بسمه تعالی

School of Computer Engineering

Advanced Computer Networks

Course Overview

Seyed Hamed Rastegar

Fall 1401

Course Information

- Objective: Gain a good familiarity with selected advanced and emerging topics in computer networking.
- No. of Credits: 3
- Sessions: 10:30-12 AM on Sun./Tue.
- Instructor: Seyed Hamed Rastegar, Email: s.hamedrastegar@gmail.com
- Prerequisites:
  - Course: Computer Networks.

Contents

- Why computer networking?
- Layered Architecture: OSI and TCP/IP Model
- Advanced and emerging topics
- Advanced Computer Networks Course
- Course Syllabus and Grading Policy

Why computer networking?

- A computer network is a system in which multiple computers are connected to each other to communicate, and share information and resources.

- Characteristics of a Computer Network:
  - Share resources from one computer to another.
  - Create files and store them in one computer, access those files from the other computer(s) connected over the network.
  - Connect a printer, scanner, or a fax machine to one computer within the network and let other computers of the network use the machines available over the network.
  - By developing a computer network, you can make an audio or video call and can communicate with others.

Layered Architecture: OSI and TCP/IP Model

- Design and study of computer networks however needs a systematic and organized approach.
- Layered architecture for computer networks realizes the intended systematic approach while makes the design and study more simple.
- In this regard, different functionalities in computer networks are categorized and various layers are introduced.
- Two well-known layering approaches:
  - OSI Model
  - TCP/IP (Internet protocol suite)

Layered Architecture: OSI Model

- The open systems interconnection (OSI) model is a conceptual model created by the International Organization for Standardization (ISO) which enables diverse communication systems to communicate using standard protocols.
- The OSI provides a standard for different computer systems to be able to communicate with each other.
- The OSI Model can be seen as a universal language for computer networking.
- It's based on the concept of splitting up a communication system into seven abstract layers, each one stacked upon the last.

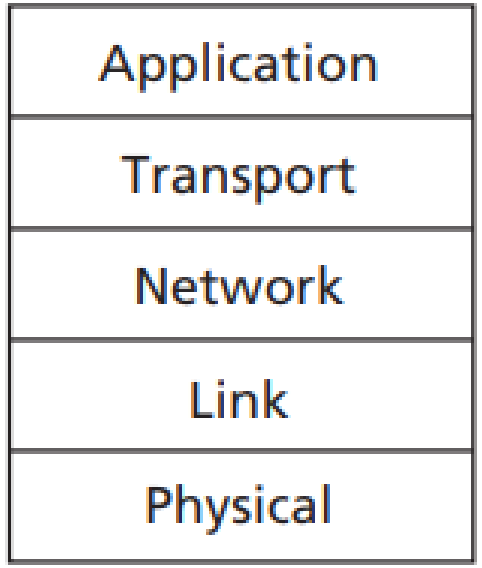
Layered Architecture: OSI Model

- The OSI Reference Model describes functions of the networking or telecommunication system independently from the underlying technology infrastructure.

- It divides data communication into seven abstraction layers and standardizes protocols into appropriate groups of networking functionality to ensure interoperability within the communication system **regardless of the technology type, vendor, and model.**

Layered Architecture: TCP/IP Model

- The OSI model was originally developed to facilitate interoperability between vendors and to define clear standards for network communication.
- However, the older TCP/IP model remains the ubiquitous reference framework for Internet communications today.
- It was designed and developed by USA Department of Defense (DoD) in 1960s and is based on standard protocols.

