CENG 362 Computer Networks

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Lecture Outline: Course Overview

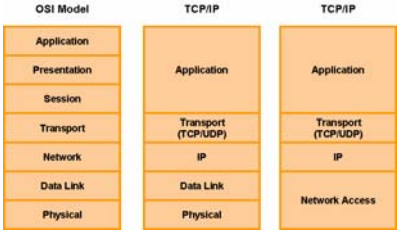
1. **Course Description and Objectives**
2. Roadmap of Networking
3. Requirements and Assumptions
4. Computer Networks Lab
5. Course Outline
6. Text Books and Other Lecture Materials
7. Course Activities and Grading

Course Description

- **Catalog Description:** OSI reference model, Internet and TCP/IP. Application layer protocols: HTTP, FTP, SMTP, POP3, and DNS. Socket programming, transport layer services, flow and congestion control, network layer and IP protocol, addressing, routing, data link layer protocols, local area networks.
- CENG 362 is a **one-semester** introduction to **computer networking (data communication)** theory, applications, and programming with a **focus on the Internet and its applications**.
- It covers networking topics **beginning from the application-layer** then going down the protocol stack (**a top-down approach**), allowing computer engineering students to quickly **write networking applications** while **learning the theory and practice** of computer networking.
- **Programming in Java** is an important component of the course.
- Some **network programs, simulators** and **educational multimedia materials** will be also used to teach the networking fundamentals.

Objectives

- Teaching mainly **TCP/IP layers and protocols** (Application Layer, Transport Layer, Network Layer, and Data Link Layer)
- **Hands-on experience on networking** (using routers, host computers, switches, cables, packet analyzers, network monitoring and management tools, …)
- Teaching the **fundamentals of data communication**.
- Opening the hood of the Internet and **learning how Internet works**.



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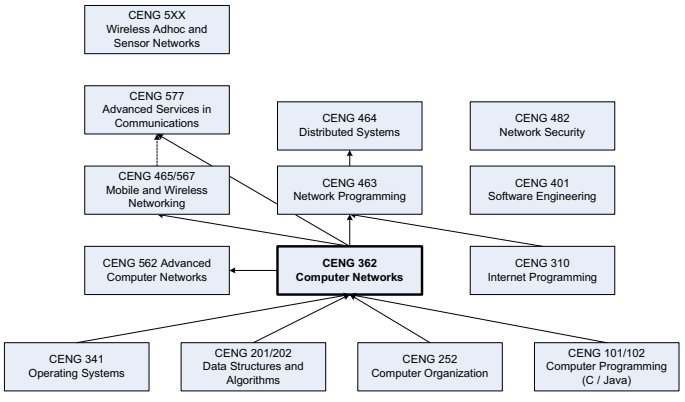
Roadmap for Networking



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Requirements

- A basic understanding of algorithms (CENG 201/202 Data Structures and Algorithms)
- No difficult math, but you have to be comfortable looking at problems analytically
- CENG 341 Operating Systems
- Linux (for Lab Experiments)
- A previous course in Computer Organization (e.g. CENG 252) is required.
- You must be able to program in a structured high-level programming language, especially Java. (You will be only introduced to TCP/UDP Socket Programming using Java, no advanced Java is required.)

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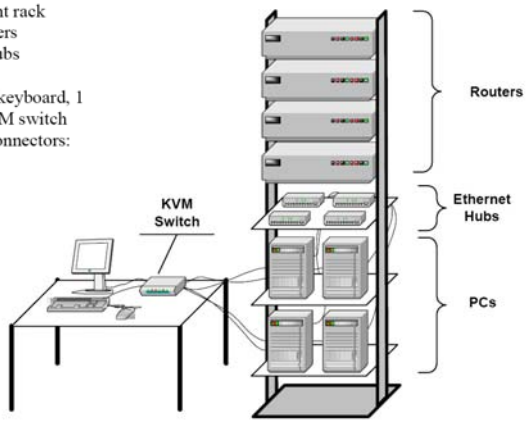
Computer Networks Laboratory

- The course has a lab section. Sign up for a lab section!
- The lab is in E106 and E108 in Engineering Building.
- The workload of the labs is significant:
  - 2 lab hours per week + prelab (lab quiz) + postlab.
  - Postlab: For each lab you will prepare a lab report.
- There will be 1 (introduction) +10 labs; almost one lab every week
- The first lab is in this week!
- Labs are done in groups of 4.
- If you want to switch lab sections after the sign-up, you need to find a partner to swap with.

