Computer Networks

– Introduction

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

General Course Information

- Course Web page
- Course email address
  - cs257@cs.rochester.edu
- Textbook
- Accounts in computer science labs
  - If you don’t have one, sign up on a sheet AND see Marty

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 ...

Network Traffic

- 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
### Network Protocol: An Example

A human protocol and a computer network protocol:

- **Human Protocol:**
  - Hi
  - Got the time?
  - 4:00
- **TCP Protocol:**
  - TCP conn. req
  - TCP conn. response
  - Get http://www.cs.rochester.edu
  - (file)

### Network Architecture: Layers

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

### 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).

### 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
Protocols for the Internet Architecture

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

OSI Model

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

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).

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.
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).

Socket Programming

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

Overview of TCP Sockets

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.
Socket Programming Notes

- **gethostbyname()**
  - Query name server for IP to name translation.

- **connfd = accept(listenfd, ...)**
  - Server waiting for a connection request.

  **Notes**
  - Returns when the connection with a new client is established and ready for data transfers
  - Data communications are done through the connection socket, not the listening socket
  - One listening socket for the whole server, one connection socket per active connection with a client

Socket Programming Notes

- **read/recv, write/send**
  - Data transfer calls.
  - **Note**
    - TCP communications are stream-oriented, with no clear sense of message boundaries
    - when one sends 2000 bytes, the other side may receive twice (with 1460 bytes the first time, and 540 bytes the next time)

  **How do you know when you are done with receiving?**
  - Your protocol semantics should tell, three typical ways (next slide)

Socket Programming Notes

Protocol on the end of message and how to write your receiver code?

- Fixed-size messages defined by protocol
  - **read/recv** for a certain size?
  - Must retry in case you don’t get all the first time
  - Likely fine with one try if the size is small

- Fixed-size header which contains a field that indicates the size of body
  - Read the header
  - The rest is similar to above

- Always ends with a special pattern (e.g., an empty line “\n\n”)
  - Be careful that the ending pattern may straddle over two packets
Important!
- Check the return code of every socket call
- Do error processing, warning messages for all cases
- See UNIX manual pages for error codes and possible meaning

Learn Network Programming
- Learn to use UNIX manual pages
- Find information on the web
- Reference book
- Help each other
  - Help with basic questions on network programming, NOT writing code for each other’s assignment
- C versus Java

Assignment #0
- Part I: warmup on socket programming, not graded
- Part II: network measurement
  - measuring transmission delays for varying TCP traffic
  - report local as well as wide-area measurements
  - report stable results

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