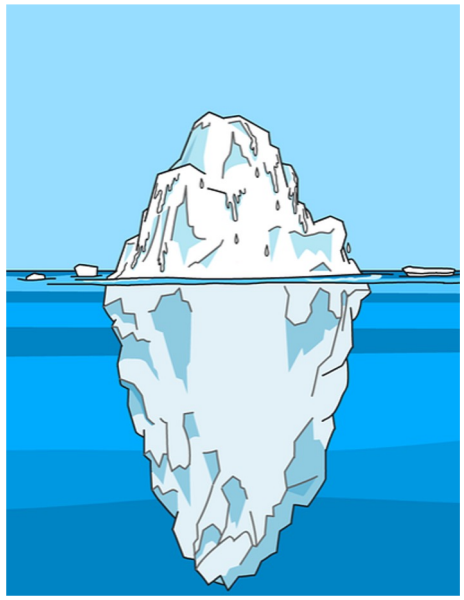


Increasing Internet security by bridging research and operations

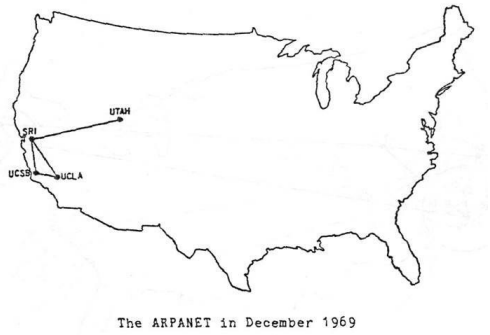
Cristian Hesselman

TALK.CYBERcni.fr
Dec 7, 2022

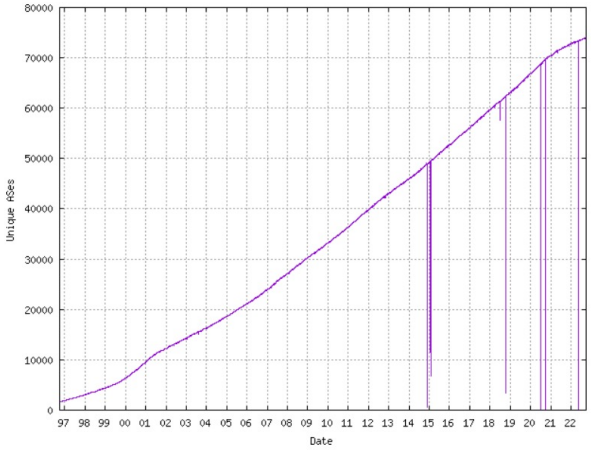
TUCCR. SIDN LABS

Internet security focused on availability (as in CIA)

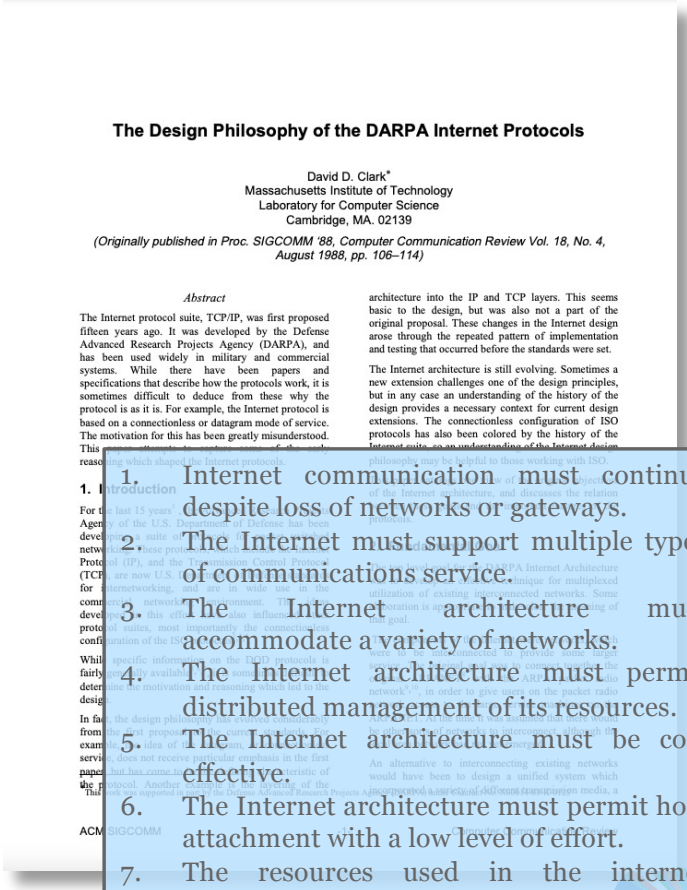
Birthplace of the Internet
UCLA, Sep 2017



The ARPANET in December 1969



https://www.cidr-report.org/as2.0/



The Design Philosophy of the DARPA Internet Protocols

David D. Clark*
Massachusetts Institute of Technology
Laboratory for Computer Science
Cambridge, MA. 02139

(Originally published in Proc. SIGCOMM '88, Computer Communication Review Vol. 18, No. 4, August 1988, pp. 106–114)

Abstract

The Internet protocol suite, TCP/IP, was first proposed fifteen years ago. It was developed by the Defense Advanced Research Projects Agency (DARPA), and has been used widely in military and commercial systems. While there have been papers and specifications that describe how the protocols work, it is sometimes difficult to deduce from these why the protocol is as it is. For example, the Internet protocol is based on a connectionless or datagram mode of service. The motivation for this has been greatly misunderstood. This

architecture into the IP and TCP layers. This seems basic to the design, but was also not a part of the original proposal. These changes in the Internet design arose through the repeated pattern of implementation and testing that occurred before the standards were set.

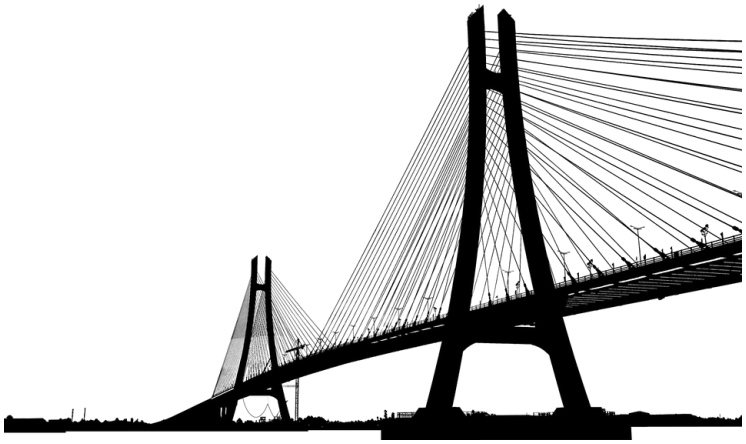
The Internet architecture is still evolving. Sometimes a new extension challenges one of the design principles, but in any case an understanding of the history of the design provides a necessary context for current design extensions. The connectionless configuration of ISO protocols has also been colored by the history of the

1. Internet communication must continue despite loss of networks or gateways.
2. The Internet must support multiple types of communications service.
3. The Internet architecture must accommodate a variety of networks.
4. The Internet architecture must permit distributed management of its resources.
5. The Internet architecture must be cost effective.
6. The Internet architecture must permit host attachment with a low level of effort.
7. The resources used in the internet architecture must be accountable.

