Master Course
Computer Networks
IN2097
Lecture starts at 10:15

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Outline - Introductory lession

- Knowing each other
  - Who studies what?
  - What ist your background?
- Learning Outcomes
- Course Outline
- Organisational Formalities
- Overview
- Recapitulation

Questions

- Who is new at TUM?

- Who studies what?
  - Diploma degree?
  - Master in Informatics?
  - Master in Informatics – English Track?
  - Master in Information Systems [Wirtschaftsinformatik]?
  - Master in Communications Engineering MSCE?
  - Other Master courses?
  - Bachelor in Informatics?
  - Bachelor in Information Systems [Wirtschaftsinformatik]?
  - Other courses?

More Questions

- Which previous relevant courses?
  - IN0010 - Grundlagen Rechnernetze und Verteilte Systeme?
  - Other Courses in Computer Networks?
  - iLab (Internet Lab)?
  - Other Networking Lab courses?
  - What else?
- Other related courses?
  - Network Security?
  - Peer-to-Peer Communications and Security?
- Other relevant skills?
  - C programming skills?
  - Setting up a (virtualized) unix / linux server?

Intended Learning Outcomes and Competences

- Goals of the course
  - Learn to take responsibility for yourself
  - Think about the topics
    (do not repeat content of theses slides without deeper understanding)
  - Learn to formulate and present technical problems
  - Understand the principles
    - What is the essence to be remembered in some years?
    - What would you consider suitable questions in an exam?
  - Learn from practical project performed during course

General Learning Outcomes

- Knowlege
  - Being able to reproduce facts
- Understanding
  - Being able to explain properties with own words
- Applying
  - apply known methods to solve questions
- Analyzing
  - Identifying the inherent structure of a complex system
- Synthesis
  - Creating new solutions - from known elements
- Assessment
  - Identifying suitable criteria and perform assessment

Learning Outcomes
- what students are expected to acquire from the course

- Knowledge, Understanding, Applying
  - protocols:
    application layer, transport layer, network layer, data link layer
  - concepts:
    measurements, signalling, QoS, resilience

  ⇨lectures, exercise questions
  final examination
- Applying, Analyzing, Synthesis, Assessment
  - special context: IPv6 vs. IPv4, DNS, tunneling
  - tools: svn, measurement tools, ...
  - methods: plan, configure, administer system and network, measure, program, reflect

  ⇨course project

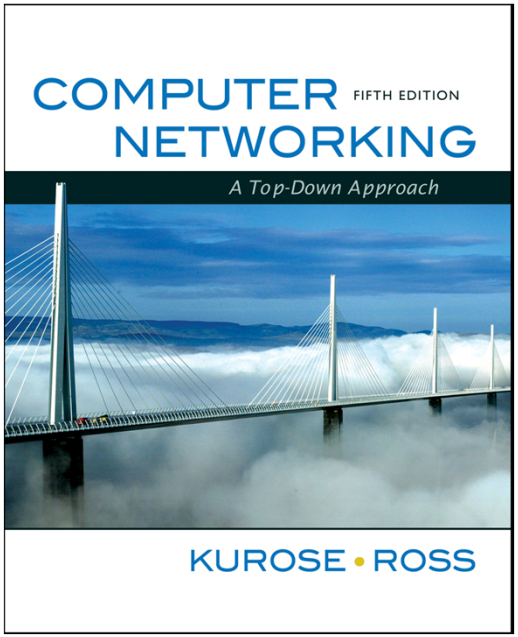
Course Outline (tentative)

- Part 1: Internet protocols
  1. Overview on Computer Networks
  2. Application Layer
  3. Transport Layer
  4. Network Layer
  5. Link Layer
- Part 2: Advanced Concepts
  6. Node Architectures and Mechanisms
  7. Quality of Service
  8. Measurements
  9. Signalling
  10. Resilience
  11. Design Principles and Future Internet

Acknowledgements

- *Significant parts of Part 1 of this lecture are based on the book*

  Computer Networking: A Top Down Approach ,
  5th edition.
  Jim Kurose, Keith Ross
  Addison-Wesley, April 2009.
- The lecture is based to a significant extent on slides by Jim Kurose and Keith Ross



