CIS 551 / TCOM 401

Computer and Network Security

Spring 2006

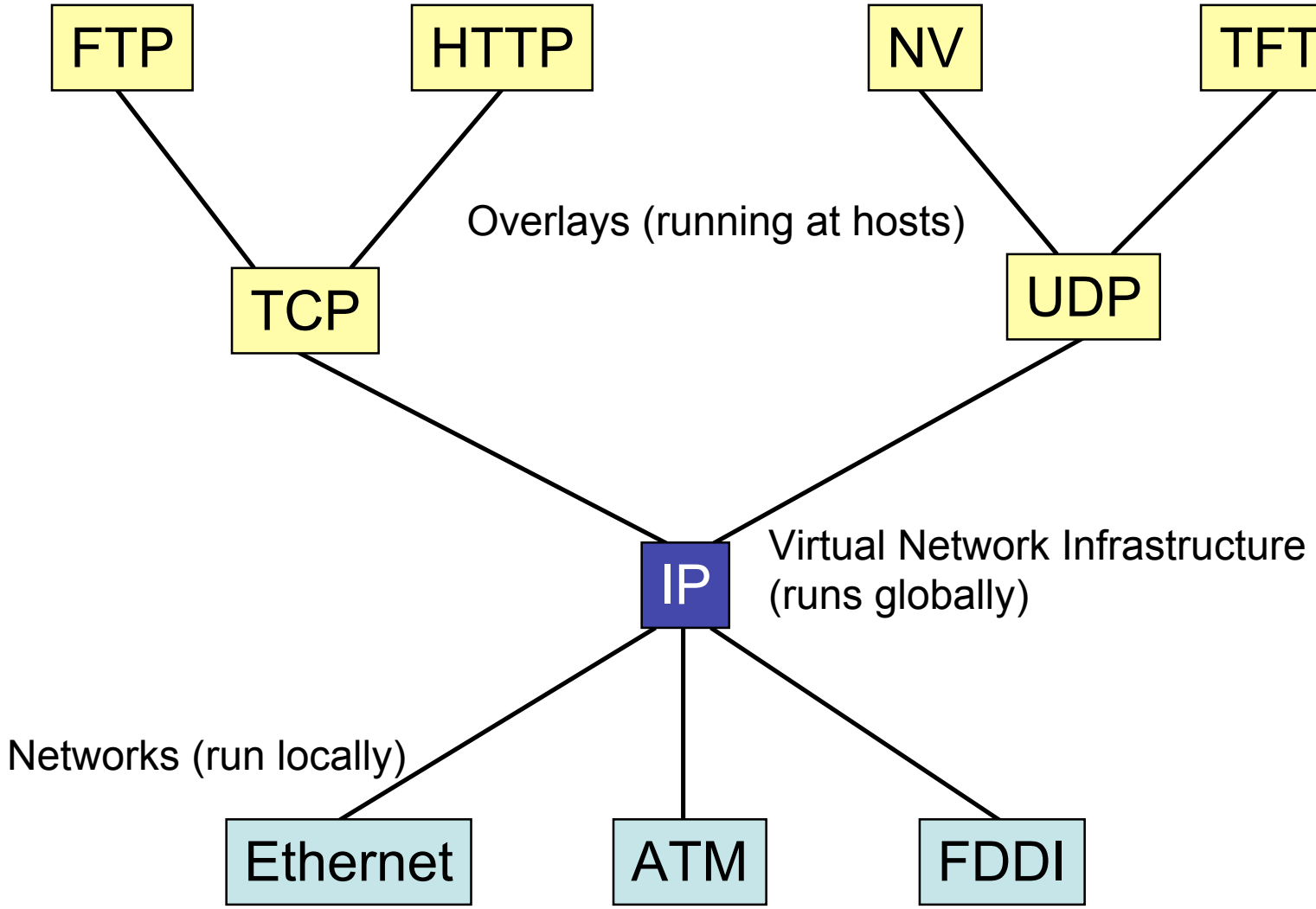
Lecture 17

Announcements

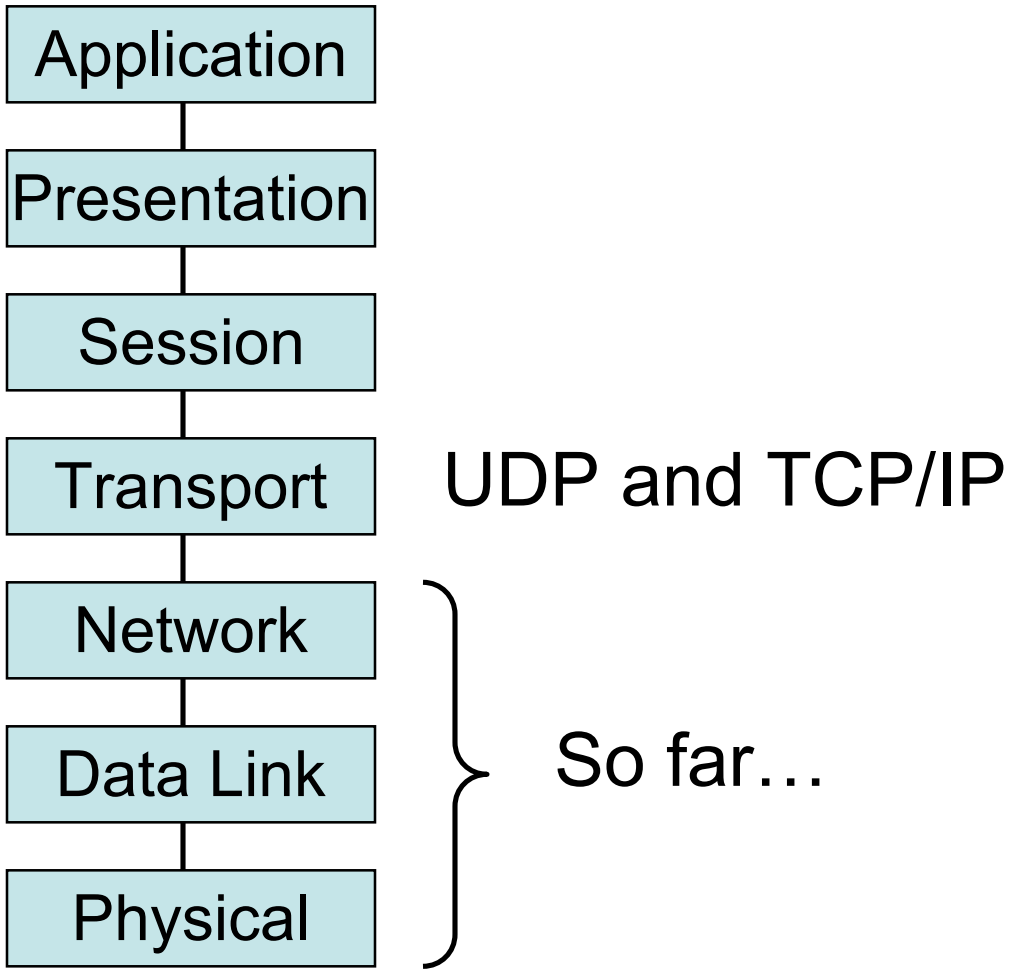
- Project 3 will be available on the web today.
  - Due Date: April 21st (Last day of classes)
  - Group project: you must work in groups of 2 or 3 people.
    - Mail groups to cis551staff@seas.upenn.edu
    - If you have trouble finding a group, post on the class news group

- Final Exam has been Scheduled:
  - Friday, May 5th
  - 9-11 a.m.
  - Moore 216

Internet Protocol Interoperability



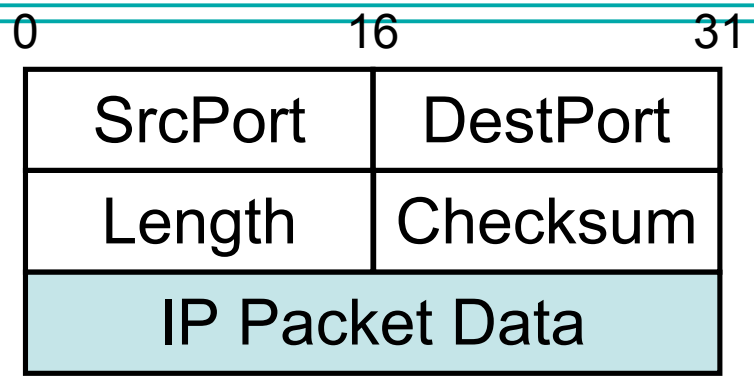
Protocol Stack Revisited



Application vs. Network

Application Needs	Network Char.
Reliable, Ordered, Single-Copy Message Delivery	Drops , Duplicates and Reorders Messages
Arbitrarily large message s	Finite message size
Flow Control by Receiver	Arbitrary Delay
Supports multiple applications per-host	…

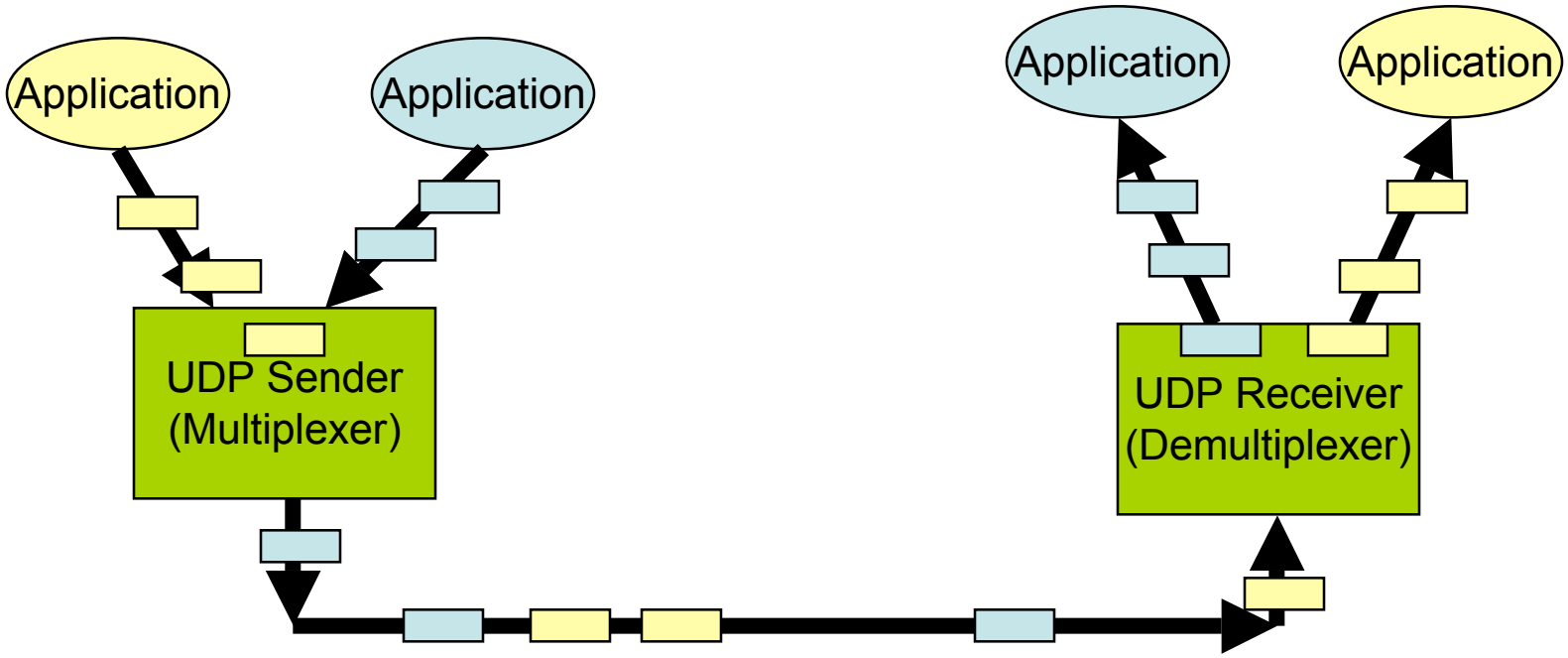
User Datagram Protocol (UDP)



