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Computer Networks
Summary

Prof. Dr. Oliver Hahm

Frankfurt University of Applied Sciences
Faculty 2: Computer Science and Engineering
oliver.hahm@fb2.fra-uas.de
https://teaching.dahahm.de

February 15, 2022

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Organizational

- The exam will take place at Messe Frankfurt, Hall 11 on February 21, 2022 at 16:30 CET
- You will be allowed to bring a cheat sheet and a calculator
- Note the current pandemic regulations, in particular . . .
    - Wearing a mask is mandatory during the entire time on the Messe area
    - You have either to provide a certified negative test result or fulfill the 2G+ requirements
    - The university ask all students – if possible – to obtain a *Frankfurt UAS Card* to facility the entrance checks

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Content

- All necessary formulas, concrete numbers, and some conversion tables will be given in the exam (see mock exam)
- The exam will consist of similar tasks as in the exercise sheets and look similar to the mock exam
- There will be no exercise on cryptography

Reminder

- What is necessary to pass the exam?
- You should be able to . . .
    - explain main concepts and ideas with your own words,
    - select a suitable solution for a given problem,
    - analyze a given solution and detect (potential) problems, and
    - explain your answers.

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Your Feedback

- 20 students participated in the evaluation survey on the lecture
- 10 participating in the evaluation on the exercises
- The grade for the lecture 2.0 (median)
- The grade for the exercises 1.5 (median)
- The majority states they have improved their knowledge on computer networks during the course

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Your Feedback in Details

- Positive
    - Good structure
    - Examples and analogies
    - Exercises
    - Opportunity to ask questions
    - My explanations
- Room for improvement
    - The order (bottom up vs. top down)
    - Missing real life examples, no big picture
    - Too much content
    - Presentation was boring and in a monotone way
    - A lot of abbreviations

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My Feedback

My initial request to you

- Participate lively

- Ask questions!

- A key attribute for science is scepticism

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My Feedback

My initial request to you

- Participate lively
- $\rightarrow$ At least some of you
- Ask questions!

- A key attribute for science is scepticism

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My Feedback

My initial request to you

- Participate lively
→ At least some of you
- Ask questions!
→ You did
- A key attribute for science is scepticism

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My Feedback

My initial request to you

- Participate lively

→ At least some of you

- Ask questions!

→ You did

- A key attribute for science is scepticism

→ Again: some of you did

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Being online

- *Being online* means to be connected to the Internet

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Being online

- *Being online* means to be connected to the Internet
  - → You can use the WWW via HTTP

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Being online

- *Being online* means to be connected to the Internet
  - → You can use the WWW via HTTP
  - → Your browser can communicate end-to-end to a webserver over TCP

Being online

- *Being online* means to be connected to the Internet
  - $\rightarrow$ You can use the WWW via HTTP
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  - $\rightarrow$ The IP datagrams find the best way towards the server

Being online

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  - $\rightarrow$ Your browser can communicate end-to-end to a webserver over TCP
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  - $\rightarrow$ You connect towards your local gateway via WLAN or Ethernet

Being online

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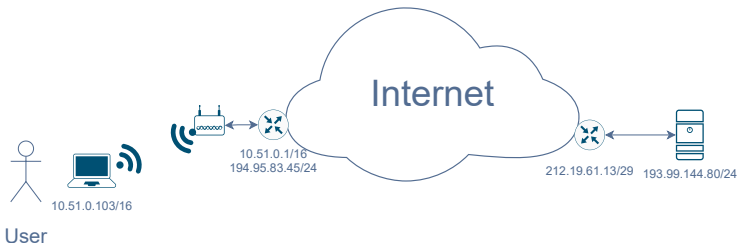
How does the Internet work?

- How do you access videos on YouTube?

- What's the deal with a *lag* in online gaming?

- Who can read my mails?

- How can we transmit data through the air (aka wireless networking)?

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How does the Internet work?

- How do you access videos on YouTube?
→ Access the YouTube server via IP, allow high throughput via TCP, stream the video via HTTP
- What's the deal with a *lag* in online gaming?

