

Computer and Communication Networks (2026)

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Course Instructors



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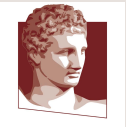
Learning Objectives

- Understand the different **architectural layers** and building blocks of Computer and Communication Networks, including the **physical, medium access control, network, transport, and application layers**
- **Solve problems related to the design and operation** of organizational and wide-area networks at the physical and logical levels.
- **Understand how the TCP/IP protocols influence** the performance of network applications.
- Use **network traffic analysis tools** to identify network problems.
- Evaluate the **performance** of modern network technologies with basic performance metrics and understand trends in the area of communication networks.
- Obtain a basic understanding of **wireless** communications and mobile networking.
- Obtain a basic understanding of **security** mechanisms



Why a class in Networks?

- **How much time do you spend online each day?**
  - Computer, smartphone, tablet
  - Social media, chatbots, gaming
  - Other applications
- **Which network services and network protocols do you use on a daily basis?**
  - Email, HTTP, …
- **How much do you rely on the Internet to perform important tasks, such as banking, home security, etc**



Why a class in Networks (2)



Network infrastructure, physical interconnection, and communication among devices worldwide

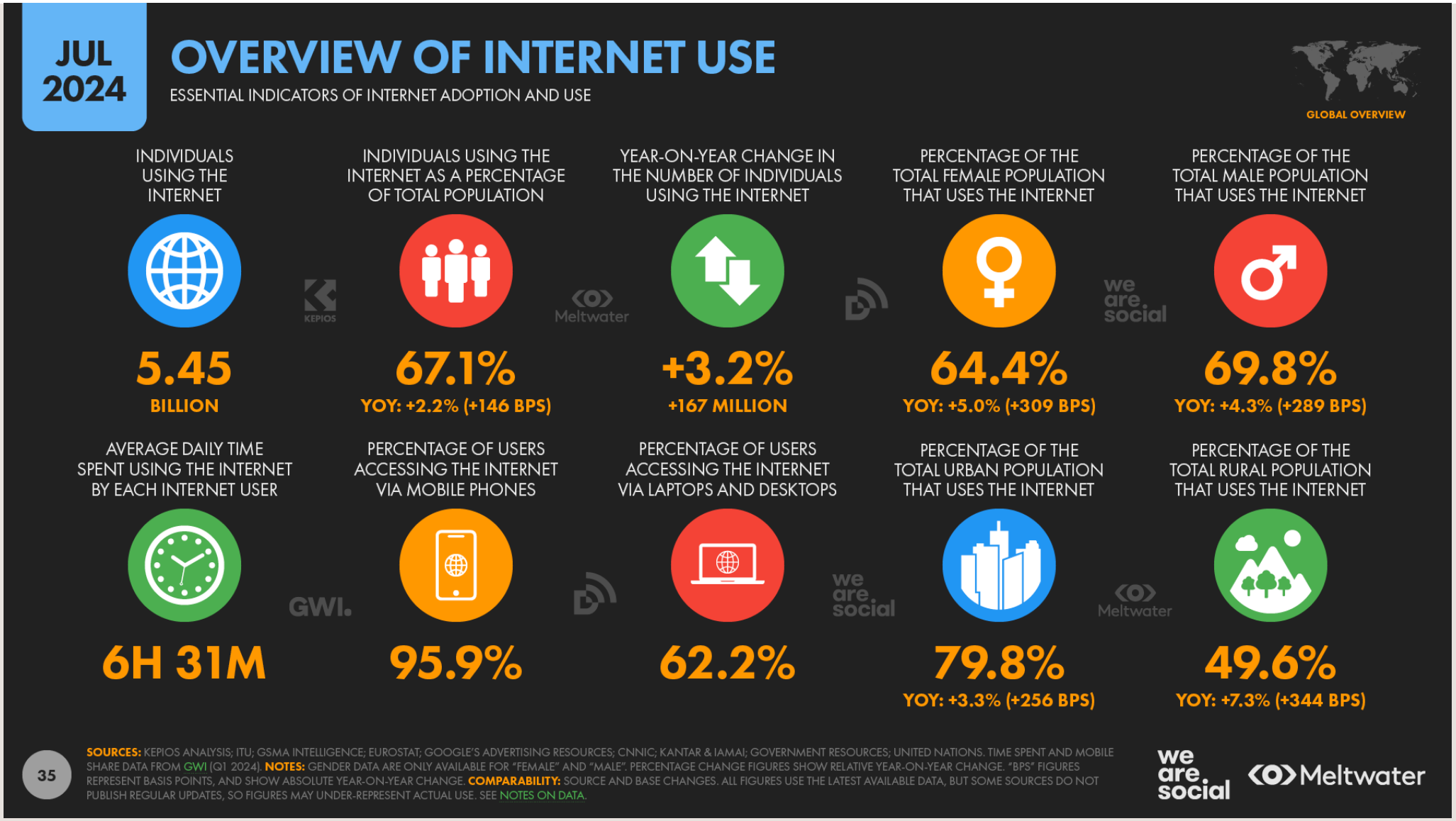
An ecosystem of services and applications built over the network infrastructure