Today's goal

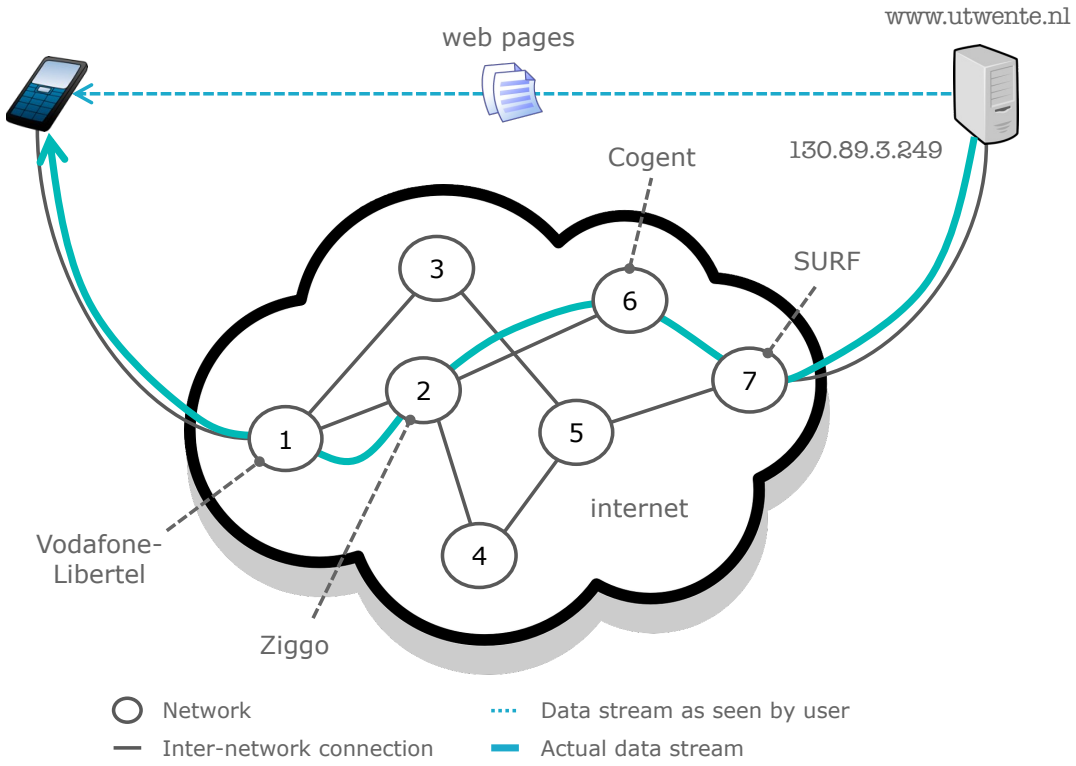
- Showcase how we increase security of the Internet infrastructure by bridging research and operations and get your feedback on our work

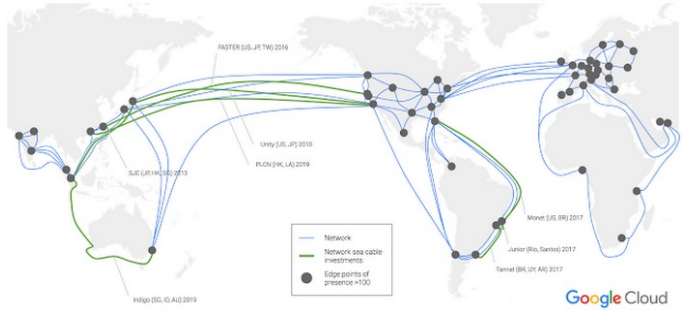
- Targeted result: inspiration for the technology transfer paragraph of your project proposal or how to engage in that type of work yourself

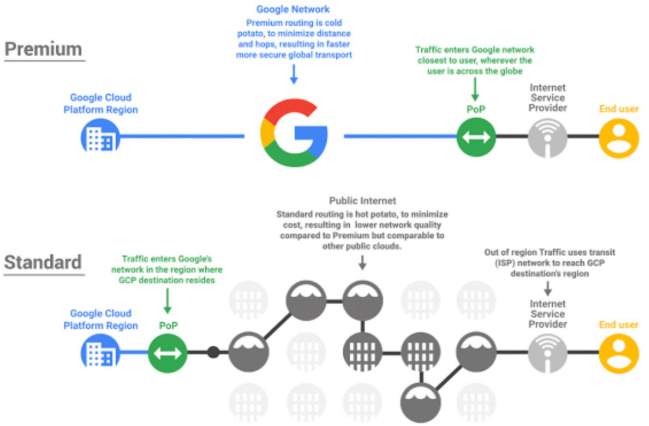


The Internet

High-level operation of the Internet



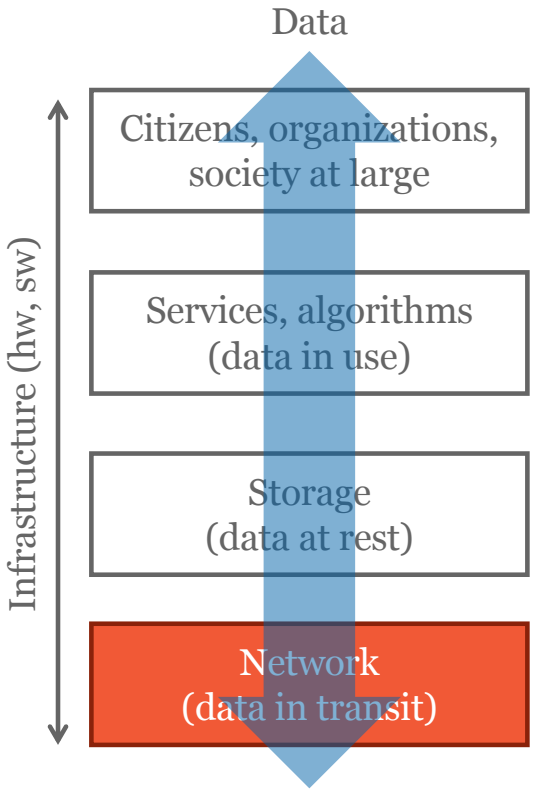


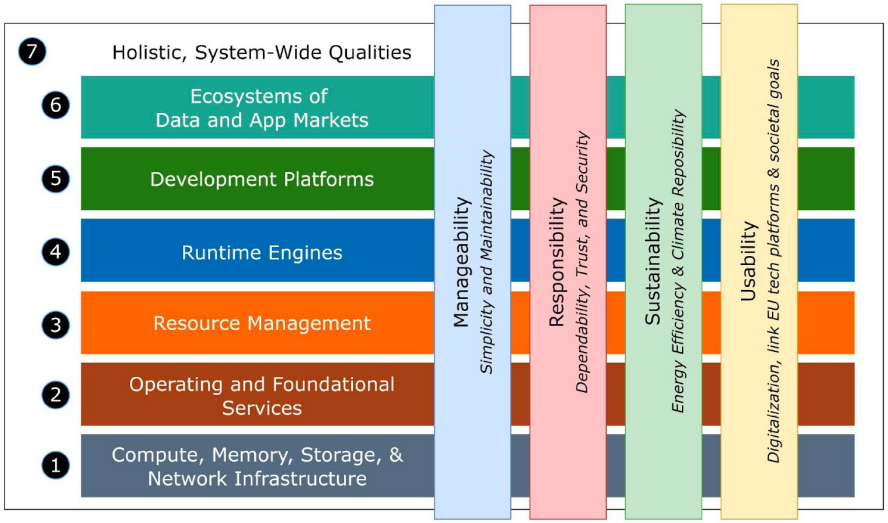


- Routers: tens to tens of thousands per network
- Connection points: one to hundreds per network
- Engineers: a handful to hundreds per network
- Per-AS planning and coordination, no central authority

References: [1-4]

The invisible foundation of our digital world





A. Iosup and F. Kuipers (Editors), "Future Computer Systems and Networking Research in the Netherlands: A Manifesto", May 2022

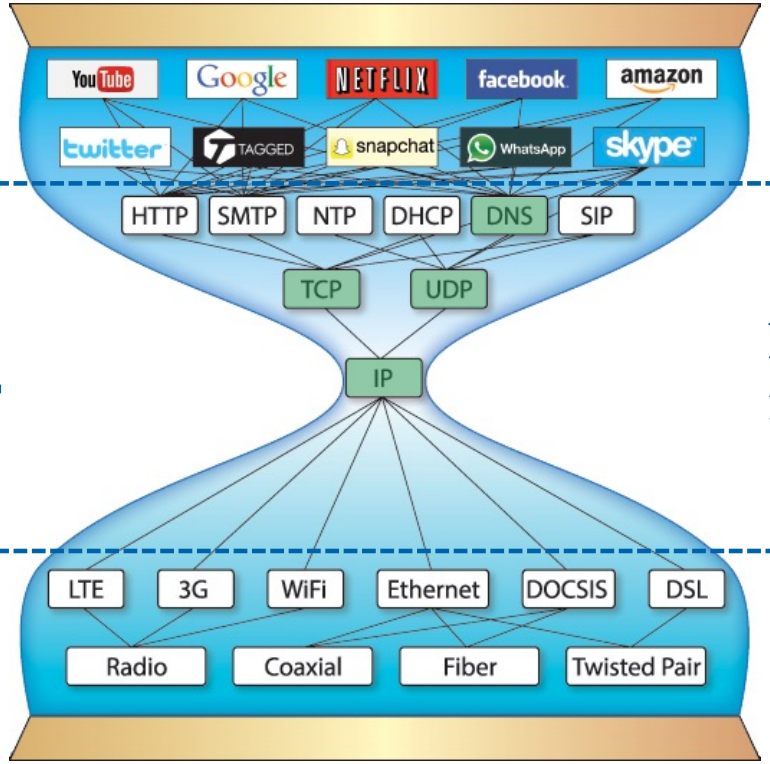
Recommended viewing: Henning Schulzrinne (Columbia University), "Networking: The Newest Civil Engineering Challenge", SIGCOMM Lifetime Achievement Award keynote, SIGCOMM 2022, Amsterdam, August 2022, https://www.youtube.com/watch?v=5lvXIqI_mQ4

