

Your Covid responsibilities on campus (and elsewhere)

- If you have **symptoms**, stay at home, even if they're only very minor. Do not come to class.
- If you **travelled** to an area marked red or amber by the Dutch government in the past two weeks, then you are strongly advised to go into preventive quarantine for 10 days. Do not come to class.
- Pay particular attention when **you enter or leave** the lecture room, **minimize walking around** to a keep 1.5-meter distance at all times
- This is a **shared responsibility for all of us**, not just to protect yourself but your fellow students, friends, family, and teaching staff as well



Advanced Networking: Introduction

Geert Heijenk, Pieter-Tjerk de Boer, Roland van
Rijswijk-Deij, Bas Bleijerveld, Cristian Hesselman

University of Twente | September 2, 2020

Your teaching team



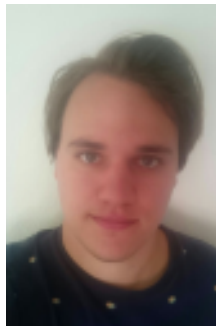
Geert Heijenk
(teacher)



Pieter-Tjerk de Boer
(teacher)



Roland van Rijswijk-Deij
(teacher)



Bas Bleijerveld
(teaching assistant)



Cristian Hesselman
(teacher and coordinator)

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Today's goal

- Provide an overview of Advanced Networking (ANET)
- Answer questions you may have on assessment, deliverables, etc.
- Result: understanding of ANET and provide inspiration on the topic of internetworking

Agenda

- High-level introduction to internetworking
- Course overview
- Brief introduction of SIDN Labs
- Q&A

How the Internet works

(from a 50,000-foot perspective)

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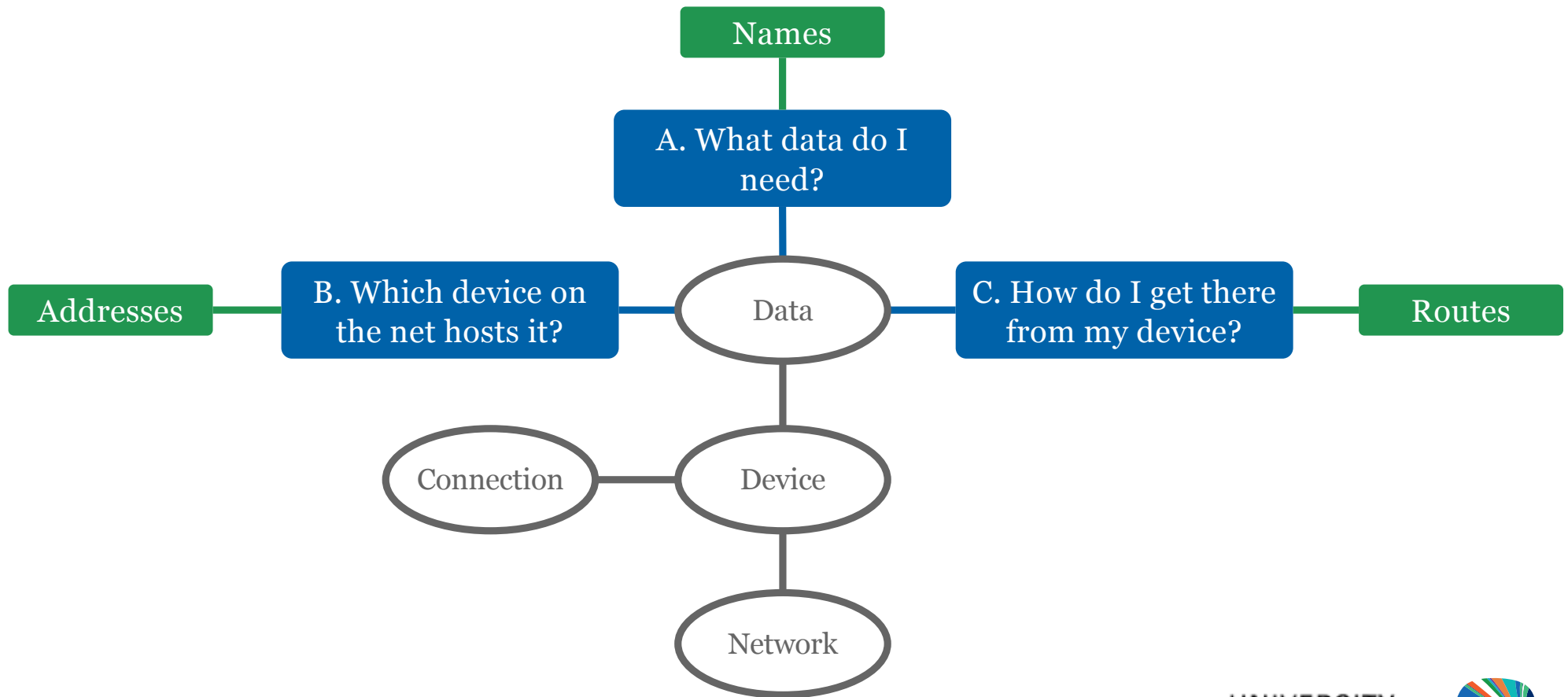
Wikipedia

