Advanced Networking: Introduction

Geert Heijenk, Pieter-Tjerk de Boer, Roland van Rijswijk-Deij, Niels Overkamp, Cristian Hesselman

University of Twente | September 7, 2022

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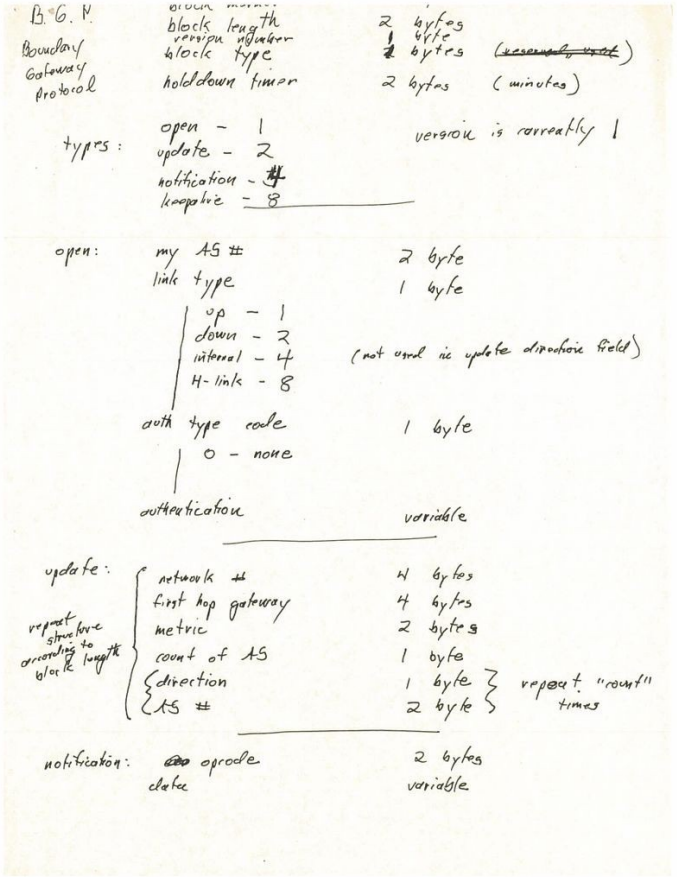
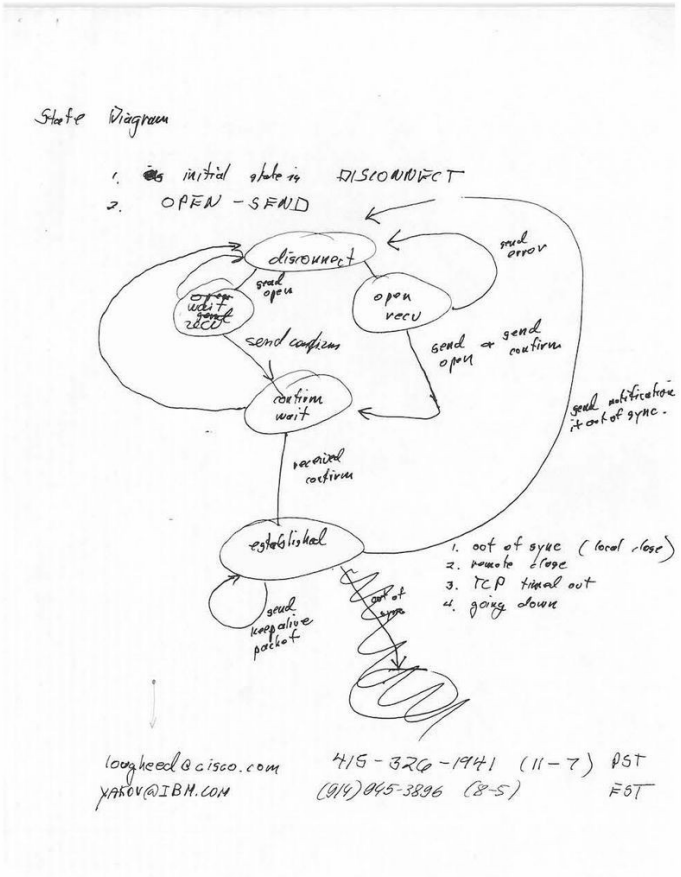
Advanced networking in 1989 :-)





https://computerhistory.org/blog/the-two-napkin-protocol/

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Your teaching team

Geert Heijenk
(teacher)

Pieter-Tjerk de Boer
(teacher)

Roland van Rijswijk-Deij
(teacher)

Niels Overkamp
(teaching assistant)

Cristian Hesselman
(teacher and coordinator)

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Today's learning objective

- Guide you through what we expect from you and why, and what you can expect from us
- Get you even more excited about internetworking :-)

- Answer questions you may have on assessment, deliverables, etc.
- Full details on the ANET site at https://courses.sidnlabs.nl/anet/

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Agenda

- High-level introduction to how the Internet works (and a bit of history)
- Course overview (admin talk)
- Short overview of the P4 lab assignment (Niels)
- Q&A
- Introduction of SIDN Labs (if time permits)

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How the Internet works

(from a 50,000-foot perspective)

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What is the Internet?

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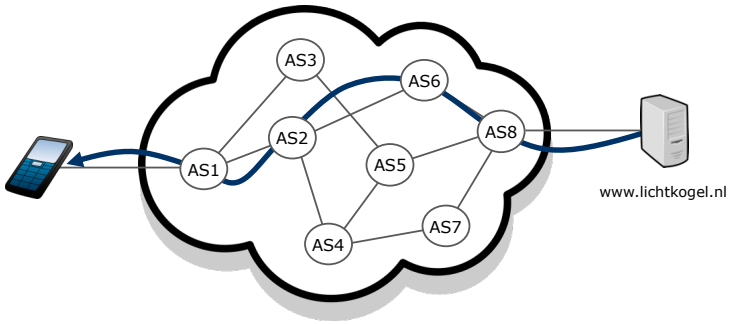
Wikipedia: networks of networks

- Internet: “the global system of interconnected computer networks that use the Internet protocol suite (TCP/IP) to link devices worldwide. It is a **network of networks** that consists of private, public, academic, business, and government networks of local to global scope, linked by a broad array of electronic, wireless, and optical networking technologies”

- Computer network: “a digital telecommunications network which allows nodes to share resources. In computer networks, computing **devices exchange data** with each other **using connections** between nodes (data links.) These data links are established over cable media such as wires or optic cables, or wireless media such as WiFi”



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A set of properties or values

Critical Property	Benefits
1 An Accessible Infrastructure with a Common Protocol that is open and has low barriers to entry	Unrestricted access and common protocols deliver global connectivity and encourage the network to grow. As more and more participants connect, the value of the Internet increases for everyone.
2 Open Architecture of Interoperable and Reusable Building Blocks based on open standards development processes voluntarily adopted by a user community	Open architecture creates common interoperable services, which deliver fast and permissionless innovation everywhere. The inclusive standardization process and demand-driven adoption ensures that useful changes are adopted, while unnecessary ones disappear.
3 Decentralized Management and a Single Distributed Routing System which is scalable and agile	Distributed routing delivers a resilient and adaptable network of autonomous networks, allowing for local optimizations while maintaining worldwide connectivity.
4 Common Global Identifiers which are unambiguous and universal	A common identifier set delivers consistent addressability and a coherent view of the entire network, without fragmentation or fractures.
5 A Technology Neutral, General-Purpose Network which is simple and adaptable	Generality delivers flexibility. The Internet continuously serves a diverse and constantly evolving community of users and applications. It does not require significant changes to support this dynamic environment.

ISOC, "The Internet Way of Networking – Defining the critical properties of the Internet", Sep 2020

Table 1: Abstract Architectural Criteria for Characterizing the Internet

Network Engineering	Economic
(1) layered architecture	(1) General Purpose Platform
(2) end-to-end packet connectivity	(2) Markets
(3) global address space	(3) Open Access
(4) interconnecting multiple ASes	(4) Permission-less Innovation
(5) global reach	(5) Decentralized, distributed ownership & control
(6) inter-AS routing protocol	
(7) shared set of standardized protocols	

W. Lehr, D. Clark, S. Bauer, A. Berger, P. Richter, "Whither the public Internet?", Journal of Information Policy 9, Aug 2019

