CMPE 150: Introduction to Computer Networks

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Lecture 2

CMPE 150 Winter’13
Lab Session Schedule

• Lab sessions.
  – Mon 12-2pm
  – Tue 12-2pm
  – Wed 10-12pm
  – Thu 10am-12pm

• Where is the lab?
  – BE 301A.
Announcements

• Communication:
  – E-mail preferred.
  – Send e-mail to instructor and TAs.

• Try to have uniform distribution across lab sessions.
  – It’s to everyone’s advantage!
Lab

• Recall that one of your responsibilities is to come to the lab PREPARED!
  – At least bring the lab.
  – Bring USB key.
Introduction

Fundamental concepts, terminology

Chapter 1
Concepts and Terminology

• Definition of computer networks.
• Examples of networks.
• The Internet
  – Components: links, end hosts, and routers.
  – Collection of interconnected networks
• The Internet’s structure: hierarchical
  – Network edge.
  – Access networks.
  – Network core.
    • Backbone.
• Protocols.
What is a computer network?

• From Wikipedia:

“A computer network, or simply a network, is a collection of computers and other hardware interconnected by communication channels that allow sharing of resources and information.”
What is a communication network?

• From Wikipedia:
  “A communication network is a collection of terminals, links, and nodes which connect to enable communication between users of the terminals.”
What are the components of a communication network?

- Links, nodes, and “terminals”.
- What’s the difference between “nodes” and “terminals”?
# To network or not to network?

## Why network?

- Resource sharing
  - Hardware.
  - Software.
  - Data!
- Robustness
- Load balancing

## Why not?

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To network or not to network?

Why network?

- Resource sharing
  - Hardware.
  - Software.
  - Data!
- Robustness
- Load balancing

Why not?

- SECURITY!!!
The Networks Around Us

• This course focuses on the Internet, but there are many other networks.
• Examples of other networks we use everyday?
  – “Snail mail”, i.e., postal delivery service.
The Networks Around Us

POTS: Plain Old Telephone Service
The Networks Around Us

PCI Express

Bluetooth®
The Networks Around Us
So how do we describe the Internet?

“The Internet is a series of tubes”
- Late Ted Stevens, US Senator
The Internet

• The Internet versus an internet?
• “Internet” is an abbreviation of “internetwork”
  – Collection of interconnected networks, with no central administration or management
  – A “network” has a single administrative authority
What made the Internet so popular?

✓ Originally designed for file transfer, remote login, and e-mail.

It took almost 25 years for a killer application to emerge!
What’s the Internet: “Nuts and Bolts” View

- Millions of connected computing devices: *hosts = end systems*
  - Running *network apps*
  - Communication links
    - Fiber, copper, radio, satellite
  - Transmission rate = *bandwidth*
  - Routers: forward packets (chunks of data)
“The Internet of Things”

IP picture frame
http://www.ceiva.com/

Web-enabled toaster +
weather forecaster

World’s smallest web server
http://www-ccs.cs.umass.edu/~shri/iPic.html

Internet phones
What’s the Internet: “Nuts and Bolts” View

• *protocols* control sending, receiving of msgs
  – e.g., TCP, IP, HTTP, Skype, Ethernet

• *Internet*: “network of networks”
  – loosely hierarchical
What’s the Internet: “Service” View

- Communication Infrastructure enables distributed applications:
  - Web, VoIP, email, games, e-commerce, file sharing
- Communication services provided to apps:
  - reliable data delivery from source to destination
  - “best effort” (unreliable) data delivery
What’s a Protocol?

human protocols:
• “What’s the time?”
• “I have a question”
• Introductions.

... specific messages sent
... specific actions taken when messages received, or other events

network protocols:
• Machines rather than humans
• All communication activity in Internet governed by protocols

 Protocols define format, order of messages sent and received among network entities, and actions taken on message transmission, receipt.
What’s a Protocol?
a human protocol and a computer network protocol:

Q: Other human protocols?
A Closer Look at Network Structure:

- **Network edge:** applications and hosts
  - Access networks, physical media: wired, wireless communication links
- **Network core:**
  - interconnected routers
  - network of networks
The Network Edge

- **End systems (hosts):**
  - run application programs
  - e.g. Web, email
  - at “edge of network”

  - **Client/server model**
    - client host requests, receives service from always-on server
    - e.g. Web browser/server; email client/server

  - **Peer-peer model:**
    - minimal (or no) use of dedicated servers
    - e.g. Skype, BitTorrent
Two Basic Problems in Communications

1. How to share a physical communication path across multiple users?
   - Key to reducing cost

2. How to communicate between users without a direct link between them?
   - Needed for constructing large networks
Early POTS Network
Early POTS Network

Circa 1903
Sharing a Communication Path

Two approaches:

1. Circuit Switching
   - Method used in Plain Old Telephone System
   - Customer buys fixed capacity for the duration of call
   - Example: 64,000 bits/second for a 5-minute phone call
   - Customer charged a per-minute fee