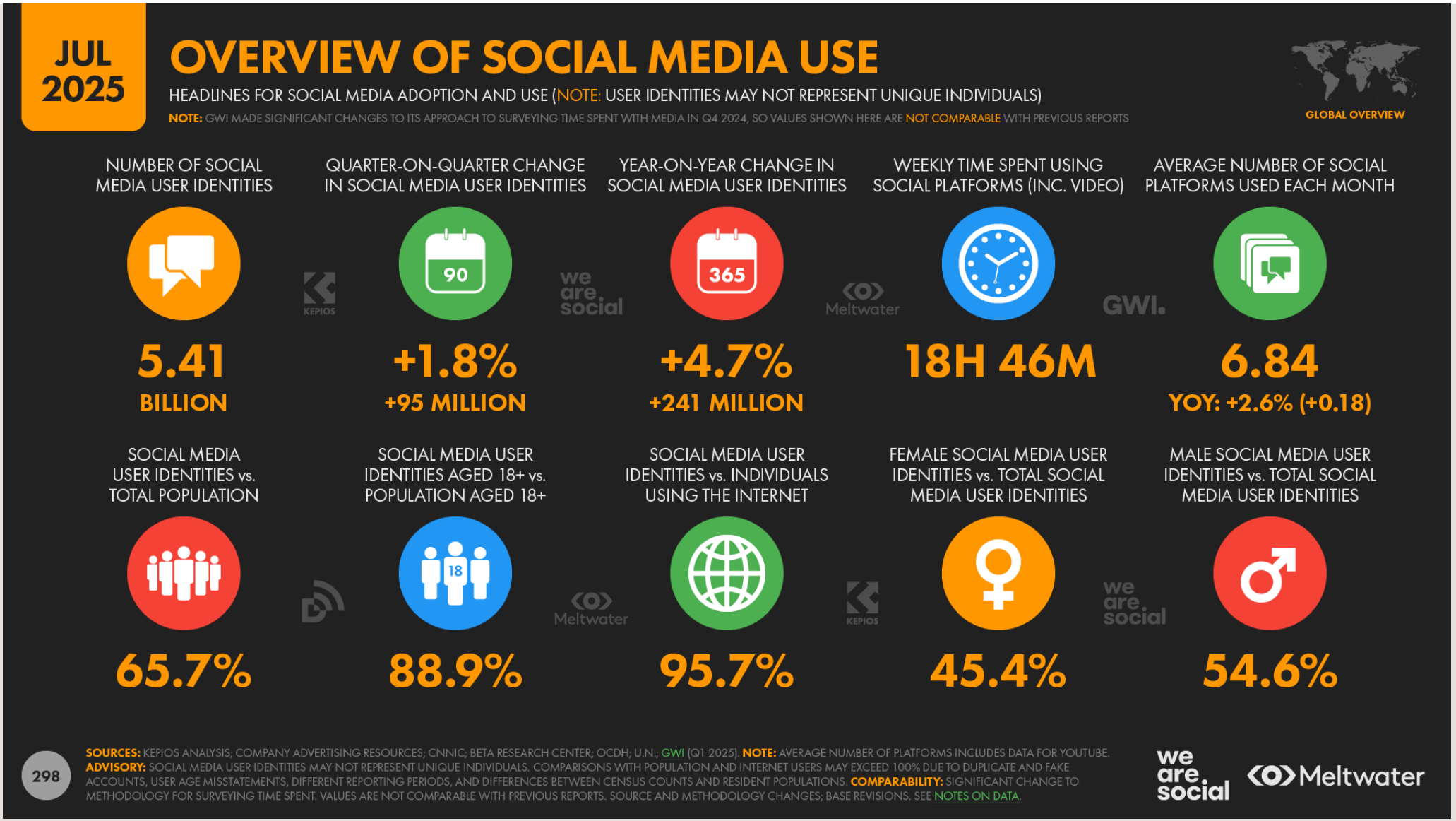
Why a class in networks (3)