- 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”

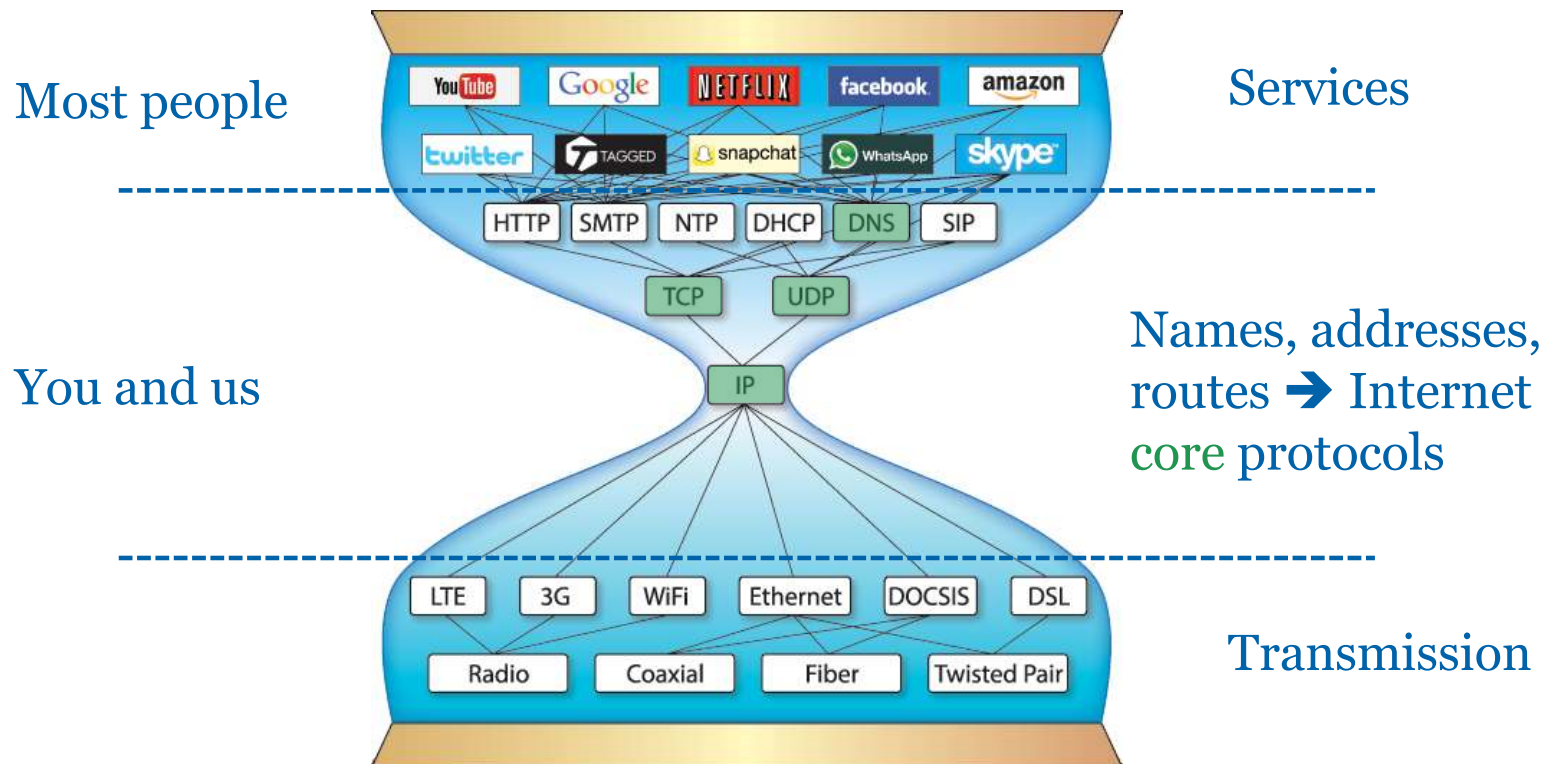


“The Internet works because a lot of people **cooperate** to do things together”