SIDN LABS

Under the hood: protocols and services

Most people

Services



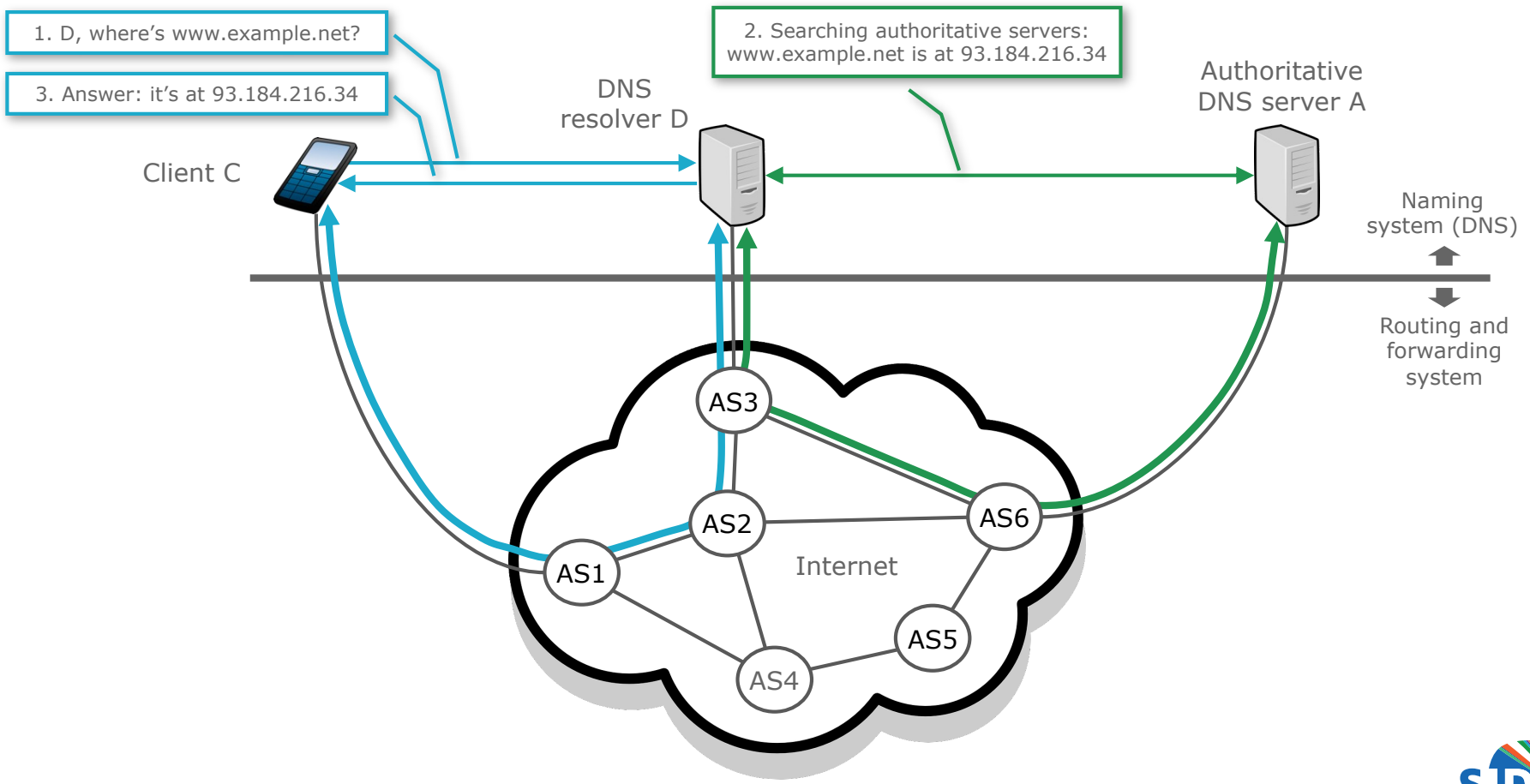
Orgs such as SIDN,
RIPE, ICANN, IETF

Names, addresses,
routes, transports

Transmission

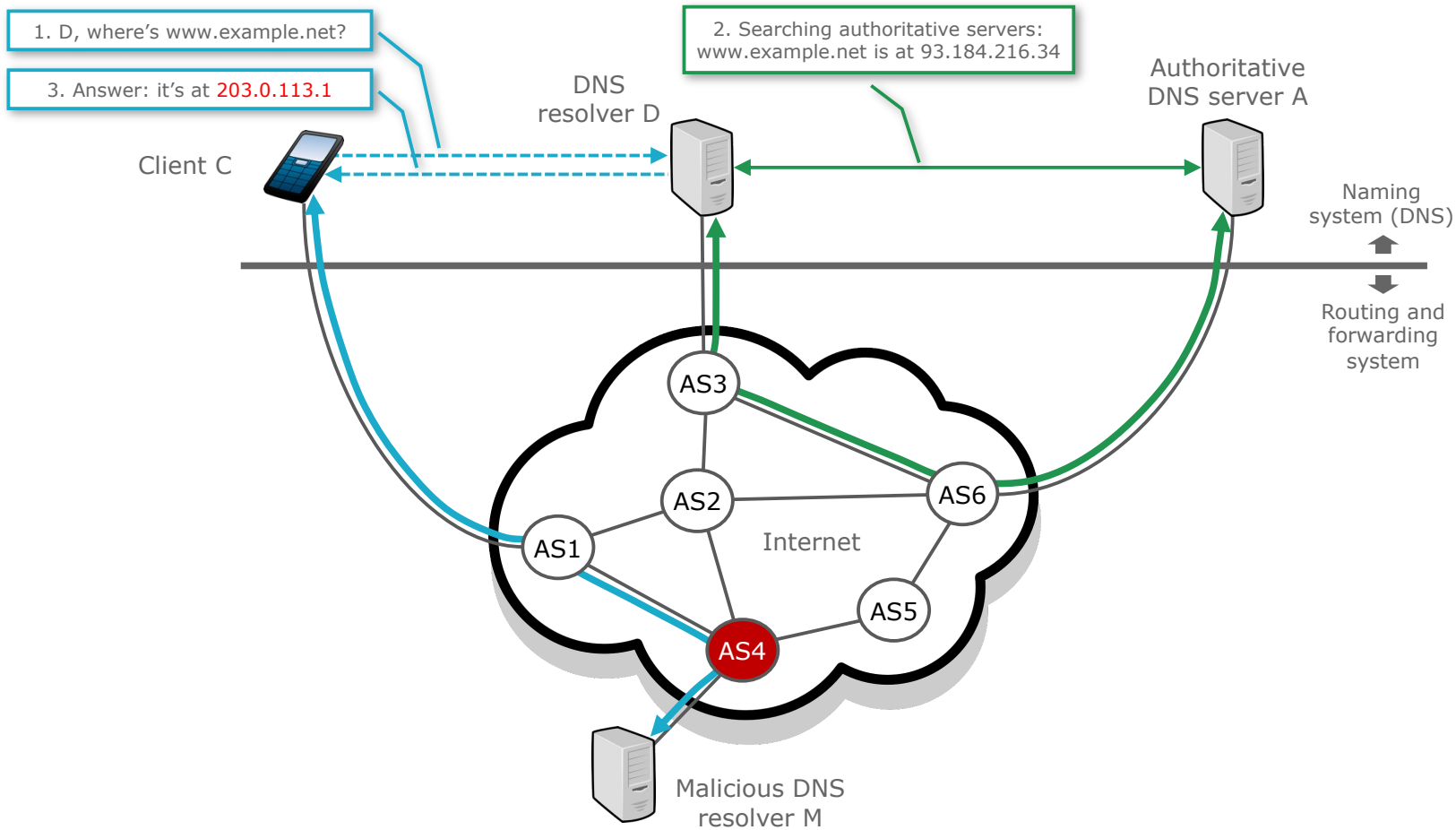
SIDN LABS

What can happen when it's insecure under the hood?