- Simplest transport-layer protocol
- Just exposes IP packet functionality to application level
- *Ports* identify sending/receiving process
  - Demultiplexing information
  - (port, host) pair identifies a network process

UDP End-to-End Model

- Multiplexing/Demultiplexing with Port number



Using Ports

- Client contacts Server at a *well-known port*
  - SMPT: port 25
  - DNS: port 53
  - POP3: port 110
  - Unix talk : port 517
  - In unix, ports are listed in /etc/services
- Sometimes Client and Server agree on a different port for subsequent communication

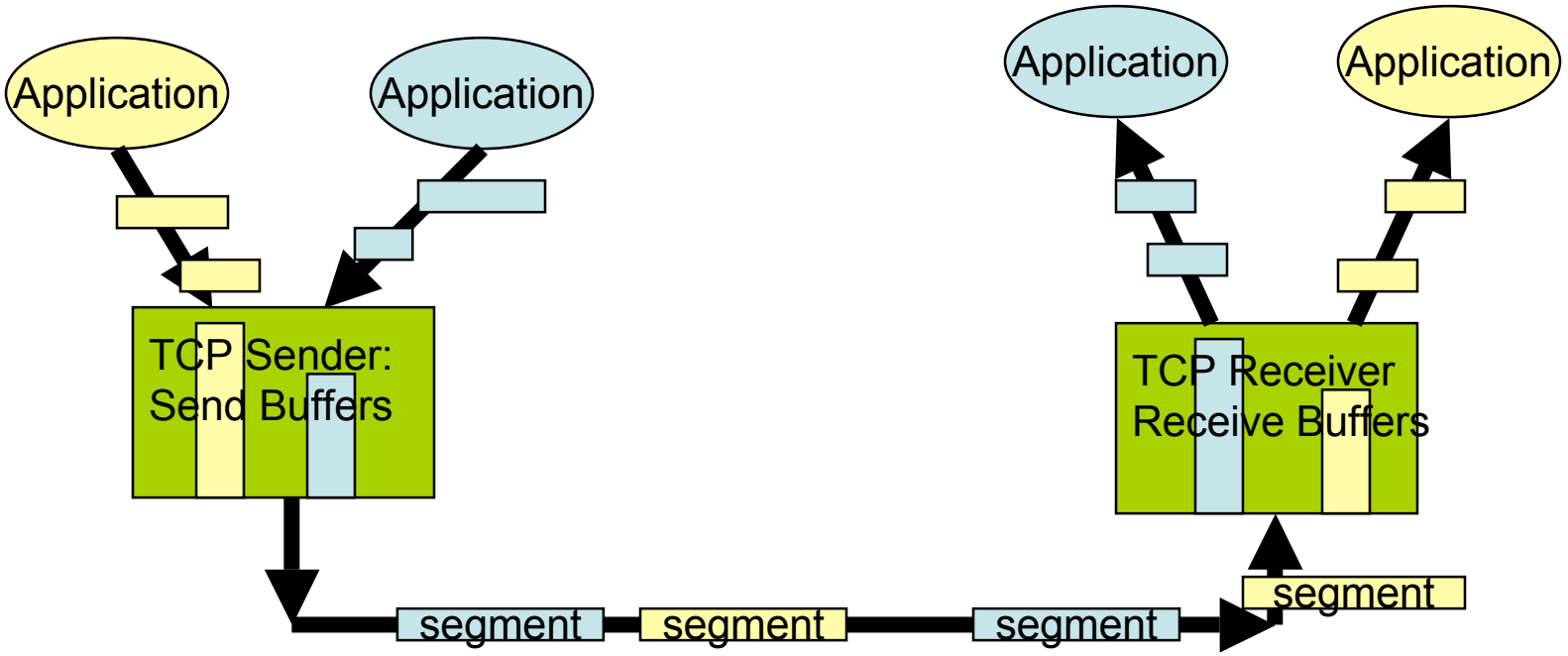
- Ports are an abstraction
  - Implemented differently on different OS's
  - Typically a message queue

Transmission Control Protocol (TCP)