– Jon Postel (1943-1998)

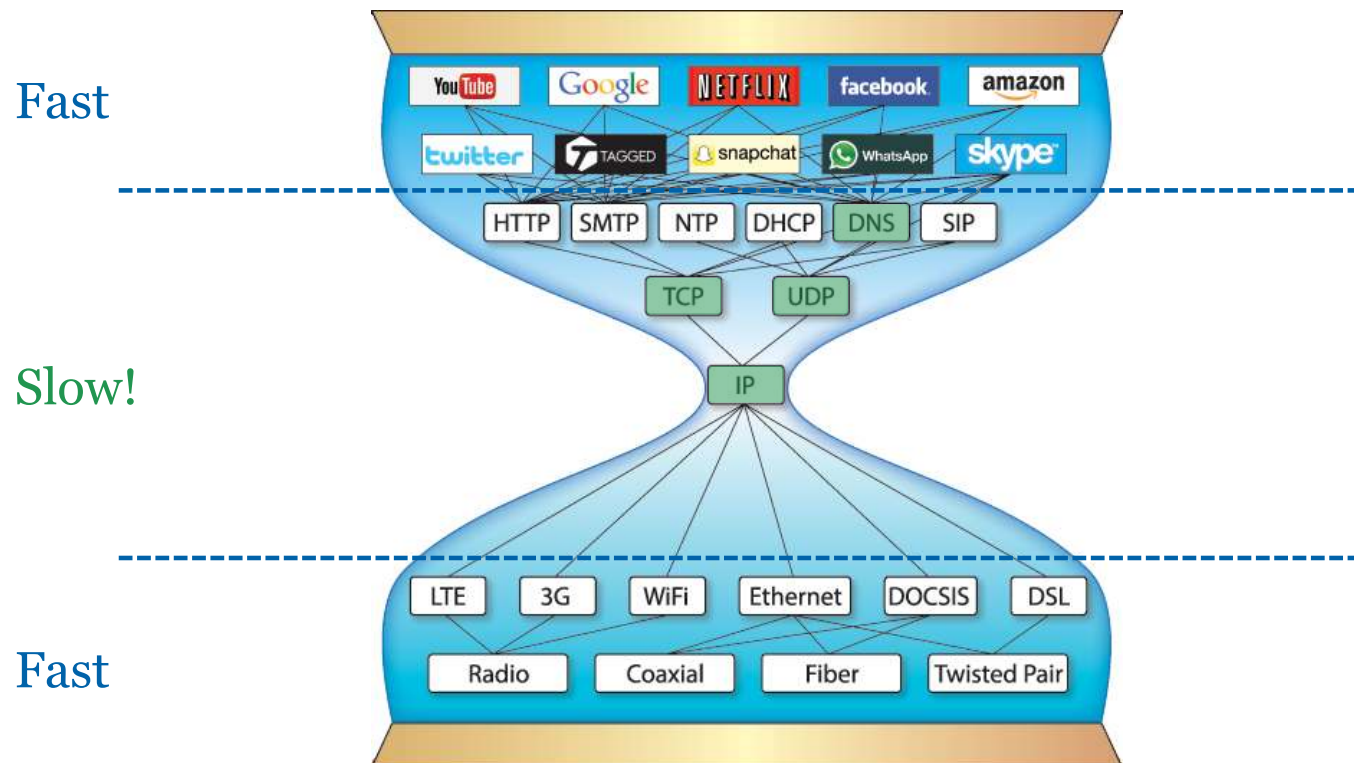
Key concepts of inter-networking (1978)



Under the hood: protocols and services



Rate of change



First packet ever...