- We have been using networks for several decades.
- Especially during the last three decades:
  - Wi-Fi
  - Cellular telephony: 2G – 5G
  - 1970s – 1990s: Innovations in wired networks
  - 1990s – 2010s: Innovations in wireless networks





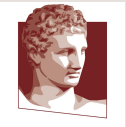
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Source: https://datareportal.com/global-digital-overview

The present and future of Networks

- Convergence with Artificial Intelligence
  - Edge Computing: AI close to the sources of data (near wireless devices and users)
  - Enabling intelligent services (Augmented/Virtual Reality, autonomous cars, drones)
- Smart cities, energy, agriculture, healthcare, security
- Software-Defined Networking (SDN)
  - Initially for wired networks, but more recently also for wireless networks
- Internet of Things (IoT)
- Blockchain and Distributed Ledgers
- Network Function Virtualization (NFV)
- 6th- and 7th-generation networks (6G, 7G) – AI agents



Applications

- **Mobile Augmented Reality (Mobile AR)**
  - Overlays virtual layers of information and content onto the physical scene captured by a device's camera
  - Potential to revolutionize education, healthcare, entertainment, maintenance and repair, and tourism
- Future communication technologies involving holograms and immersive reality
- Autonomous Vehicles and Vehicle-to-Vehicle (V2V) Networks
- Major changes in transportation
- Unmanned Aerial Vehicles (UAVs) and UAV Networks
  - Applications across various fields, e.g., agriculture, security, and surveillance
  - For example, fire detection



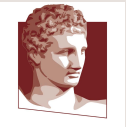
Applications (2)

- **Cognitive Personal Assistants and Recommender Systems**
  - Improving everyday life, especially for people with disabilities
- **Mobile Health (mHealth) Applications**
  - Improving the patient experience
  - Supporting treatment through the collection of clinical data with the help of IoT
  - Real-time patient monitoring
  - Timely interventions
- **Industrial Robotics**
  - Enhancing production efficiency in **Industry 4.0**
- **Advanced Smart City Services**
  - Surveillance
  - Real-time traffic congestion prediction
  - Intelligent energy demand management



The future of networks

- 6G/7G Wireless Networks
  - New services and applications
- Artificial Intelligence and Machine Learning for Networks
- But also Networks for AI, e.g., Federated Learning
- Large Language Models (LLMs) over Networks
- Agent Networks and Agentic AI
- Quantum Internet
  - https://qutech.nl/research-engineering/quantum-internet/
  - https://en.wikipedia.org/wiki/Quantum_network



A plausible scenario

- **Imagine the following medical emergency scenario in a city**
- Autonomous ambulance units coordinate with drones that deliver blood samples; hospital servers analyze medical images in real time; wearable sensors continuously monitor patients.
- Operation under extreme time constraints
- Adaptation to unpredictable network and data conditions in real time
- Life-critical decision-making on devices with limited computing power, energy, and connectivity, through the collaboration of agents performing different tasks.