- Most widely used protocol for reliable byte streams
  - Reliable, in-order delivery of a stream of bytes
  - Full duplex: pair of streams, one in each direction
  - Flow and congestion control mechanisms
  - Like UDP, supports ports
- Built on top of IP (hence TCP/IP)

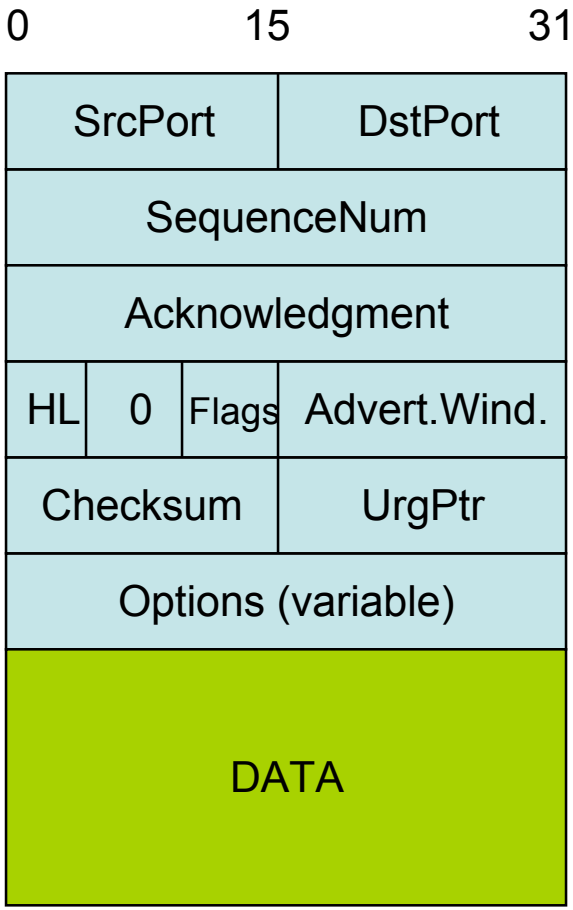
TCP End-to-End Model

- Buffering corrects errors but may introduce delays

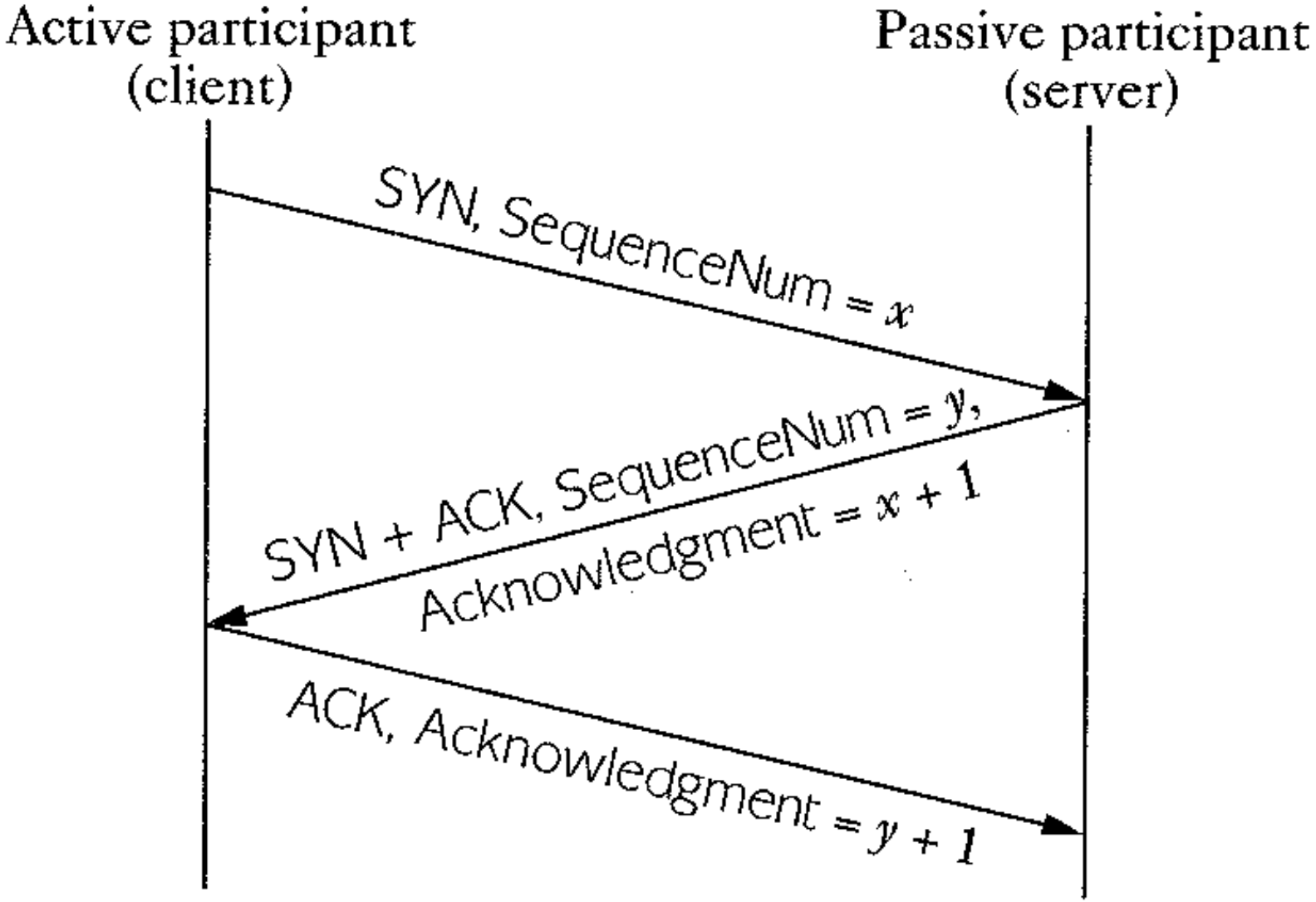