References: [5]

What can happen when it's insecure under the hood?

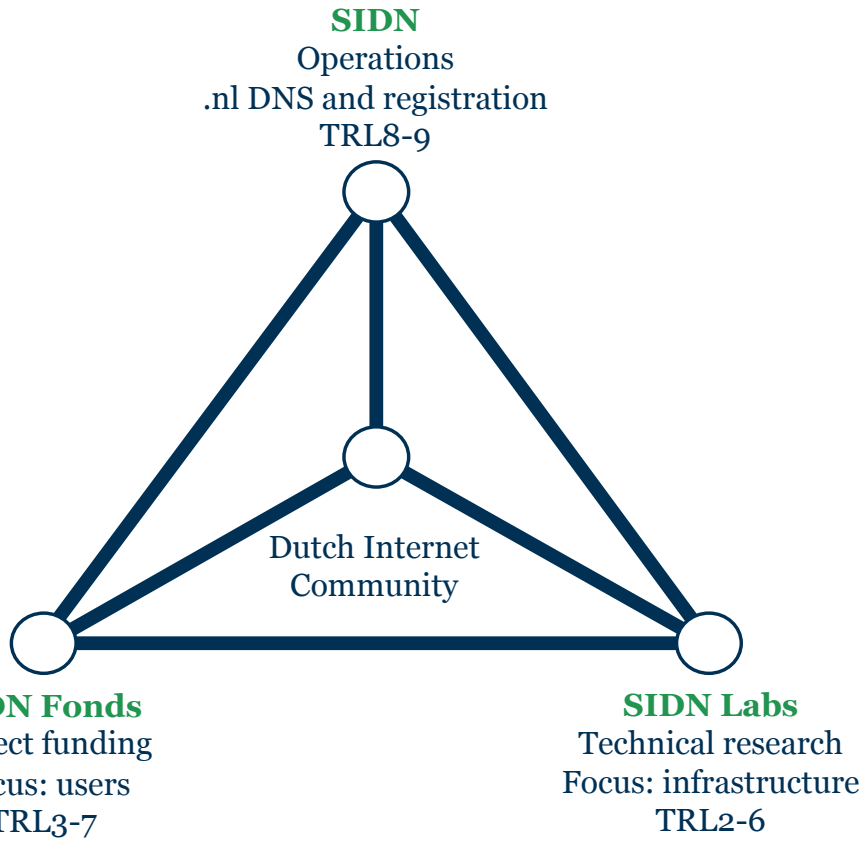


References: [5]

SIDN and SIDN Labs

SIDN is the operator of the .nl top-level domain

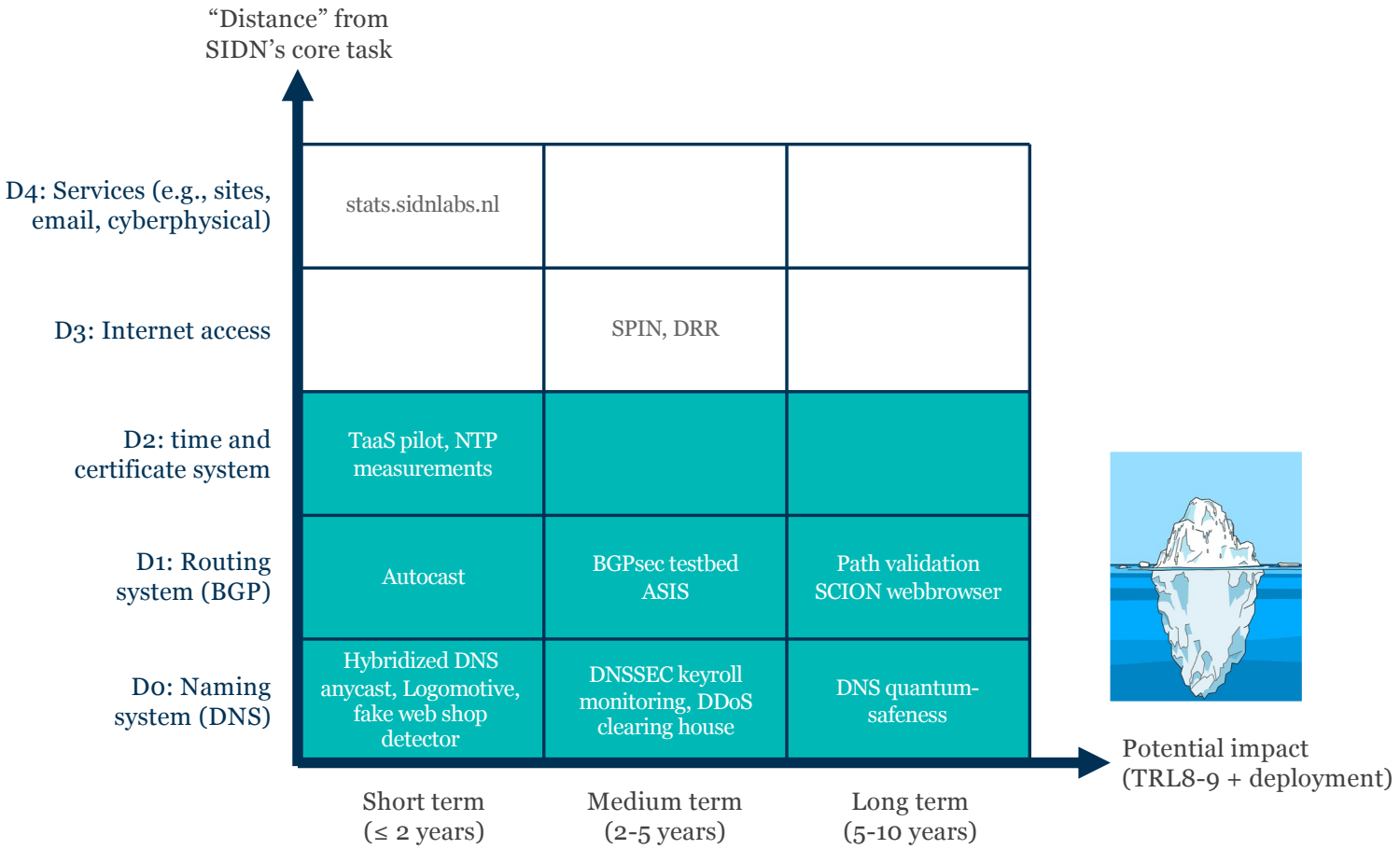
- Not-for-profit private organization for the benefit of Dutch society
- Securely manage .nl, the Dutch national extension on the internet (63% market share)
- Critical service provider: DNS infrastructure and domain name registration (6.3M names)
- Increase the value of the Internet in the Netherlands and elsewhere