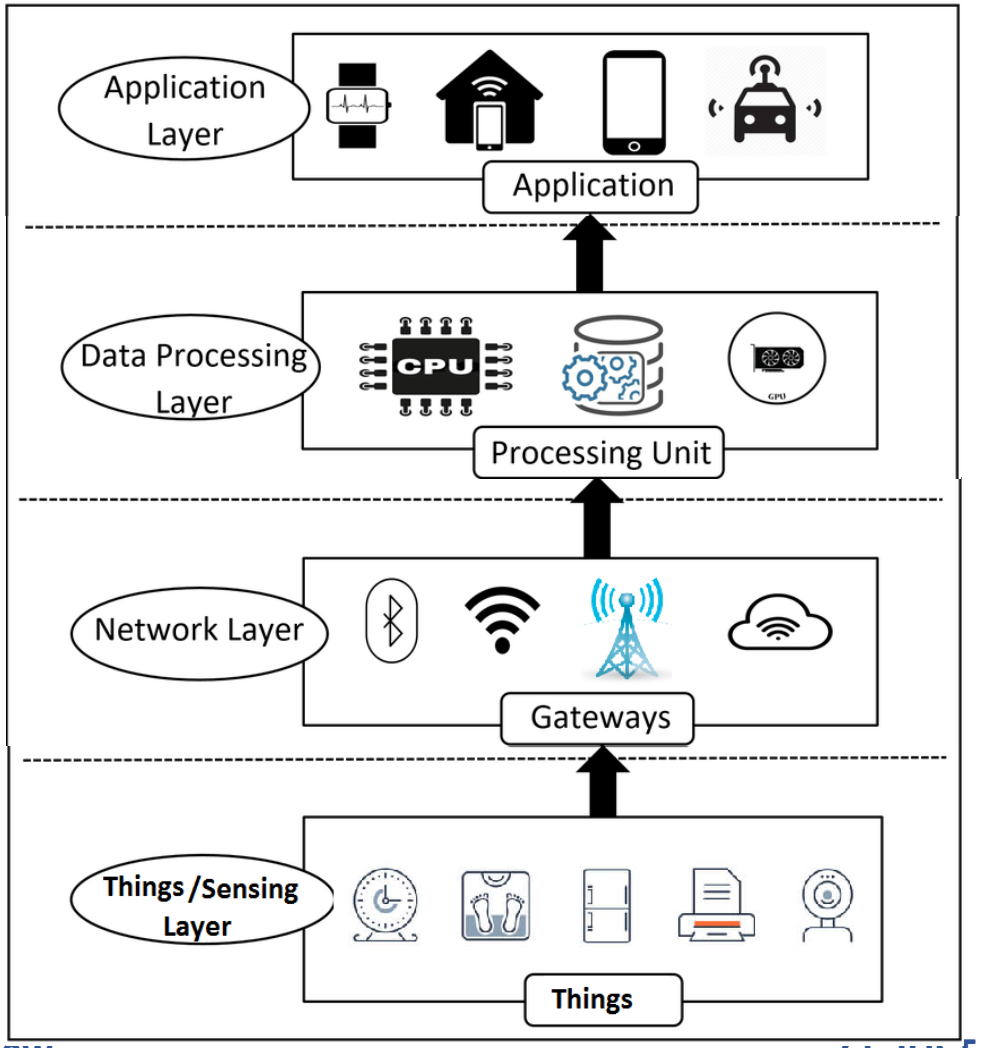


Five-layer Internet protocol stack

Advanced Computer Networks

- The role of networking in the new technologies and applications: **IoT**

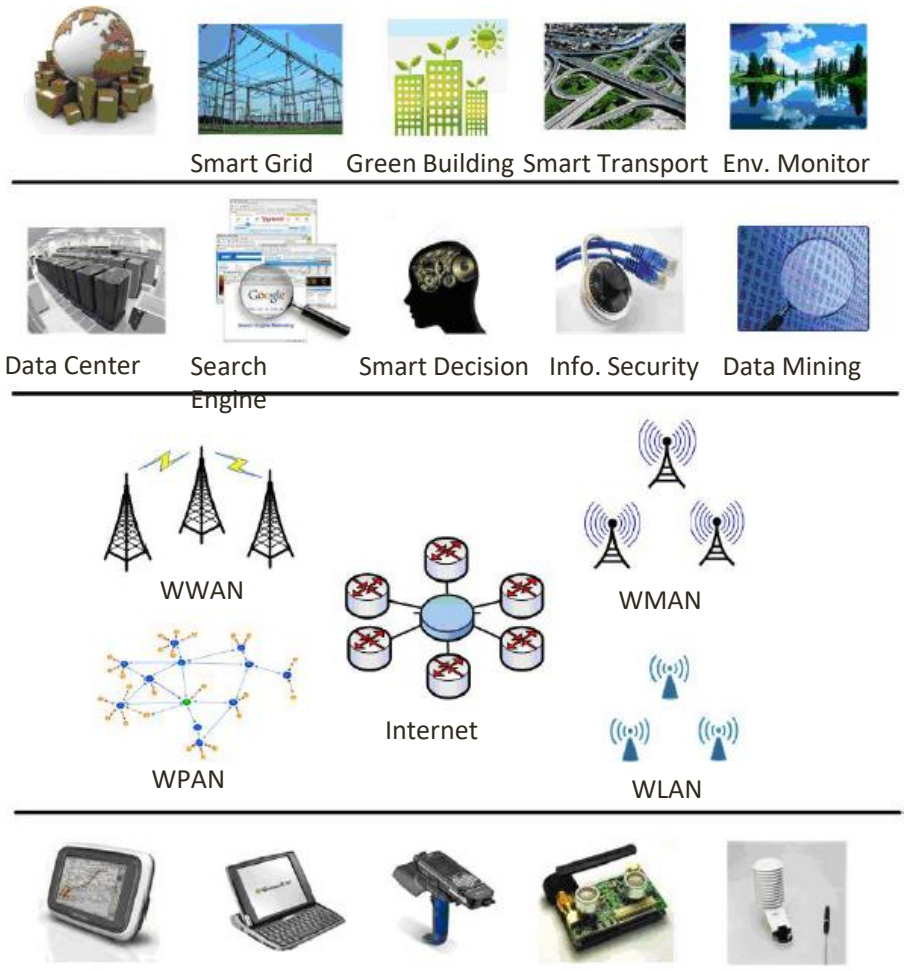
- **Remarks:**
  - ➢The traditional methods and protocols of Internet might not fit to IoT case.
  - ➢Therefore, a variety of networking protocol are used in IoT due to its specific characteristics.



