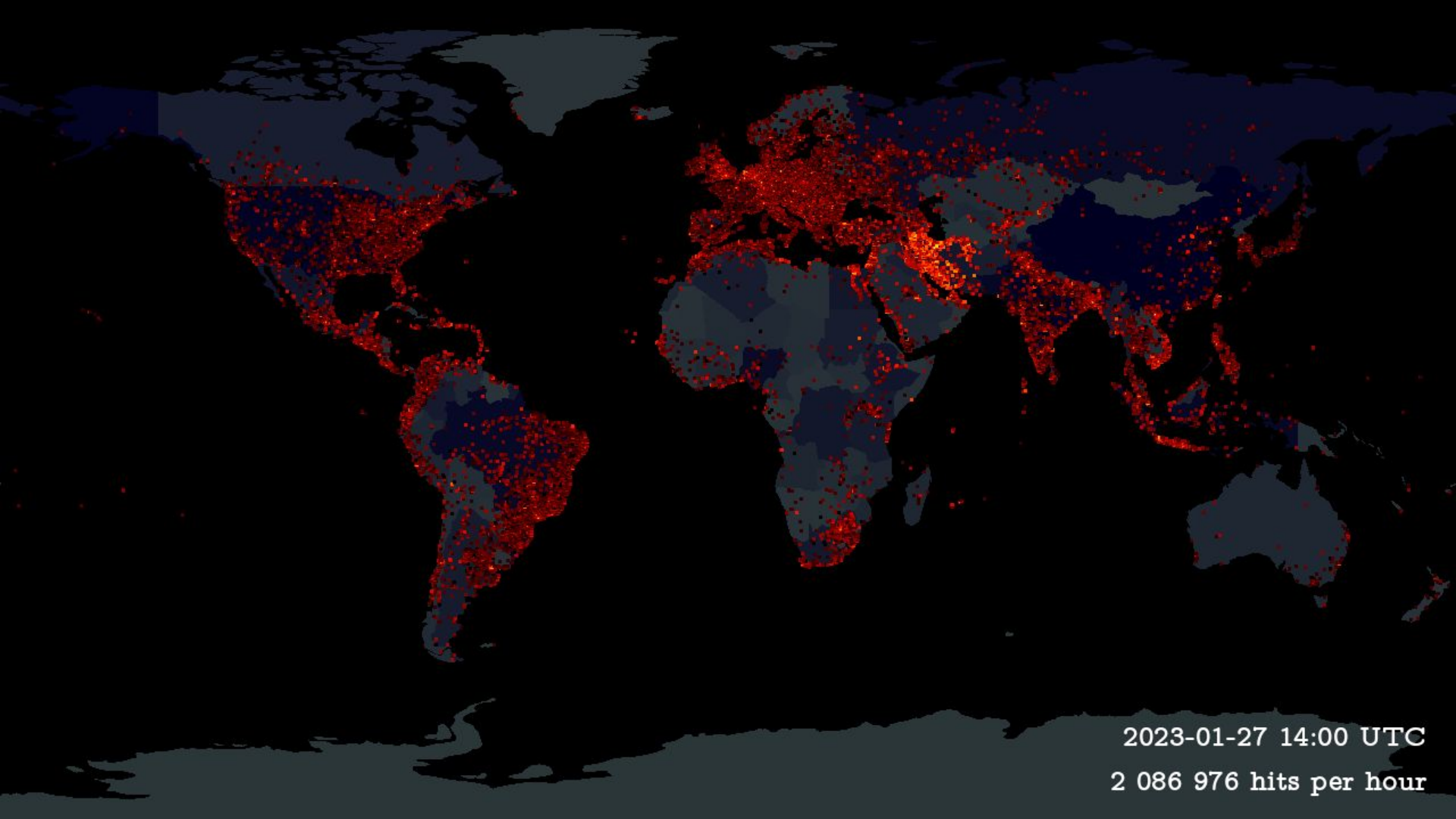

Netnod NTS-KE
Christer Weinigel, Netnod AB
Heatmap produced with Datashader
Geo-IP provided by DB-IP (CC BY 4.0)
2022-02-23 18:00 UTC
838 hits per hour


2022-02-24 17:00 UTC
1 536 hits per hour


2022-10-01 17:00 UTC
1 359 hits per hour

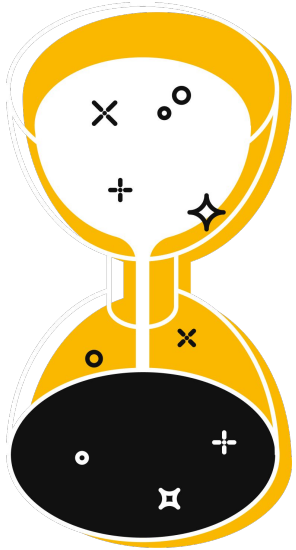

2022-11-07 17:00 UTC
10 365 hits per hour


2022-11-14 17:00 UTC
103 126 hits per hour


2023-01-27 14:00 UTC
2 086 976 hits per hour

Timeline

- New servers in Stockholm
  - February 2022, 1 000-2 000 hits per hour, only enthusiasts
- Nothing happened for 8 months
  - Mid October, usage started to rise slowly
- During November usage exploded
  - November 7, 10 000 hits per hour
  - November 14, 100 000 hits per hour
- Usage kept rising until January
  - Mid January, 1 000 000 hits per hour
  - End of January, 2 000 000 hits per hour
- Thousandfold increase in traffic in less than three months
- At least 5 million unique IP addresses




Thanks for listening!
NET NOD
Visit us at: netnod.se