Packet Format

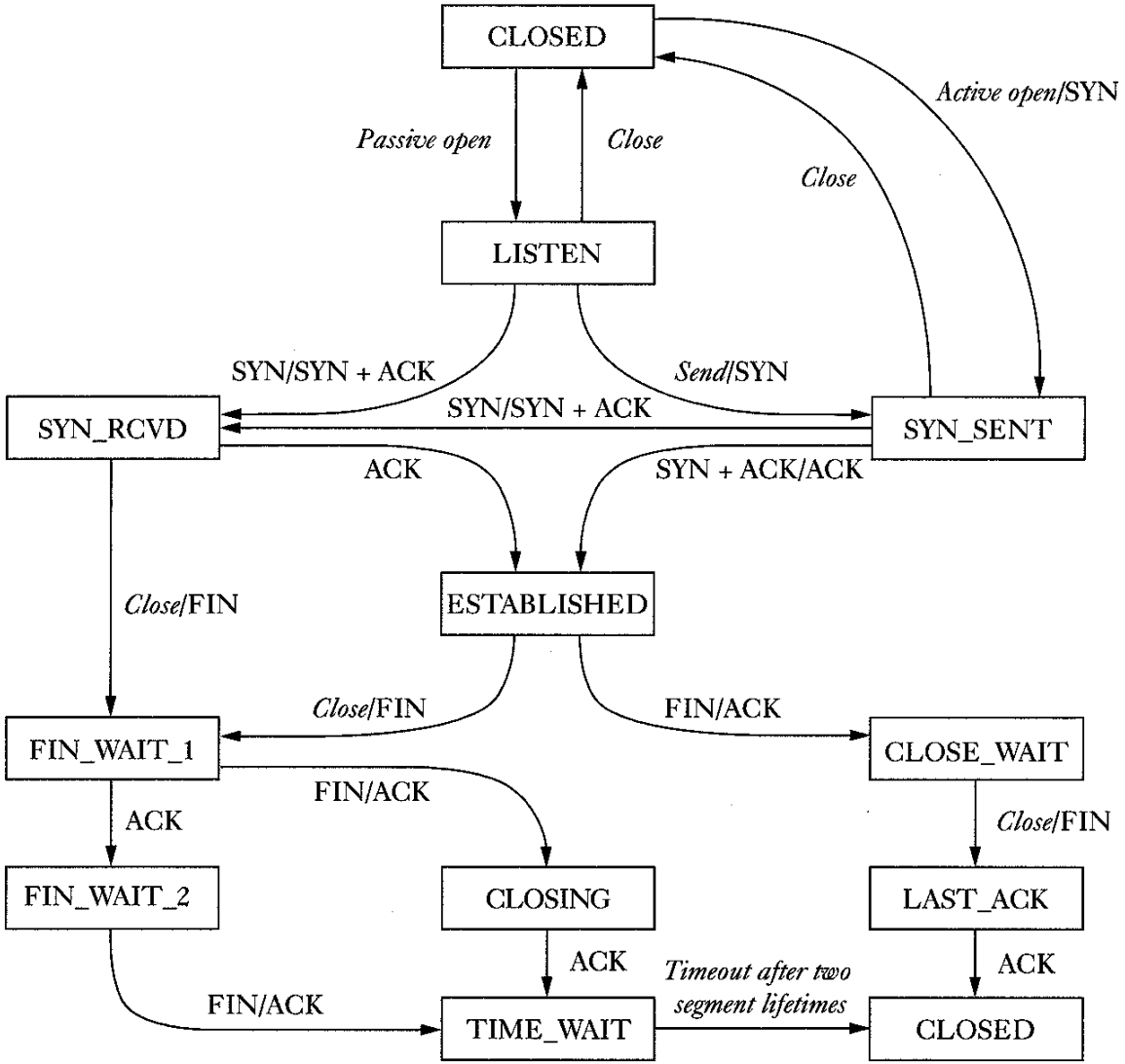
- Flags
  - SYN
  - FIN
  - RESET
  - PUSH
  - URG
  - ACK
- Fields



Three-Way Handshake



TCP State Transitions



TCP Receiver

- Maintains a buffer from which application reads
- Advertises < buffer size as the window for sliding window
- Responds with Acknowledge and AdvertisedWindow on each send; updates byte counts when data O.K.
- Application blocked until read() O.K.