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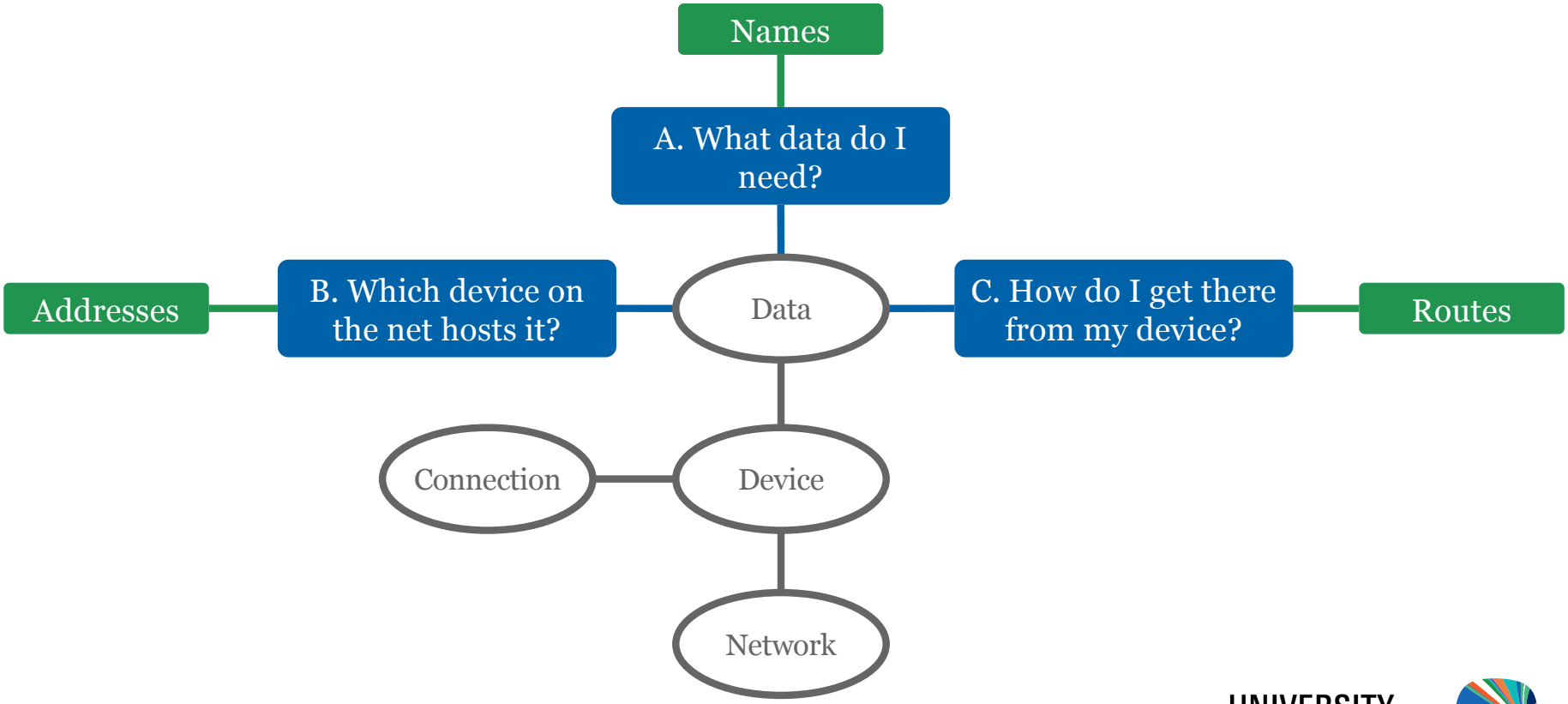
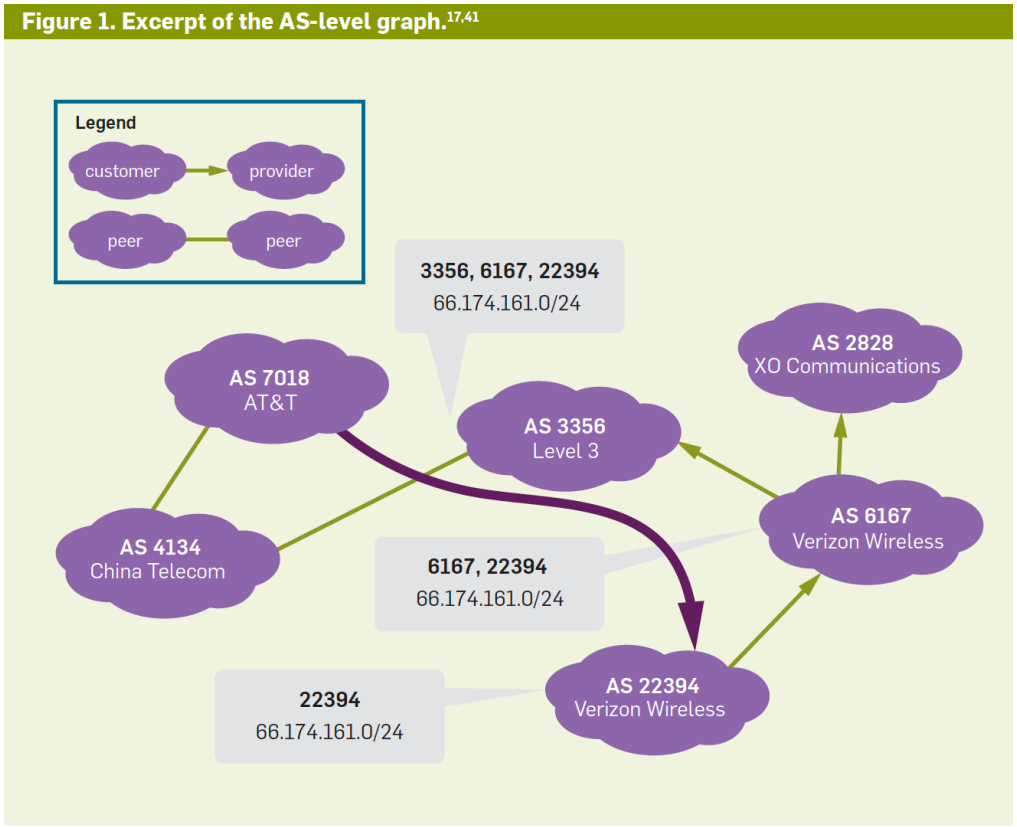
Key concepts of inter-networking (1978)



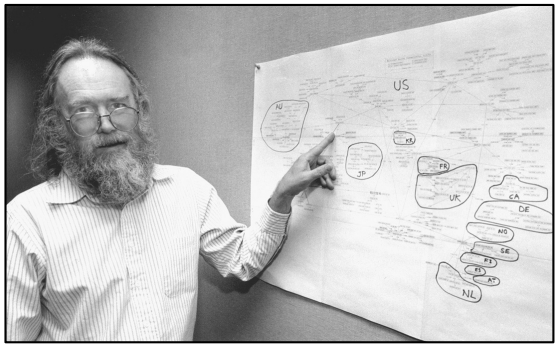
J. Shosh, “Inter-Network Naming, Addressing, and Routing”, Internet Experiment Note #19, January 1978

Largest collaboration ever

Figure 1. Excerpt of the AS-level graph.[17,41]



S. Goldberg, "Why is it taking so long to secure internet routing?", Communications of the ACM, Vol. 57, Issue 10, Oct 2014, pp. 56–63, https://doi.org/10.1145/2659899



"The Internet works because a lot of people **cooperate** to do things together"
– Jon Postel (1943-1998)

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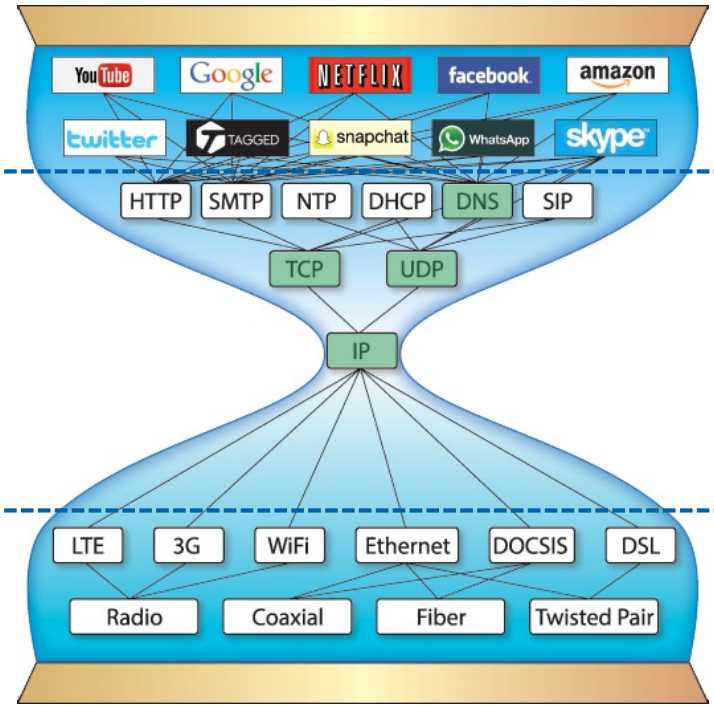
Under the hood: protocols and services

Most people

You and us



Services

Names, addresses, routes, transports

Transmission

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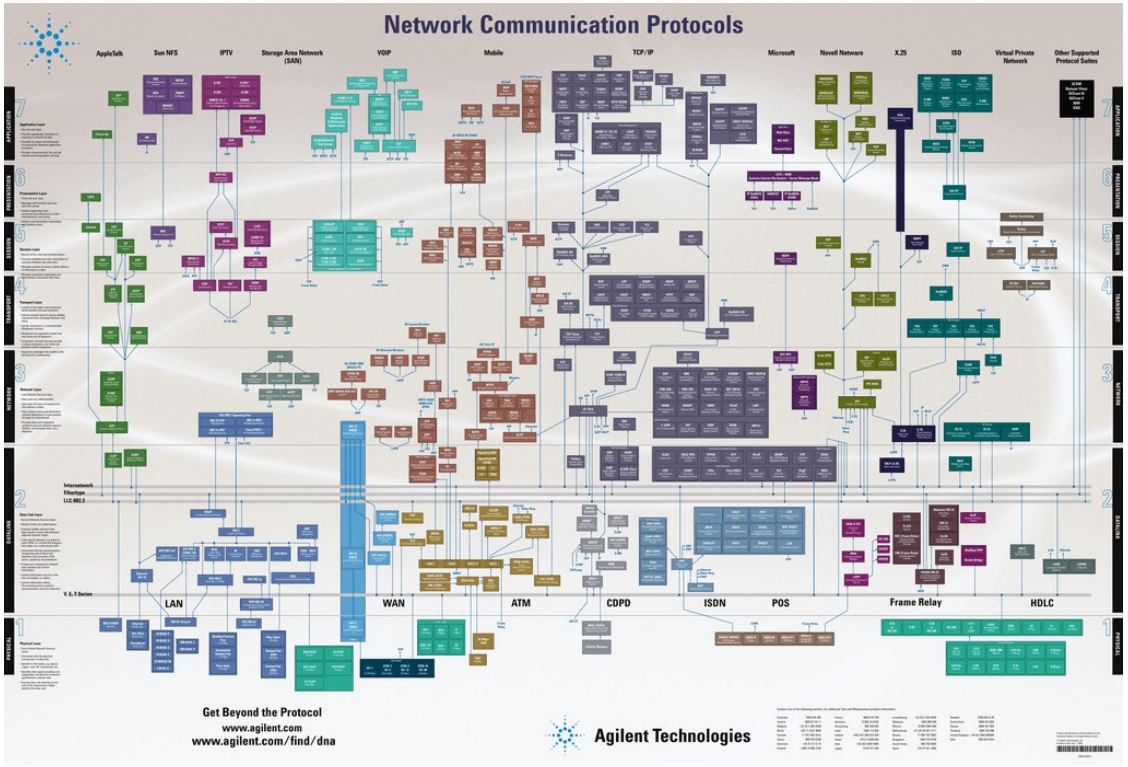
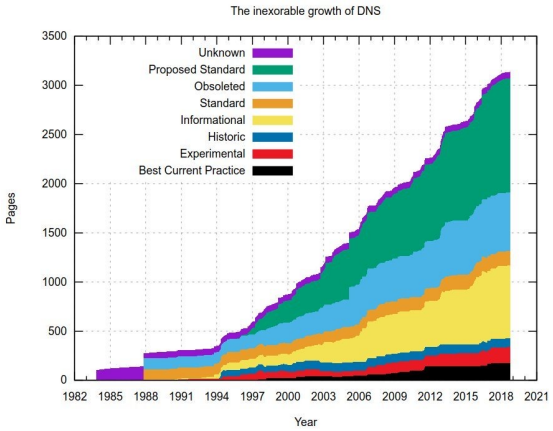
The complexity is huge