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How does the Internet work?

- How do you access videos on YouTube?
- → Access the YouTube server via IP, allow high throughput via TCP, stream the video via HTTP
- What's the deal with a *lag* in online gaming?
- → Use UDP for low latency, deal with end-to-end delay
- Who can read my mails?

- How can we transmit data through the air (aka wireless networking)?

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- Who can read my mails?
→ Everyone – Unless you use TLS for encrypting the transport and use PGP/GPG or S/MIME to encrypt the mail itself
- How can we transmit data through the air (aka wireless networking)?

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How does the Internet work?

- How do you access videos on YouTube?
→ Access the YouTube server via IP, allow high throughput via TCP, stream the video via HTTP
- What's the deal with a *lag* in online gaming?
→ Use UDP for low latency, deal with end-to-end delay
- Who can read my mails?
→ Everyone – Unless you use TLS for encrypting the transport and use PGP/GPG or S/MIME to encrypt the mail itself
- How can we transmit data through the air (aka wireless networking)?
→ Use of radio waves as unguided transmission media and coordinate the access via CSMA/CA

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Objective

Now you should . . .

- understand what the term *"online"* means,
- be able to explain what the *Internet* is,
- know how computers communicate,
- know what protocols are,
- be familiar with the layers of a network stack,
- understand how the data finds its way, and
- be conscious of security and privacy concerns of computer networks.

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Key Terms (1/5)

- Host, Client, Server, Peer
- Network service
- Network protocol
- Transmission medium
- PAN/BAN, LAN, MAN, WAN
- Synchronous vs. asynchronous communication
- Unicast, broadcast, multicast, anycast
- Connection-oriented vs. connectionless
- Simplex, half-duplex, full-duplex
- Topology
- Bandwidth, Throughput, Goodput, and Latency/Delay
- Reference models and layers

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Key Terms (2/6)

- Analog and digital signals
- Quantization and Sampling
- Frequency, period, amplitude, phase
- Bandwidth, symbol rate, and date rate
- Line encoding, baseline wander, clock recovery, and modulation
- Coaxial cables, twisted pair, and fiber optic cables

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Key Terms (3/6)

- Ethernet (IEEE 802.3), Token Ring (IEEE 802.5), WLAN (IEEE 802.11), and Bluetooth
- Frames, byte/bit stuffing
- Physical network addresses AKA MAC addresses
- Bridges, switches, forwarding, and Spanning Tree Protocol
- ALOHA, CSMA (CD and CA), MACA, TDMA, FDMA, CDMA
- Error control, error detection, error correction
- Hamming distance, parity check, CRC
- ARP and NDP

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Key Terms (4/6)

- IPv4 and IPv6, packet header
- IP addresses, ranges, classes, network ID, subnet ID, host ID
- Private or unique local addresses, link-local addresses, and NAT
- IP fragmentation, MTU
- ICMP, ping, and traceroute
- Address autoconfiguration, DHCP, SLAAC
- Internetworking, router, forwarding, and routing
- Autonomous systems, Inter and intra domain routing
- Routing algorithms and metrics
- Distance vector routing and link state routing
- Bellman-Ford and Dijkstra algorithm, RIP, OSPF, IS-IS, and BGP
- Count-to-infinity and split horizon

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Key Terms (5/6)

- End-to-end transport, multiplexing, and (well-known) ports
- Reliability, ordering, flow control, and congestion control
- TCP, UDP, and QUIC
- Sockets
- TCP sequence numbers and acknowledgement numbers
- Three-way handshake, data transmission, and connection termination
- AIMD, Slow start, congestion avoidance, sliding window, silly window syndrome, (duplicate) ACKs, fast retransmit, and fast recvovery
- SYN flood DOS attack
- Head of line blocking

Key Terms (6/6)

- DNS, domain, resource record, zone, label, TTL, FQDN
- NTP, stratum level
- Telnet, and SSH
- HTTP, HTTP methods and status codes
- SMTP, IMAP, POP, MUA, MTA, Spam
- Information security, CIA triad, authentication and authorisation, security threats