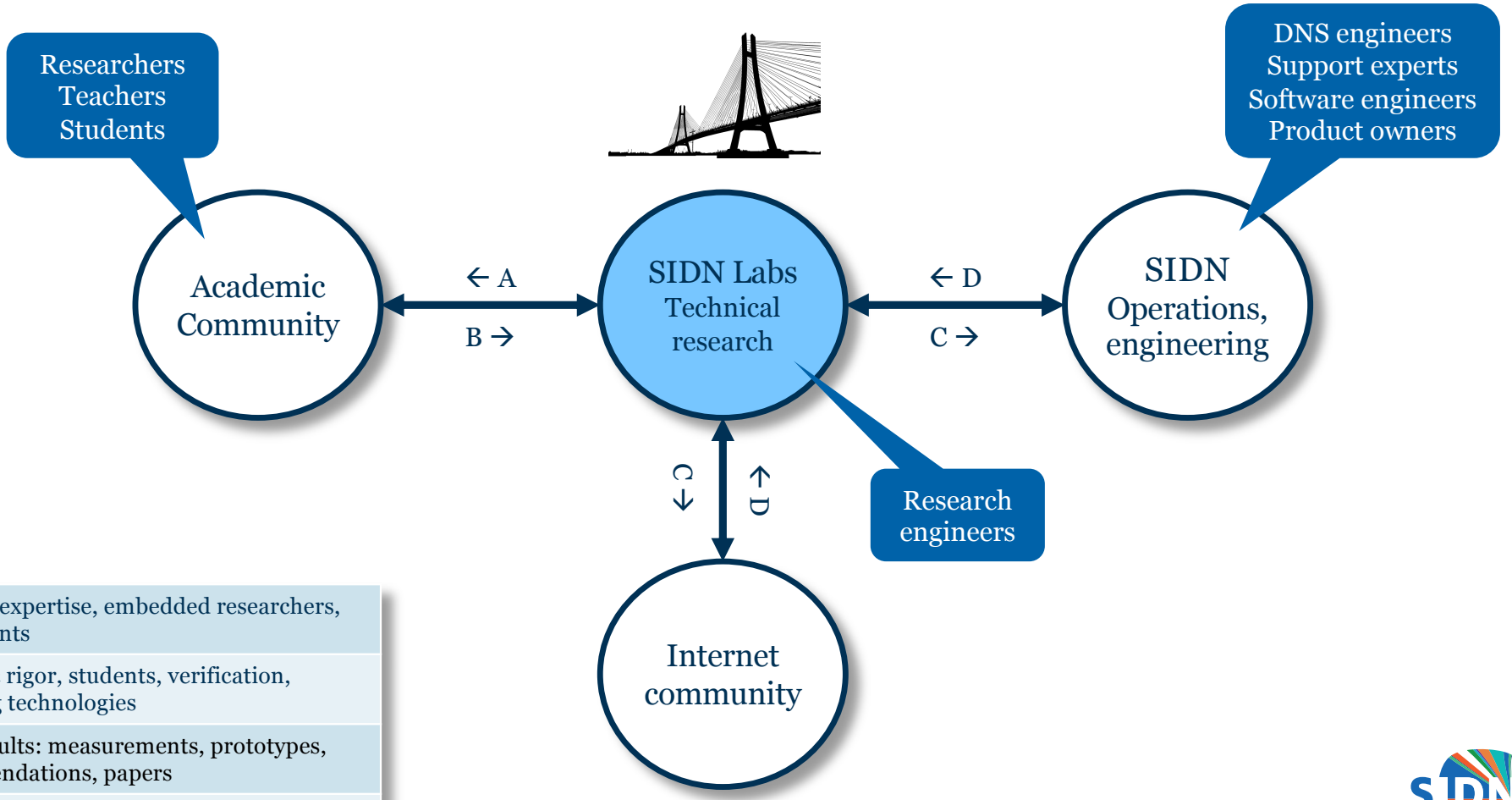
I ♥ .nl

SIDN LABS

Increasing Internet security at SIDN Labs



Our way of working: applied and open security research



A	Industry expertise, embedded researchers, investments
B	Scientific rigor, students, verification, emerging technologies
C	Open results: measurements, prototypes, recommendations, papers
D	Feedback, operational needs and experience

Internet security: 7 case studies

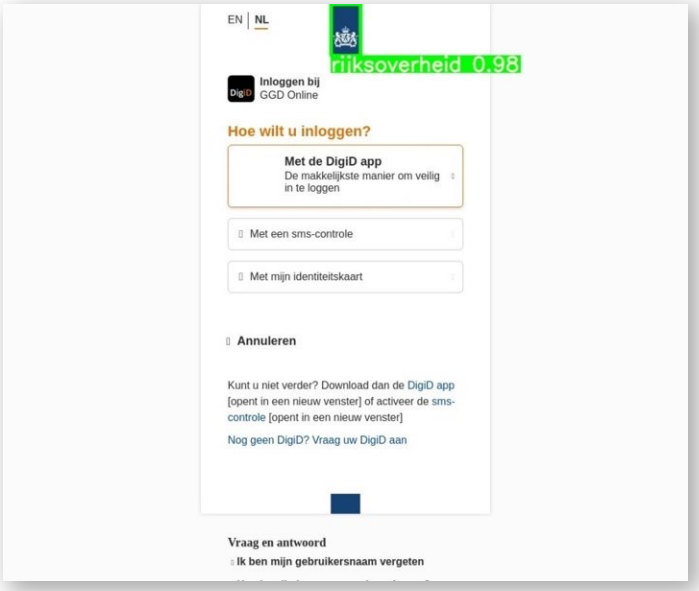
Details: www.sidnlabs.nl

Case study #1: online impersonation

- We developed Logomotive, a tool that crawls the .nl zone and detects logo usage

- Pilots with Dutch Government (DPC) and *Thuiswinkel Waarborg*

- Results:
  - Several sites removed from the zone
  - Dashboard in use at SIDN's anti-abuse desk
  - Logomotive part of SIDN's BrandGuard service
  - Peer-reviewed paper at PAM2022, blogs



Label	Full-Zone	Newly-Registered
Total	12862 (100.00%)	53
Without gov. logo (FP)	1164 (9.05%)	0 (0.00%)
With gov. logo (TP)	11698 (90.95%)	53 (100.0%)
Benign	10595 (82.37%)	32 (60.38%)
Government impersonation	151 (1.17%)	17 (32.09%)
Phishing	3 (0.02%)	3 (5.66%)
Potential threat	73 (0.57%)	9 (16.98%)
Other (false endorsements, satire, etc.)	75 (0.58%)	5 (9.43%)
Government domains	952 (7.40%)	4 (7.55%)
In portfolio	636 (4.94%)	2 (0.00%)
Not in portfolio	316 (2.46%)	2 (3.77%)
Added	109 (0.85%)	1 (1.89%)
Pending	207 (1.61%)	1 (1.89%)

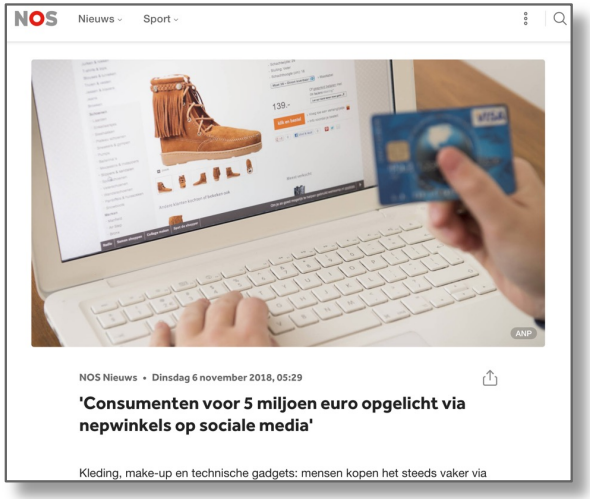
Case study #2: fake web shops

- Sales of fake shoes was a big problem in the .nl zone back in 2016-2018

- Developed tools to detect fake shops, partnered with registrars and ISC to remove them

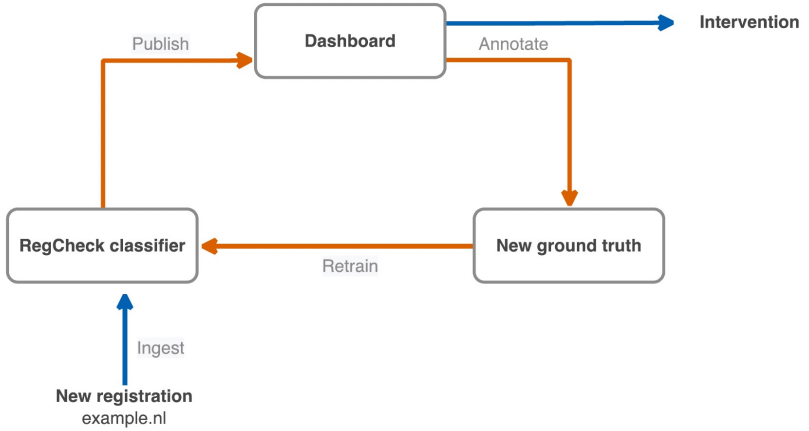
- Results:
  - Fake shops virtually gone from the .nl zone
  - Increased online safety for users
  - Dashboard in use at SIDN's anti-abuse desk
  - Peer-reviewed paper at PAM2020, blogs

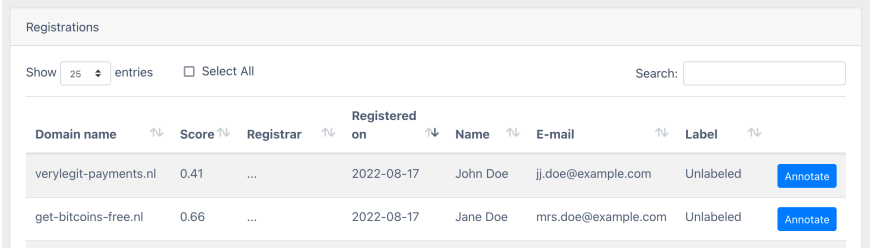
Year	Taken down
2022	192
2021	224
2020	481
2019	4,340
2018	~12,000