https://www.ietf.org/blog/herding-dns-camel/

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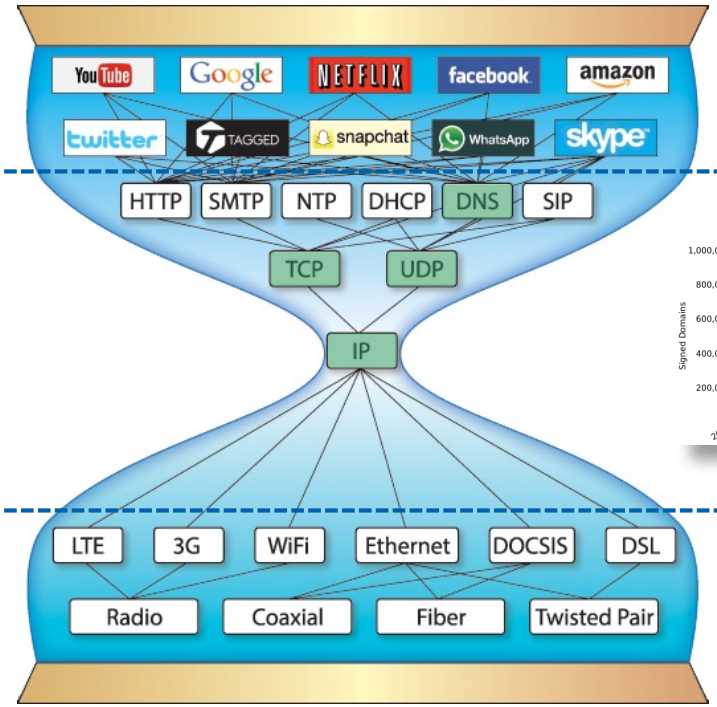
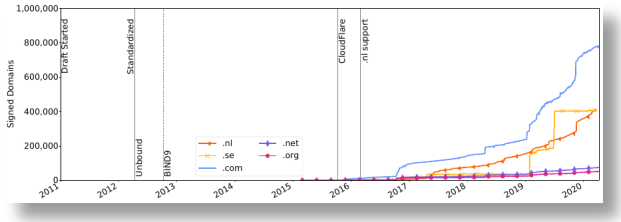
Rate of change

Fast

Slow!

Fast





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When did the Internet start?

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First packet ever: Oct 29, 1969

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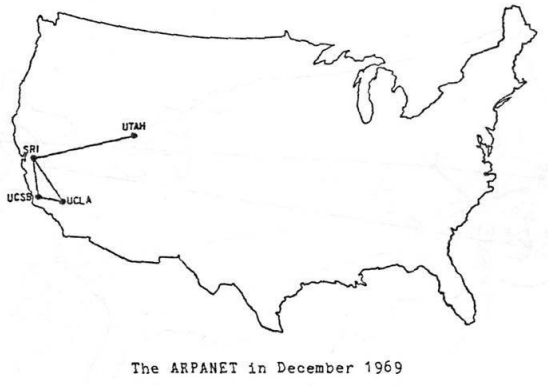
The origins of TCP/IP's design

Birthplace of the Internet
UCLA, Sep 2017



The ARPANET in December 1969

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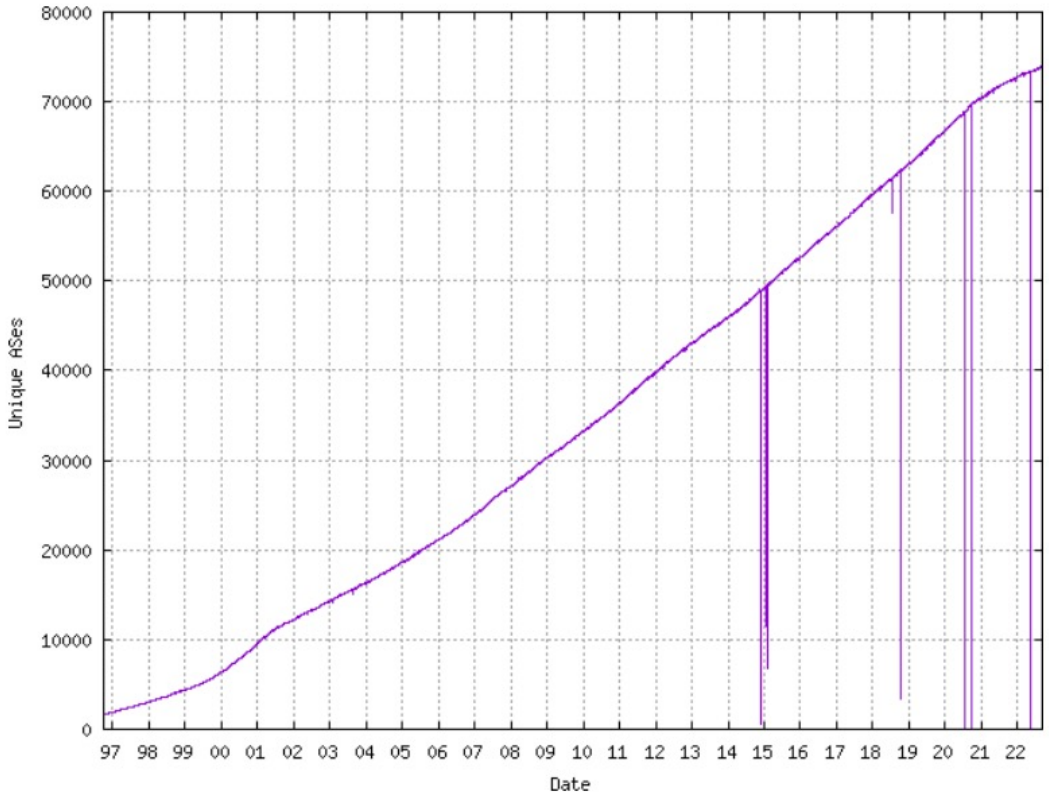
Fast forward to 2022

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



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Where can the Internet be improved?

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TCP/IP lessons learned

- Thin waist enabled worldwide deployment
  - Simple network layer (IP+BGP), weak demands on underlying networks
  - Stateless, unreliable, unordered, best-effort delivery

- Additions investigated include:
  - Multipoint communications, in addition to point-to-point model
  - Security, which is an add-on instead of an integral part of the core protocols
  - Mobility management (movement between networks)
  - Restrict the impact of local incidents so they don't have global effects (e.g., a CA compromise)
  - Path verification capabilities

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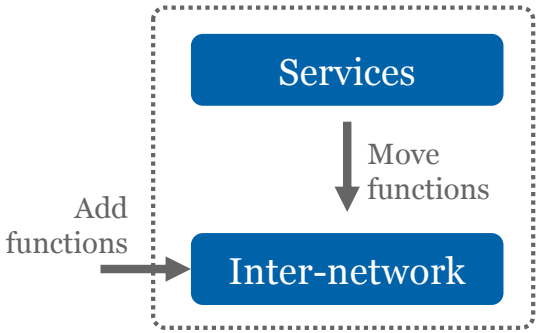
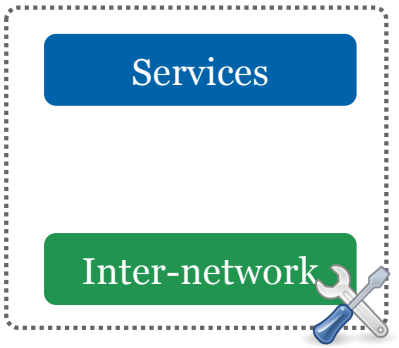
Proposed changes in the literature

Type 1: functional
Put functions not in TCP/IP in the (TCP/IP) network



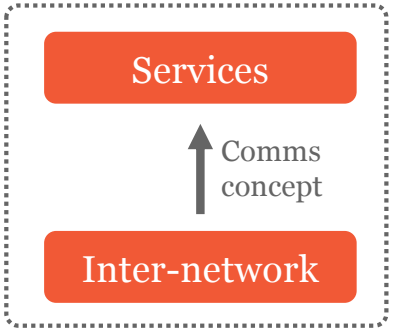
SCION
Responsible Internet
RINA
MobilityFirst
XIA

Type 2: design patterns
New generic structures for protocol stacks and/or (protocol) interfaces



TROSTKI ("layer 3.5")
RINA (layers)
XIA (addresses)
FII (interfaces)

Type 3: comms concepts
Network provides other comms abstraction than TCP/IP's host-based model



Data-centric
Service-centric
XIA, FII (future concepts)
ManyNets

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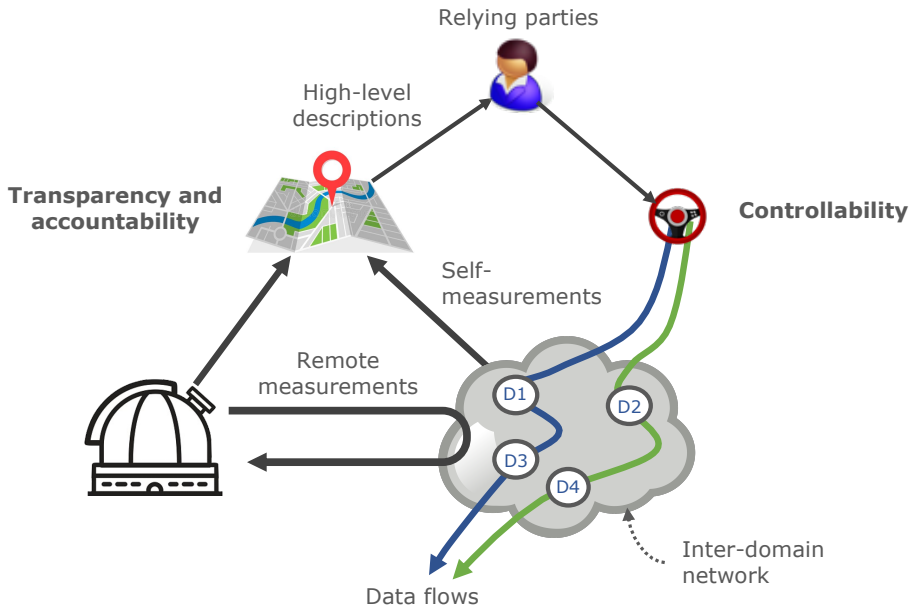
Example: the Responsible Internet