Jim Kurose
University of Massachusetts, Amherst

Keith Ross
Polytechnic Institute of New York University

Course organization

- Time slots
  - Friday, 10:15-11.45, MI H2
  - Monday, 16:15-17.45, MI H2
- TUMonline: registration required (for exam registration + Email)
- Students are requested to subscribe by October 30, 2011 in groups of two for project work at
  http://www.net.in.tum.de/en/teaching/ws1011/vorlesungen/masterkurs-rechnernetze/
  ⇨ link to registration form for svn access
- Questions and Answers / Office hours
  - Prof. Dr. Georg Carle, carle@net.in.tum.de
    - After the course and upon appointment (typically Thursday 11-12)
  - Christian Grothoff, Ph.D., grothoff@net.in.tum.de
    - Drop in or by appointment.
- Course Material
  - Slides made available online (may be updated during the course).

Grading

- Course project
  - will be graded
  - 50% of final grade
- Final exam
  - 50% of final grade
- Rules for concerning examination and grading will be fixed before registration for the exam

Overview

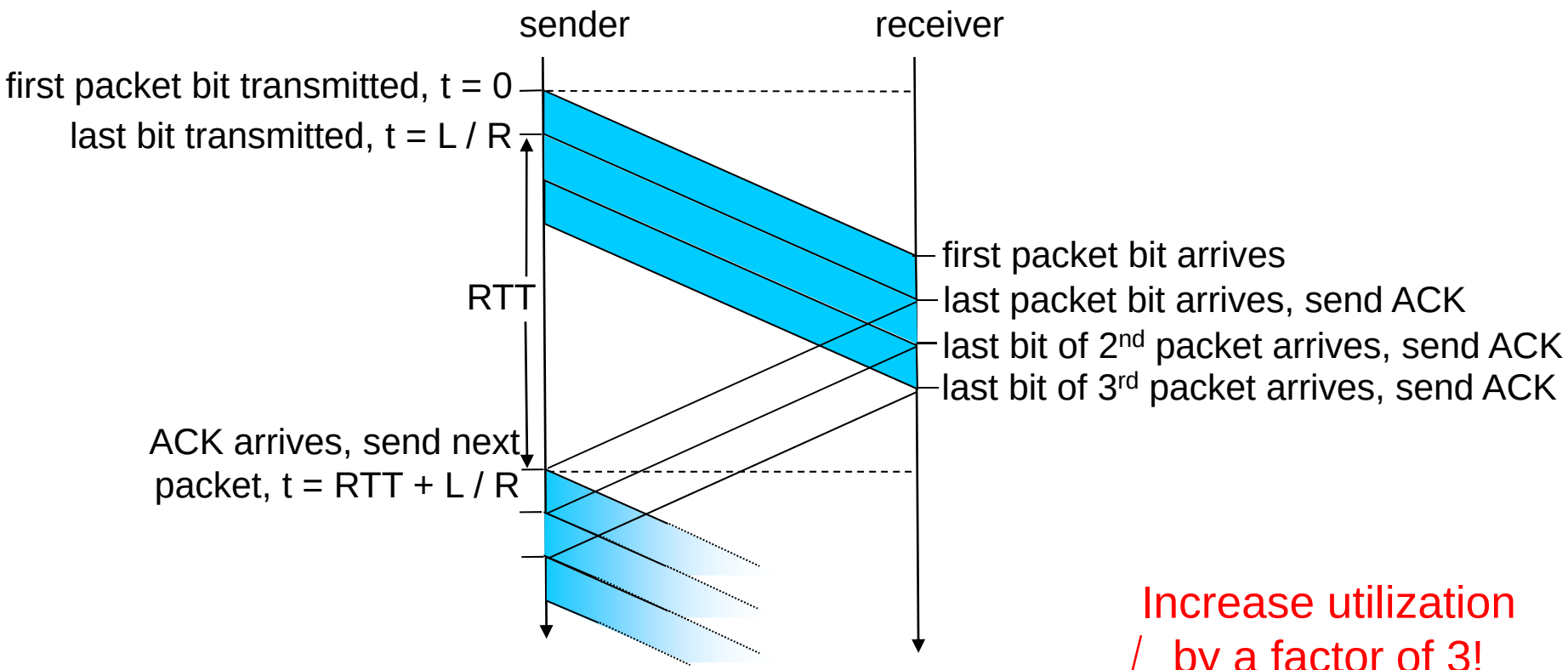
Internet Core Technologies

- DNS
- Tunneling
- IPv4
- IPv6

Chapter: Transport Layer Services

- Transport-layer services
- Multiplexing and demultiplexing
- Connectionless transport: UDP
- Connection-oriented transport: TCP
  - segment structure
  - reliable data transfer
  - flow control
  - connection management
- TCP congestion control