Case study #3: registration checker (RegCheck)

- Abuse regularly involves recent registrations
- We developed RegCheck for and with SIDN's abuse analysts to quickly inspect such domains
- Results:
  - Daily used "production prototype"
  - 3 machine learning models based on abuse reports (phishing, fake webshops, etc.)
  - User interface that gives hints about algorithm's decisions (explainable ML)
- Follow-up research project with DNS Belgium (.be registry)



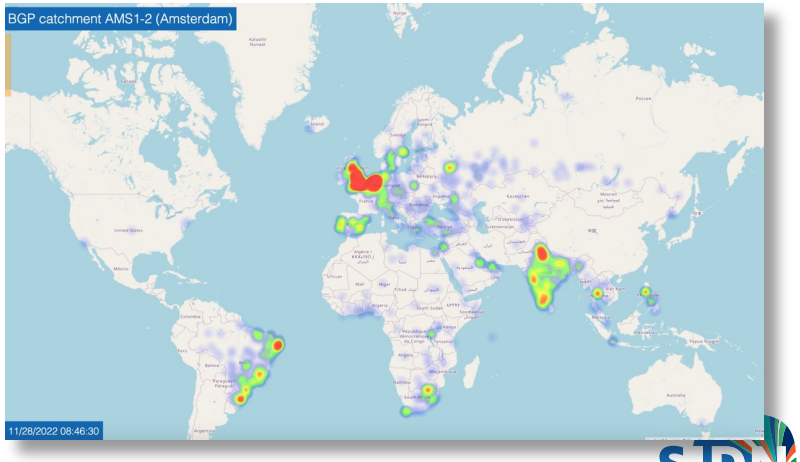


Case study #4: anycast testbed

- Send traffic any of a set of the same nodes at different locations => increase availability

- SIDN Labs' anycast testbed
  - 30 sites across the globe
  - Dynamically add/remove nodes
  - Catchment heatmaps
  - any.time.nl and other experimental services
  - http://dnstest.nl/anycast2020/

- Blueprint for .nl's production anycast infrastructure, measurements with academia



Case study #5: large-scale DNS measurements

- Help operators to make empirically-grounded DNS engineering choices (RFC9199)

- We carried out 6 studies with University of Twente and University of Southern California

- Results:
  - Reengineering of SIDN's DNS infra
  - Recommendations for Dutch government's DNS
  - Anteater tool for DNS operators
  - 6 peer-reviewed papers, RFC9199, blogs

Independent Submission — G. Moura
Request for Comments: 9199 — SIDN Labs/TU Delft
Category: Informational — W. Hardaker
ISSN: 2070-1721 — J. Heidemann
USC/Information Sciences Institute
M. Davids
SIDN Labs
March 2022

Considerations for Large Authoritative DNS Server Operators

Abstract

Recent research work has explored the deployment characteristics and configuration of the Domain Name System (DNS). This document summarizes the conclusions from these research efforts and offers specific, tangible considerations or advice to authoritative DNS server operators. Authoritative server operators may wish to follow these considerations to improve their DNS services.

It is possible that the results presented in this document could be applicable in a wider context than just the DNS protocol, as some of the results may generically apply to any stateless/short-duration anycasted service.

This document is not an IETF consensus document: it is published for informational purposes.

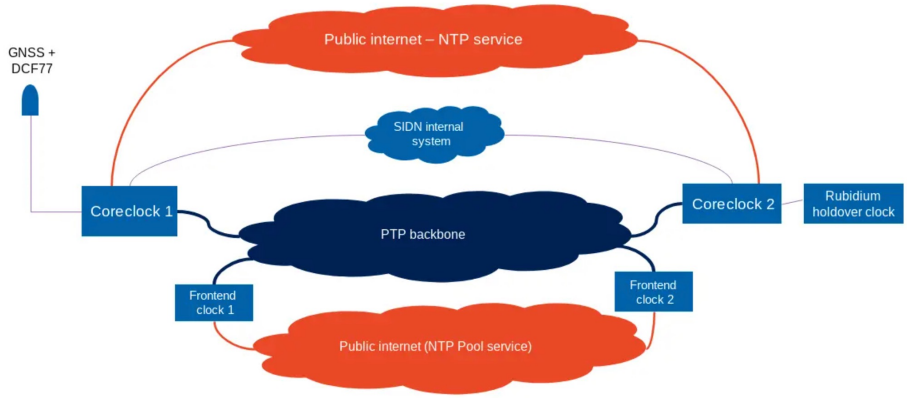
Status of This Memo

This document is not an Internet Standards Track specification; it is published for informational purposes.

This is a contribution to the RFC Series, independently of any other

Case study #6: TimeNL

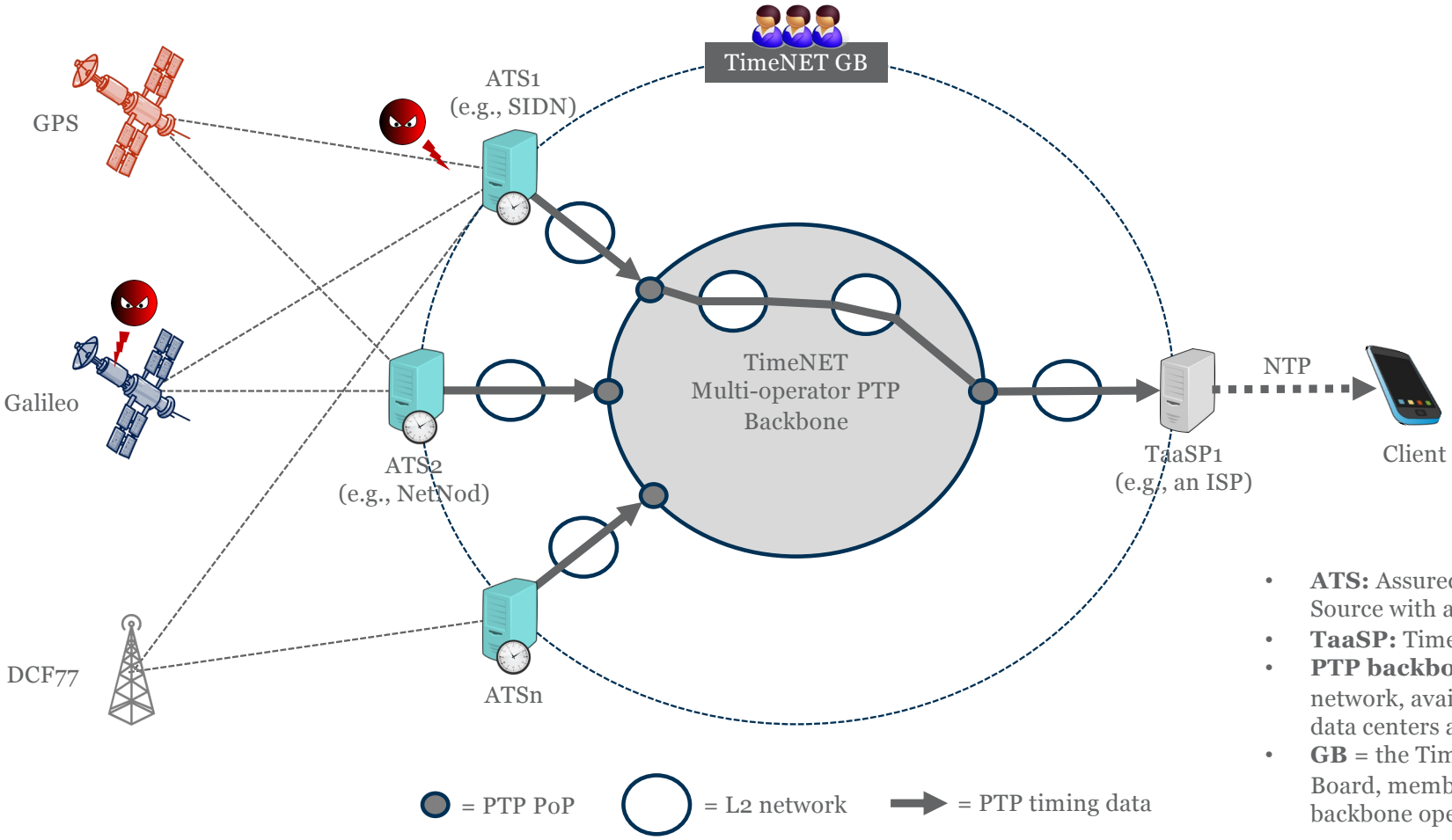
- Accurate time is crucial for many security applications (e.g., DNSSEC, OTTP)
- Public NTP services often poorly documented (e.g., used time sources, support levels)
- We set up TimeNL, our transparent and well-managed public NTP service
- Results: time.nl, nts.time.nl, ntp.time.nl (located in Arnhem, NL), any.time.nl (anycast)
- More NTP traffic than DNS traffic for .nl ☺