The origins of TCP/IP's design

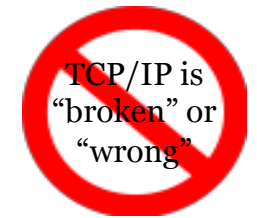


Birthplace of the Internet
@UCLA, Sep 2017



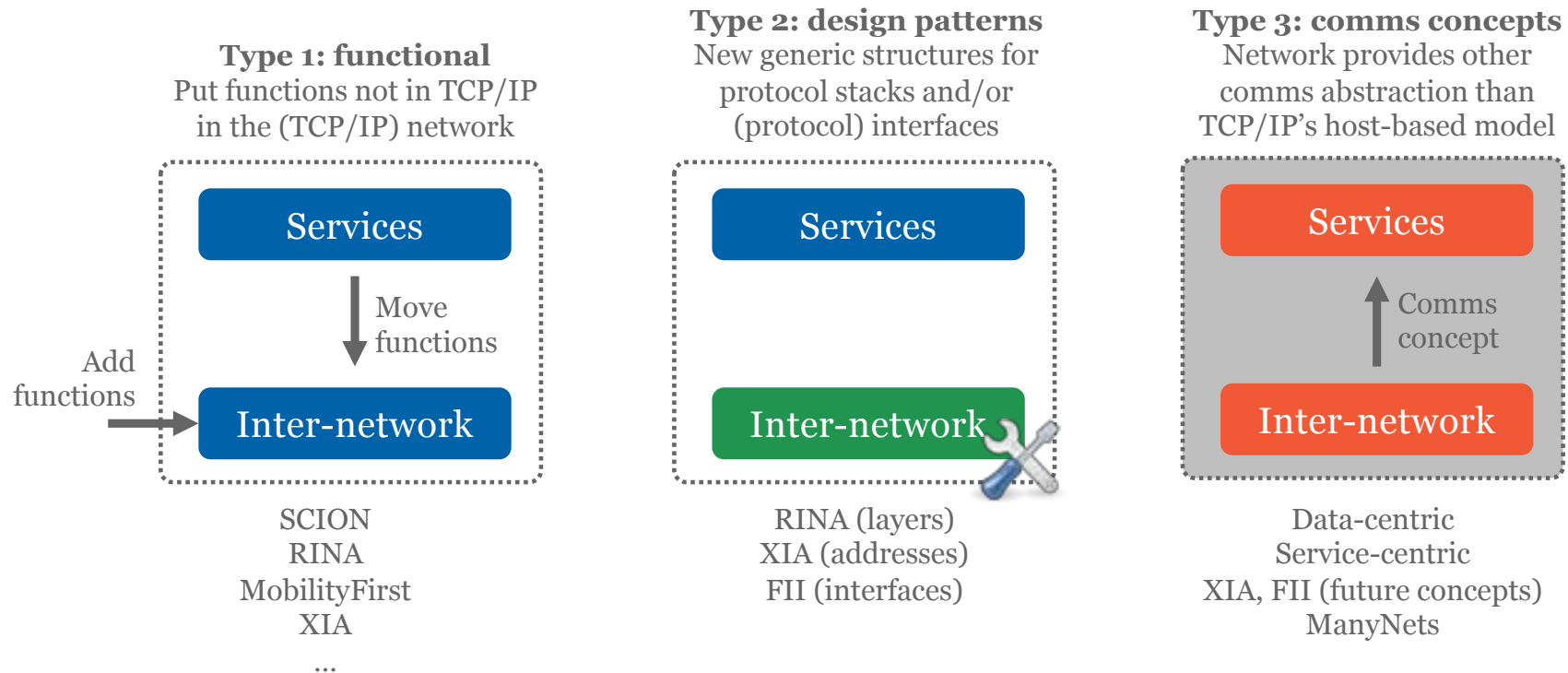
Design decisions

TCP/IP lessons learned



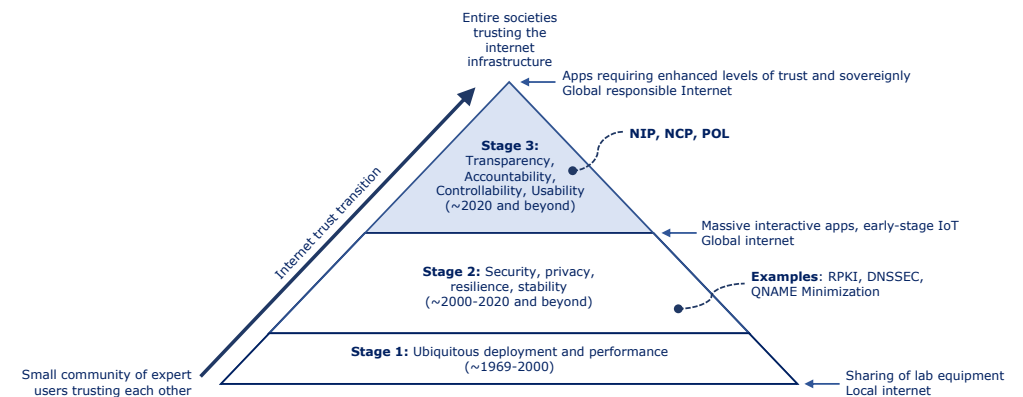
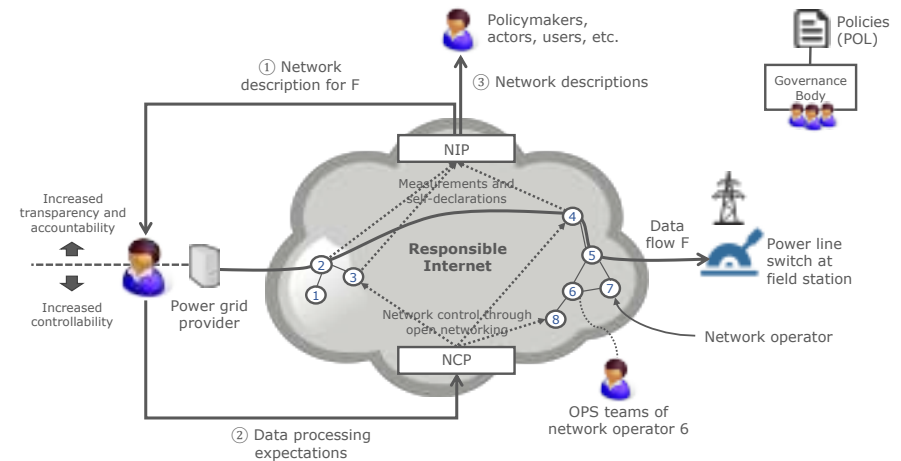
- Thin waist enabled worldwide deployment
 - Simple network layer (IP+BGP), weak demands on underlying networks
 - Stateless, unreliable, unordered, best-effort delivery
- Issues investigated include:
 - Designed for point-to-point applications (“conversations”), not for multipoint (dissemination)
 - Security is an add-on, not an integral part of the core protocols
 - Does not support mobility (movement between networks)
 - No support for quality guarantees (e.g., latency guarantees for autonomous vehicles)
 - Local incidents may have global effects (e.g., a CA compromise)
 - No path control and verification for applications that need it (e.g., critical infra services)

Proposed changes in the literature



A responsible Internet

- Higher degrees of trust and sovereignty by making the Internet more transparent, accountable, controllable at the network-level
- Added value for critical infrastructure operators (e.g., energy grids), policy makers, network operators, citizens, others
- Enables several societal, economic, and scientific breakthroughs because it changes the Internet's 1960s-1970s trust model
- Aligns with similar developments in AI (responsible AI) and cloud services (GAIA-X)



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
- However, folks extend the Internet continually to meet needs of societies and services
 - Increased trustworthiness and sovereignty
 - 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