Pipelining for increased utilization



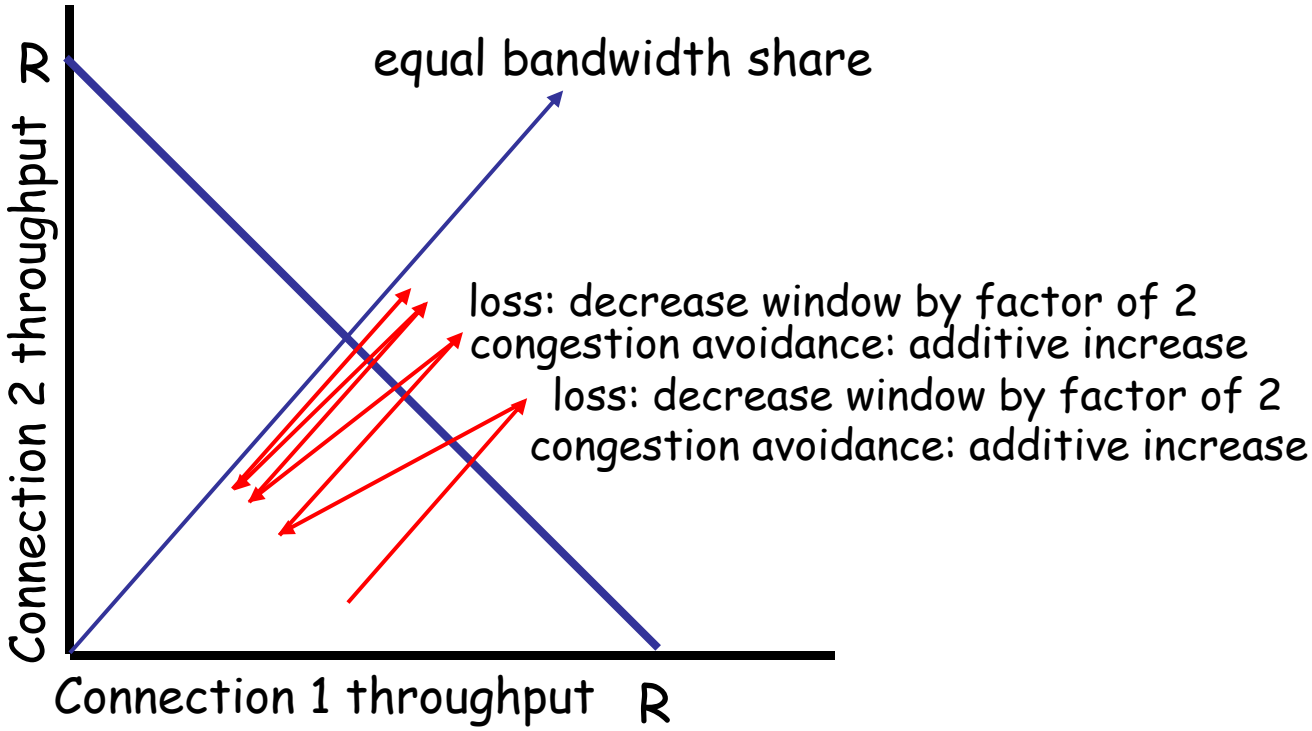
Increase utilization by a factor of 3!

$$U_{sender} = \frac{3 * L / R}{RTT + L / R} = \frac{.024}{30.008} = 0.0008$$

Why is TCP fair?