TCP Sender

- Maintains a buffer; sending application is blocked until room in the buffer for its write
- Holds data until acknowledged by receiver *as successfully received*
- Implement window expansion and contraction; note difference between *flow* and *congestion* control

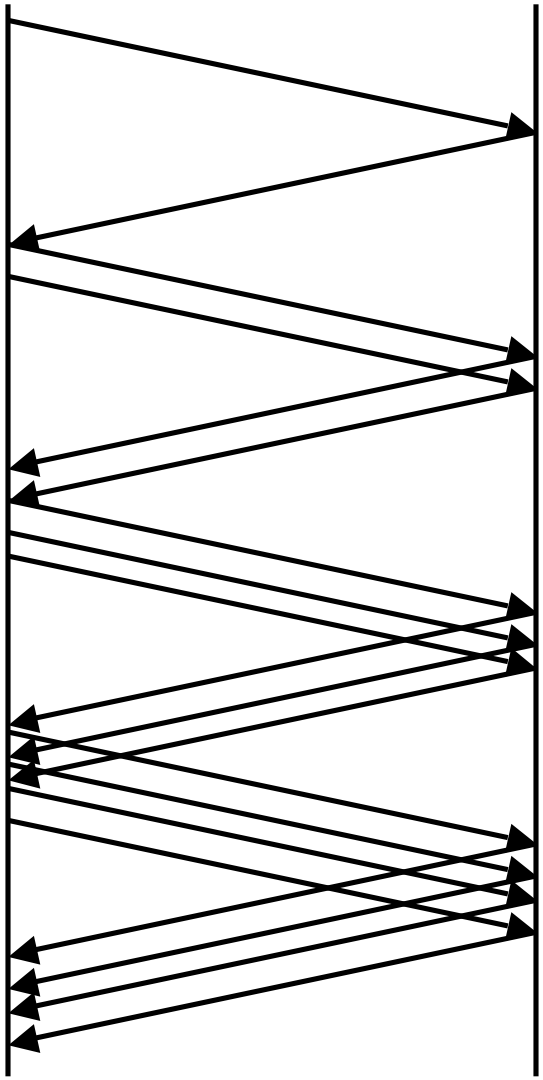
TCP Flow & Congestion Control

- Flow vs. Congestion Control
  - Flow control protects the recipient from being overwhelmed.
  - Congestion control protects the network from being overwhelmed.
- TCP Congestion Control
  - Additive Increase / Multiplicative Decrease
  - Slow Start
  - Fast Retransmit and Fast Recovery

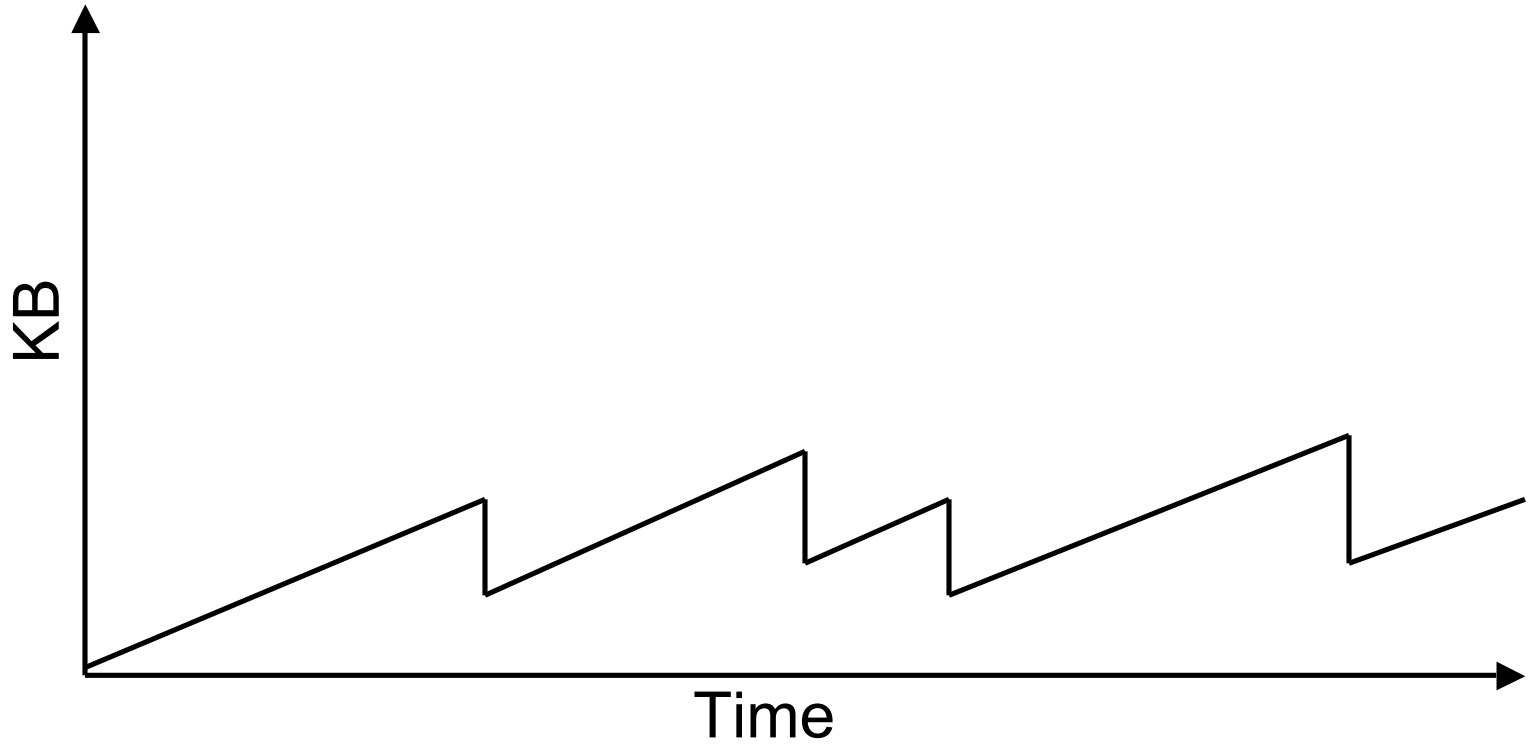
Increase and Decrease

- A value CongestionWindow is used to control the number of unacknowledged transmissions.
- This value is increased linearly until timeouts for ACKs are missed.
- When timeouts occur, CongestionWindow is decreased by half to reduce the pressure on the network quickly.
- The strategy is called “additive increase / multiplicative decrease”.