Course overview

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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 inter-networking 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
- Prerequisites: introductory course on computer networks, such as the bachelor module Network Systems at the University of Twente

Assessment

- Goal: evaluate to what extend you attained ANET's learning goals
- Deliverables
 1. **8 multiple choice tests** on papers/RFCs, each covering **two** ANET papers, to be completed both individually and in groups
 2. A **P4 program** that configures the packet handling functions of a P4-programmable network switch, to be carried out individually at home
- Pass if $((\text{average score of 8 individual tests}) * 70\% + (\text{average score of 8 group tests}) * 30\%) * (\text{score of lab assignment}) \geq 5.5$ AND $(\text{average score of 8 individual tests}) \geq 5.5$

Deliverable #1: multiple choice tests

- One individual tests per lecture: assess your understanding of **two** papers
- One group test: do the two individual test once more, but in groups (group-based learning)
- One topic per lecture (e.g., BGP security)
- Not tested: open discussion based on a few open questions at the end of each lecture

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

Deliverable #2: 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** at home
- Teaching Assistant (Bas) signs off through regular “sign-off sessions” on Canvas
- 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

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

- You'll need to submit your P4 code through Canvas (unzipped) so we can confirm that you yourself carried out the work (SimCheck)
- We'll have a paper on P4 in the second on-campus lecture and we'll provide detailed information on the lab assignment through an online introductory lecture (see ANET schedule)

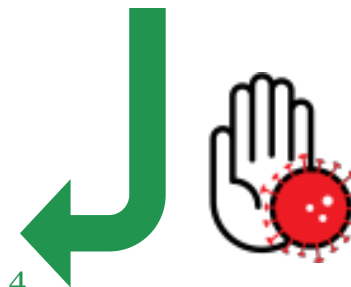
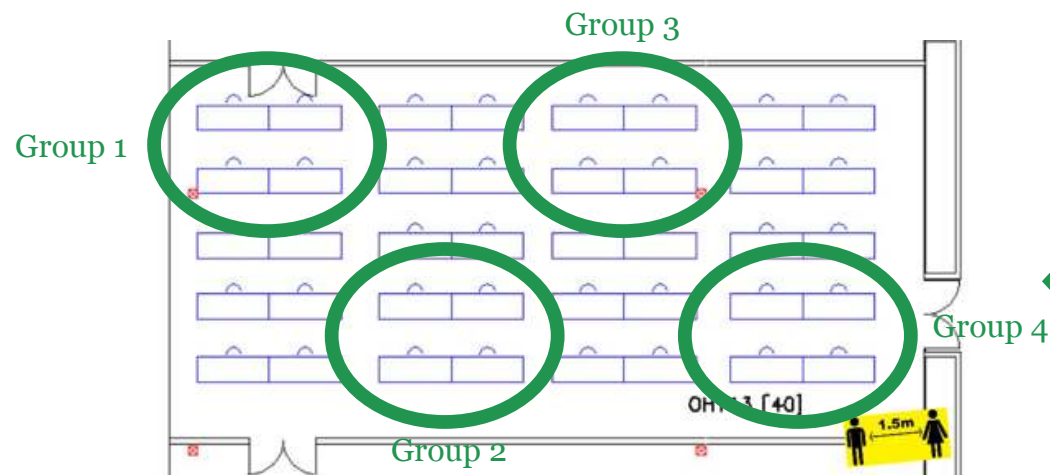
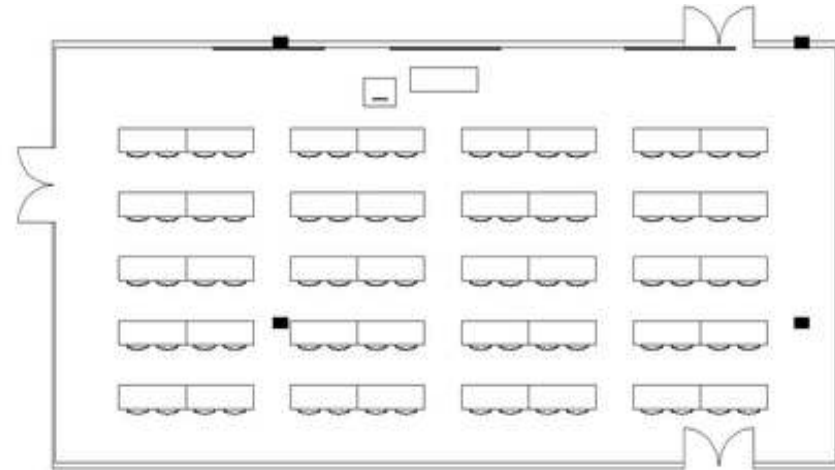
ANET schedule 2020/2021