Two competing sessions:

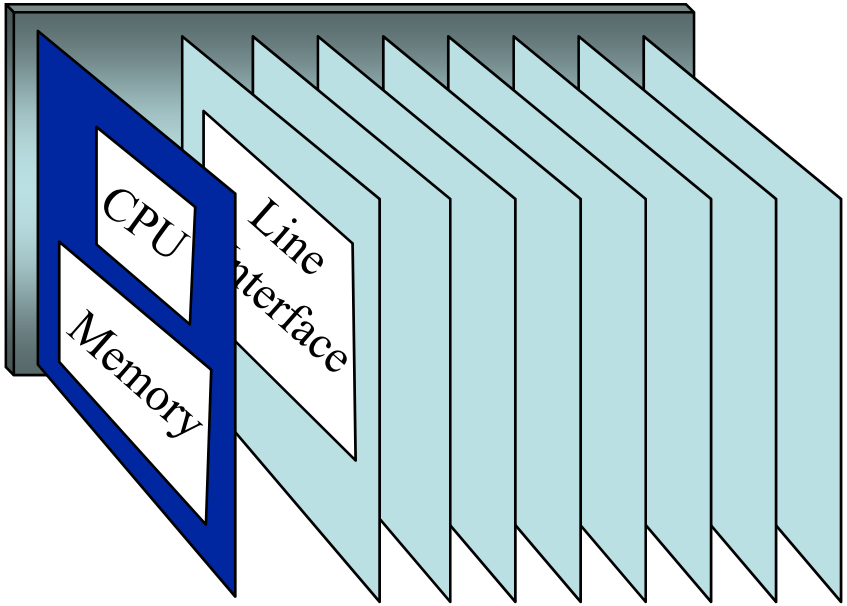
- Additive increase gives slope of 1, as throughout increases
- multiplicative decrease decreases throughput proportionally

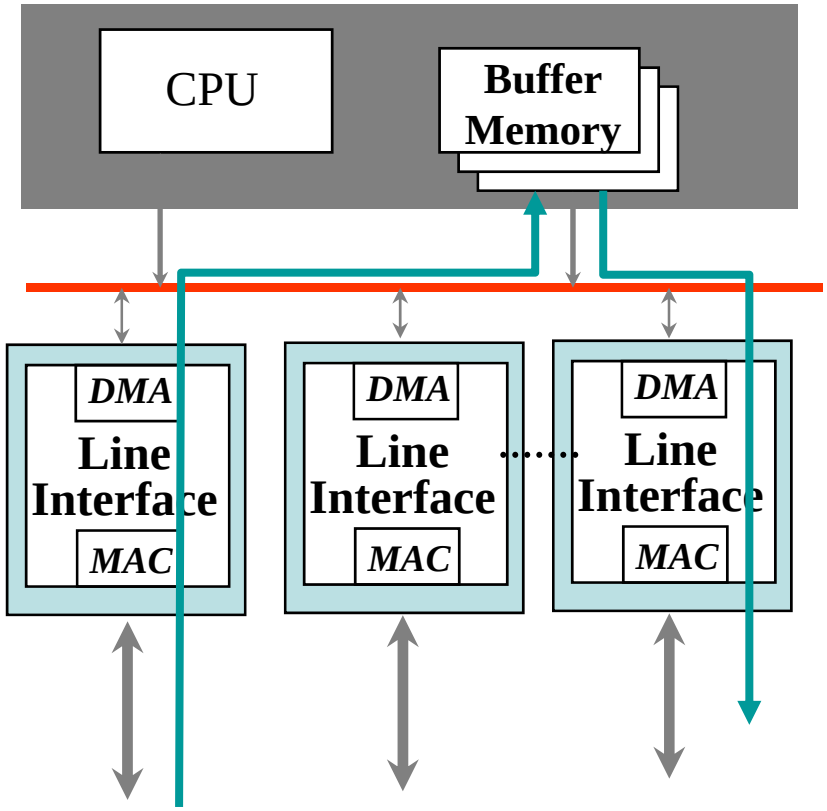


Chapter: Network Layer - Routing

- Routing algorithms
  - Link state
  - Distance Vector
  - Hierarchical routing
- Routing in the Internet
  - RIP
  - OSPF
  - BGP
- Broadcast and multicast routing