- Addresses lack of insight in and control over Internet's end-to-end structure and operation
- Tree new **design goals**: controllability, accountability, and transparency (CAT)
- Hypothesis: enables relying parties to communicate with more confidence and trust
  - Critical service providers
  - Policy makers
  - Network operators
  - Individuals



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Summary

- Relatively simple design of the Internet's core protocols solved problem of ubiquitous connectivity, Internet now critical for almost every aspect of our everyday life and for our society

- Challenge: how to align the Internet's services with society's increased demands?
  - Higher levels of trust and autonomy to support new safety-critical applications
  - New network functions (e.g., security, privacy, real-time guarantees)
  - New (open programmable) internet designs

- We expect that some of these extensions and designs will have an impact on deployed network infrastructure in the next few years and ANET will help you navigate that space

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Course overview

Details at https://courses.sidnlabs.nl/anet-2022/

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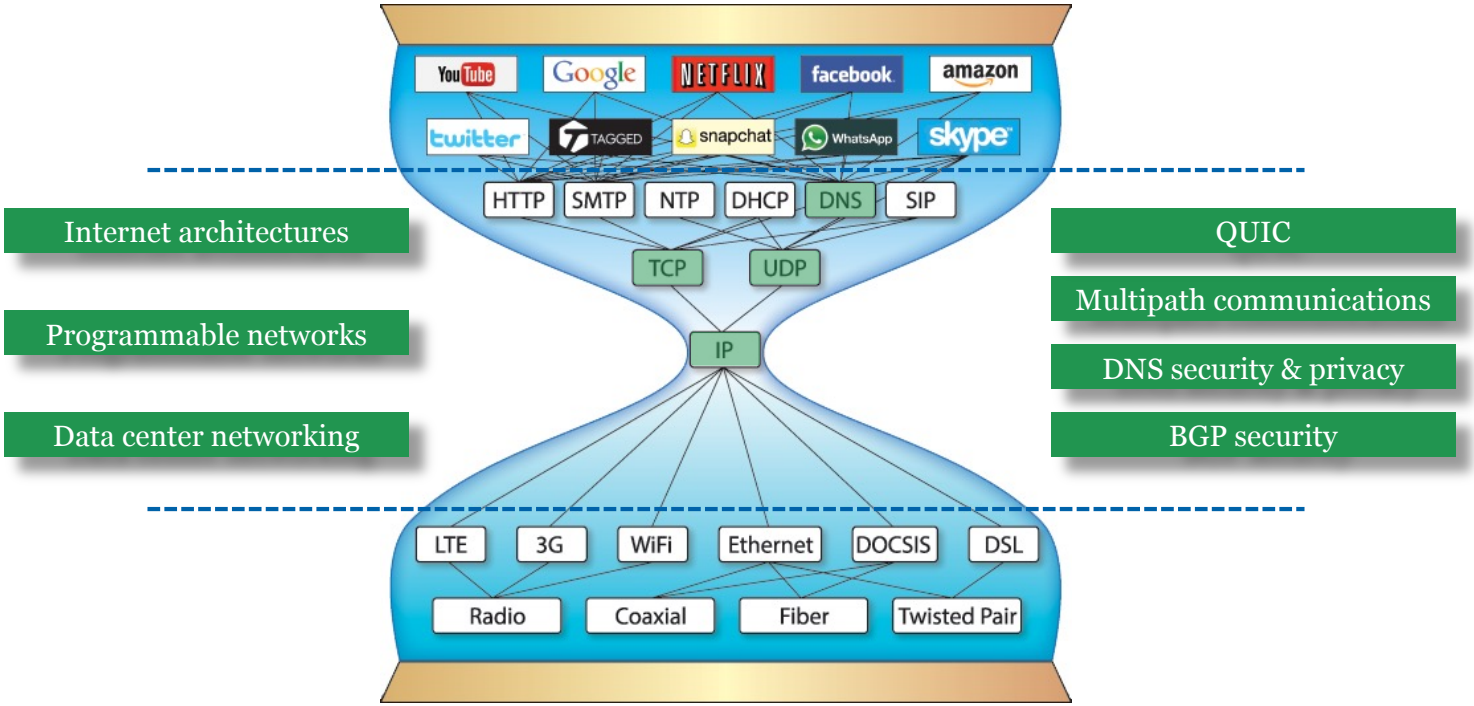
ANET topics



ANET is an **overview** course based on **research** papers. It complements Internet Security, which goes more into depth on the security of **specific Internet protocols**.

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Learning goals

- After successful completion of the course Advanced Networking (ANET) you will be able to:
  - Analyze, compare, and discuss various **advanced Internet concepts**, such as secure inter-domain routing and multi-path data delivery
  - Understand and discuss important **challenges and proposed experimental solutions**, including non-IP-based internetworking systems
  - Apply a domain-specific language such as **P4** to implement basic data plane functionality of an open programmable router, which is important for future Internet infrastructures

- Enhance your research skills because you'll need to independently review and analyze research papers and RFCs

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Prerequisites

- Introductory course on computer networks

- Such as the bachelor module Network Systems at the University of Twente

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Staying up to date

- ANET public homepage
  - https://courses.sidnlabs.nl/anet/
  - Authoritative source: papers, assessment, deliverables, etc.
  - Public site so other teachers/universities can potentially learn from our format

- ANET Canvas site
  - Announcements and comms with teachers
  - Uploading and archiving deliverables

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ANET is a collaboration with SIDN Labs

- Motivation for SIDN Labs
  - Proud to help educating the next generation of Internet (security) engineers and researchers
  - Aligns with our research on secure future Internet infrastructures (www.2stic.nl)
  - Perhaps interest some of you to check out our work for an M.Sc. project ☺

- Extends ongoing academic-industry research collaboration
  - SIDN Labs: improve security and resilience of SIDN's services and wider Internet using latest academic insights, methodologies, network, and creative thinking
  - UT: further improved research and education using SIDN's operational experience, unique datasets, and industry network

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Lectures

https://courses.sidnlabs.nl/anet-2022/#schedule

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Regular lectures

- Eight **interactive technical lectures**
  - Protocols and Internet architectures/deployments
  - Motivation: enhance your “networking horizon”

- Each lecture revolves around a **specific theme**
  - Topics cover core functions of inter-domain networking (e.g., naming, routing, security)
  - Motivation #1: give you a broad overview of advanced networking functions
  - Motivation #2: our research interests (we love to talk about the work we do :-)

- Attendance is **mandatory** because of group tests and discussions (see next slides)

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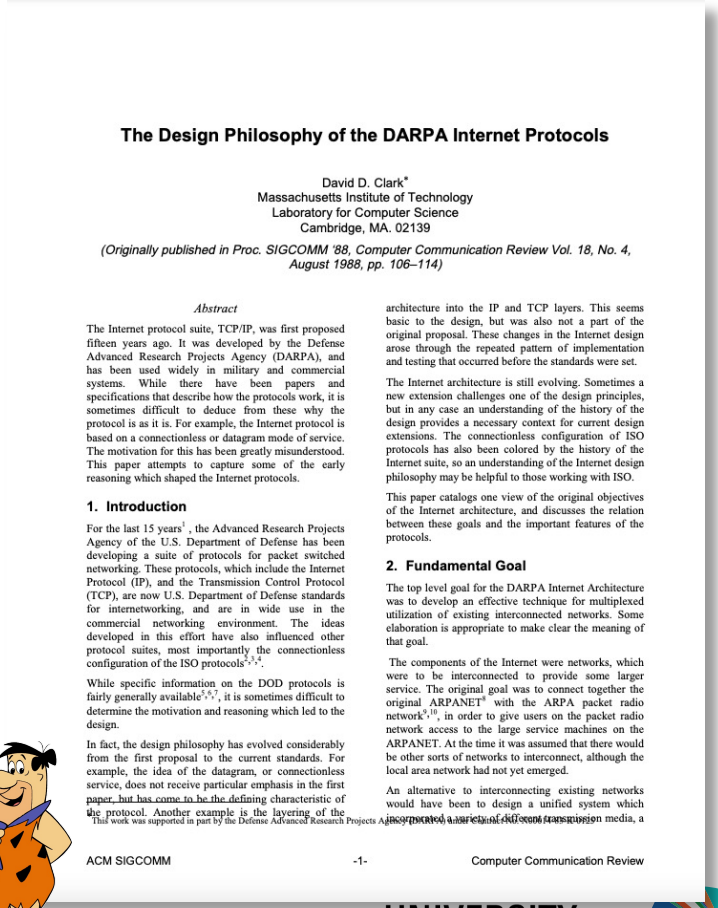
Themes

- "Going up the stack": programmable networks (hardware), BGP security, DNS security and privacy, multi-path communication, QUIC, data center networking, Internet architectures
- Papers cover almost a quarter of a century of networking research, with the oldest one from the Internet's proverbial "stone age" (1995)
- Help you understand generic network architectures and principles, not so much latest and greatest topics
- Additional reading on the ANET site



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 paper attempts to capture some of the early reasoning which shaped the Internet protocols.

1. Introduction

For the last 15 years[1], the Advanced Research Projects Agency of the U.S. Department of Defense has been developing a suite of protocols for packet switched networking. These protocols, which include the Internet Protocol (IP), and the Transmission Control Protocol (TCP), are now U.S. Department of Defense standards for internetworking, and are in wide use in the commercial networking environment. The ideas developed in this effort have also influenced other protocol suites, most importantly the connectionless configuration of the ISO protocols[2,3,4].

While specific information on the DOD protocols is fairly generally available[5,6,7], it is sometimes difficult to determine the motivation and reasoning which led to the design.

In fact, the design philosophy has evolved considerably from the first proposal to the current standards. For example, the idea of the datagram, or connectionless service, does not receive particular emphasis in the first paper, but has come to be the defining characteristic of the protocol. Another example is the layering of the 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 Internet suite, so an understanding of the Internet design philosophy may be helpful to those working with ISO.

