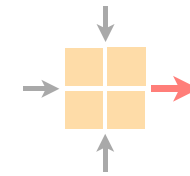# Advanced Topics in Communication Networks | Fall 2023 |

Networked Systems
ETH Zürich — seit 2015

This course covers advanced topics and technologies in computer networks, both theoretically and practically.

The goal for this course is to provide students with a deeper understanding of existing and upcoming Internet routing and forwarding technologies used in large-scale computer networks such as Internet Service Providers (e.g., Swisscom or Deutsche Telekom), Content Delivery Networks (e.g., Netflix) and Data Centers (e.g., Google).

Besides covering the fundamentals, the course will be "hands-on" and will enable students to play with the technologies in realistic network environments, and even implement some of them on their own during labs.

News

Jan 4	Previous years' exams are now available.
Dec 28	The solutions for the second exercise session are now online.
Dec 19	The last (but not least!) session of AdvNet is today. Slides are now online.
Dec 5	The solutions for the security block are now online in gitlab.
Nov 29	The solutions for week 2's exercise session are now (finally) online. Week 3's solutions will be coming soon.

Contact

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Assistants

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Research group Networked Systems

Chat room #adv-net-23 (Please read the 📄 Instructions)

Mail adv-net@ethz.ch

Location & time

Lecture
Tuesdays, 2:15 pm–4 pm

Exercise sessions
Tuesdays, 4:15 pm–6 pm

| In-person | ML E 12 |
| Recordings | ETH Video Portal (accessible with an ETH login) |

Course information	Materials

Week 1

19.09

Lecture Introduction, Course organization. Hierarchical routing (Part 1)

- 📄 Introduction
- 📄 Hierarchical Routing (Part 1)

Exercise None this week. Start in week 2.

Week 2

26.09

Lecture Hierarchical routing (Part 2). Prefix filtering and aggregation.

- 📄 Slides

Exercise Routing and forwarding scalability

- 📄 Assignment (📄 Solutions)

Extra readings

- iBGP Deceptions: More Sessions, Fewer Routes. Vissicchio et al., IEEE INFOCOM, 2012
- Using routers to build logic circuits: How powerful is BGP? Chiesa et al., IEEE ICNP, 2013
- Network Recovery. Protection and Restoration of Optical, SONET-SDH, IP, and MPLS. Vasseur et al., 2004 (Check Section 4.14 "Incremental Dijkstra" for a more in-depth description of iSPF. Free access from within the ETH network!)
- Constructing optimal IP routing tables. Draves et al., IEEE INFOCOMM, 1999. (Introduces the ORTC algorithm.)
- On the Aggregatability of Router Forwarding Tables. Liu et al., IGI Global, 2014 (Introduces the 4 level of aggregability.)
- SMALTA: Practical and Near-Optimal FIB Aggregation. Uzmi et al., ACM CoNEXT, 2011 (ORTC, with updatability in mind.)
- Scaling the Internet Routing System Through Distributed Route Aggregation. Sobrinho et al., IEEE/ACM TON, 2016 (Introduces DRAGON.)

Week 3

03.10

Lecture Fast convergence, Multiprotocol Label Switching (MPLS)

- 📄 Slides

Exercise Routing scalability (the end), fast convergence, and some MPLS

- 📄 Assignment (📄 Solutions)

Extra readings

- Achieving Sub-Second IGP Convergence in Large IP Networks. Francois et al. ACM SIGCOMM CCR, 2005
- Basic Specification for IP Fast Reroute: Loop-Free Alternates. Atlas and Zini. IETF RFC 5286, 2020
- Remote Loop-Free Alternate (LFA) Fast Reroute (FRR). Bryant et al. IETF RFC 57490, 2015
- Blink: Fast Connectivity Recovery Entirely in the Data Plane. Holterbach et al. USENIX NSDI, 2019
- FAst in-network GraY failure detection for ISPs. Costa Molero et al. ACM SIGCOMM, 2022

Week 4

10.10

Lecture Data-plane programmability (Part 1)

- 📄 Slides

Coding Exercise Building a L2 switch using P4

- 📖 README

Extra readings

- P4 Language and Related Specifications
- P4 Learning. A compilation of useful resources for data plane programming made and maintained by our group.