SIDN LABS

Vision: assured time for the EU through TimeNET

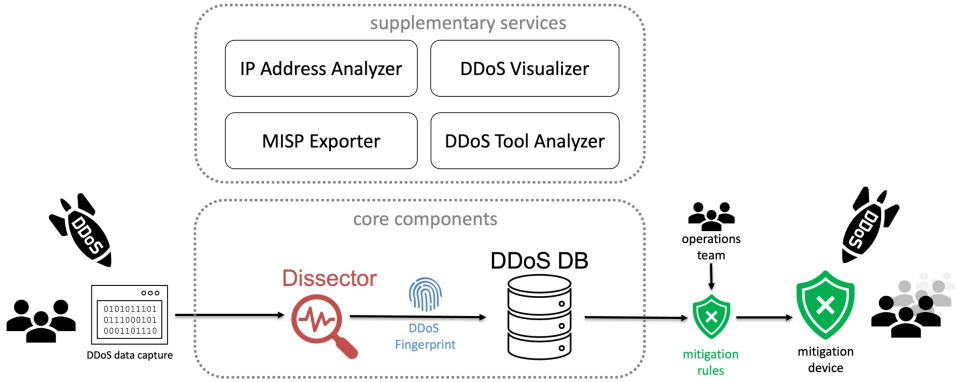
NEW

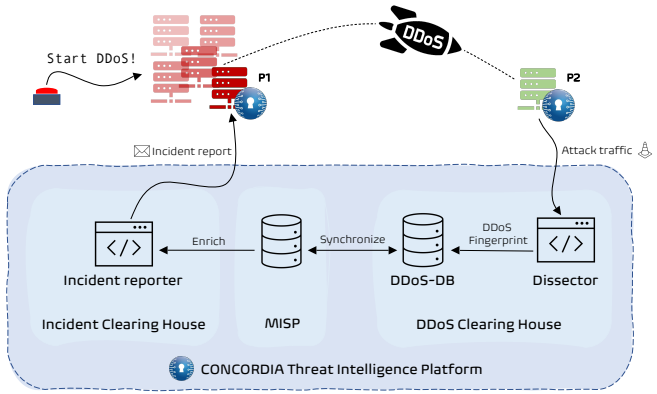


- **ATS:** Assured Time Source (Time Source with a holdover clock)
- **TaaSP:** Time as a Service Provider
- **PTP backbone:** multi-operator L2 network, available at PoPs such as data centers and IXPs
- **GB** = the TimeNET Governance Board, members are ATS operators, backbone operators, and TaaSPs

Case study #7: DDoS Clearing House

- Increase level DDoS proactiveness for (critical) service providers
- Joint work with: SURF, UT, Telecom Italia, Uni Zürich, Siemens, FORTH, NL-ADC
- Results:
  - Technical pilots in the Netherlands and Italy
  - Transition to production at NBIP (in progress)
  - Testbed, also to be used as a “cyber range”
  - DDoS clearing house cookbook



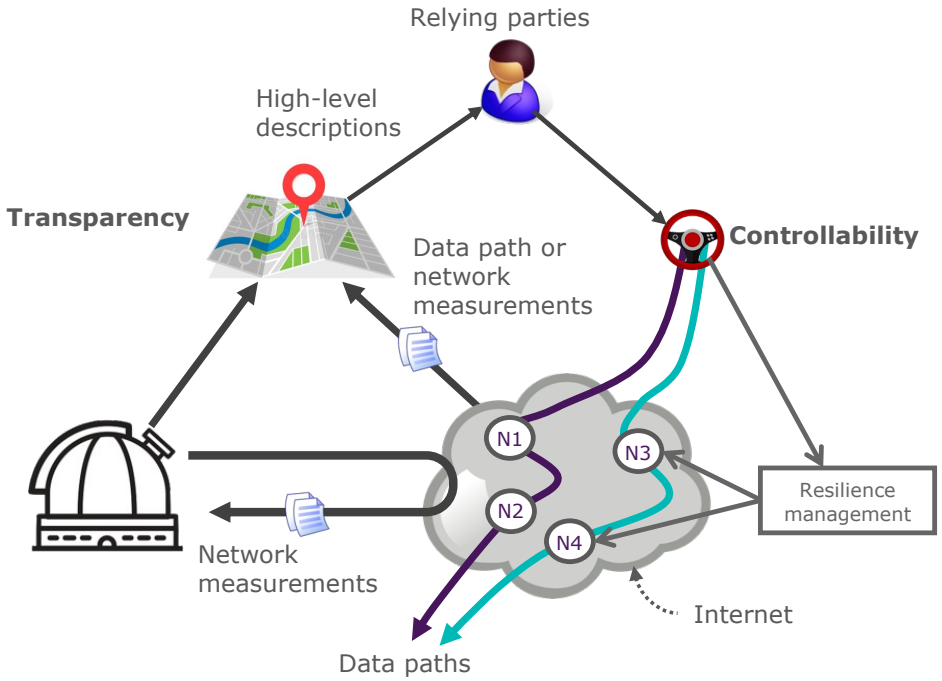


This work was funded by the European Union’s Horizon 2020 Research and Innovation program under Grant Agreement No 830927. Project website: https://www.concordia-h2020.eu/

Vision on the Internet

Vision: the responsible Internet

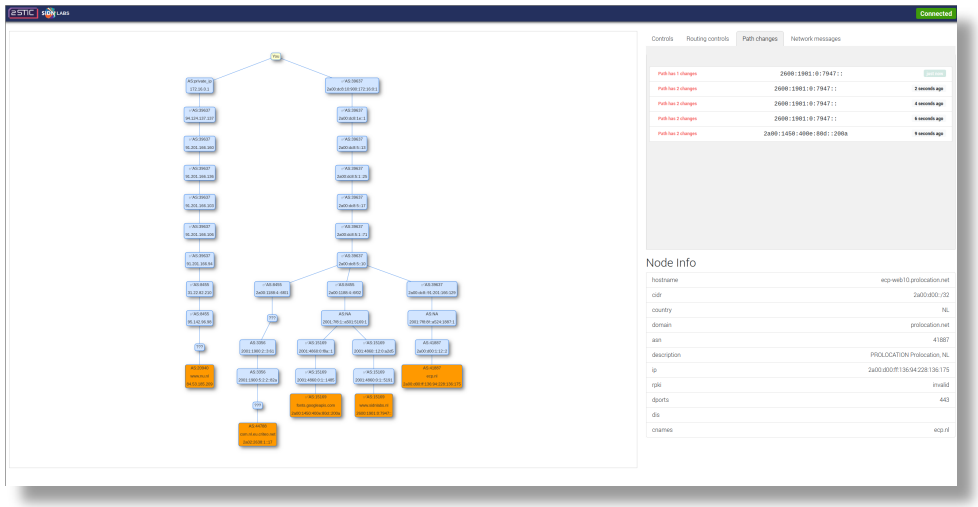
- Transparency: logical, cryptographically verifiable “map” of data paths and the macro-level structure of the Internet
- Controllability: route data paths “around” untrusted networks or modify networks to increase resilience
- In addition to existing Internet properties, such as open, generic, distributed and decentralized
- Hypothesis: benefits individuals, critical infra, network operators, public policy makers



References: [6] (concept) and [7] [8] [9] [10] (potential benefits)