This paper catalogs one view of the original objectives of the Internet architecture, and discusses the relation between these goals and the important features of the protocols.

2. Fundamental Goal

The top level goal for the DARPA Internet Architecture was to develop an effective technique for multiplexed utilization of existing interconnected networks. Some elaboration is appropriate to make clear the meaning of that goal.

The components of the Internet were networks, which were to be interconnected to provide some larger service. The original goal was to connect together the original ARPANET[8] with the ARPA packet radio network[9,10], in order to give users on the packet radio network access to the large service machines on the ARPANET. At the time it was assumed that there would be other sorts of networks to interconnect, although the local area network had not yet emerged.

An alternative to interconnecting existing networks would have been to design a unified system which incorporated a variety of different transmission media, a

This work was supported in part by the Defense Advanced Research Projects Agency (DARPA) under Grant [illegible] and by the [illegible]

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One theme per lecture

- One **introductory paper**
  - Tested through a closed book multiple-choice test in class
  - First do the test individually, then the same test in a group with 2-3 of your fellow students
  - Group test enables you to learn from your peers by discussing the test's questions

- Two **advanced papers** that explore the topic in more depth
  - Tested through a blog and a presentation
  - One or two presentations per lecture, schedule on the ANET site

- We'll publish the **best blog** on the ANET website (with the author's consent)

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Timetable (yes, micromanagement)

Time	What
10:45	Arrival, put your cell phone in your bag, pick up hardcopy of tests at teacher's desk, sit down
10:45-10:55	Individual test of introductory paper Teacher will pick up the tests when everyone is done
10:55-11:00	Organize into groups (teacher divides you across groups)
11:00-11:10	Group test of introductory paper (closed book) Teacher will pick up the tests when everyone is done
11:10-11:30	Discussion of the paper
11:30-11:45	Break
11:45-12:00	Presentation #1 (10 minutes presentation, 5 minutes Q&A)
12:00-12:15	Presentation #2 (10 minutes presentation, 5 minutes Q&A)
12:15-12:30	Discussion of the two papers
12:30	Adjourn

Guest lectures

- Goal: give you a flavor of operational network infrastructure and current research
- Fri Oct 7: Prof. Cristel Pelsser of Uni Louvain (BE) on routing research (date TBC)
- Mon Oct 17: Ralph Koning and Caspar Schutijser (SIDN Labs) on SCION-in-P4 and SCIONlab
- Open to everyone

UCLouvain

SCION
SCALABILITY, CONTROL, AND ISOLATION ON NEXT-GENERATION NETWORKS

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P4 lab exercises

- One extended intro, two on-campus lab sessions
- Making the lab exercises at home is fine, but you'll need to come to campus to sign them off
- Lab sessions run by Niels (student assistant)
- More details in his talk :-)

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Your deliverables

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Overview

1. A total of **8 multiple-choice tests** on introductory papers
2. A **blog** in which you review one of the advanced papers
3. A **presentation** of 15 minutes about that paper at one of the lectures
4. Lab **exercises** about programing for a P4-enabled router

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Deliverable #1: multiple choice tests

- One individual tests per lecture: assess your understanding of the introductory paper
- One group test: do the individual test once more, but in groups (group-based learning)
- One topic per lecture (e.g., BGP security)
- Not tested: 20 min open discussion at the end of each lecture
- Grade = maximum of ((S-G)/(Q-G))*9+1 and 1

Make sure to **browse** a few of the ANET papers this week to double-check that ANET matches your interests, study plan, prerequisites, etc.

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Deliverable #2: blog

- 1.500 words tops
- The blog must be self-contained and capture the essence of the paper
- Your target audience are readers with a background in computer networking
- Goal: readers should be able assess if they'd like to read the full paper based on your blog
- Examples of blogs on the ANET site
- Writing a good blog takes time!

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Example topics

Design paper (e.g., [SCION])	Measurement paper (e.g, [DNS-SP])
• What is the problem that the authors aim to solve? • What requirements do the authors articulate for their work? • What does the high-level design and operation of their proposed system look like? • How does the design address the requirements? • What are the pros and cons of the authors' work and why? • What would you do differently? • Would you recommend the paper to interested readers?	• What is the problem that the authors aim to solve? • What methodology and experimental setup do the authors use? • What are their key findings and conclusions? • How do they propose others use their measurement study? • What are the pros and cons of the authors' work and why? • What would you do differently? • Would you recommend the paper to interested readers?

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Write the blog in your own words

Style		Example
Citing	✓	In our lab experiment, we use Manufacturer Usage Descriptions (MUDs) [RFC8250] to describe the network behavior of IoT devices.
Quoting	✓	MUD was designed to "provide a means for end devices to signal to the network what sort of access and network functionality they require to properly function" [RFC8250]
Copying	✗	MUD was designed to provide a means for end devices to signal to the network what sort of access and network functionality they require to properly function [RFC8250]

- Also cite and quote sources where you are a co-author, if applicable

- As per the university's policy, no forms of plagiarism are tolerated (check through Canvas)

Who writes about which paper?

- Indicate your **ranked top 5** (1st, 2nd, 3rd, etc.) through Canvas by **Fri Sep 9, 2022**

First name	Blogs about
…	[…]
…	[…]
…	[…]
…	[…]
…	[…]
…	[…]
…	[…]
…	[…]
…	[…]
…	[…]

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Grading of your blog

- We will evaluate your blog based on the following criteria:
  - Understanding: how well did you understand the paper, for instance in terms of the problem it aims to solve and the paper's key points?
  - Analysis: to what extent did you provide a critical analysis of the paper, for instance in terms of the pros/cons of the work, limitations of the proposed solution/approach, and potential improvements?
  - Clarity: structure, language, and readability of the blog

- The ANET teacher who gives a particular lecture will evaluate the blogs of that lecture
  - In addition, one of the other teachers will review your blog for a cross-check
  - They both use the evaluation criteria listed above to grade your blog

Deliverable #3: presentation

- Present your blog to your peers in at most 15 minutes, including 5 minutes of Q&A
- Teachers will score based on clarity, structure, and how well you responded to questions
- Your fellow students will do the same through a feedback form that we'll hand out
- Pointers on how to make a presentation are on the ANET website

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Deliverable #4: P4 lab assignment (1/2)

- Goal: learn how to program the packet handling functions of a simulated router using the domain-specific language P4

- Carry out the P4 assignment **individually** during the two lab sessions or at home

- Teaching Assistant (Niels) signs off **at one of the two lab sessions**

- Key **requirements** you'll need to fulfil to get your P4 assignments signed off are:
  - Your P4 code needs to run and shows the expected behavior
  - You're able to explain the Teaching Assistant what's going on and why
  - You added comments to your P4 code explaining what you did and why

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Deliverable #4: P4 lab assignment (2/2)

- We'll have a paper on P4 in the second lecture
- Niels will provide a short lab intro after my talk
- Extended introduction on Wed Sep 21

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Assessment

- Goal: evaluate to what extend you attained ANET's learning goals

- Pass if (((average score of your 8 individual tests)*25% + (average score of your 8 group tests)*25% + (score of your blog)*40% + (score of your presentation)*10%) * (score of your lab assignment)) >= 5.5

- The scores of the tests, blog, and presentation are between 1 (worst) and 10 (best)

- The score of the lab assignment is either 1 (pass) or 0 (fail)

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Important dates

- Ranked top five of papers you'd like to blog about (1st, 2nd, etc.): **Fri Sep 9, 2022**
- Individual and group test: **at each lecture**
- Blog and presentation: **one week after the lecture** in which you presented the paper
- Lab assignment: **at the two lab sessions** (see ANET schedule)

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Plan ahead!

- You need to deliver every week

- Writing a good blog and making a presentation takes time!

> *"I love deadlines. I love the whooshing noise they make as they go by."*
> *-- Douglas Adams*

Change log

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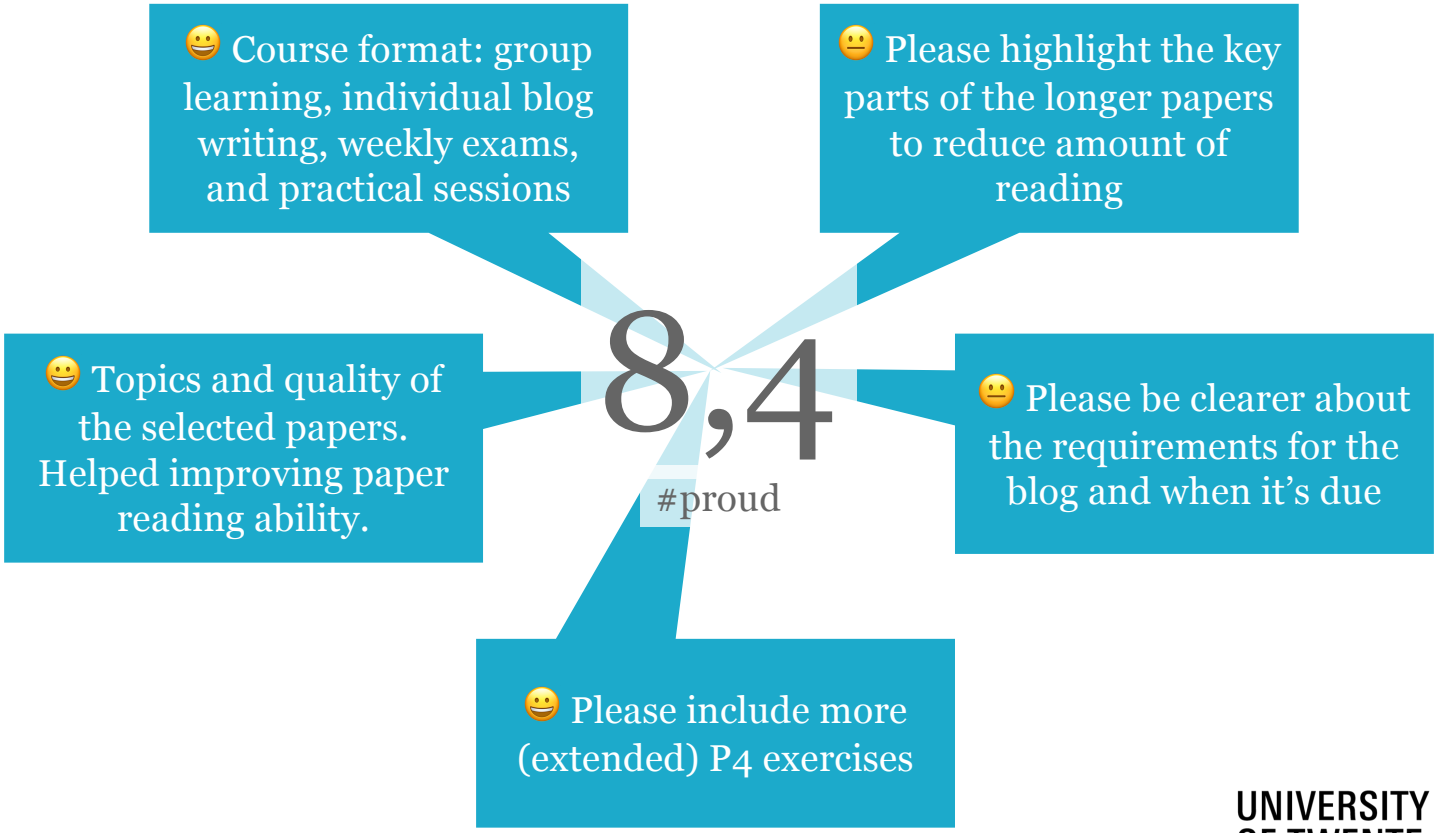
Class of 2021/2022 feedback (summary)