Scenario (2)

- This scenario is not science fiction!
- Today's AI and networked systems remain fundamentally unprepared for such realities:
- Centralized, static architectures
- Rigid pre-trained models that cannot quickly adapt to new data
- Inability to support modular services such as those described in the example above
- Inability to operate reliably under resource constraints



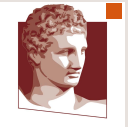
Main objective of the course

- Learn how Communication Networks work, with a focus on the Internet
- What are the protocols: DNS, HTTP, NAT, ICMP, 802.11, Ethernet, MAC, LAN, OSPF, DHCP, IPv4, BGP, etc.
- What happens when I browse the Web?
- How does information provided by an organization somewhere in the world reach my device?
- Fundamental concepts — the foundations for future technologies



Course topics (1)

- Introduction and Fundamental Concepts
- Basic Concepts and Terminology
- What is the Internet? What is a protocol?
- Network Edge and Network Core
- Network Edge: Access Networks and Transmission Media
- Network Core: Circuit Switching and Packet Switching
- Network Performance Measures
  - Delay
  - Throughput
  - Packet Loss
- Layering and Internet Standards
- Historical Overview and Current Developments
- Uses of Computer Networks



Course topics (2)

- Physical Layer
  - Mechanisms of wireless propagation of electromagnetic waves
  - Transmission media (wired and wireless)
  - Bit transmission (signals, frequencies, bandwidth), digital modulation
  - Multiplexing: Time-Division, (Orthogonal) Frequency-Division, and Code-Division
  - Transmission and reception (digital transmitter and receiver)
  - Performance limits and channel capacity
  - Wireless transmission



Course topics (3)

- Data Link Layer
  - Error control
  - Error detection and error correction
- Medium Access Control sublayer
  - Channel sharing: TDMA, CDMA, (O)FDMA, SDMA
  - Multiple access protocols: Aloha, CSMA/CD (WiFi), wired Ethernet)
  - Switches and their use, forwarding



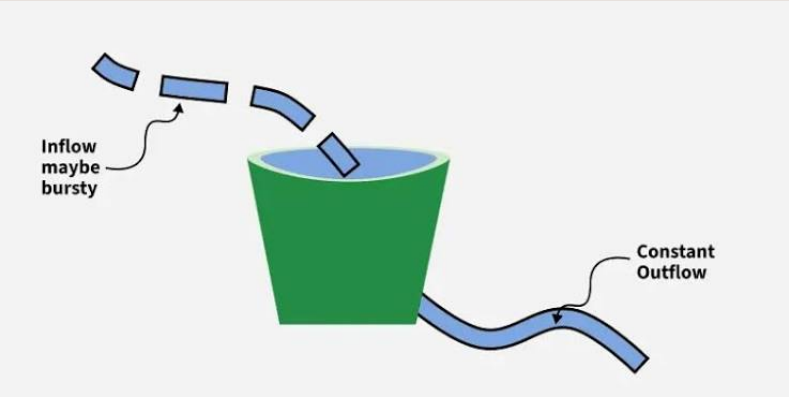
Course topics (4)

- Network Layer: Network Connectivity, IP Addresses, and Subnetting
  - Router Architecture: Forwarding, switching techniques, input and output queues, scheduling
  - Network Design: Packet switching, connectionless and connection-oriented services
  - Network-Layer Protocols: IPv4, IPv6, ARP, ICMP, DHCP, NAT
  - Routing Algorithms: Bellman-Ford, Dijkstra
  - Internet Routing Protocols: RIPv2, OSPF, BGP
- Software-Defined Networking (SDN)



Course topics (5)