Advanced Computer Networks

- The role of networking in the new technologies and applications: **IoT**

➢ IoT Architecture: A classified view

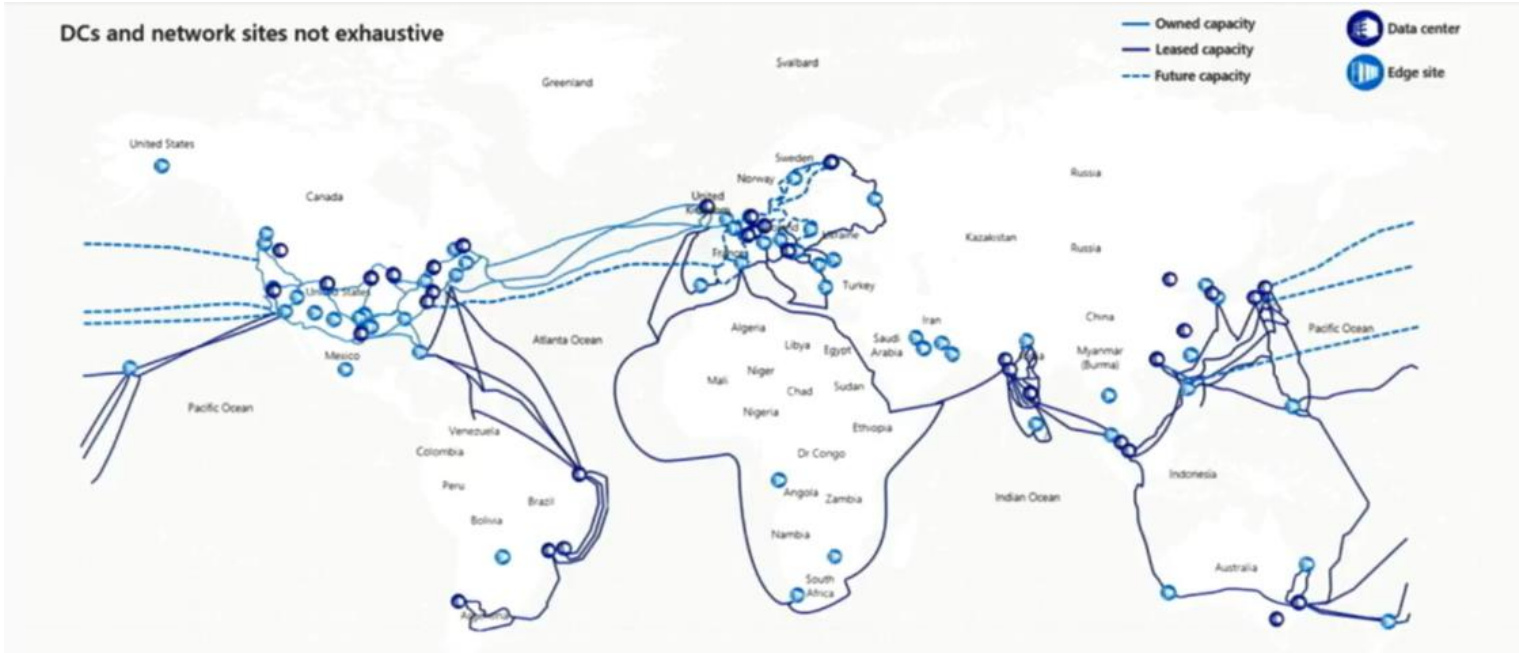


Advanced Computer Networks

- The role of networking in the new technologies and applications: **IoT**
- **Some related protocols and technologies:**
  - Traditional Technologies
    - RFID
    - NFC
    - Bluetooth
    - Mesh Networks: ZigBee, ZWave
  - LPWAN Technologies: SigFox, LoRa, NB-IoT
  - Higher Layer Communication Protocols
    - Network
      - Routing Protocols: 6LowPAN, RPL
    - Session: MQTT, CoAP, AMQP