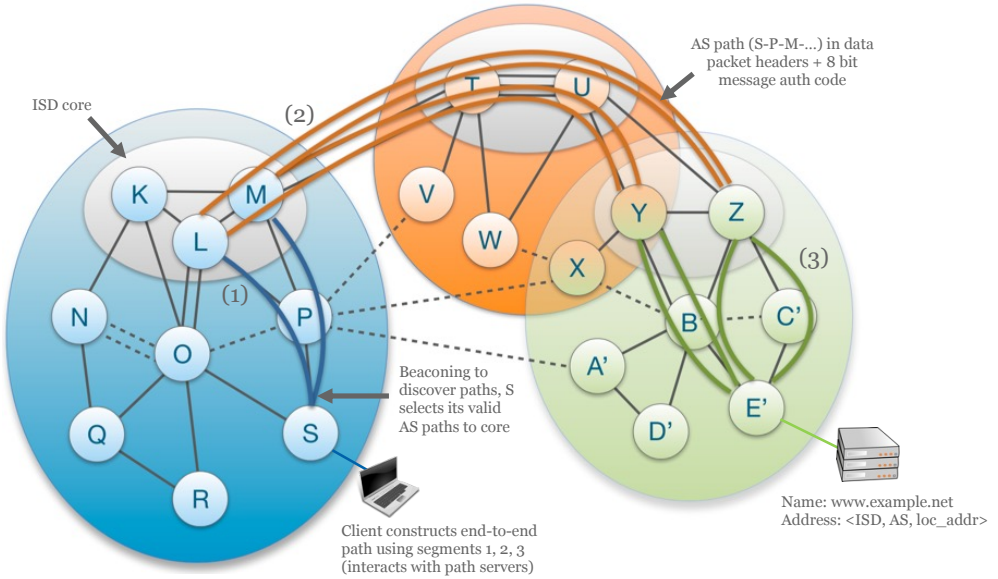
Path Visualizer (PathVis)

- The Internet's routing system is a black box
- PathVis enables ordinary users to get a feel for how their traffic traverses the Internet
- Shows the entire path to endpoints for connections that a host establishes
- Dynamically generates alerts on path changes
- Open source later this month



Experiments with SCION

- SCION aims to improve security of inter-domain routing and isolation of compromise
- Our goal: assess to what extent SCION concepts can improve Internet security
- Results
  - Implementation of SCION data plane protocol in P4, feedback to ETH Zurich
  - Taught students about SCION and other types of architectures (University of Twente)
  - Connection to SCIONlab

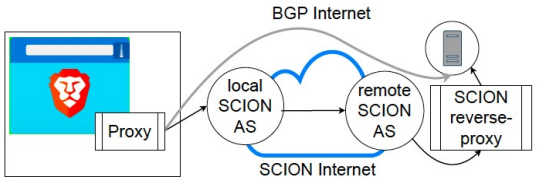


CATRIN project: a small-scale responsible Internet

- www.catrin.nl: 1.9M Euros from NWO, 7 Ph.D. students, 11 partners from NL, 8 international
- Design and prototyping of network descriptions, protocol extensions, evaluation via test networks
- Developing value-added service designs for network operators and enabling them to enhance the public Internet
- Validation with organizations and individuals (e.g., via browser extensions)

RIPE NCC
RIPE Atlas

Open INTEL



References: [11]

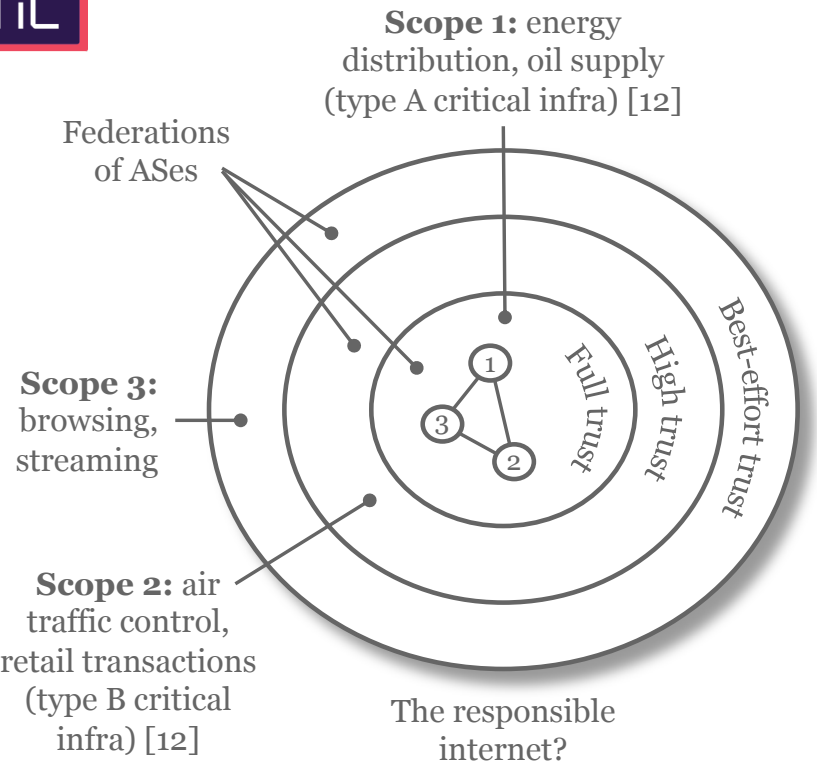
This research received funding from the Dutch Research Council (NWO) as part of the CATRIN project

NWO

SIDN LABS

What do we need in the Netherlands and Europe?

- A strong technical Internet community with a clear vision on the Internet that combines research, policy and operations
- An open data platform for ongoing Internet measurement, with sustainable funding and opportunity for experimentation
- An open nationwide test network to develop, evaluate and translate technology into services and sustainable funding for it
- ICT curricula with more attention to topics such as social values and digital autonomy



Lessons learned

A few lessons learned about technology transfer

- Define problems and validate preliminary results with (external) users/domain experts
- Set up long-term relationships with academia and research labs (e.g., by seconding staff)
- Combine scientists, engineers, and operators (in one team/under one roof if possible)
- Set up a dedicated (joint) research network, such as for measurements, prototypes, pilots
- Make results generic and public, apply them yourself (“eat your own dogfood”)
- Keep in mind that peer-reviewed publications are a means, not a goal

SDN LABS

Volg ons

SIDN.nl

@SIDN

SIDN

Q&A and discussion

www.sidnlabs.nl | stats.sidnlabs.nl

Cristian Hesselman
Director of SIDN Labs
cristian.hesselman@sidn.nl | +31 6 25 07 87 33 | @hesselma

References

1. D. McPherson, “Routing without rumor: securing the Internet routing system”, Global Commission on the Stability of Cyberspace’s Cyberstability Paper Series, Dec. 2021, https://hcss.nl/report/routing-without-rumor-securing-the-internets-routing-system/
2. T. Arnold, E. Gurmericliler, G. Essig, A. Gupta, M. Calder, V. Giotsas, and E. Katz-Bassett. 2020. (How Much) Does a Private WAN Improve Cloud Performance?. In Proceedings of IEEE INFOCOM
3. P. Gigis, M. Calder, L. Manassakis, G. Nomikos, V. Kotronis, X. Dimitropoulos, E. Katz-Bassett, and G. Smaragdakis, “Seven Years in the Life of Hypergiants’ off-Nets”, ACM SIGCOMM, 2021.
4. G. Huston, “The Death of Transit?”, RIPE Labs, Oct 2016, https://labs.ripe.net/author/gih/the-death-of-transit/
5. SSAC Briefing on Routing Security, June 2022, https://www.icann.org/en/system/files/files/sac-121-en.pdf
6. C. Hesselman, R.Holz, P. Grosso, “Three more things you need to know about the Responsible Internet”, June 2021, https://www.sidnlabs.nl/en/news-and-blogs/three-more-things-you-need-to-know-about-the-responsible-internet
7. J. Chromik, “Process-aware SCADA traffic monitoring: a local approach”, Ph.D. thesis, University of Twente, July 2019
8. Kc Claffy, D. Clark, “Challenges in measuring the internet for the public interest”, Journal of Information Policy, Volume 12, 2022, https://par.nsf.gov/biblio/10356826-challenges-measuring-internet-public-interest
9. R. Sommese, M. Jonker, J. van der Ham, and G. C. M. Moura “Assessing e-Government DNS Resilience”, 2022 International Conference on Network and Service Management (CNSM 2022), Thessaloniki, Greece
10. J. Ceron, L. Bertholdo, C. Hesselman, G. Moura, “Mapping concentrations of device vendors in IXPs”, Dec 2020, https://www.sidnlabs.nl/en/news-and-blogs/mapping-concentrations-of-device-vendors-in-ixps
11. A. Davidson, M. Frei, M. Gartner, H. Haddadi, J. Subirà Nieto, A. Perrig, P. Winter, F. Wirz, “Tango or Square Dance? How Tightly Should we Integrate Network Functionality in Browsers?”
12. NCTV, “Overzicht vitale processen”, https://www.nctv.nl/onderwerpen/vitale-infrastructuur/overzicht-vitale-processen