

# FG INET: Intelligent Networks

An-Institut Deutsche Telekom Laboratories

**Prof. Anja Feldmann, Ph.D.**

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<http://www.net.t-labs.tu-berlin.de/>

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## 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
  - Nadi Sarrer / Oliver Hohlfeld
- ❑ Web site
  - <http://www.net.t-labs.tu-berlin.de/>

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## 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
    - 7 Research Groups + 30 Researchers + 40 Ph.D. students so far: INET, Quality and Usability (QU Lab), Security in Telecommunications (SecT), Service Centric Networking (SNET)
  - Innovation development
    - Project work, e.g., IP-TV, Overarching AAA

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## Dr. Stefan Schmid

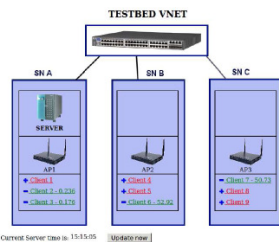
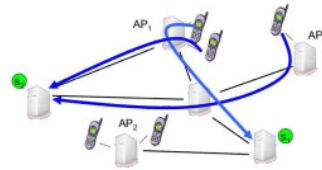
- Biography:
  - PhD in *Distributed Computing Group* (DISCO) @ ETH Zürich
  - Postdoc at *Chair for Efficient Algorithms* (TU München) and *Chair for Theory of Distributed Systems* (Uni Paderborn)
  - Senior Research Scientist @ Deutsche Telekom Laboratories
- Research Interests:
  - Robust and scalable architectures for distributed systems (dealing with churn, self-stabilization, etc.)
  - Network virtualization (e.g., embeddings or service migration)
  - (Distributed) algorithms
  - Peer-to-peer systems (e.g., BitThief), wireless networks (e.g., robust medium access), social networks (e.g., Wuala)
  - Incentives, mechanism design, game theory

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## Example: Network Virtualization

### Virtual networks

- Decoupling of services from resource infrastructure
- Virtual networks embedded dynamically, where and when most useful!
- No knowledge of future requests: online embedding algorithms needed!



### Use case: Agile mobile provider

- Move servers "closer to requests"
- Improves Quality-of-Service...
- ... but need to take into account migration costs!
- How to be „competitive“?
- We also develop prototypes...

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## Florin Ciucu, Ph.D.

### Biography:

- B.Sc. in Informatics, Faculty of Mathematics, University of Bucharest
- M.Sc. in Computer Science, George Mason University, USA
- Ph.D. in Computer Science, University of Virginia, USA
- Senior Research Scientist at Deutsche Telekom Laboratories

### Research Interests:

- Performance analysis of computer and communication systems
  - Overflow and delay analysis in queueing networks
  - Optimal resource allocation (e.g., buffer size in routers)
  - Capacity of multi-hop wireless networks
- Randomized algorithms
  - Medium Access Control (Aloha, CSMA/CD)
  - Scheduling in multi-hop wireless networks
  - Traffic policing

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## Example: Buffer Size in Routers

- Buffers needed to handle the frequent situation

$$\text{incoming\_data\_rate} > \text{router\_data\_rate}$$

- Interesting tradeoff: Large vs. Small

Buffer Size	Loss	Delays	Costs	All-Optical Networks
Large	small	large	large, e.g., \$15000	no
Small	large	small	small	yes

- Topics of interest
  - The impact on end-to-end multimedia quality (e.g., video)
  - How small buffers should be? (Nobody knows after 40 years)

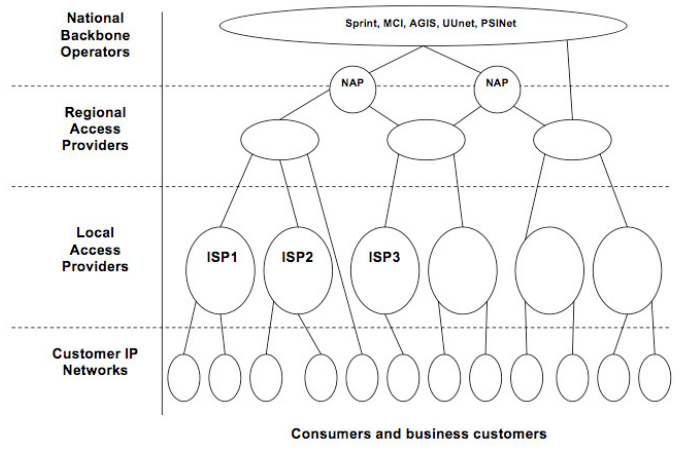
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## Current research topics