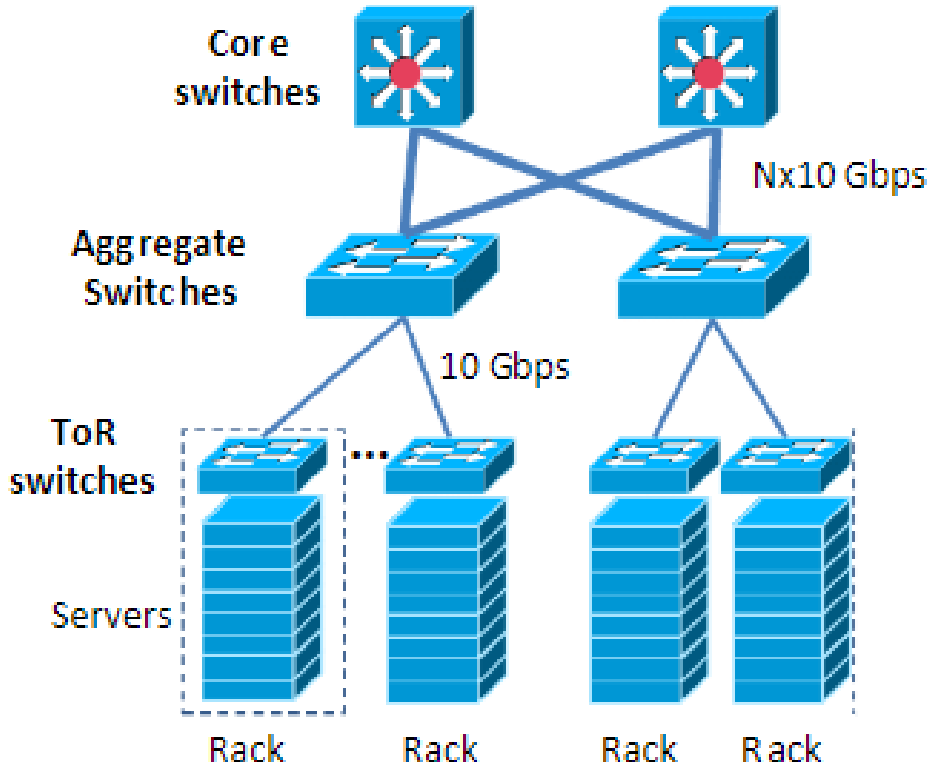
Advanced Computer Networks

- The role of networking in the new technologies and applications: **Cloud Computing and Data centers**
- Data Center Networks:
  - **Inter Data center networks**
  - Intra Data Center Networks



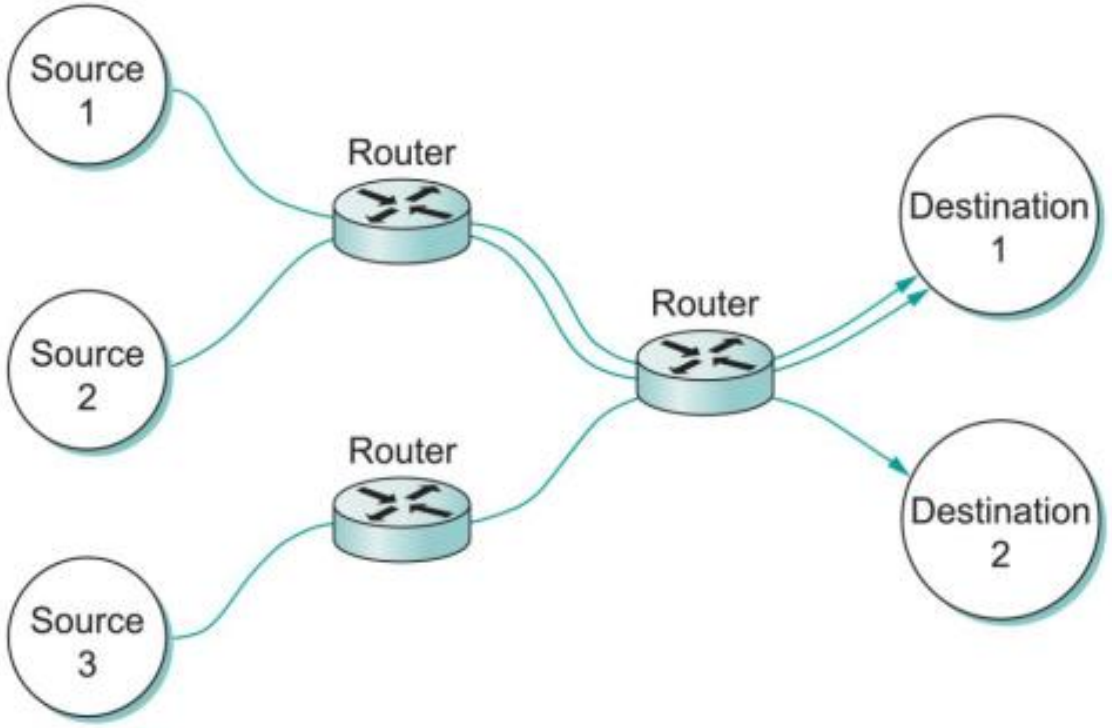
Advanced Computer Networks

- The role of networking in the new technologies and applications: **Cloud Computing and Data centers**
- Data Center Networks:
  - Inter Data center networks
  - **Intra Data Center Networks**



Advanced Computer Networks

- The role of networking in the new technologies and applications: **Cloud Computing and Data centers**
- Congestion Control
  - Applied to all network layers
  - Close relation to resource allocation
  - When the available resource is less than the demands the network is said to be congested
    - Congestion control and resource allocation is required.
  - Controlling the rate of traffic sources
  - Controlling queues in network routers and switches



Advanced Computer Networks

- The role of networking in the new technologies and applications: **Network Softwarization**

- Network softwarization is a new concept to design and operate network and computing infrastructures.