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Changes based on feedback class of 2021/2022

- Changed deadline for the blog to one week after the presentation
- Provided more guidance for writing the blog (design vs. measurement paper)
- Updated list of papers: [DCN2], [ICING], and [TUSSLE]
- Added a P4 exercise

P4 lab assignment

Niels Overkamp

University of Twente | September 7, 2022

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To what extent do you understand what we expect from you and why, and what you can expect from us?

👍✊👎

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Got even more excited about inter-domain networking?

👍✊👎

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Fact sheet

Advanced Networking (ANET)	
EC	5 (140 hours)
Prerequisites	Introductory course in computer networking, such as the bachelor module Network Systems at the UT
Coordinator	Cristian Hesselman (SIDN Labs, University of Twente)
E-mail	c.e.w.hesselman@utwente.nl
Teaching team	Dr. Pieter-Tjerk de Boer Prof. Geert Heijenk Prof. Roland van Rijswijk-Deij Niels Overkamp (TA) Prof. Cristian Hesselman
Quartile	1A (Sep 5 thru Nov 11, 2022)
Academic year	2022/2023
Capacity	Max 16 students

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Volg ons

SIDN.nl

@SIDN

SIDN

Q&A

Next lecture: **Mon Sep 21, 10:45-12:30**
Programmable networks

Cristian Hesselman
Director of SIDN Labs

+31 6 25 07 87 33
c.e.w.hesselman@utwente.nl
@hesselma

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SIDN LABS

SIDN Labs: a more trusted and resilient Internet through use-inspired basic research

Cristian Hesselman

September 7, 2022

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SIDN is the operator of the .nl TLD

- Objective: increase society's confidence in the Internet

- Provide secure and fault-tolerant registry services for .nl
  - Anycasted DNS services with DNSSEC support
  - Registration and domain protection services

- Increase the value of the Internet in the Netherlands and elsewhere
  - Enable safe and novel uses (SIDN Fonds, IRMA)
  - Increase infrastructure security and trustworthiness (SIDN Labs)

- Not-for-profit private organization with a public role based in Arnhem

.nl = the Netherlands
17M inhabitants
6.2M domain names
3.4M DNSSEC-signed
2.5B DNS queries/day
8.6B NTP queries/day

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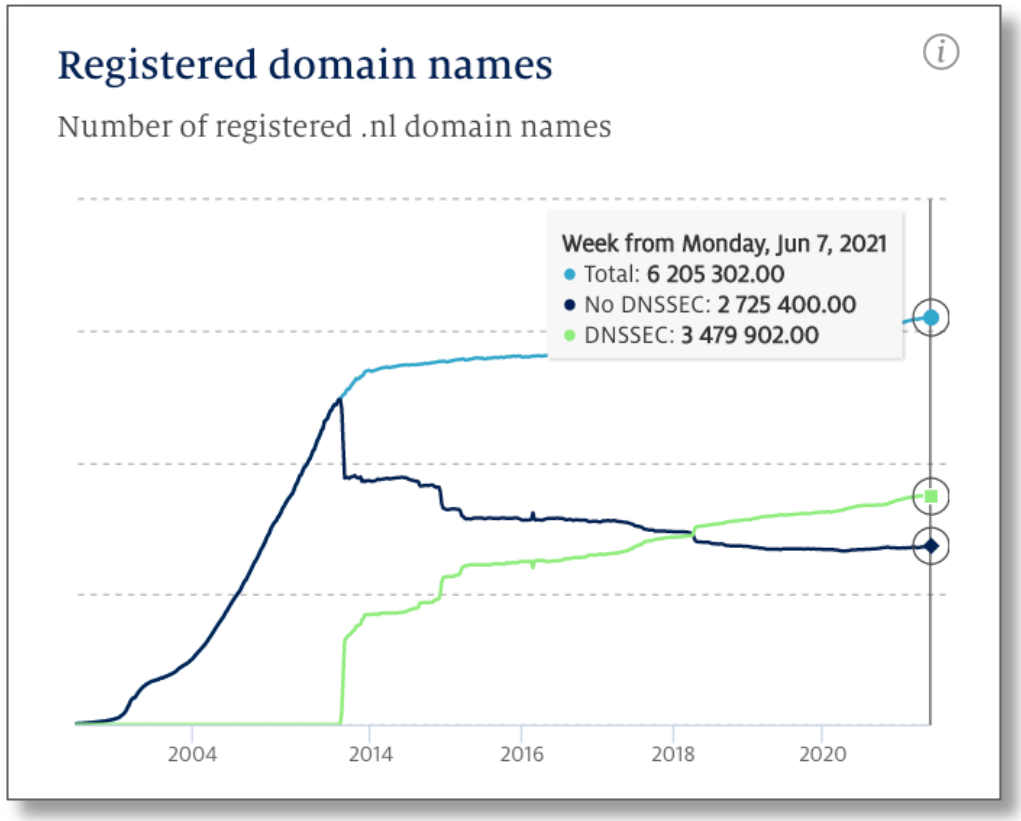
Number of .nl domain names (stats.sidnlabs.nl)



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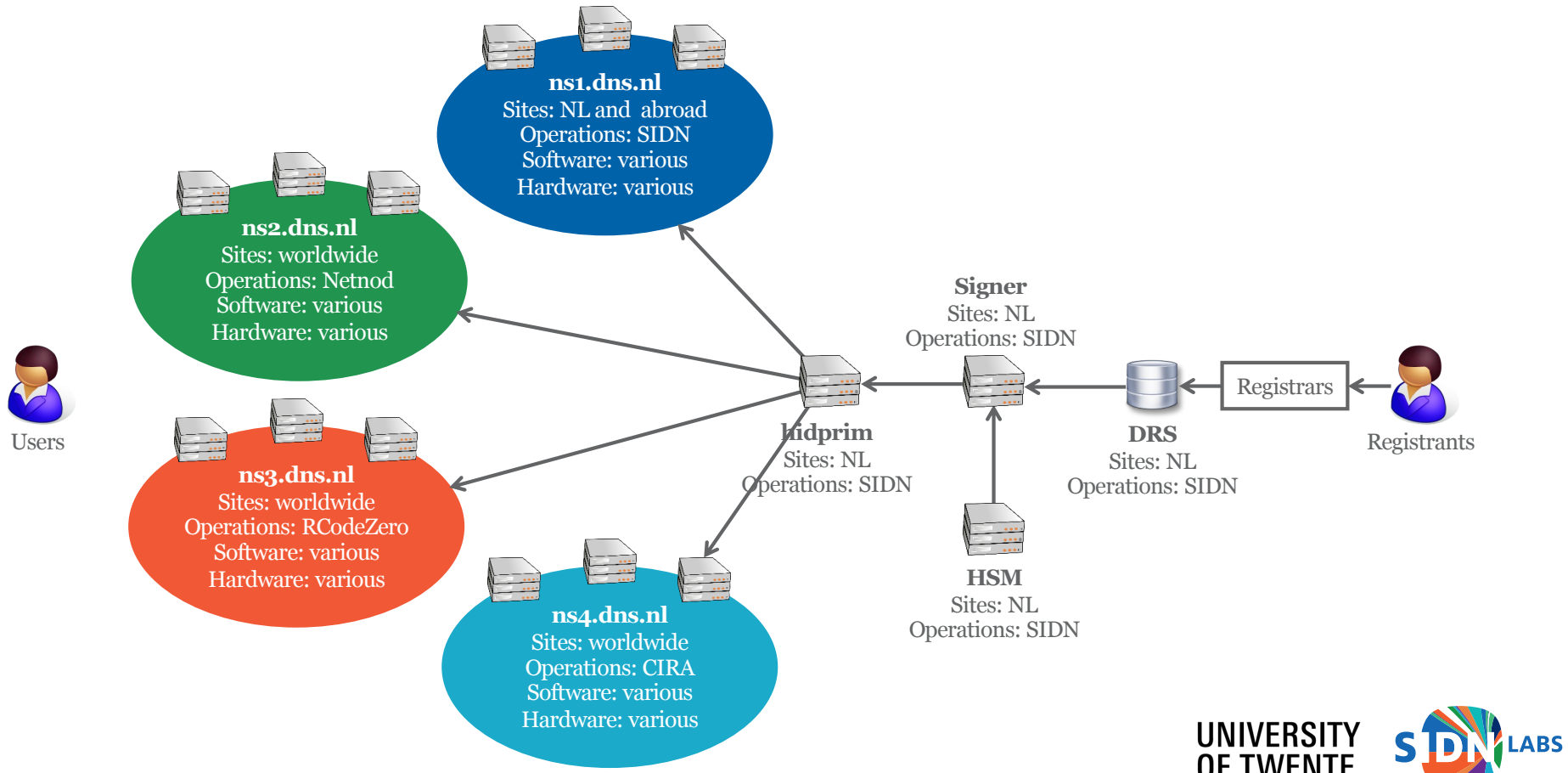
Heterogeneous and fault-tolerant DNS infrastructure