- [Aggregate-Based Congestion Control for Pulse-Wave DDoS Defense. Gran Alcoz et al. ACM SIGCOMM, 2022](#)
- [FAst in-network GraY failure detection for ISPs. Costa Molero et al. ACM SIGCOMM, 2022](#)
- [SP-PIFO: Approximating Push-In First-Out Behaviors using Strict-Priority Queues. Gran Alcoz et al. USENIX NSDI, 2020](#)
- [Blink: fast connectivity recovery entirely in the data plane. Holterbach et al. USENIX NSDI, 2019](#)
- [ditto: WAN Traffic Obfuscation at Line Rate. Meier et al. NDSS, 2022](#)
- [Hardware-Accelerated Network Control Planes . Costa Molero et al. ACM HotNets, 2018](#)

Week 5

17.10

Lecture Data-plane programmability (Part 2)

- 📄 [Slides](#)

Exercise Load Balancing

- 📖 [README](#)

Week 6

24.10

Lecture Network verification

- 📄 [Slides](#)

Exercise Building a simple, but functional (!) network verifier

- 📖 [README](#)

Extra readings

- [A General Approach to Network Configuration Verification. Beckett et al. ACM SIGCOMM, 2017](#)
- [Metha: Network Verifiers Need To Be Correct Too! Birkner et al. USENIX NSDI, 2021](#)
- [Probabilistic Verification of Network Configurations. Steffen et al. ACM SIGCOMM, 2020](#)

Week 7

31.10

Lecture Network Verification (Part 2)

- 📄 [Slides](#)

Exercise Building a simple, but functional (!) network verifier (Part 2)

- 📖 [README](#)

Extra readings

- [Program Synthesis by Sketching. Armando Solar Lezama, Ph.D dissertation, University of California, Berkeley, 2008.](#)

Week 8

07.11

Lecture Network Verification (Part 3)

- 📄 [Slides](#)

Exercise Building a simple, but functional (!) configuration synthesizer

- 📖 [README](#)

Extra readings

- [Syntax Guided Synthesis. Rajeev Alur et al., IEEE FMCAD'13.](#)
- [Network-wide Configuration Synthesis. Ahmed El-Hassany et al., CAV'17.](#)
- [NetComplete: Practical Network-Wide Configuration Synthesis with Autocompletion. Ahmed El-Hassany et al., NSDI'18.](#)
- [Learning to Configure Computer Networks with Neural Algorithmic Reasoning. Luca Beurer-Kellner et al., NeuroIPS'22.](#)
- [On the Complexity of Network-Wide Configuration Synthesis. Tibor Schneider et al., ICNP'22.](#)
- [Config2Spec: Mining Network Specifications from Network Configurations. Rüdiger Birkner et al., NSDI '20.](#)

- Snowcap: Synthesizing Network-Wide Configuration Updates. Tibor Schneider et al., SIGCOMM '21.
- Taming the transient while reconfiguring BGP. Tibor Schneider et al., SIGCOMM '23.

Week 9　　**Lecture**　Network measurements (Part 1)

14.11
- 📄 Slides

Exercise　Implementing a Bloom Filter and a Count-MinSketch in P4

- 📖 README

Extra readings

- 📄 Extended slides on probabilistic data structures. Note that the extensions are not part of the exam.

Week 10　　**Lecture**　Network measurements (Part 2)

21.11
- 📄 Slides

Exercises　Network inference

- 📄 AS-level topology (📄 Solutions)
- 📄 Network tomography (📄 Solutions)

Week 11　　**Lecture**　Network security

28.11
- 📄 Slides

Exercise　Defending against DDoS attacks

- 📖 README (📄 Solutions)

Extra readings

- Aggregate-Based Congestion Control for Pulse-Wave DDoS Defense. Gran Alcoz et al. ACM SIGCOMM, 2022
- Poseidon: Mitigating Volumetric DDoS Attacks with Programmable Switches. Zhang et al. NDSS, 2020
- Ripple: A Programmable, Decentralized Link-Flooding Defense Against Adaptive Adversaries. Xing et al. USENIX Security, 2021
- Jaqen: A High-Performance Switch-Native Approach for Detecting and Mitigating Volumetric DDoS Attacks with Programmable Switches. Liu et al. USENIX Security, 2021
- Mew: Enabling Large-Scale and Dynamic Link-Flooding Defenses on Programmable Switches. Zhou et al. IEEE S&P, 2023
- SmartCookie: Blocking Large-Scale SYN Floods with a Split-Proxy Defense on Programmable Data Planes. Yoo et al. USENIX Security, 2024

Week 12　　**Lecture**　Transport Protocols

5.12
- 📄 Slides
- 📄 QUIC Slides (Guest talk by Brian Tramell)

Exercise　Evaluating and comparing transport protocols

- 📄 Task
- 📄 Solution

Extra readings

- CUBIC: A New TCP-Friendly High-Speed TCP Variant
- RFC 8684: TCP Extensions for Multipath Operation with Multiple Addresses
- RFC 9000: QUIC: A UDP-Based Multiplexed and Secure Transport

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Week 13　　**Lecture**　Congestion Control

12.12
- 📄 Slides

Exercise Analyzing congestion control

- 📄 Task
- 📄 Solution

Week 14   **Lecture**   Sustainable Networking

19.12
- 📄 Slides

Previous Exams

04.01

Disclaimer: Please be mindful that most of the topics are new this year and therefore are not covered in previous years' exams. Also, topics in common (e.g. p4) were not necessarily covered at the same technical depth.

- 📄 2021
- 📄 2022 (Feb)
- 📄 2022 (Aug)