- It aims at delivering services and applications with greater agility and cost effectiveness.

- Network softwarization is done mainly by minimizing the dependency on hardware as well as making vendor lock-in as low as possible.

Advanced Computer Networks

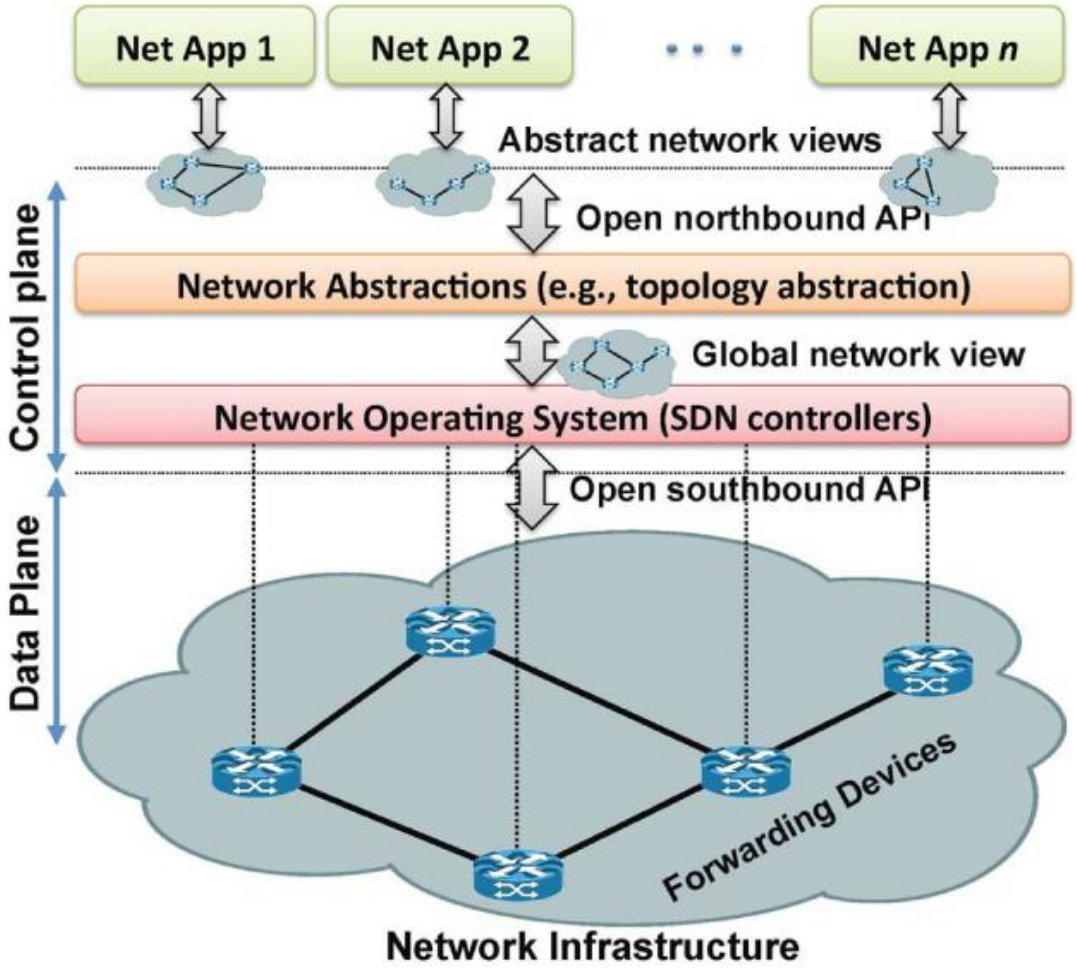
- The role of networking in the new technologies and applications: **Network Softwarization**