Computer Networks Lab

Basic Computer Networks Lab Equipment

1. 19" equipment rack
2. 4 Cisco Routers
3. 4 Ethernet Hubs
4. 4 hosts
5. 1 Monitor, 1 keyboard, 1 mouse, 1 KVM switch
6. Cables and connectors:



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Course Outline (Tentative)

Week	Topics Covered
1	**Course Overview**, **Introduction** to Computer Networks and the Internet (chp 1)
2	**Application Layer (1):** Principles of App. Layer Protocols, TCP/UDP Socket Programming. (chp 2)
3	**Application Layer (2):** TCP/UDP Socket Programming (continued) and HTTP (chp 2)
4	**Application Layer (3):** FTP, SMTP, DNS, Web Servers, Peer-to-Peer Networking (chp 2)
5	**Transport Layer (1):** Transport-Layer services, Multiplexing and Demultiplexing, Connectionless Transport: UDP, Principles of Reliable Data Transfer (chp 3)
6	**Transport Layer (2):** Connection-Oriented Transport: TCP, Principles of Congestion Control (chp 3)
7	**Transport Layer (3):** Congestion Control; TCP Congestion Control in TCP (chp 3) and Review for Midterm Exam I
8	**Midterm Exam I**
9	**Network Layer (1):** Network Service Models, Routing Principles, Link State and Distance Vector Routing, Hierarchical Routing (chp 4)
10	**Network Layer (2):** IP Protocol: IPv4 Addressing, Moving a Datagram, Datagram Format, IP Fragmentation, ICMP, DHCP, NAT, Routing in the Internet (chp 4)
11	**Network Layer (3):** What's Inside a Router, IPv6, Multicast Routing, Mobility (chp 4)
12	**Link Layer and LANs (1):** Introduction and Services, Error Detection and Correction, Multiple Access Protocols (chp 5) **Midterm Exam II**
13	**Link Layer and LANs (2):** LAN addresses and ARP, Ethernet, Hubs, Bridges, and Switches, (chp 5)
14	**Link Layer and LANs (3):** PPP, ADSL, ATM, Frame Relay (chp 5)

Look at the course web page for the updated course schedule

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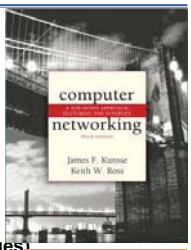
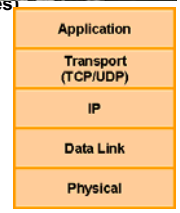
Text Books (Required 1)

- ***Computer Networking: A Top-Down Approach Featuring the Internet***, 3rd Edition, J. F. Kurose, K. W. Ross, Addison Wesley, 2004.



Chapters

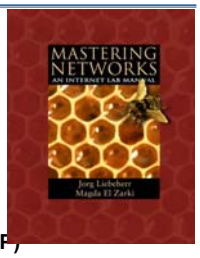
1. Computer Networks and the Internet
2. Application Layer
3. Transport Layer
4. The Network Layer
5. The Link Layer and Local Area Networks (500 pages)
6. Wireless and Mobile Networks
(CENG 567/465 Mobile and Wireless Networking)
7. Multimedia Networking
(CENG 577 Advanced Services in Communications
8. Security in Computer Networks
(CENG 482 Network Security)
9. Network Management



Text Books (Required 2)

Lab Manual:

- ***Mastering Networks: An Internet Lab Manual***, J. Liebeherr, M. E. Zarki, Addison-Wesley, 2004.



Chapters

1. Introduction to the Internet Lab
2. Single Segment IP Networks
3. Static Routing
4. Dynamic Routing Protocols (RIP, OSPF, BGP)
5. LAN Switching
6. Transport Protocols (UDP and TCP)
7. NAT and DHCP
8. The Domain Name System
9. SNMP
10. IP Multicast

Text Books (Recommended)

Recommended

- *Computer Networks (4th Edition)*, Andrew S. Tanenbaum, Prentice Hall, 2003.
- *Computer Networking with Internet Protocols*, William Stallings, Prentice Hall, 2003.
- *Data and Computer Communication (7th Edition)*, William Stallings, Prentice Hall.
- *Computer Networks: A Systems Approach (3rd Edition)*, L. Peterson and B. Davie, Morgan Kaufmann, 2003.

Special Reference

- **Java Ağ Programcılığı**, H. Gümüşkaya, Ö. Boyacı, ALFA, 2003.