Additive Increase



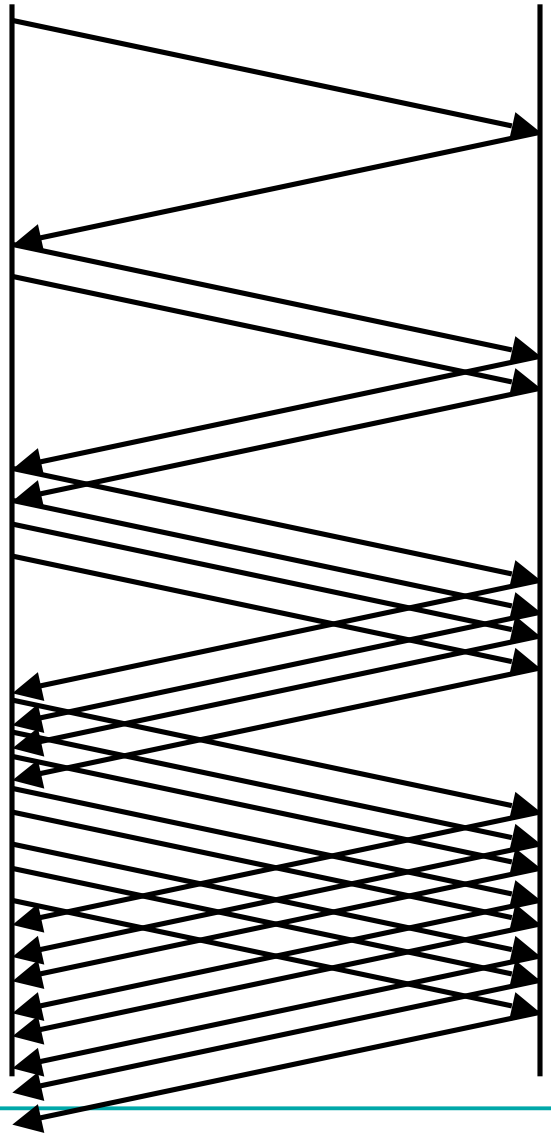
TCP Sawtooth Pattern



Slow Start

- Sending the entire window immediately could cause a traffic jam in the network.
- Begin “slowly” by setting the congestion window to one packet.
- When acknowledgements arrive, double the congestion window.
- Continue until ACKs do not arrive or flow control dominates.

Slow Start



Network Vulnerabilities

- Anonymity
  - Attacker is remote, origin can be disguised
  - Authentication
- Many points of attack
  - Attacker only needs to find weakest link
  - Attacker can mount attacks from many machines
- Sharing
  - Many, many users sharing resources
- Complexity
  - Distributed systems are large and heterogeneous
- Unknown perimeter
- Unknown attack paths

Syn Flood Attack

- Recall TCP's 3-way handshake:
  - SYN --- SYN+ACK --- ACK
- Receiver must maintain a queue of partially open TCP connections
  - Called SYN_RECV connections
  - Finite resource (often small: e.g. 20 entries)
  - Timeouts for queue entries are about 1 minute.

- Attacker
  - Floods a machine with SYN requests
  - Never ACKs them
  - Spoofs the sending address (Why? Two reasons!)

Reflected denial of service

- Broadcast a ping request
  - For sender's address put target's address
  - All hosts reply to ping, flooding the target with responses

- Hard to trace
- Hard to prevent
  - Turn off ping? (Makes legitimate use impossible)
  - Limit with network configuration by restricting scope of broadcast messages

(Distributed) Denial of Service

- Coordinate multiple subverted machines to attack
- Flood a server with bogus requests
  - TCP SYN packet flood
  - > 600,000 packets per second
- Detection & Assessment?
  - 12,800 attacks at 5000 hosts! (in 3 week period during 2001)
  - IP Spoofing (forged source IP address)
  - http://www.cs.ucsd.edu/users/savage/papers/UsenixSec01.pdf
- Prevention?
  - Filtering?
  - Decentralized file storage?