- The main components: SDN, NFV, and Cloud Computing

Advanced Computer Networks

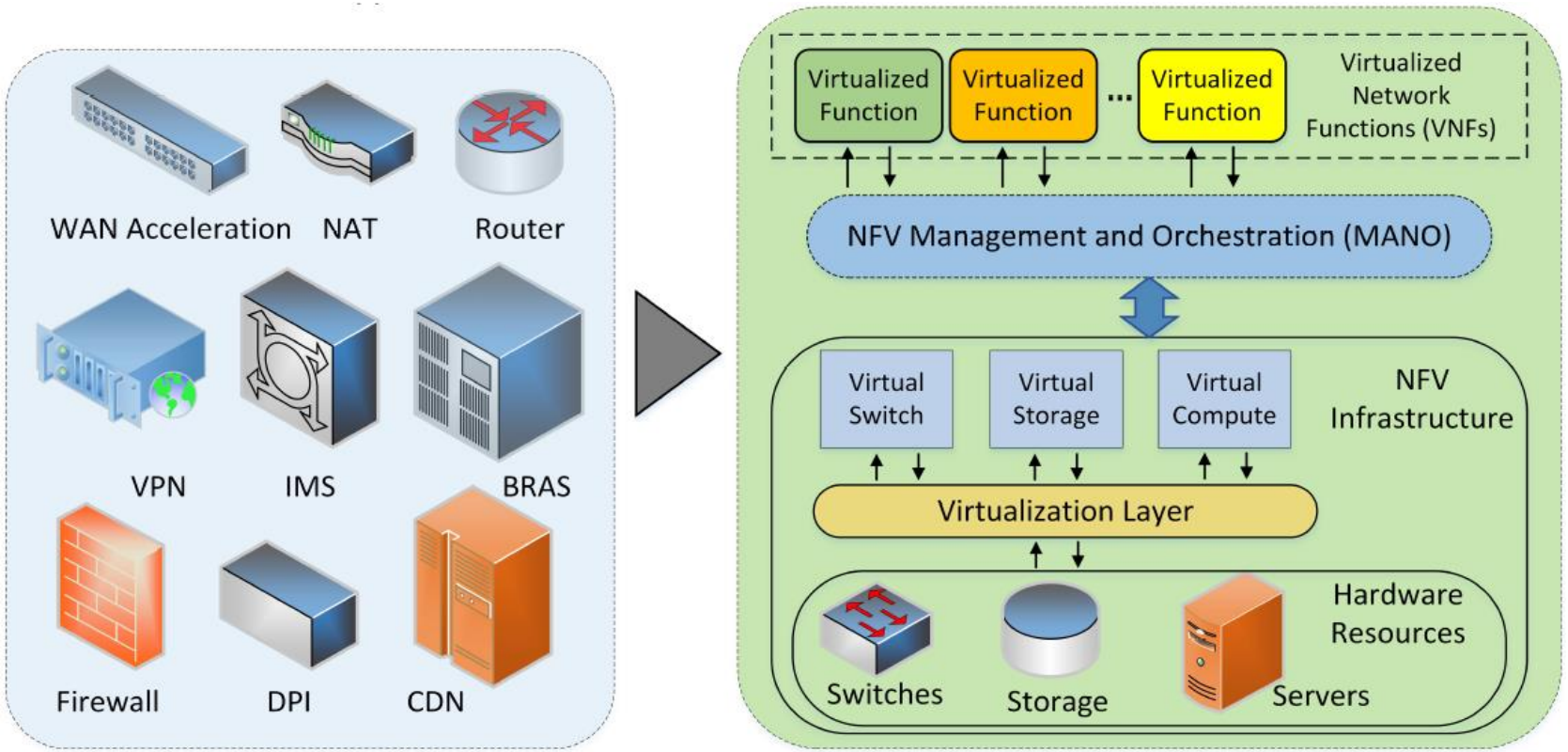
- The role of networking in the new technologies and applications: **Network Softwarization**
- The main components: SDN (Software Defined Networking)

MAC src	MAC dst	IP src	IP dst	TCP port	Action
*	10:20:..	*	*	*	Port 1
*	*	217.99.*	*	*	Table 6
*	.:38:aa:..	*	*	*	Drop
*	*	*	7.7.9.4	25	Drop
*	*	*	*	69	Local
*	*	*	*	*	controller