1. Java'ya Giriş
2. Java Programlama Dili
3. Bilgisayar Ağları ve TCP/IP
4. Temel Web Kavramları ve Teknolojileri
5. Applet'ler ile Web Programcılığına Giriş
6. Ağ Yazılımları Haberleşme Modelleri
7. Java Thread'leri ve Çok-Thread'li Yazılım Tasarımı
8. Ağ Programlarının Yapı Blokları: Java Stream'ler
9. Java Ağ Paketi ve Yüksek Seviyeli Sınıflar ile Ağ Programcılığına Giriş
10. TCP Soket Programcılığı
11. UDP Soket Programcılığı
12. Multicast Haberleşme Modeli ve Programcılığı
13. JDBC ile Ağ Verisine Erişim
14. RMI ile Dağıtık Uygulamalar
15. Java Web Programcılığı
16. Servlet'ler ile Web Programcılığı
17. JSP ile Web Programcılığı

Lecture Slides and Other Lecture Materials

Lecture Slides

- You can download the updated new lecture slides after (unfortunately) the lecture from the course's web site.
- You can download the old lecture slides from the previous year's course web page.
- **Bring printouts of the old lecture slides to class:**
  If you bring the lecture slides to class, you can **take notes** on these slides, **being active**, **follow the lecture** and **not boring and asleep in class**.

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Course Activities

- **Lectures:** Theoretical foundations and background.
- **Lab Experiments:** Practical foundations and hands-on experience.
- **Homework Assignments:** There will be 5 assignments.
  The purpose of the homework is to give you a chance to exercise the knowledge gained from the recent class material.
- **Midterm Exam:** There will be 2 midterm exams.
- **Final Exam:** There will be a comprehensive exam at the end of the course.
- **Attendance:** Important in order to learn the topics in a timely manner. Attendance will be forced by taking attendance.

Grading

Course Grading:

30 % : Lab Experiments and Lab Exam
15 % : Homework Assignments
15 % : Midterm I
15 % : Midterm II
25 % : Final Exam (a comprehensive exam)

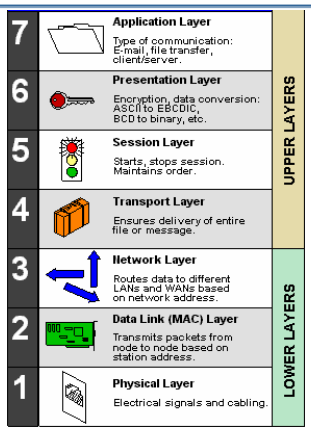
Lab Grading:

Each Lab Grade = 20 % Pre Lab Quiz
80 % Lab Report (team report)
Final Lab Grade = 70 % Lab Grades Average +
30 % Lab Exam

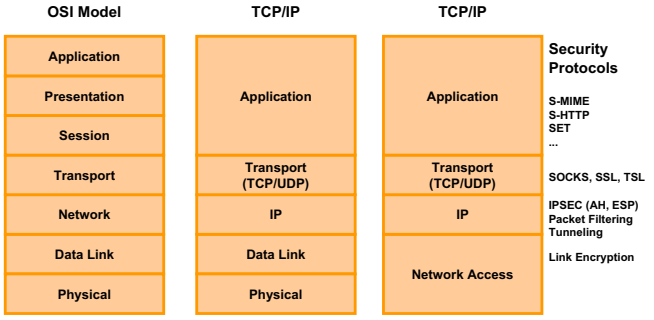
Quick Review of Computer Networking and TCP/IP

- OSI and TCP/IP Reference Models
- IP Addresses, Ports and Socket, and Socket Programming
- Transport-Level Protocols: TCP and UDP
- TCP and UDP Based Communication

OSI Reference Model

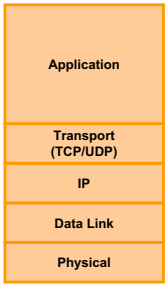


OSI and TCP/IP Reference Models

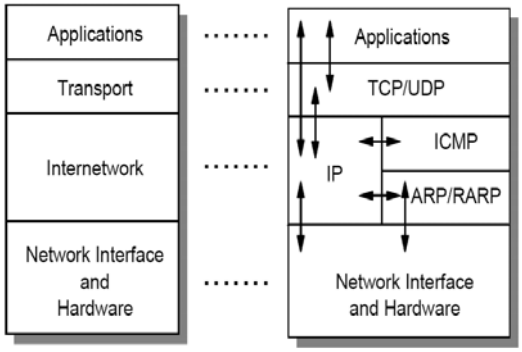


TCP/IP (Internet) Protocol Stack

- **Application:** supporting network applications
  - HTTP, FTP, SMTP, POP3, SNMP, …
- **Transport:** host-host data transfer
  - TCP, UDP
- **Network:** routing of datagrams from source to destination
  - IP, routing protocols
- **Link:** data transfer between neighboring network elements
  - PPP, Ethernet, 802.11, …
- **Physical:** bits “on the wire”