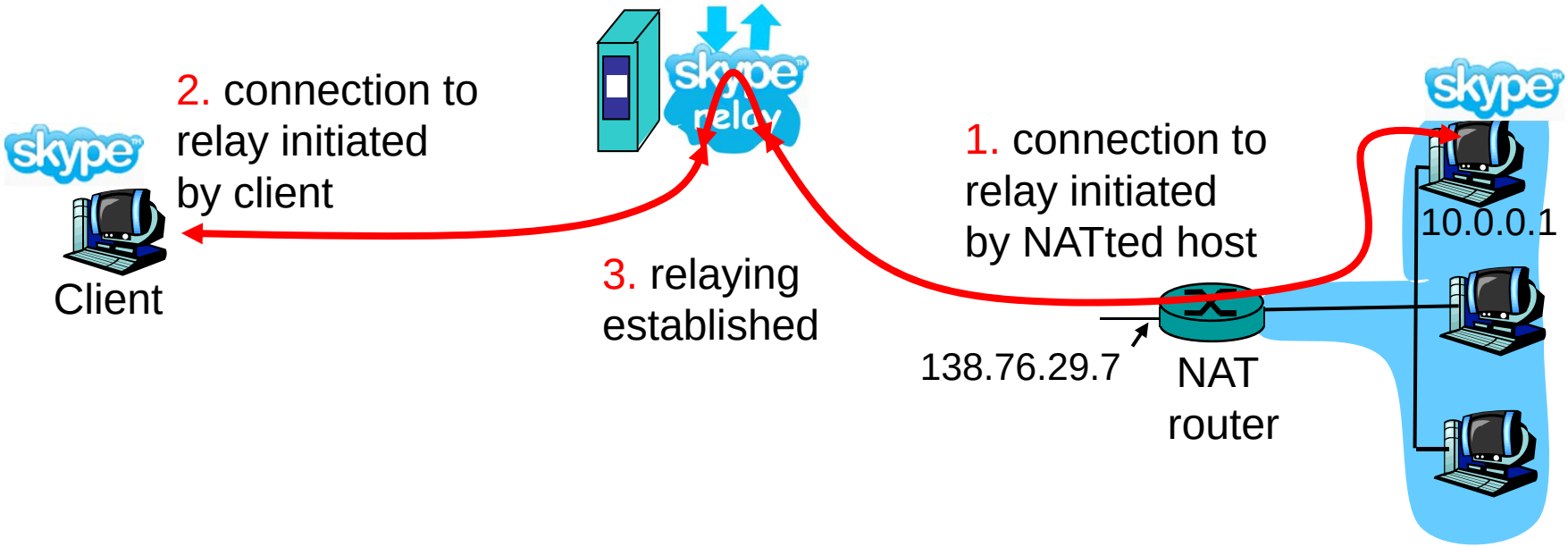
- First-Generation IP Routers





NAT Traversal

- One of several NAT traversal solutions:
  relaying (e.g. used in Skype)
  - NATed client establishes connection to relay node
  - External client connects to relay node
  - relay node forwards packets between two connections

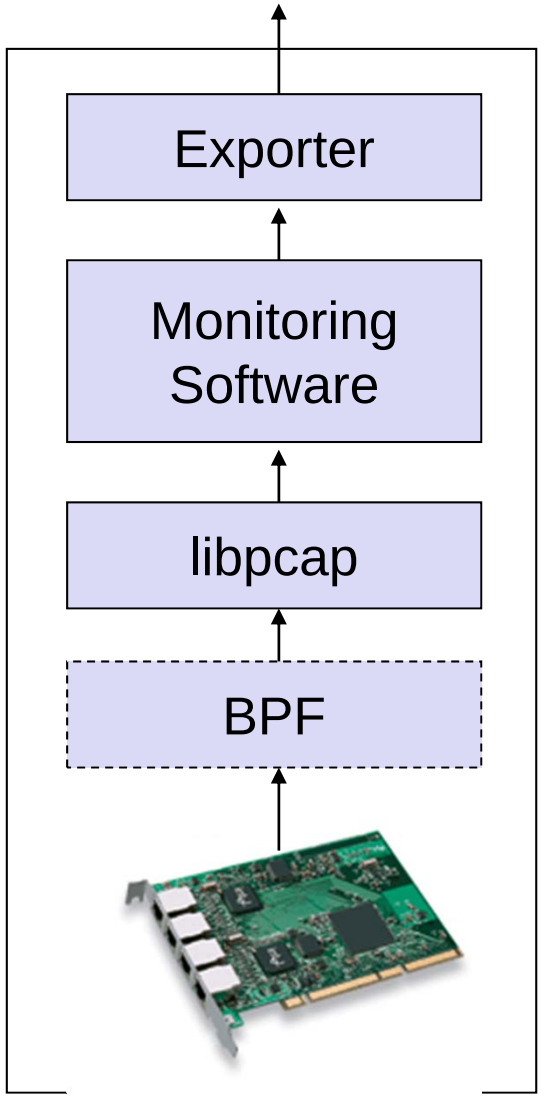


Network Measurements

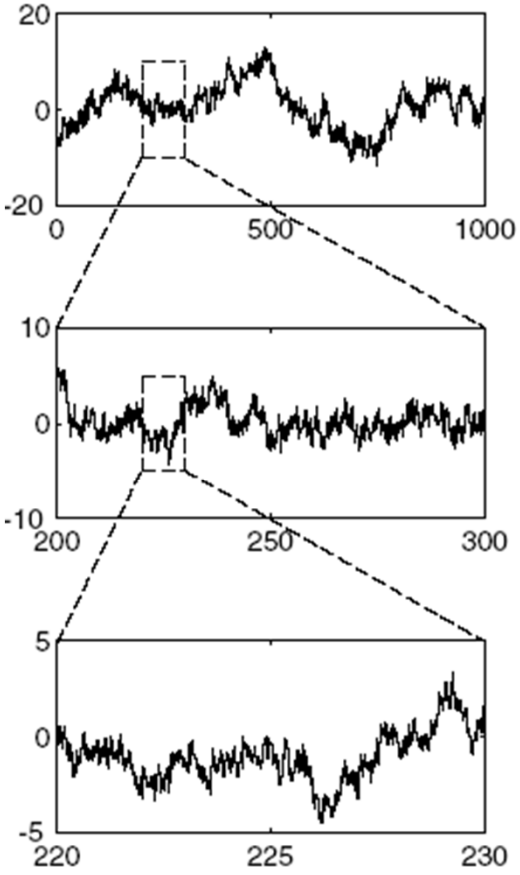
- Introduction
- Architecture & Mechanisms
- Protocols
  - IPFIX (Netflow Accounting)
  - PSAMP (Packet Sampling)
- Scenarios

Monitoring Probe

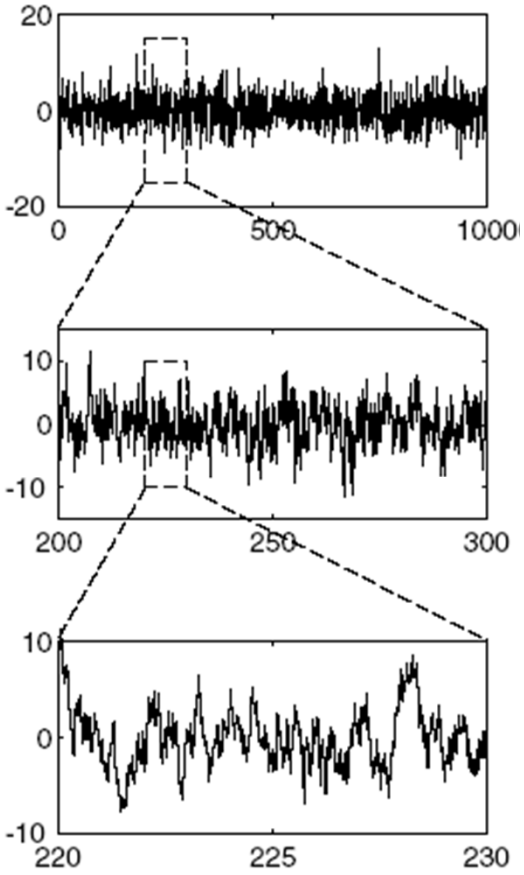
- Standardized data export
- Monitoring Software
- HW adaptation, [filtering]
- OS dependent interface (BSD)
- Network interface



Self-Similar Stochastic Process



(a) Self-Similar Process



(b) Non-Self-Similar Process

Quality-of-Service Support

- Link virtualization: ATM
- Providing multiple classes of service
- Providing Quality-of-Service (QoS) guarantees
- QoS Architectures
  - Integrated Services
  - Differentiated Services