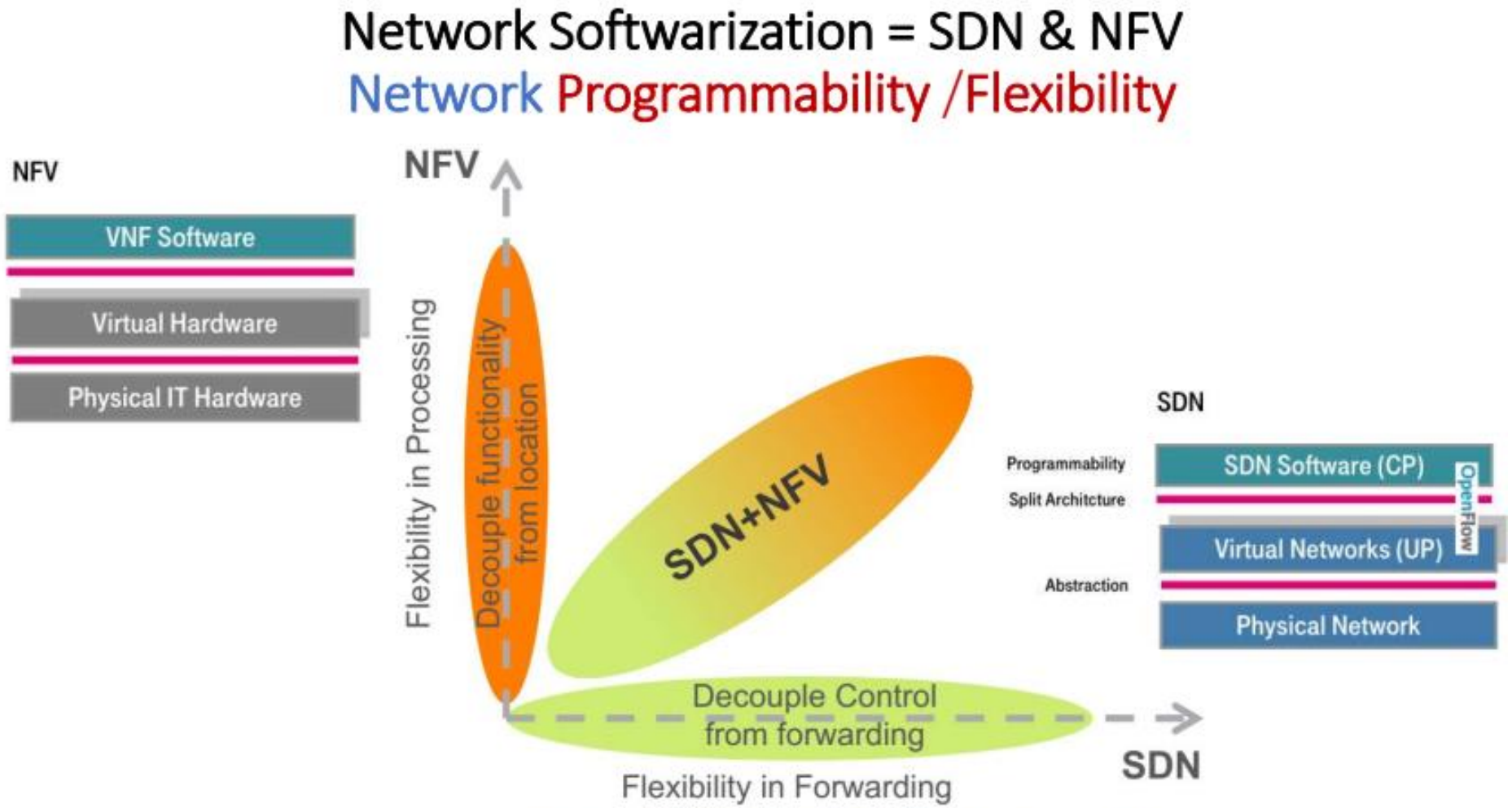


Advanced Computer Networks

- The role of networking in the new technologies and applications: **Network Softwarization**
- The main components: NFV (Network Function Virtualization)



Advanced Computer Networks



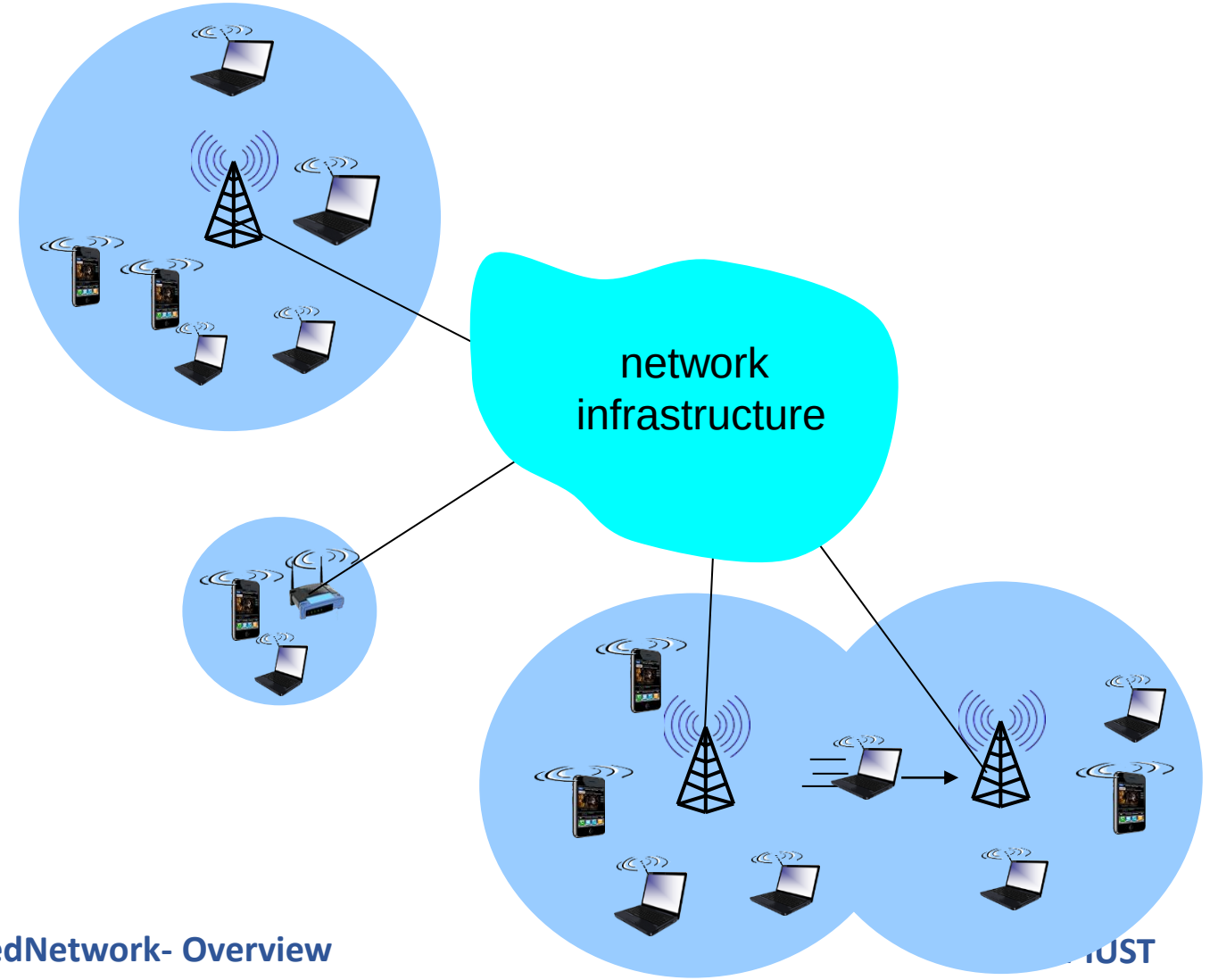
Sources: Ahmad Rostami, Ericsson Research (Kista): http://www.itc26.org/fileadmin/ITC26_files/ITC26-Tutorial-Rostami.pdf and Uwe Michel, T-Systems