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

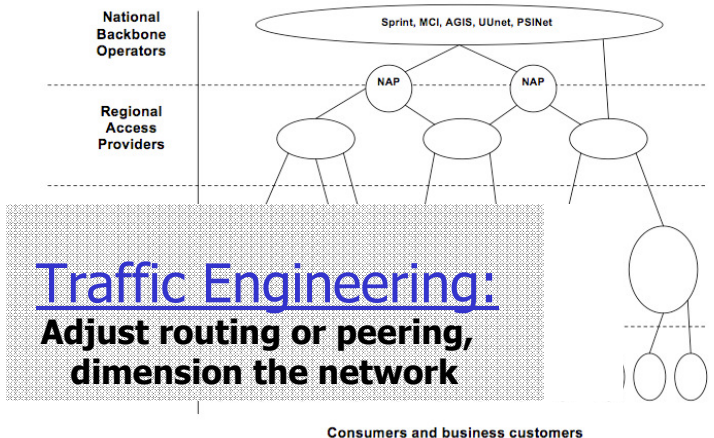
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# Internet and traffic engineering



Source: Arbor Networks 2009

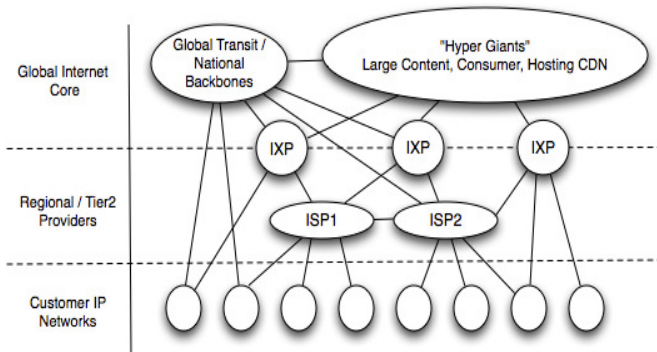
# Internet and traffic engineering



→ **Offline Process**

Source: Arbor Networks 2009

## The new Internet

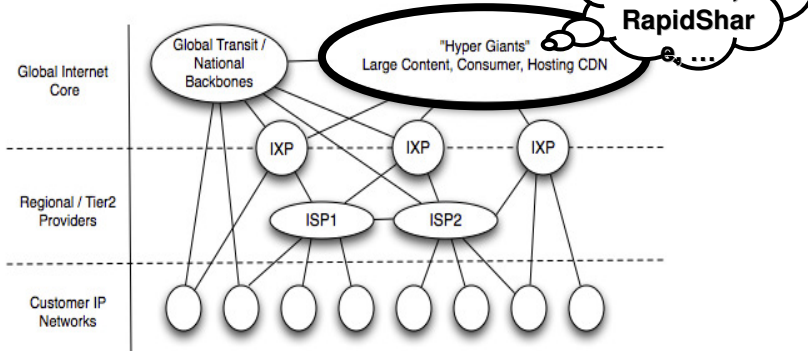


Source: Arbor Networks  
2009

→ **New core of interconnected content and consumer networks**

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## The new Internet

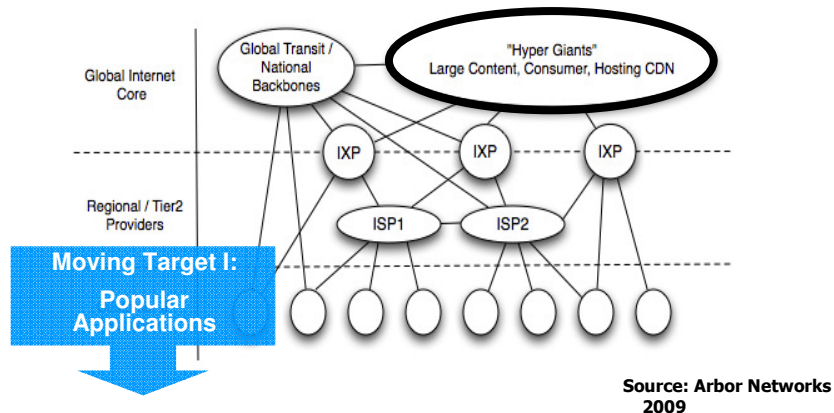


Source: Arbor Networks  
2009

→ **New core of interconnected content and consumer networks**

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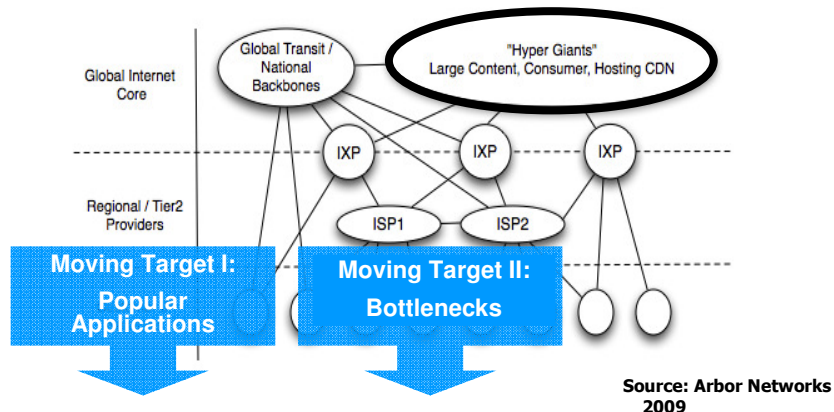
## The new Internet