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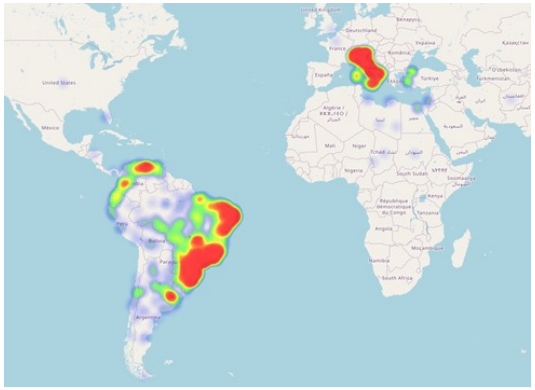
A more flexible DNS infrastructure (ns1.dns.nl)

- Virtual machines at cloud providers
- Vultr, Packet (Equinix), Heficed
- Control over VMs and operating systems
- Complements “as a service” and owned infra
- BIRD-based BGP sessions to cloud providers
  - Path pre-pending
  - BGP communities

Anycast2020 sites



BGP tuning based on catchments

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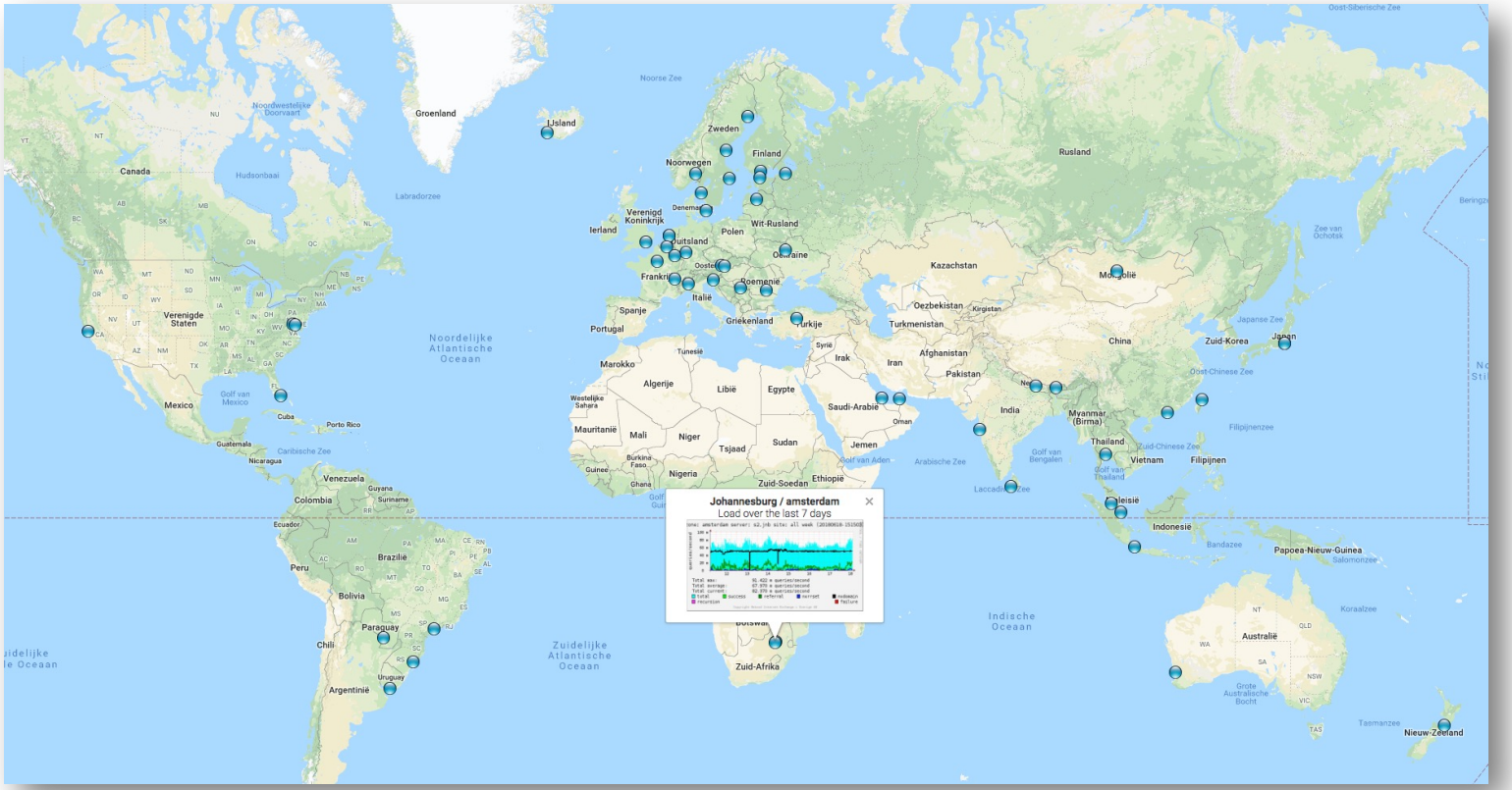
ns2.dns.nl (Netnod)



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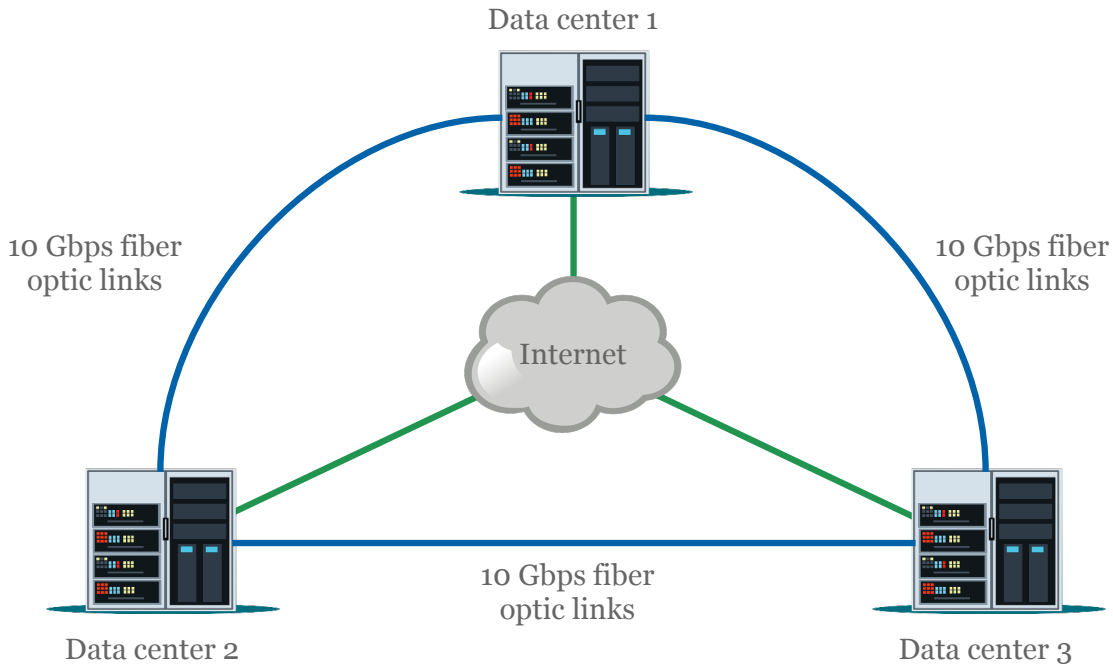
Registration infrastructure (DRS, RDAP, WHOIS, …)



99.96% availability
Full-automatic failover

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Other security areas

- System monitoring and patching (with NCSC-NL and others)
- Secure software development
- Infrastructure penetration testing
- Large-scale and collaborative DDoS mitigation drills (Dutch Anti-DDoS Coalition)
- Security Operations Center (ISO 27001)
- Proactive and collaborative abuse mitigation (phishing, malware, fake shops, etc.)

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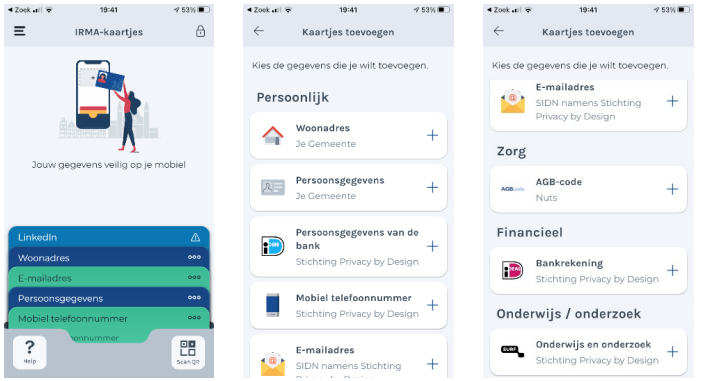
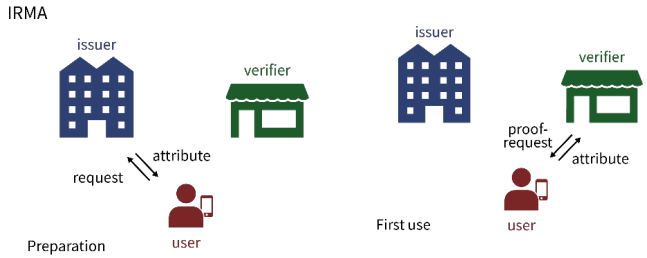
I Reveal My Attributes (IRMA)

- Solution for decentralized identity management
- Increases users' data autonomy
- Reduces big tech user profiling
- Enables security verification through open source
- Development at SIDN (from University of Nijmegen)





Gemeente Amsterdam · Nijmegen · VGZ

https://www.sidn.nl/en/theme/online-identity

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SIDN Labs = research team

- Goal: increase the short and long-term security of our society's internet infrastructure, for .nl and the Netherlands in particular

- Strategies:
  - Use-inspired basic research (measurements, design, prototyping, evaluation)
  - Make results publicly available and useful for various target groups
  - Apply results at SIDN and elsewhere ("eat your own dogfood")
  - Work with universities, infrastructure operators, and other labs

- Three research areas: network security (DNS, NTP, BGP), domain name security, new network security paradigms (programmable networks, fundamental design changes)