- Transport Layer
  - Transport protocols
    - UDP
    - TCP
  - Principles of congestion control
  - Flow control
  - TCP congestion control
- Application Layer
  - Web-based applications
  - Content Distribution Networks (CDNs)





Course topics (6)

- Wireless and mobile networks
  - Wireless LANs
  - 4G/5G cellular networks
  - Mobility management
  - Introduction to 6G networks
- Security
  - Introduction to computer network security
  - Message integrity, digital signatures, authentication
  - TCP and network-layer security



…and an existential question:

- Why learn all this if ChatGPT exists?
- Answer 1: Yes, but it has its limitations.
- Answer 2: Yes, but if you do not understand what it tells you, how can you use it effectively?
- To get a good answer, you need to ask the right and specific question — something you can do only if you UNDERSTAND the fundamental concepts
- These systems can sometimes produce “hallucinations” — plausible-sounding but incorrect information
  - To determine whether an answer is correct, you need to have a solid understanding of the fundamental concepts and ideas.



Lectures

- **Lectures (theory):** Friday 09:00-13:00
  - classroom T108, 1st floor, Address: Trias 2, GR 113 62, Athens
- **Tutorials:**
  - Exercise solving: classroom T108
  - Wireshark: REMOTELY (date/time to be announced).
    - Network Protocol Analyzer
    - Traffic analysis
    - Network monitoring
    - Experimental/practical topics on networks and basic protocols



Assignments

- **Prerequisites:** Students should have a basic understanding of Computer Systems.
- **Assignments:**
  - Homework: assign **a set of exercises** based on tutorials;
    - similar type of exercises will be part of the final exam
  - Wireshark project: a set of tasks to complete using Wireshark based on the tutorials
    - There will be an **oral exam** for this



Grading

- **Grading:** Final grade calculated as follows:
  - 80%: final written exam
  - 10%: homework (set of exercises)
  - 10%: Wireshark project
- Important: 20% above will count only if grade in final written exact > 4/10



Communication

- In email communication, please write your full name in the
- Communicate with Dimitra Halima Nassar Kyriakidou (dnassar@aueb.gr) for
  - questions about solved exercises and tutorial
  - questions about Wireshark projects and notes
- Communicate with Iordanis Koutsopoulos, Vasilios Siris or George Xylomenos {jordan, vsiris, xgeorge@aueb.gr for
  - questions about the class, grades
  - questions about the theory lectures



eClass Plaform

https://eclass.aueb.gr/courses/ERASMUS165/

- IMMEDIATE course registration is required to receive announcements via e-mail and access the course material.
  - Announcements
  - Lecture slides from theory sessions
  - Tutorial exercises (problem statements and solutions)
  - Laboratory lecture materials
  - Assignment submission
  - Grades for assignments, the midterm, and the final examination



Bibliography and educational material

- Course materials will be based on:
  - J. F. Kurose and K. W. Ross, “Computer Networking: A Top-Down Approach”, 9th edition, Pearson, 2025.
- An alternative textbook is:
  - A. S. Tanenbaum, N. Feamster and D. J. Wetherall, “Computer Networks”, 6th edition, Pearson, 2021.
- Lecture slides for the theory sessions
- Tutorial exercises and solved problem material
- Laboratory lecture materials



More bibliography

- Other books
  - Communication Networks: A Concise Introduction (Synthesis Lectures on Learning, Networks, and Algorithms), J. Walrand, S. Parekh, Springer, 2nd edition, 2017
  - Communication Networks: An Optimization, Control, and Stochastic Networks Perspective, R. Srikant, Lei Ying, Cambridge University Press, 1st edition, 2014
- Other sources:
  - E. Modiano slides, MIT: https://ocw.mit.edu/courses/16-36-communication-systems-engineering-spring-2009/pages/lecture-notes/ for the PHY and Link Layer
  - University of Washington, https://courses.cs.washington.edu/courses/cse461/24wi/