Chapter: Signaling

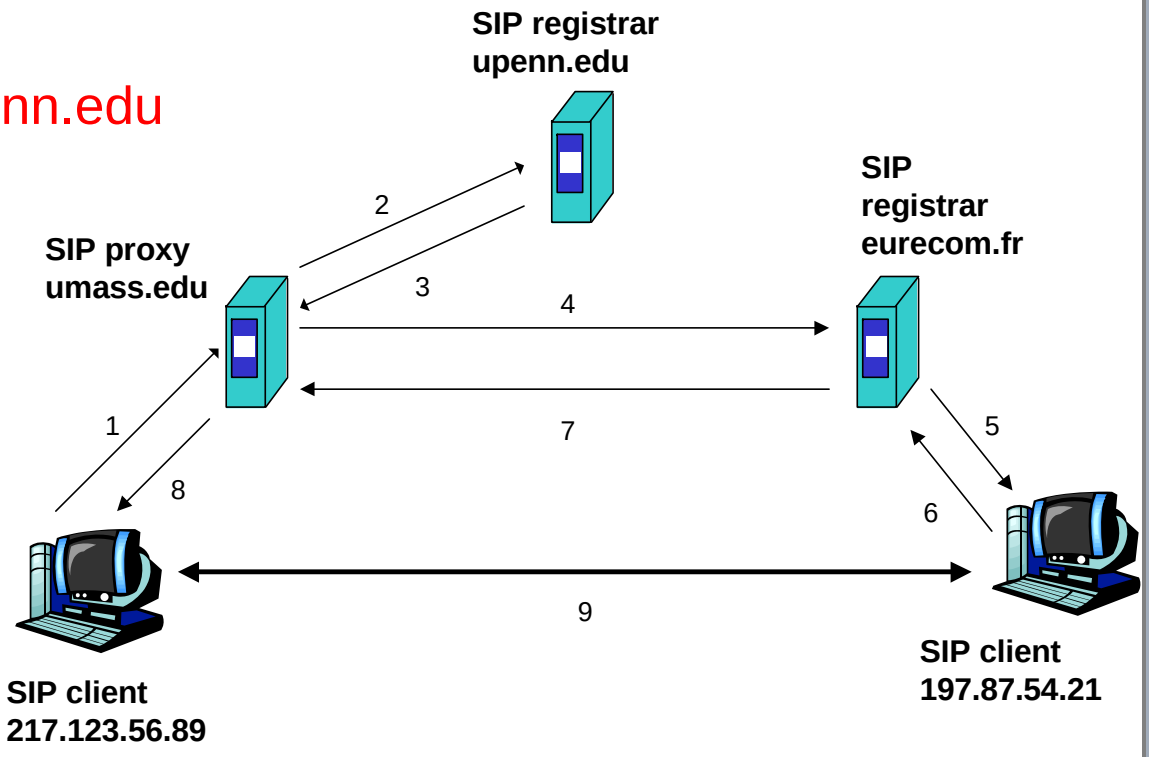
signaling: exchange of messages among network entities to enable (provide service) to connection/call

- before, during, after connection/call
  - call setup and teardown (state)
  - call maintenance (state)
  - measurement, billing (state)
- between
  - end-user <-> network
  - end-user <-> end-user
  - network element <-> network element
- examples
  - Q.921 and SS7 (Signaling System no. 7): telephone network
  - Q.2931: ATM
  - RSVP (Resource Reservation Protocol)
  - H.323: Internet telephony
  - **SIP** (Session Initiation Protocol): Internet telephony

Voice over IP Example

Caller jim@umass.edu
places a call to keith@upenn.edu

(1) Jim sends INVITE message to umass SIP proxy.
(2) Proxy forwards request to upenn registrar server.
(3) upenn server returns redirect response, indicating that it should try keith@eurecom.fr



(4) umass proxy sends INVITE to eurecom registrar.
(5) eurecom registrar forwards INVITE to 197.87.54.21, which is running keith's SIP client.
(6-8) SIP response sent back
(9) media sent directly between clients.
Note: SIP ack messages not shown.

Chapter: Resilience

- Definition:
  - "Resilience is the persistence of *dependability* when facing *changes*."
- Changes can be particularly *attacks*

Chapter: Design principles and Future Internet

- Network design principles
  - common themes: indirection, virtualization, multiplexing, randomization, scalability
  - implementation principles
  - network architecture: the big picture, synthesis

- Future Internet approaches