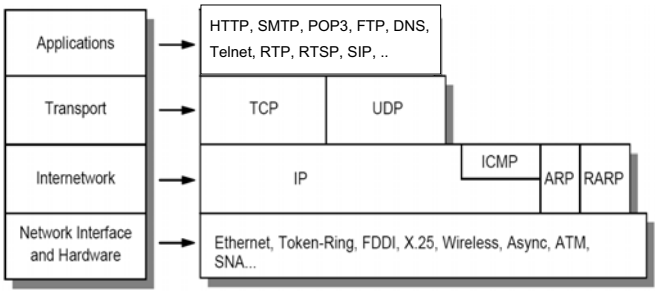


TCP/IP (Internet) Protocol Stack

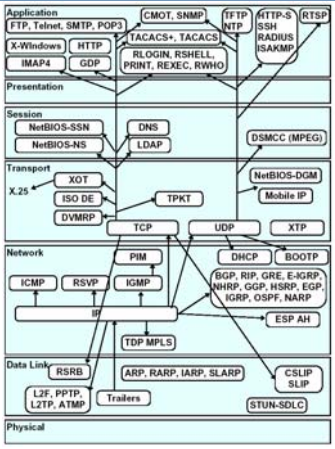


Each layer represents a package of functions

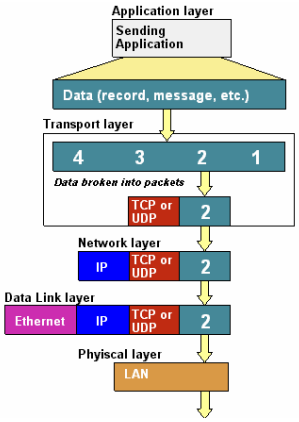
Detailed TCP/IP (Internet) Protocol Stack



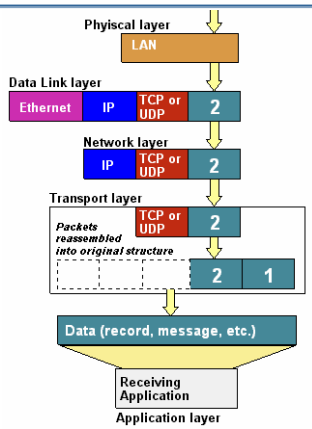
Do you want more details?



Data Traveling in Protocol Stack



Data Traveling in Protocol Stack



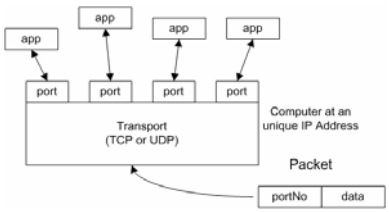
Connection in TCP/IP

A connection between two machines in TCP/IP is defined by:

- Transport layer protocol (TCP or UDP)
- IP address of local machine
- Port number used on the local machine
- IP address of remote machine
- Port number used on the remote machine

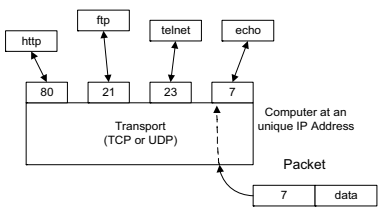
Transport-Level Protocols: Ports

- TCP and UDP protocols use **ports** to map incoming data to a particular process running on a computer.
- IP Datagram identifies the **host** and the **port** that it's destined for.
- The **computer is identified** by its **32-bit IP address**, which IP uses to deliver data to the right computer on the network.
- **Ports are identified by** a 16-bit integer number, ranging from 0 to 65535, which TCP/UDP use to deliver the data to the right application.



Well-known Ports

- Port numbers between 0 and 1023 are restricted (**well-known ports**) -- they are reserved for use by well-known services such as HTTP and FTP and other system services.
- Your applications should not attempt to bind to these ports.