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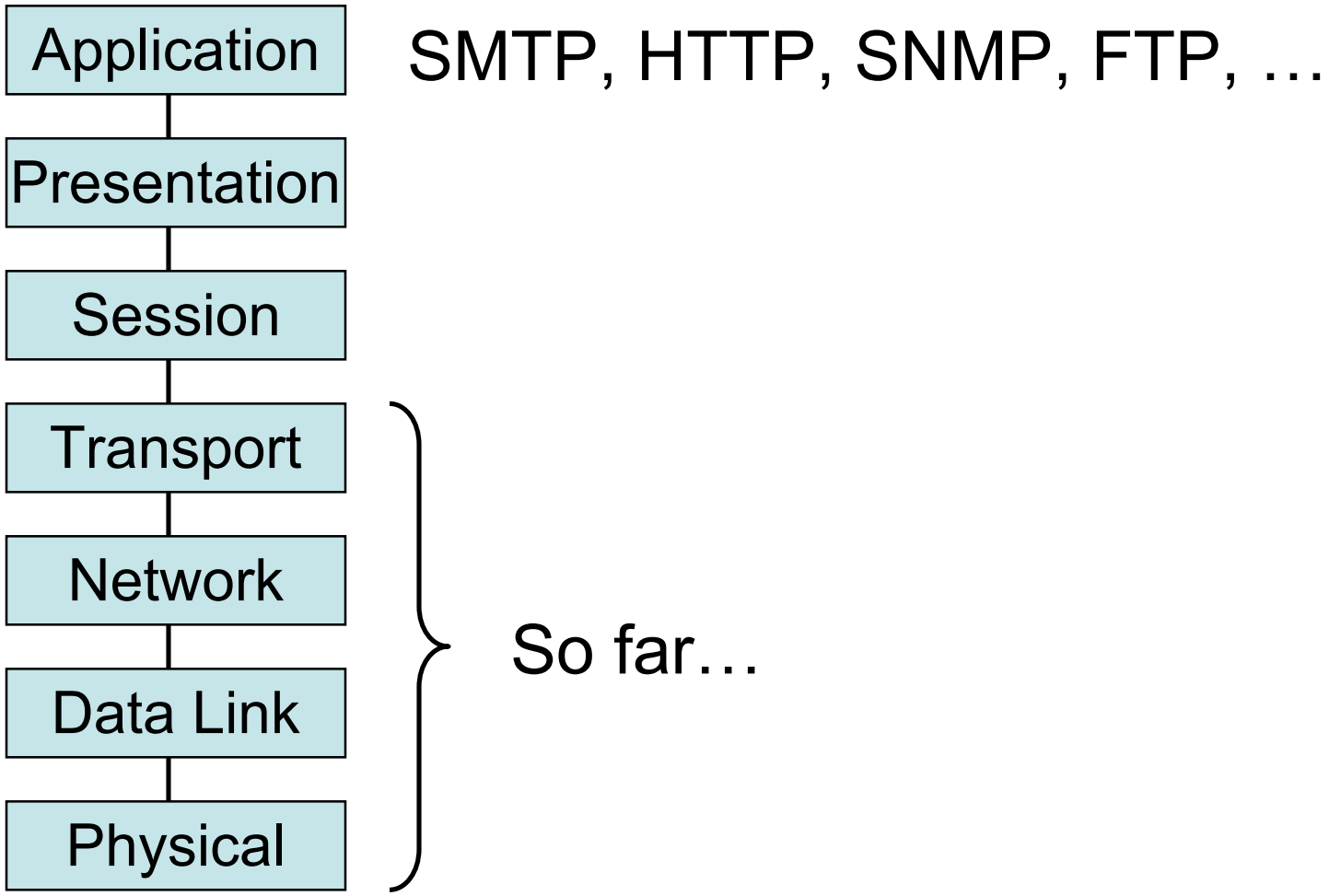

Common Features

- SMTP, HTTP, SNMP, FTP…
  - Request/Reply protocols built on TCP or UDP
  - Designed to handle a fixed set of messages
  - Companion *data format*
  - Many applications

Protocol	Data Format	Programs
SMTP	RFC 822 and MIME	Pine, NSMail, Eudora,Outlook,...
HTTP	HTML	Explorer, Netscape, Opera,…
SNMP	MIB	snmpget, snmpset,…

SMTP: Simple Mail Transfer Protocol

- Data format RFC822
  - Adopted around 1982, extended 1993, 1996
  - http://www.faqs.org/rfcs/rfc822.html
  - ASCII text
  - Header and Body

- MIME: Multipurpose Internet Mail Extensions
  - Mail systems assume ASCII
    - Only 64 valid characters A-Z, a-z, 0-9, +, /
  - Some datatypes include arbitrary binary data (e.g. JPEG)
  - Base64 encoding
    - 3 bytes of data map to 4 ASCII Characters
    - A=0,B=1,…

RFC822 Headers

- <CRLF>-terminated lines containing pairs of form **`type: value`**
- Many valid Header types
- Some headers filled out by client
  - **`To: stevez@cis.upenn.edu`**
  - **`Subject: CSE331`**
- Others filled out by mail delivery system
  - **`Date:`**
  - **`Received:`**
  - **`From:`**

From: Steve Zdancewic <stevez@cis.upenn.edu>
MIME-Version: 1.0
To: stevez@cis.upenn.edu
Subject: Example Mail
Content-Type: multipart/mixed; boundary="------------020307000708030506070607"

This is a multi-part message in MIME format.
--------------020307000708030506070607
Content-Type: text/plain; charset=us-ascii; format=flowed
Content-Transfer-Encoding: 7bit

This is the body.

--------------020307000708030506070607
Content-Type: text/plain; name="example.txt"
Content-Transfer-Encoding: 7bit
Content-Disposition: inline; filename="example.txt"

Hello

--------------020307000708030506070607
Content-Type: image/jpeg; name="doc.jpg"
Content-Transfer-Encoding: base64
Content-Disposition: inline; filename="doc.jpg"

/9j/4AAQSkZJRgABAQEASABIAAD//gAXQ3JlYXRlZCB3aXRoIFRoZSBHSU1Q/9sAQwAIBgYH
BgUIBwcHCQkICgwUDQwLCwwZEhMPFB0aHx4dGhwcICQuJyAiLCMcHCg3KSwwMTQ0NB8n
OT04...

SMTP

- Mail Reader
  - User edits/reads/search e-mail
- Mail Daemon
  - Process running on each host (port 27)
  - Uses SMTP/TCP to transmit mail to daemons on other machines
  - Most daemons based on Berkley's **sendmail**
- Mail Gateways
  - Store and forward e-mail (much like IP router)
  - Buffers on disk
  - Attempts to resend