→ **New core of interconnected content and consumer networks**

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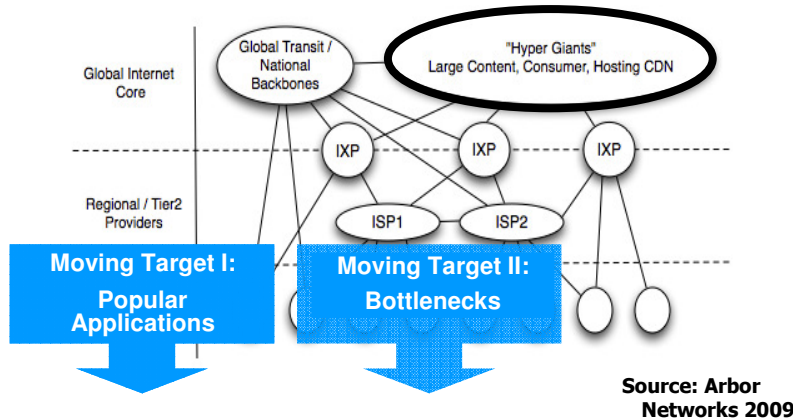
## The new Internet



→ **New core of interconnected content and consumer networks**

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# The new Internet



→ **New core of interconnected content and consumer networks**

→ **ISPs lost control of their traffic**

# The new Internet

Global Internet Core

Regional / Tier2 Providers

Moving Target I: Popular Applications

Moving Target II: Bottlenecks

→ **New content**

→ **ISPs**

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



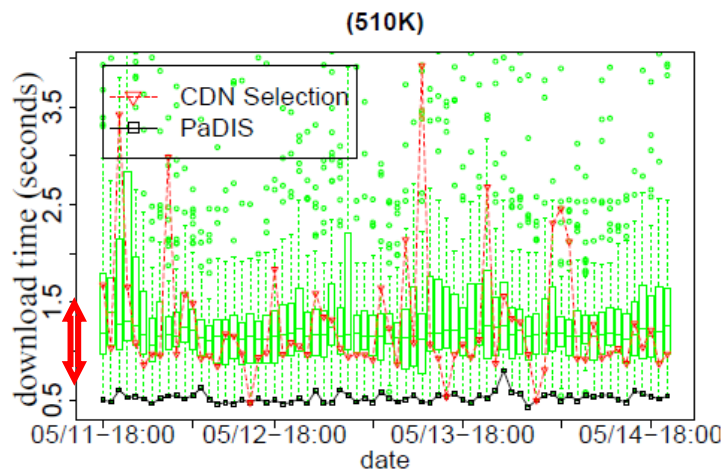
## Challenge

### **Content-aware Traffic Engineering**

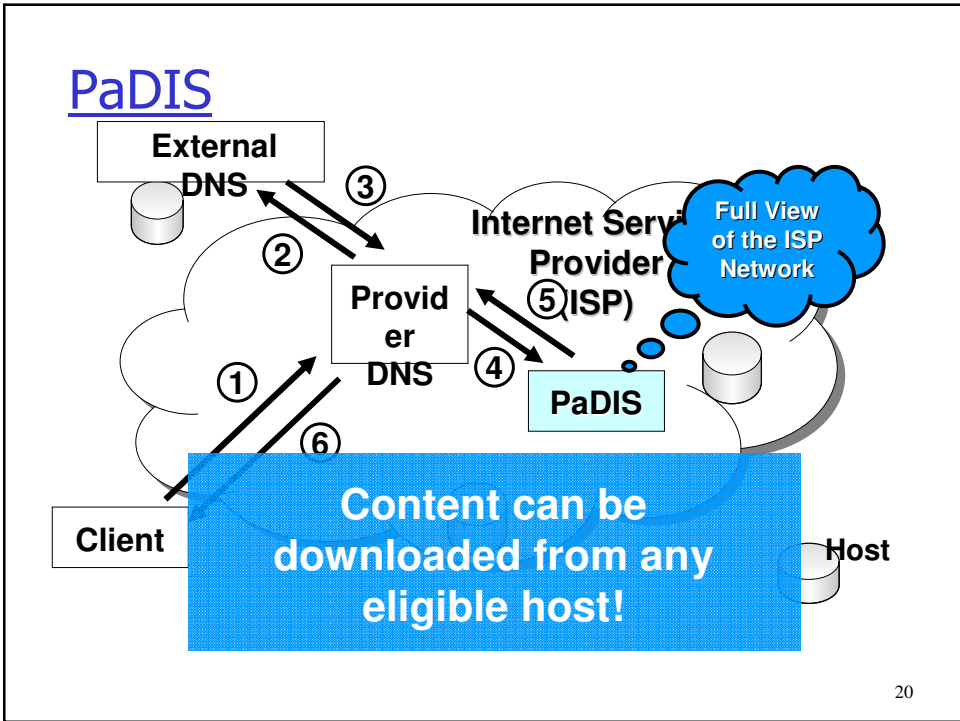
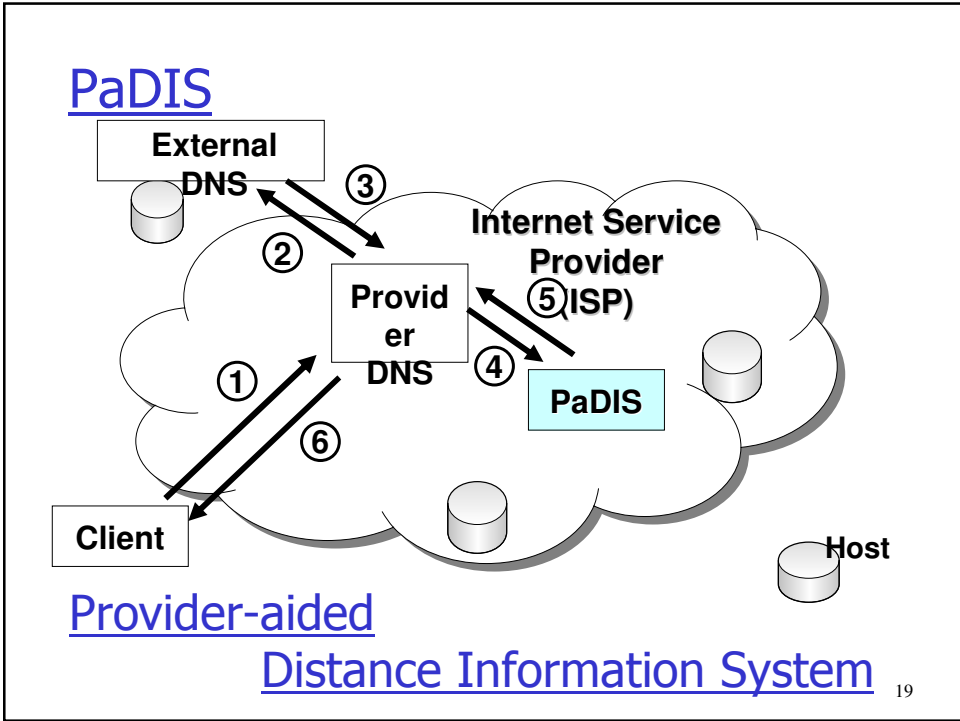
**ISPs re-gain control of their traffic  
by biasing host selection**

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## Improving content access time Case study: CDN



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## 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!**

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## Teaching

- ❑ Lectures (Vorlesungen)
- ❑ Seminars (Seminare)
- ❑ Lab courses (Praktika)
- ❑ Projects (Projekte)
- ❑ Theses (Diplom / Master / Bachelor)
  
- ❑ PGT: Project Group Meeting (Doktorandenseminar)
- ❑ NLS: Networking Lecture Series (external visitors)

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## 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)

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## 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

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## 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

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## 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 series (20 minutes)

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# 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

### Course Overview

WiSem	SoSem
<b>NPA: Network Protocols &amp; Architectures (VL+UE) 6LP</b> 	<b>IR or IS or IM: Internet Routing, Security, Measurement (VL) 3LP</b> 
<b>ML: MeshLab (PR) 6LP</b> 	<b>RL: RouterLab (PR) 6LP</b> 
<b>SE: Routing (SE) 3LP</b> 	<b>SE: Measurement (SE) 3LP</b> 

### Example Module Paths

Bachelor 0-15 LP	NPA (6LP)	NPA (6LP) SE+PJ (9LP)	
Master 12-27LP	IR, IS, IM, SE (6/9LP) ML or/and RL (6/12 LP)	IR, IS, IM, SE (6/9LP) ML or/and RL (6/12 LP)	NPA (6LP) IR, IS, IM, SE (6/9LP) ML or/and RL (6/12 LP)

**PJ: Projekt (PJ) 6LP or 12LP**

**Bachelor Thesis (12LP)**

**Master Thesis (30 LP)**

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