Advanced Computer Networks

- The role of networking in the new technologies and applications: **Mobile and Wireless Networks**

- Two main scenarios:
  - WiFi (802.11) Networks
  - Cellular Networks

➢ Due to the existence of the wireless channel, user mobility, and types of services, new methods and protocols in different layers are required in these scenarios.



Advanced Computer Networks

- The role of networking in the new technologies and applications: **Mobile and Wireless Networks**
- Some related topics:
  - Contention-based and fixed access scheduling in WiFi and Cellular networks.
    - Related methods: CSMA, FDMA, TDMA.
  - Using network softwarization in radio access and core of these networks.
  - Hidden terminal problem in WiFi networks >> RTS/CTS scheme.
  - Mobility issues, and Handoff schemes.

Advanced Computer Networks

- The role of networking in the new technologies and applications: **Multimedia Transmission and Networking.**

➢ People in all corners of the world are currently using the Internet to watch movies and television shows on demand.

➢ Internet movie and television distribution companies such as Netflix in North America and Youku in China have practically become household names.

➢ However, people are not only watching Internet videos, they are using sites like YouTube to upload and distribute their own user-generated content, becoming Internet video producers as well as consumers.

➢ Moreover, network applications such as Skype allow people to not only make "telephone calls" over the Internet, but to also enhance those calls with video and multi-person conferencing.

Advanced Computer Networks

- The role of networking in the new technologies and applications: **Multimedia Transmission and Networking.**
- A multimedia application can be classified as
  - Streaming stored audio/video,
    - **Related Topics**: client buffering, prefetching, and adapting video quality to available bandwidth
  - Conversational voice/video-over-IP, (Skype, RTP, SIP)
    - **Key features**: highly sensitive to end-to-end delay but can tolerate occasional loss of data
  - Streaming live audio/ video.
- Each of these classes of applications has its own unique service requirements that differ significantly from those of traditional elastic applications such as e-mail, Web browsing, and remote login.
- It is important to distinguish one class of traffic (e.g., delay-sensitive applications such as conversational voice) from another (e.g., elastic applications such as browsing Web pages), and provide differentiated service among multiple classes of traffic.

Advanced Computer Networks

- About the course:

  - ❖ A course devoted to discuss advanced and emerging topics in computer networking.
  - ❖ Offered via variety of different topics around the globe.
  - ❖ We thus pick several selected useful and also emerging topics to cover in the current course.

Course Syllabus (Main items)

1. **Introduction**: Review on Basics of Computer Networks.
2. **Congestion Control:** Traditional Methods, New Approaches, Mathematical Framework.
3. **Network Softwarization:** Virtualization, SDN, and NFV.
4. **Internet of Things (IoT)**: Networking technologies for IoT (RFID, NFC, WPAN, Wireless Mesh Networks, LPWAN, LWM2M, LTE-M, etc.)
5. **Mobile and Wireless Networks:** WiFi and Cellular Networks, and related technologies in different layers of the network.
6. **Multimedia Networking:** Challenges, Requirements, and Methods.
7. **Other related topics based on time and subjects:** Cloud and Data Center Networking**,** Quality of Service (QoS), Security, Traffic Engineering and Routing, Randomization.

References

- Course slides and class notes.
- Books:
  - Kurose, J.F. and Ross, K.W. **Computer Networking: A Top-Down Approach**. Addision Wesley. (2013-2021)
  - Peterson, L.L. and Davie, B.S. **Computer Networks: A Systems Approach.** Morgan Kaufmann, 2022.
- Any other material and used reference will be announced and uploaded on LMS.

Grading Policy

- Quiz, Midterm and Final Exams: ~ 70-75%
- Assignments and Paper Readings: ~ 10-15%
- Course Project: ~ 15%
- Bonuses for class activities, and significant performance in assignments and projects.