2. Packet Switching
   - Used in the Internet
   - Best effort model: Users send data when ready, network makes no guarantees
Circuit Switching

Each conversation takes a fixed slice of the network capacity on the phone network.
Circuit Switching: FDM and TDM

FDM

Example:
4 users

TDM

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Packet Switching

"I AM A DIGITAL WIRELESS INTERNET DEVICE! IF YOU CALL ME A 'CELL PHONE' ONE MORE TIME, YOUR SERVICE WILL BE TERMINATED!"
Packet Switching

- Bit stream divided into chunks called **packets**
- A packet is a self-contained chunk of information transmitted on networks
  - Generated by some protocol
  - Typically contains a “header” and a “payload”
- Packet header may contain id of sender and receiver, sequence number to determine order, etc.
Packet Switching: Statistical Multiplexing

Sequence of A & B packets does not have fixed pattern, bandwidth shared on demand ➔ *statistical multiplexing*. 
Packet Switching

- Packets may be formed by encapsulating other packets
  - One protocol may take a packet generated by another protocol, add a header, and send it as a new packet
  - Occurs commonly when protocols are layered
- Also called “frames”, “datagrams”, “segments”, etc.
Packet Switching

- Each end-end data stream divided into packets
- User A, B packets share network resources
- Each packet uses full link bandwidth
- Resources used as needed

Resource contention:
- Aggregate resource demand can exceed amount available
- Congestion: packets queue, wait for link use
- Store and forward: packets move one hop at a time
  - Node receives complete packet before forwarding

Bandwidth division into “pieces”
  - Dedicated allocation
  - Resource reservation

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Voice on the Internet

Voice sent out as packets (network capacity used only when a packet is sent).
Does Packet Switching always win?

- “Free for all” model
  - Users get to transmit without making reservations
- Packets sent along the path go through switching points (routers)
  - Queues in routers could get long (long delay for users)
  - Routers might have to throw away packets when queues get too long (packet loss)
- Delay and loss are the two ways users pay for the cheaper service
Summary: Circuit versus Packet Switching

- **The fundamental question:** how is data transferred through net?
  - circuit switching: dedicated circuit per call: telephone net
  - packet-switching: data sent thru net in discrete “chunks”
Summary: Circuit Switching versus Packet Switching

- Phone networks allocate a fixed slice of their capacity to each call
  - The capacity is reserved for the duration of the call
  - Predictable quality (great for users)
  - Inefficient use of network capacity (oops, it costs more)
  - Technology called “circuit switching”

- Internet based on packet switching
  - No reservation of any resources in the network
  - “Pay as you go” model
  - Network capacity can be shared better (costs less for users)
  - Quality can be unpredictable
Protocol “Layers”

Networks are complex!

- many “pieces”:
  - hosts
  - routers
  - links of various media
  - applications
  - protocols
  - hardware, software

**Question:**
Is there any hope of organizing structure of network?

Or at least our discussion of networks?
### Organization of air travel

- **ticket (purchase)**
- **baggage (check)**
- **gates (load)**
- **runway takeoff**
- **airplane routing**

- **ticket (complain)**
- **baggage (claim)**
- **gates (unload)**
- **runway landing**
- **airplane routing**

- a series of steps
Layering of Airline Functionality

Layers: each layer implements a service
  – via its own internal-layer actions
  – relying on services provided by layer below
Why Layering?

Dealing with complex systems:

- explicit structure allows identification, relationship of complex system’s pieces
  - layered reference model for discussion
- modularization eases maintenance, updating of system
  - change of implementation of layer’s service transparent to rest of system
    - e.g., change in gate procedure doesn’t affect rest of system
- layering has its pros and cons
Internet protocol stack

- **application**: supporting network applications
  - FTP, SMTP, HTTP
- **transport**: process-process data transfer
  - TCP, UDP
- **network**: routing of datagrams from source to destination
  - IP, routing protocols
- **link**: data transfer between neighboring network elements
  - PPP, Ethernet
- **physical**: bits “on the wire”
ISO/OSI reference model

- Layering model developed by International Organization for Standardization (ISO)
  - Same folks who standardize hardware for doors and windows
- Called Open System Interconnect (OSI) model
- More comprehensive layering model than the Internet model
- Less interesting today because of the dominance of the Internet
ISO/OSI reference model

- **presentation**: allow applications to interpret meaning of data, e.g., encryption, compression, machine-specific conventions
- **session**: synchronization, checkpointing, recovery of data exchange
- Internet stack “missing” these layers!
  - these services, *if needed*, must be implemented in application
  - needed?
Packet Encapsulation

DATA FILE

Application Layer

TCP Layer

IP Layer

Link Layer

Physical Layer

TRANSMIT

MAC header  IP header  TCP header  DATA  crc
Encapsulation