Lect.	Date	Loc.	Topic
O1	Mon Aug 31	-	NO LECTURE
C1	Wed Sep 2	OH113	ANET introduction Intro P4 lab assignment (short)
O2	Mon Sep 7	Canvas	Guest Lecture #1: design and evolution of the Internet
C2	Wed Sep 9	OH113	Programmable Networks [SDN] [P4]
O3	Mon Sep 14	Canvas	Guest Lecture #2: the Internet's interconnection landscape
C3	Wed Sep 16	OH113	BGP Security [BGP1] [BGP2]
O4	Mon Sep 21	Canvas	Intro P4 lab assignment (extended)
C4	Wed Sep 23	OH113	Data Center Networking [DCN] [B4]
O5	Mon Sep 28	Canvas	P4 sign-off session #1
C5	Wed Sep 30	OH113	Multi-path communication [MTCP1] [MTCP2]
O6	Mon Oct 5	Canvas	P4 sign-off session #2
C6	Wed Oct 7	OH113	QUIC [QUIC1] [QUIC2]
O7	Mon Oct 12	Canvas	P4 sign-off session #3
C7	Wed Oct 14	OH113	Emerging inter-networks part I [CYCLE] [TLOTS]
O8	Mon Oct 19	Canvas	P4 sign-off session #4
C8	Wed Oct 21	OH113	DNS security and privacy [P-DNS] [DoH]
O9*	Mon Oct 26	-	NO LECTURE
C9*	Wed Oct 28	OH113	Emerging inter-networks part II [SCION] [NDN]
O10*	Mon Nov 2	-	NO LECTURE
C10*	Wed Nov 4	-	NO LECTURE

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Tests on campus in Oost Horst 113 (OH113)



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Timetable and expected behavior in OH113

Time	What
17:45-17:50	Arrival at OH113, put your cell phone in your bag, pick up hardcopy of tests at teacher's desk, sit down Mind the 1.5m distance
17:50-18:10	Individual test papers 1 and 2 (closed book) Teacher will pick up the tests when everyone is done
18:10-18:15	Organize into G groups (teacher divides you across groups) Mind the 1.5m distance
18:15-18:45	Group test papers 1 and 2 (closed book) Teacher will pick up the tests when everyone is done
18:45-19:00	Break, mind the 1.5m distance
19:00-19:15	Plenary discussion on answers of both tests
19:15-19:30	Detailed discussion on details of one paper (open book)
19:30	Adjourn, mind the 1.5m distance



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Guest lectures (online, Mon Sep 7 and Mon Sep 14)

- Goal: broaden your horizon on inter-domain networking, in particular to give you a flavor of the history and operational side of the Internet
- Lecture #1: Kees Neggers on the design and evolution of the Internet
 - https://en.wikipedia.org/wiki/Kees_Neggens
 - Prepare questions about [RINA2] and put them on Canvas, I opened a message thread for it
 - Deadline: Fri Sep 4, noon
 - Agenda: talk by Kees (30 minutes), discussion (30 minutes)
- Lecture #2: Henk Steenman on the Internet's peering landscape (open session)
 - <https://www.ams-ix.net/ams/team>

Online house rules (Mondays)

- Join with your mic muted, do not join in listen-only mode
- Unmute (and optionally turn on your cam) if you want to speak :-)
- Or post your questions/comments in the chat
- But you'll probably know this by now ;-)

Important dates

- Individual and group tests: at each lecture
- Lab assignment: at the sign-off sessions (see ANET schedule)
- Up to date schedule: see <https://courses.sidnlabs.nl/anet-2020>

