FG INET: Internet Network Architectures

An-Institut Telekom Innovation Laboratories

Prof. Anja Feldmann, Ph.D.

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http://www.inet.tu-berlin.de/
INET: Research Group

- **Location**
  - Telefunkenhochhaus, 16. Stock

- **Office hours**
  - Tuesday 12:30 – 13:00
  - After the lecture or per e-mail

- **Contact**
  - Best per e-mail 😊

- **Teaching contact**
  - Arne Ludwig / Oliver Hohlfeld

- **Web site**
  - [http://www.inet.tu-berlin.de/](http://www.inet.tu-berlin.de/)
T-Labs

- Institute at TU Berlin funded by Deutsche Telekom AG
- Co-locates researchers from TU Berlin and project managers of Deutsche Telekom
- Two parts
  - Strategic research
    - 6 Research Groups + 30 Researchers + 40 Ph.D. students
    - Internet Architecture (INET), Quality and Usability (QU Lab), Security in Telecommunications (SecT), Service Centric Networking (SNET), Assessment of IP-based Apps, Design Research Lab
  - Innovation development
    - Project work, e.g., IP-TV, Overarching AAA
Dr. Stefan Schmid

 Biography:
- PhD in *Distributed Computing Group* (DISCO) @ ETH Zürich
- Postdoc at *Chair for Efficient Algorithms* (TU München) and *Chair for Theory of Distributed Systems* (Uni Paderborn)
- Senior Research Scientist @ Deutsche Telekom Laboratories

 Research Interests:
- Robust distributed systems
- Online Algorithms
- Software defined networking
- Network virtualization
Robust Distributed Systems

Robust overlay networks: self-stabilizing topologies

Robust medium access & competitive resource sharing

Online Algorithms

How to deal with uncertainty? Online migration of servers, competitive access control, …

FIB Compression & SDN

Offload traffic to software controller and aggregate prefixes

CloudNets & Prototype

CloudNets: connect virtual nodes with virtual networks (prototype architecture with NTT DoCoMo)
Dr. Marco Canini

- Biography:
  - Ph.D. in Computer Science and Engineering @ University of Genoa
  - Postdoc @ EPFL, Intern @ Intel Research & Google
  - Senior Research Scientist @ T-Labs

- Research Interests:
  - Software-Defined Networking
  - Reliability of Networked Systems
  - Design and Implementation of Networked Systems
  - Energy-Efficient Networks
Bugs in Software-Defined Networking

- Explores state-space efficiently
- Tests unmodified NOX applications
- Library of correctness properties
- Finds bugs in real applications

- Network programmability raises the possibility of bugs!
- NICE is a systematic approach to test OpenFlow Apps

Diagram:
- Controller
- OpenFlow program
- Install rule
- Drop packet
- Host A
- Packet
- Switch 1
- Install rule Delayed!
- Switch 2
- Host B

Flowchart:
- Input
  - Unmodified OpenFlow program
  - Network topology
  - Correctness properties (e.g., no loops)
- NICE
  - No bugs
  - In Controller Execution
  - State-space search
- Output
  - Traces of property violations
Dr. Petr Kuznetsov

Biography:
- M.Sc. in Mathematics in Saint-Petersburg IFMO (TU)
- Networking engineer in BCC, Saint-Petersburg
- Ph.D. in Computer Science @ EPFL
- Postdoc at Max Planck Institute for Software Systems
- Senior Research Scientist @ Deutsche Telekom Laboratories

Research Interests:
- Distributed algorithms and systems
- Synchronization and fault-tolerance
- Consistency and availability in large-scale systems
- Algebraic and combinatorial topology in computing
Example: Tractable Concurrency

- Concurrency revolution
  - All computing systems are nowadays concurrent
  - CS must master concurrency or turn into the “washing machine science”
  - Concurrent programming is tough
  - ... especially facing failures and asynchrony

- Transactional memory for tractable concurrency?
  - Ease of programming
    - all-or-nothing transactional semantics
  - Efficient use of concurrency: transactions may commit in parallel
  - Is it possible? What are the inherent costs?
Current research topics

- ISP-application collaboration
  - Content aware traffic engineering
  - Caching and content distribution networks
- Software defined networks
  - Berlin Open Wireless Mesh, OpenFlow, Software defined radios
- Broadband access evolution
  - Licensed/unlicensed spectrum, Mobile user experience
- Community-inspired optimization
- Cloud Networking
Internet and traffic engineering