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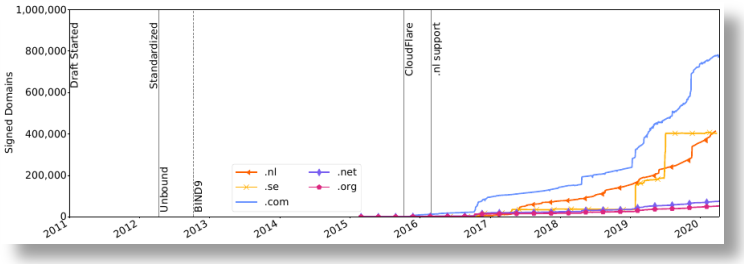
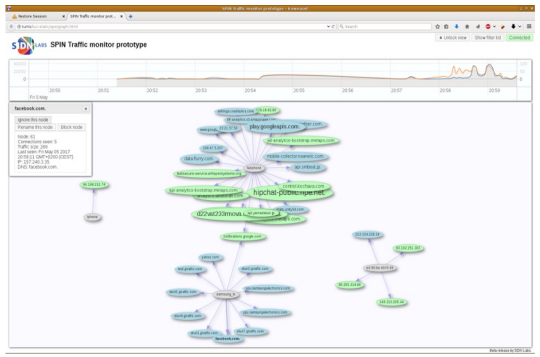
Example projects

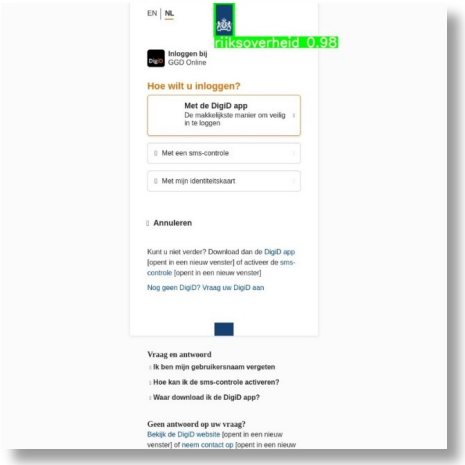


Measuring the deployment of newly standardized DNSSEC algorithms [3]

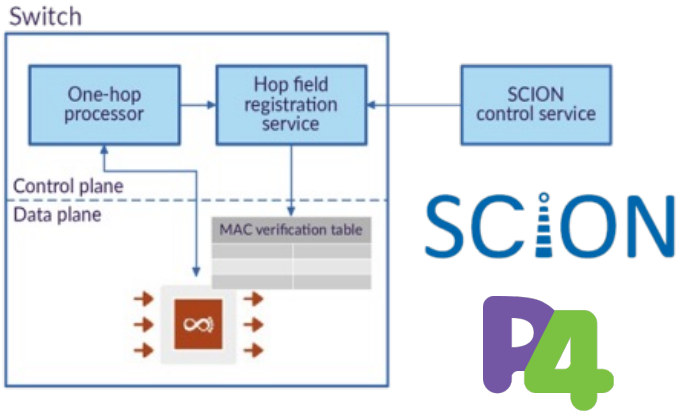
Provide well-managed and secure time services [4]



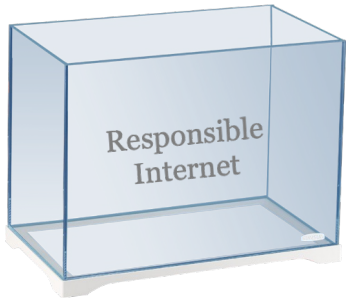
Making the IoT more secure and transparent and measure its evolution [5]



Logo detection technology to identify malicious .nl websites [6]



Experimenting with secure future networks and programmable networks [7][8]



2STiC
NWO
€1.9M

Developing a new Internet security and autonomy paradigm [9]

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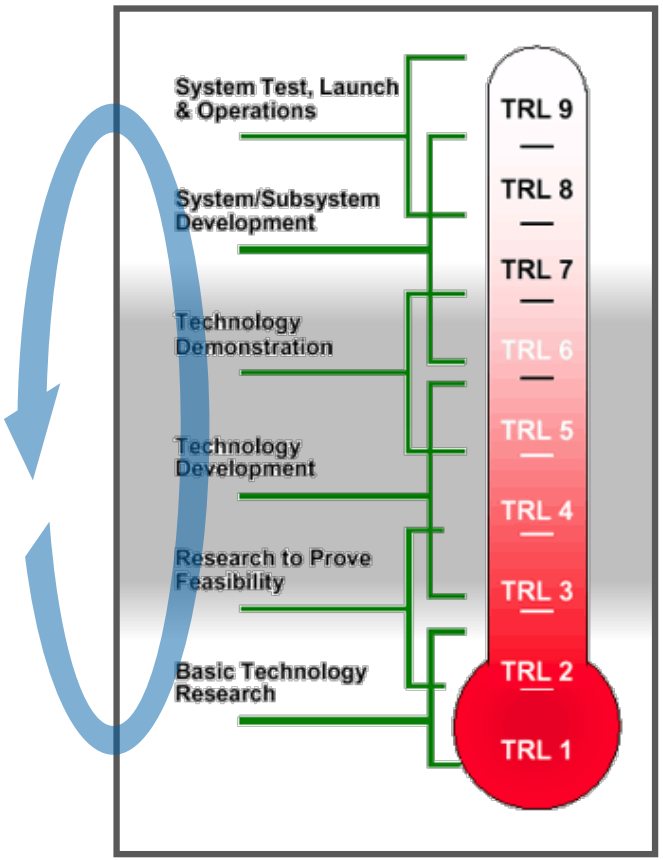
SIDN Labs and Technology Readiness Levels

SIDN Labs focuses on the **R** in R&D



Operations

Experimental

Fundamental research

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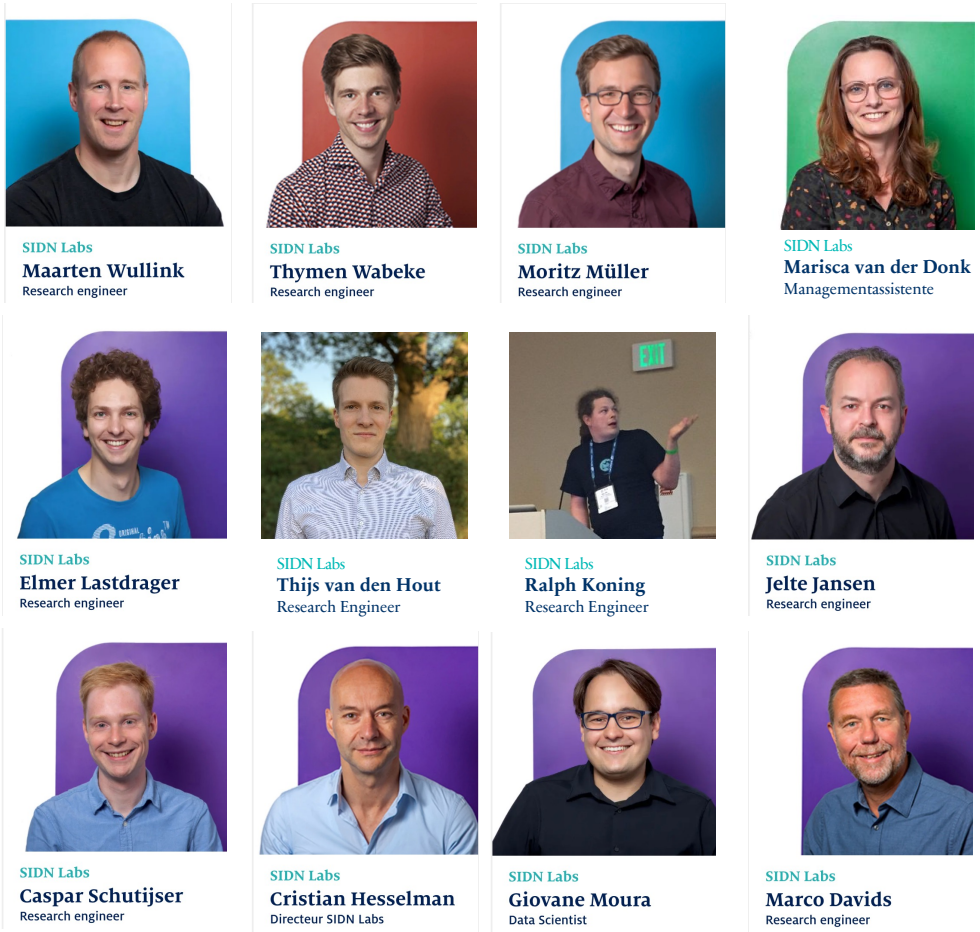
https://en.wikipedia.org/wiki/Technology_readiness_level

O'Reilly, C. A., & Tushman, M. L. (2013). Organizational ambidexterity: Past, present, and future. Academy of Management Perspectives, 27(4), 324-338

Examples of our research partners

SIDN Labs team



SIDN Labs
Maarten Wullink
Research engineer

SIDN Labs
Thymen Wabeke
Research engineer

SIDN Labs
Moritz Müller
Research engineer

SIDN Labs
Marisca van der Donk
Managementassistente

SIDN Labs
Elmer Lastdrager
Research engineer

SIDN Labs
Thijs van den Hout
Research Engineer

SIDN Labs
Ralph Koning
Research Engineer

SIDN Labs
Jelte Jansen
Research engineer

SIDN Labs
Caspar Schutijser
Research engineer

SIDN Labs
Cristian Hesselman
Directeur SIDN Labs

SIDN Labs
Giovane Moura
Data Scientist

SIDN Labs
Marco Davids
Research engineer

- Technical experts, divers in seniority and nationality
- Help SIDN teams, write open-source software, analyze large amounts of data, conduct experiments, write articles, collaborate with universities
- M.Sc students help us advance specific areas

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Team culture

- Our added value for the Dutch, European, international Internet community is central
- Flat organization with focus on increasing reliability of the Internet infrastructure
- Cross-fertilization between people for new research and innovation
- Team with professional and self-organizing technical experts
- Leadership provides high-level guidance and facilitates

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SIDN Labs history

- End of 2021: 11 colleagues, 10 research engineers
- End of 2018: start of 2STiC
- Beginning of 2017: start of SPIN
- Beginning of 2013: dedicated team (3 colleagues)
- December of 2011: research program
- Summer of 2011: weblog

Details: https://www.sidnlabs.nl/en/news-and-blogs/ten-years-of-sidn-labs

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Q&A

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