Staying up to date

- Canvas message board
- ANET homepage at <https://courses.sidnlabs.nl/anet-2020>
- Authoritative source for information about ANET
- Recommend visiting it every now and then

ANET fact sheet

Advanced Networking (ANET)	
EC	5 (140 hours)
Prerequisites	Introductory course in computer networks, such as the bachelor module Network Systems at the UT
Lecturers	dr.ir. Pieter-Tjerk de Boer (University of Twente) prof.dr.ir. Geert Heijenk (University of Twente) dr. Roland van Rijswijk-Deij (NLnetLabs and University of Twente) dr. Cristian Hesselman (SIDN Labs and University of Twente)
Student assistant	Bas Bleijerveld
Coordinator	Cristian Hesselman (SIDN Labs, University of Twente)
E-mail	c.e.w.hesselman@utwente.nl
Quartile	1 (Aug 31 – Nov 8, 2020)
Academic year	2020/2021

SIDN Labs

Operator of the .nl TLD

- *Stichting Internet Domeinregistratie Nederland* (SIDN)
- Critical infrastructure services
 - Lookup IP address of a domain name (almost every interaction)
 - Registration of all .nl domain names
 - Manage fault-tolerant and distributed infrastructure
- Increase the value of the Internet in the Netherlands and elsewhere
 - Enable safe and novel use of the Internet
 - Improve the security and resilience of the Internet itself



.nl = the Netherlands

17M inhabitants
6M domain names
3.3M DNSSEC-signed
2B+ DNS queries/day

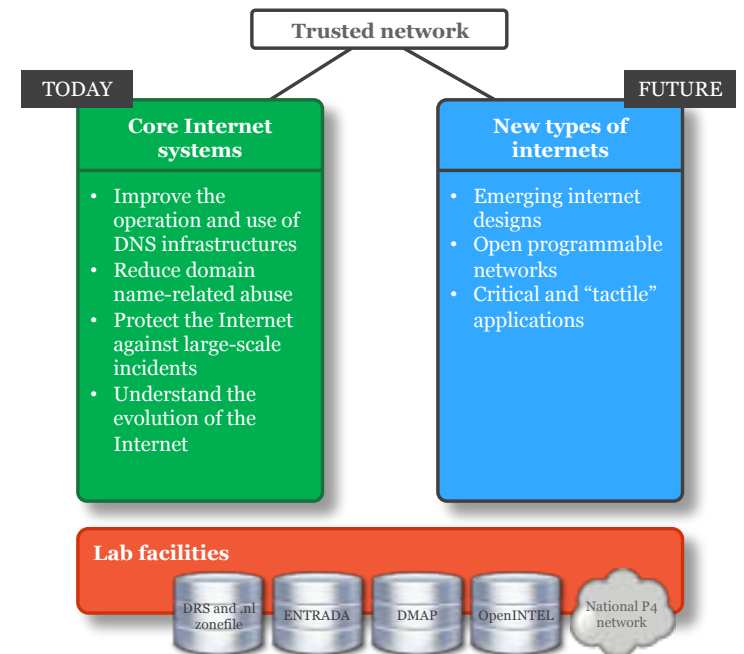
SIDNfonds

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SIDN Labs objective: to increase the trustworthiness of our society's internet infrastructure

- Trusted = secure, stable, resilient, and transparent, for .nl and NL in particular
- Strategies to get there
 - Applied research (measure, prototype, evaluate) based on validated research agenda
 - Strengthen research and operational communities (SIDN, NL, EU, global), for instance by sharing results
- 2020s: safeguard NL and EU public values like privacy and safety (“digital sovereignty”)



ANET is a collaborative course

- Motivation for SIDN Labs
 - Proud to help educating the next generation of Internet (security) engineers and researchers
 - Aligns with our research on 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
 - University: further improved research and education using SIDN's operational experience, unique datasets, and industry network

Volg ons

 SIDN.nl

 @SIDN

 SIDN

Q&A

Next lecture: **Mon Sep 7, 15:45-17:30**

Cristian Hesselman
Director of SIDN Labs

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

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