Source: Arbor Networks 2009
Internet and traffic engineering

**Traffic Engineering:** Adjust routing or peering, dimension the network

-> Offline Process

Source: Arbor Networks 2009
The new Internet

→ New core of interconnected content and consumer networks

Source: Arbor Networks 2009
The new Internet

→ New core of interconnected content and consumer networks

Source: Arbor Networks 2009
The new Internet

Moving Target I: Popular Applications

→ New core of interconnected content and consumer networks

Source: Arbor Networks 2009
The new Internet

Moving Target I: Popular Applications
Moving Target II: Bottlenecks

→ New core of interconnected content and consumer networks

Source: Arbor Networks 2009
The new Internet

Moving Target I: Popular Applications
Moving Target II: Bottlenecks

→ New core of interconnected content and consumer networks
→ ISPs lost control of their traffic

Source: Arbor Networks 2009
The new Internet

Global Internet Core

Regional / Tier2 Providers

Moving Target I:
Popular Applications

→ New content

→ ISPs

Source: Arbor Networks 2009

Moving Target II:
ISP loses control of their network

“Telekom’s chief executive, said Google and others should pay telecoms groups for carrying content on their networks.”
Challenge

Content-aware Traffic Engineering

ISPs re-gain control of their traffic by biasing host selection
Improving content access time
Case study: CDN
PaDIS

Provider-aided Distance Information System
PaDIS

External DNS

Internet Service Provider (ISP)

Full View of the ISP Network

Content can be downloaded from any eligible host!
ISP-Application cooperation

- Insight: ISP knows its network
  - Node: bandwidth, geographical location, service class
  - Routing: policy, OSPF/BGP metrics, distance to peers

- PADIS concept
  - Service of AS / ISP
  - Input: list of possible dst IPs
  - Output: ranked list of dst IPs
    - E.g., according to distances between src IP and dst IPs

- Applicable, whenever there is a choice!
Teaching

- Lectures (Vorlesungen)
- Seminars (Seminare)
- Lab course (Praktika)
- Projects (Projekte)
- Theses (Diplom / Master / Bachelor)

- PGT: Project Group Meeting (Doktorandenseminar)
- NLS: Networking Lecture Series (external visitors)
Lectures

- Network protocols and architectures (VL+UE)
  - Design principles of the Internet....
  - Base for all other INET classes

- Internet Routing (VL)
- Internet Security (VL)
- Internet Measurement (VL)
Seminars

- Internet Routing
- Internet Measurement
- How
  - Topics: Current research papers
  - Task:
    - Summary paper + presentation
    - Participation in discussion during the seminar
  - En block after the end of term
Lab courses

- Hands on exercises

- Mesh Lab
  - Understanding various wireless concepts (e.g., interference, MAC layer, multi-hop routing)
  - Experiments with mesh routers in the BOWL indoor network

- Router Lab
  - Configuring and managing networks
  - Internet experiments in a Lab
Projects and theses

- Topic:
  - See Web pages
  - Talk to members of INET
  - Suggest your own topic

- Work flow:
  - Literature/background search
  - Presentation of idea at students’ talks series (20 minutes 😊)
  - Execution of idea / preparation of thesis document
  - Presentation of results at students’ talks (20 minutes)
## Teaching at INET / Anja Feldmann

### Topics

**Internet Protocols:**
- Routing and IP
- Transport (TCP/UDP)
- Applications
- Future Internet

**Traffic Measurement**
- Workload Modeling
- Wireless
- Performance analysis
- Network Security

### Example Module Paths

**Bachelor 0-15 LP**
- NPA (6LP)  
- SE+PJ (9LP)  

**Master 12-27LP**
- IR, IS, IM, SE (6/9LP)  
- ML or/and RL (6/12 LP)  

### Course Overview

#### WiSem

- **NPA**: Network Protocols & Architectures (VL+UE) 6LP

#### SoSem

- **IR or IS or IM**: Internet Routing, Security, Measurement (VL) 3LP

- **ML**: MeshLab (PR) 6LP

- **RL**: RouterLab (PR) 6LP

- **SE**: Sem Routing (SE) 3LP

- **PJ**: Projekt (PJ) 6LP od. 12LP

- Bachelor Thesis (12LP)

- Master Thesis (30 LP)