

Computer Networks – Introduction

Outline:

- General course information.
- Some basic concepts for computer networks.
- Network programming.

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General Course Information

- Course Web page
 - <http://www.cs.rochester.edu/~kshen/csc257-fall2011>
- Course email address
 - cs257@cs.rochester.edu
- Textbook
 - Kurose and Ross, "Computer Networking: A Top-Down Approach Featuring the Internet", 4th edition, 2007; 5th edition, 2009.
- Accounts in computer science labs
 - If you don't have one, sign up on a sheet AND see Marty

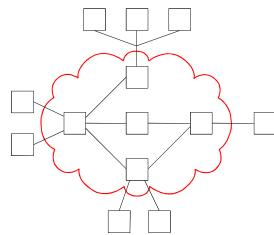
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Basic Building Blocks for Computer Networks

- Network: two or most hosts connected by links/switches



- Host nodes:
 - PCs, servers, hand-held devices, sensors ...
- Links:
 - Twisted pair, coaxial cable, phone line, optical fiber, wireless radio channels ...

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Routing and Addressing

- Routing: finding a route (path) to the destination.
- Address: identifier of network end points.
- Types of traffic/addressing
 - unicast: to a single destination node;
 - broadcast: to all nodes on the network;
 - multicast: to some subset of nodes on the network;
 - anycast: to any one in a set of nodes.

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Network Protocol: An Example

A human protocol and a computer network protocol:

time

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Network Protocol

- A network **protocol** describes how communication entities (sender/receiver) should interact to accomplish a networking task.
 - format, order of messages sent and received between network entities
 - actions taken on message transmission, receipt
- Protocols define communication interface, not node-local implementations
 - allow two sides of a communication task to be independently implemented (Google Chrome browser interacts with Microsoft IIS server).

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Network Architecture: Layers

- Separation of network functions/features allow independent design and implementation ⇒ thus **distributing the complexity**.
- Layering is a vertical separation of network functions/features.
 - **Hiding the complexity**: each layer interface hides complexity in this layer and layers below.
- Disadvantage of layering?
 - lack of full information sharing

Application programs
Host-to-host data transport
Host-to-host connectivity
Communications over link hardware

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Internet Architecture

Bottom-up:

- **physical**: electromagnetic signals "on the wire"
- **link**: digital signals (data) transfer on one link (between neighboring network elements)
 - encoding, framing, error correction, access control for shared links
- **network**: host-to-host multi-hop connectivity
 - routing, addressing
- **transport**: host-to-host data transport
 - reliable data transport, congestion control, flow control
- **application**: anything you want to do on computer networks

application
transport
network
link
physical

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Protocols for the Internet Architecture

The diagram illustrates the Internet Architecture. On the left, a vertical stack of five boxes represents the layers: application, transport, network, link, and physical. To the right, a tree structure shows protocol implementations: HTTP, SMTP, DNS, and Kai's protocol are at the application layer; TCP and UDP are at the transport layer; IP is at the network layer; Ethernet, 802.11, and PPP are at the link layer. The physical layer is not explicitly shown with protocols.

- Hourglass design.
- Understand layers, protocols, protocol implementations.

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Internet Layering on Hosts and Switches

The diagram shows how Internet layering is implemented on hosts and switches. On the left, a host stack has five layers: application, transport, network, link, and physical. On the right, a switch stack has three layers: network, link, and physical. The physical layer of the host is connected to the physical layer of the switch. The network layer of the switch is connected to the network layer of another switch. The application and transport layers of the host are connected to the application and transport layers of the switch.

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History/Dominance of the Internet

- Internet (TCP/IP) evolved from a U.S. Defense Department-supported project called ARPANET.
- Internet/ARPANET wasn't the first/only electronic network:
 - Telephone network, X.25
- The Internet becomes dominant today because:
 - Simple network core (packet switching) with efficiency and extensibility.
 - A good TCP/IP implementation was bundled with a popular UNIX operating system (Berkeley UNIX).

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OSI Model

- Session layer:** tie up different transport streams belonging to the same application
- Presentation layer:** defining uniform format for data representation

The diagram shows the seven layers of the OSI Model. On the left, an 'End host' stack has seven layers: Application, Presentation, Session, Transport, Network, Data link, and Physical. On the right, another 'End host' stack has the same seven layers. In the center, two 'switches' are shown, each with four layers: Network, Data link, Physical, and Physical. The Physical layer of the left end host is connected to the Physical layer of the first switch. The Network layer of the first switch is connected to the Network layer of the second switch. The Physical layer of the second switch is connected to the Physical layer of the right end host.

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Course Outline

- Traditional materials about computer networks
 - Data links: Ethernet etc.
 - Network: IP addressing and routing.
 - Transport: TCP/UDP.
 - Application: HTTP, FTP, SMTP, and DNS.
- Advanced topics in computer networks
 - Multimedia networking (quality of service), computer security, wireless (mobile/mesh) networks, overlay networks.
- Case studies of network systems/technologies
 - HTTP load balancing.
 - Content distribution and network caching.
 - Peer-to-peer systems.

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What we will learn?

- Practices
 - How do things work in practice?
 - In the case of Internet, the Web, p2p overlay, etc.
- Principles
 - Why things work in ways they do now?
 - Fundamental principles, design rationale (and sometimes a lack of it).

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Socket Programming

Socket: a programming interface on which application processes can communicate with remote application process.

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Socket Programming in Network Architecture

Applications

Socket

Implemented in hardware or operating system software

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TCP/UDP Sockets

Connection-oriented byte streams (TCP):

- Client/server need to establish connection before communications
- Communications flow in streams of ordered bytes
- But no clear sense of messages
 - when one sends X bytes, the other side may receive twice with X/2 bytes each

Connectionless datagram (UDP):

- No connection is needed before communications;
- Clear boundaries between groups of bytes (messages)
- But no ordering between messages.

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Port Numbers

- Multiple sockets might exist in each host.
- A **port number** identifies each such socket in each host.
- Each port number is a 16-bit number, ranging from 0 to 65535.
- Port numbers ranging from 0 to 1023 are restricted for system-level services.

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Learn Network Programming

- Reference book
 - Network programming in C: Stevens, "Unix Network Programming, Volume I", 2nd edition, 1998.
- Learn to use UNIX manual pages
- Find information on the web

- C versus Java

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Assignment #0


- Part I: warmup on socket programming, not graded

- Part II: network measurement
 - measuring transmission delays for varying TCP/UDP traffic
 - report local as well as wide-area measurements
 - report stable results

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