Well-Known TCP/IP Services and Port Assignments

Protocol	*Port*	*Encoding*	*Purpose*
Echo	7	TCP/UDP	Test protocol used to verify that two machines are able to connect by having one echo back the other's input.
Discard	9	TCP/UDP	Less useful test protocol that ignores all data received by the server.
Daytime	13	TCP/UDP	Provides an ASCII representation of the current time on the server.
ftp-data	20	TCP	FTP uses two well-known ports. This port is used to transfer files.
FTP	21	TCP	This port is used to sent ftp commands like, "put" and "get".
TELNET	23	TCP	A protocol used for interactive, remote command-line sessions.
SMTP	25	TCP	"Simple Mail Transfer Protocol" is used to send email between machines.
Time	37	TCP/UDP	A time server returns the number of seconds that have elapsed on the host machine since midnight, January 1, 1900, as a four-byte, signed, big-endian integer.
Whois	43	TCP	Simple directory service for Internet network administrators.
Finger	79	TCP	It gets information about a user or users.
HTTP	80	TCP	Hyper Text Protocol is the underlying protocol of the World Wide Web.
POP3	110	TCP	Post Office Protocol version 3 is a protocol for the transfer of accumulated email form the host to sporadically connected clients.
NNTP	119	TCP	Usenet news transfer. More formally known as the "Network News Transfer Protocol".
SNMP	161/162	UDP	Simple Network Managment Protocol is used in management of TCP/IP.
RMI Registry	1099	TCP	The RMI Registry is a registry service for Java remote objects.
Servlets	8080	TCP	Java Server API and Servlets is a web server from Sun that runs on port 8080 by default, not port 80.

Transport-Level Protocols: TCP

- TCP is a **reliable** and **connection-oriented** communication protocol on top of the unreliable, unsequenced functionality of IP.

Reliable:

- TCP provides extensive **error-checking** capabilities.
- TCP provides **reliable stream delivery**. This reliable stream delivery ensures that the data arrives in the same sequence and state in which it was sent.

Connection-oriented:

- The TCP system relies on a **virtual circuit** that is established between the requesting machine and its target.
- This circuit is opened via a 3-part process, often referred to as the **3-part handshake**.

Transport-Level Protocols: TCP

- Because of the reliable and sequenced nature of TCP sockets, they often are called **stream sockets**; you can read and write data in continuous streams of bytes without worrying about packets, headers, and so on.
- TCP is the chief protocol employed on the Internet.
- It facilitates such mission-critical tasks as file transfers and remote sessions.
- Stream socket functionality in Java is provided by the classes `java.net.ServerSocket` and `java.net.Socket`.

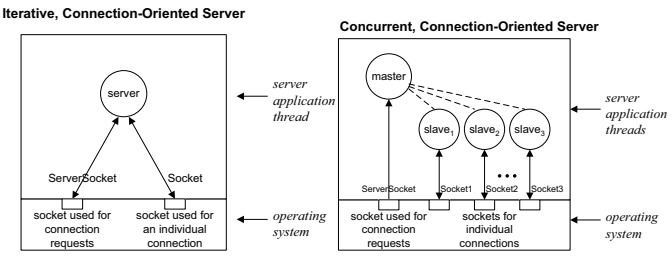
Transport-Level Protocols: UDP

- UDP is an **unreliable** and **connectionless** communication protocol.
- Datagram-based communication.
- Datagram packets are prepared by the applications.
- IP Address + Port Number are put into datagram.
- UDP-based communication is like sending letters to a post office.
- Not reliable but fast compared to TCP.
- Datagram socket functionality in Java is provided by the classes `java.net.DatagramSocket` and `java.net.DatagramPacket`.

TCP-Based Communication Steps

- A **server** application opens a socket to establish a connection with another application (client) by binding a socket to a port number. (registering the application with the system to receive all data destined for that port.)
- Server: TCP Socket = Port Number (Well-known)
- Client: TCP Socket = IP Address + Port Number (server's port)
- When a **client** makes a request from the server's port, input and/or output streams are created on the socket depending on the protocol used between the server and the client.
- No two applications can bind to the same port: Attempts to bind to a port that is already in use will fail.
- Stream based (like a phone call)
- Uses 3-way handshake, reliable but slow (compared to UDP)

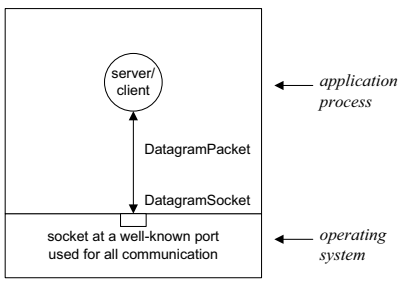
Iterative and Concurrent TCP Servers



A server implementation that processes one request at a time.

Concurrent server handles multiple requests at one time.

UDP Client or Server



The same socket is used to send data and to listen for incoming connections. Applications handle the client/server functionality.