UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Telecommunication Systems and Services

2627-1-F1802Q107

Aims

1. Knowledge and understanding
The student will acquire in-depth knowledge of the architectures and operating principles of telecommunication systems, particularly concerning access networks, network devices, and content distribution. He/she will be able to understand technical issues related to quality of service, voice coding, VoIP, and, more broadly, multimedia services.

2. Applying knowledge and understanding
The student will be able to apply the acquired knowledge to manage telecommunication networks in contexts such as residential, enterprise, and mobile connectivity. He/she will gain the ability to use software tools to emulate real-world network scenarios and understand the functioning of protocols such as OpenFlow.

3. Making judgements
The student will develop the ability to critically evaluate different design solutions in the field of telecommunications, taking into account technical, performance-related, and efficiency aspects. He/she will also be able to interpret service requirements and make informed decisions regarding their implementation and management.

4. Communication skills
The student will be able to clearly and coherently present problems and solutions related to telecommunication systems, using appropriate technical language in both academic and professional contexts.

5. Learning skills
The student will acquire the methodological skills needed to independently stay up to date with technological advancements in the telecommunications sector and to critically deepen the topics covered, including through consultation of specialized sources and technical documentation.

Contents

1. Introduction to Communication Theory, Multiplexing and Transmission Media
2. Broadband Access Networks
3. WAN Connectivity
4. Networking Devices and Software-Defined Networking
5. Quality of Service in Networks
6. Voice Coding and Voice-over-IP
7. Content Delivery Networks
8. Mobile Radio Networks

Detailed program

1. Introduction to Communication Theory, Multiplexing and Transmission Media

- Transmission channel and channel capacity
- Analog and digital modulation
- Frequency, time and code multiplexing
- Multiple access
- Twisted pair
- Optical fiber
- Radio transmission

2. Broadband Access Networks

- Copper-based networks, fiber-based networks and mixed copper/fiber networks (FTTE, FTTH, FTTC, FTTB)
- xDSL technology and vectoring
- Fixed wireless access (FWA)
- Satellite networks with GEO and LEO (low latency) satellites

3. WAN Connectivity

- Dedicated and generalized connectivity
- MPLS protocol and related signaling protocols (LDP, RSVP-TE)
- Virtual private networks (VPN): VLAN Ethernet, MPLS virtual private LAN service, IP tunneling

4. Networking Devices and Software-Defined Networking

- Router and switch architecture
- Firewall, IDS, load balancer and anti-DDoS architecture
- Basic principles of SDN (with hands-on exercises using a network emulator)
- OpenFlow protocol and P4 (with hands-on exercises using a network emulator)
- Basic principles of Network Function Virtualization (NFV)

5. Quality of Service in Networks

- Service Level Agreement e Traffic Conditioning Agreement
- Policing, shaping and marking techniques
- Scheduling techniques
- Call Admission Control (CAC)
- Integrated Services (IntServ)

- Differentiated Services (DiffServ)

6. Voice Coding and Voice-over-IP (VoIP)

- Waveform codec
- Source codec
- Hybrid codec
- Causes of voice degradation in packet switching networks
- VoIP signalling: Session Initiation Protocol (SIP)

7. Content Delivery Network (CDN)

- Principles and architecture
- DNS redirection and URL rewriting
- Akamai's CDN

8. Mobile Radio Networks

- Basic concepts on cellular networks
- Network planning
- 2G (GSM e GPRS)
- 3G (UMTS e HSPA)
- 4G (LTE)
- 5G

Prerequisites

Basic notions of TCP/IP networking; having attended the course "Signal Processing for Intelligent Systems" (or similar) is a plus

Teaching form

- 40 hours of lectures in 2 or 3 hour sessions delivered in presence
- 10 hours of practical exercises in 2 or 3 hour sessions delivered interactively in presence, using a network emulator (Mininet)

Textbook and teaching resource

On-line material on the course website, mainly slides and additional documents

Reference textbooks:

- Jim Kurose, Keith Ross, Computer Networking – A Top-Down Approach, 8th Edition, Pearson, 2021 (o relativa versione italiana intitolata "Reti di Calcolatori e Internet - Un Approccio Top-Down")
- Martin Sauter, From GSM to LTE-Advanced Pro and 5G: An Introduction to Mobile Networks and Mobile Broadband, 4th Edition, Wiley, 2021

Semester

First Year, Second Semester

Assessment method

The assessment is carried out through a written exam and a subsequent optional oral exam, at the discretion of the student or the instructor. There are no midterm exams.

The written exam consists of some open-ended questions (at least four) on the course topics. The questions may cover any topic, and three aspects will contribute to the evaluation: 1) technical correctness, 2) level of detail, and 3) pertinence.

In the case of a minimum grade of 18, the student may request to take the oral exam, which cancels the written exam grade and must be taken in the same session as the written exam. The oral exam will also cover the entire program. The instructor may require a student with a passing grade in the written exam to take the oral exam if deemed necessary.

Any changes to the exam format are under consideration and, if any, will be communicated to the students during the introductory lesson of the course.

Office hours

By appointment

Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE