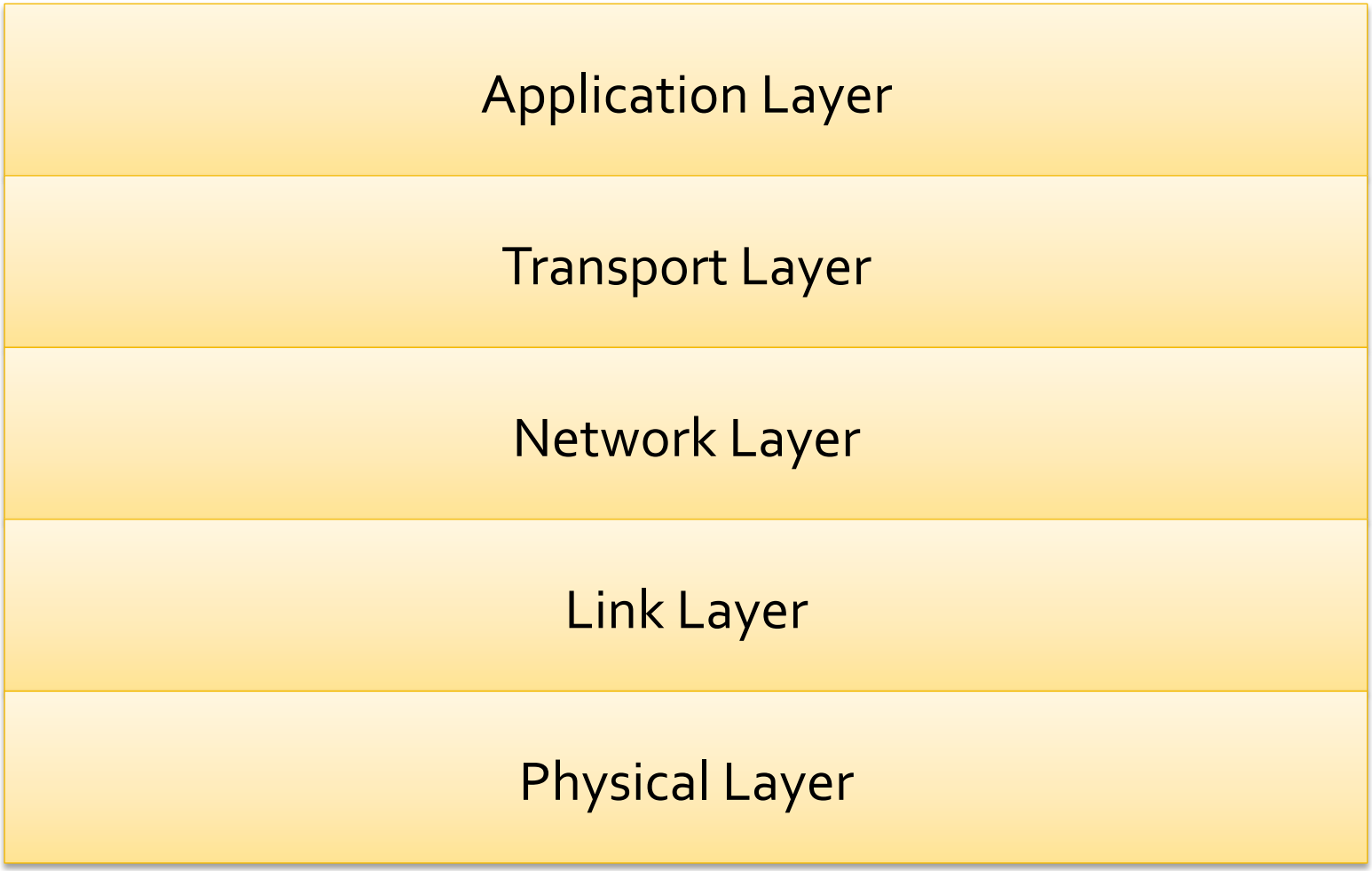
ELEC / COMP 177 – Fall 2012

Computer Networking → Sockets

Some slides from Kurose and Ross, *Computer Networking*, 5th Edition

Recap – Network Model



Recap – Physical Layer

Application Layer

Transport Layer

Network Layer

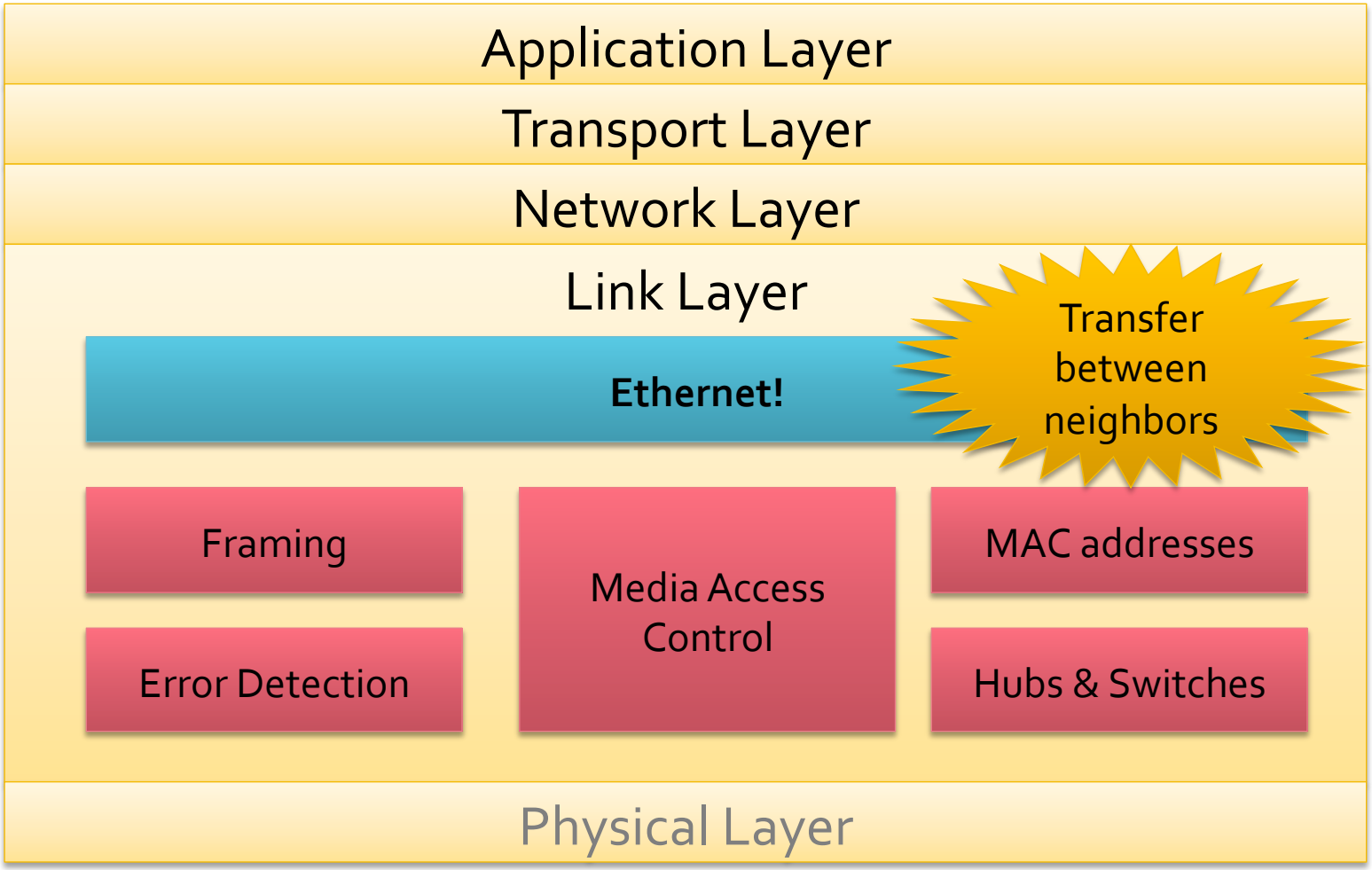
Link Layer

Physical Layer

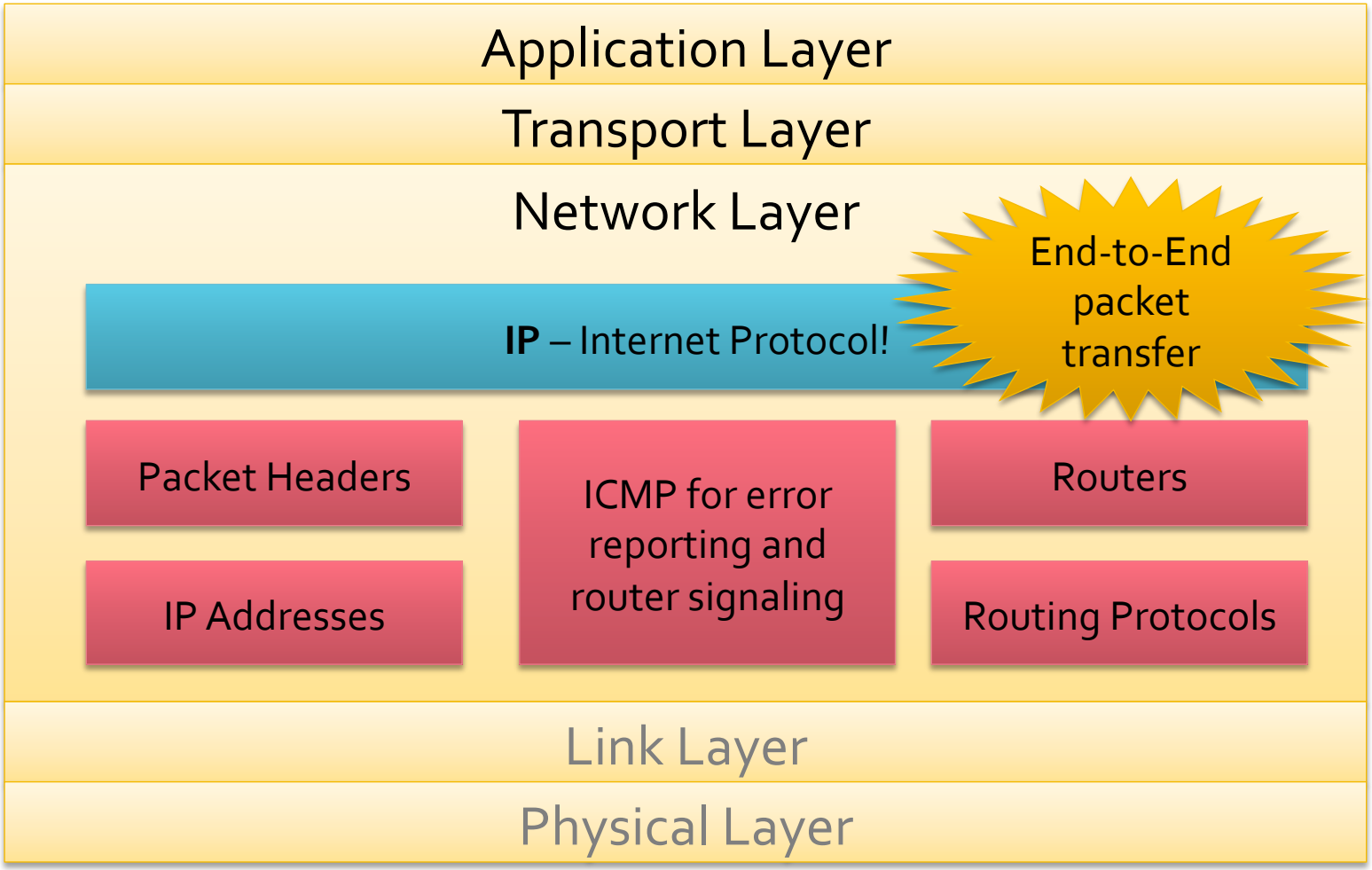
"Bits on a wire"

Encoding schemes fight:
attenuation
distortion
clock skew

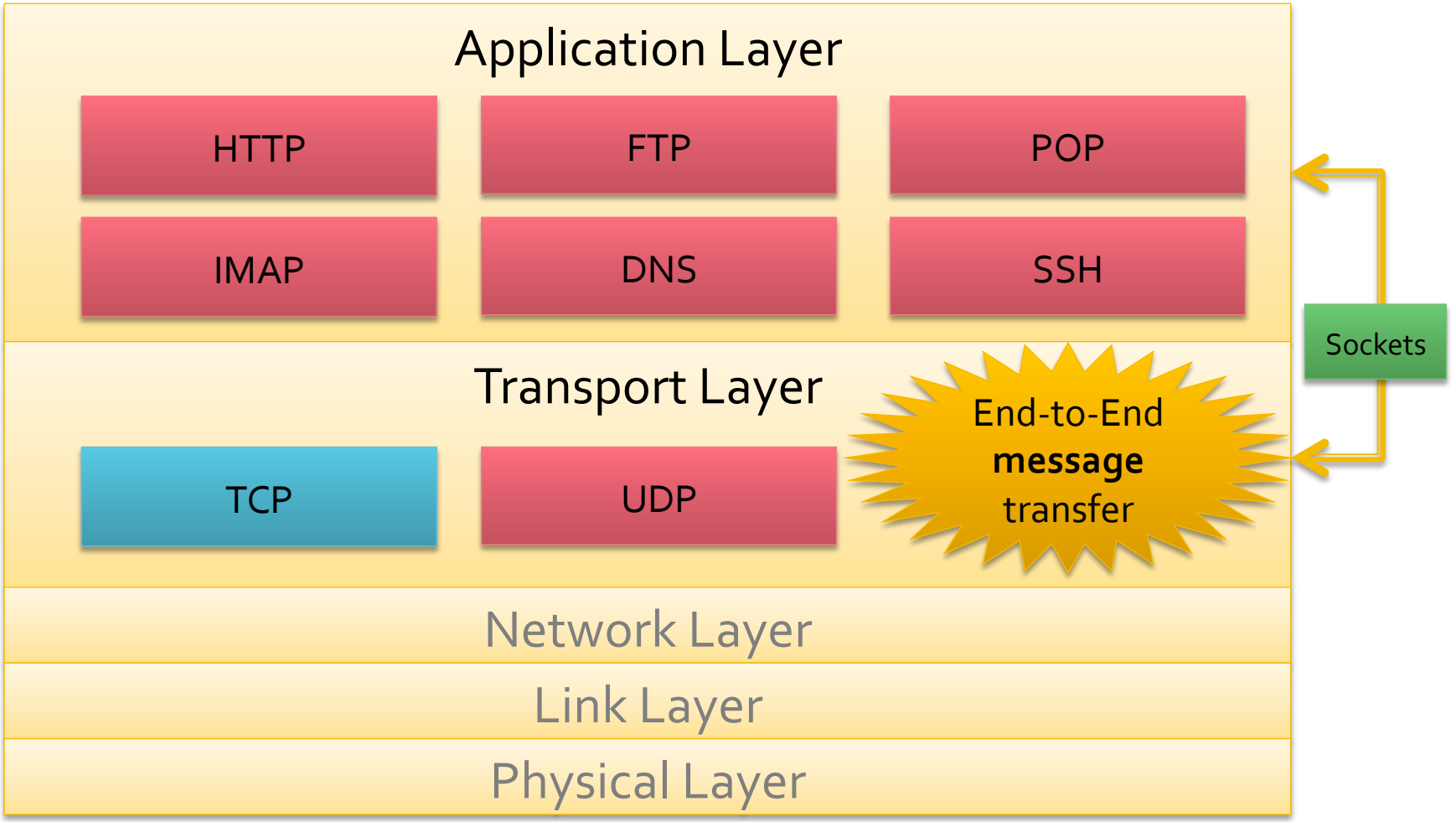
Recap – Link Layer



Recap – Network Layer



Recap – Application and Transport Layers



Sockets

Why Do We Have Sockets?

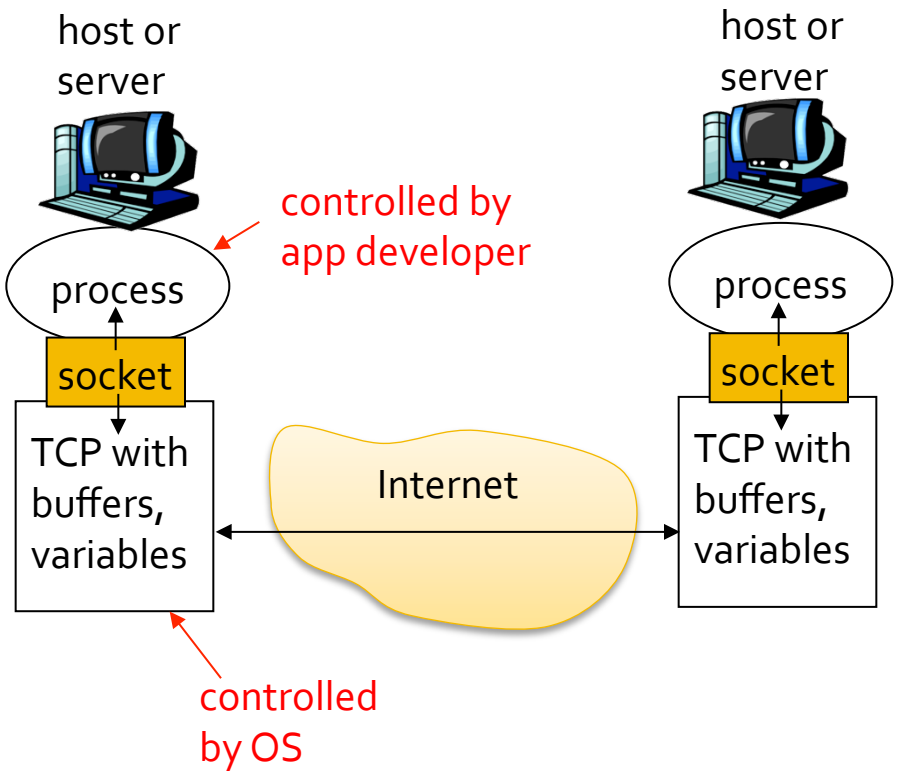
- Challenge – **Inter-process communication**
- A **process** is an independent program running on a host
  - Separate memory space
- How do processes communicate with other processes
  - On the same host?
  - On different hosts?
- Send **messages** between each other

What is a Socket?

- An interface between process (application) and network
  - The application creates a socket
  - The socket *type* dictates the style of communication
    - Reliable vs. best effort
    - Connection-oriented vs. connectionless
- Once configured the application can
  - Pass data to the socket for network transmission
  - Receive data from the socket (transmitted through the network by some other host)

What is a Socket?

- Process sends/receives messages to/from its socket
- Socket analogous to door
  - sending process shoves message out door
  - sending process relies on transport infrastructure on other side of door which brings message to socket at receiving process
- API allow customization of socket
  - Choose transport protocol
  - Choose parameters of protocol

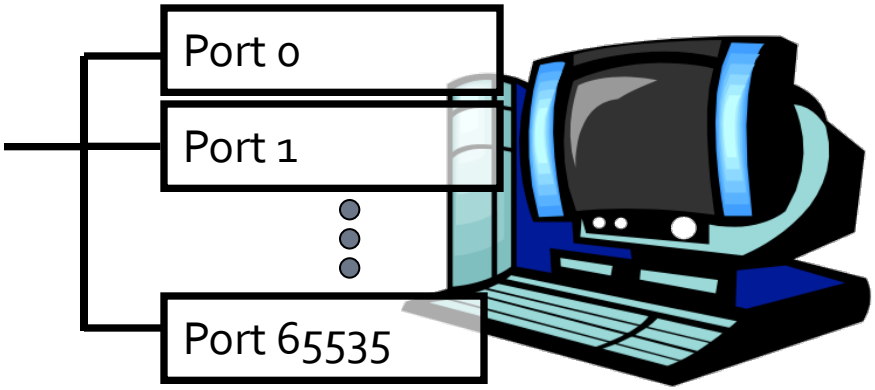


Addressing Processes

- To receive messages, each process on a host must have an **identifier**
  - IP addresses are unique
  - **Is this sufficient?**
- No, there can thousands of processes running on a single machine (with 1 IP address)
- Identifier must include
  - IP address
  - **and** port number (example: 80 for web)

Ports

- Each host has 65,536 ports
- Some ports are *reserved for specific apps*
  - FTP (20, 21), Telnet (23), HTTP (80), etc…
- Outgoing ports (on clients) can be dynamically assigned by OS in upper region (above 49,152) – called **ephemeral ports**
- See http://en.wikipedia.org/wiki/List_of_TCP_and_UDP_port_numbers



Client versus Server Processes

- **Client** process
  - Process that initiates communication
- **Server** process
  - Process that waits to be contacted
- How does this change in P2P (peer-to-peer) applications?
  - Those applications contain both client and server processes

Application-Layer Protocol

- Sockets just allow us to send raw messages between processes on different hosts
  - Transport service takes care of moving the data
- **What** exactly is sent is up to the application
  - An application-layer protocol
  - HTTP, IMAP, Skype, etc…

Application-Layer Protocol

- Both the client and server speaking the protocol must agree on
  - Types of messages exchanged
    - e.g., request, response
  - Message syntax
    - What fields are in messages
    - How fields are delineated
  - Message semantics
    - Meaning of information in fields
  - Rules for when and how processes send and respond to messages

Transport Service

- What kind of transport service do applications need?
- **Data loss – OK or forbidden?**
  - Some apps can tolerate some loss
  - Other apps requires 100% reliable data transfer
- **Latency – OK, or bad?**
  - Some apps require low delay to be effective
- **Throughput**
  - Some apps require minimum amount of throughput to be effective
  - Other apps ("elastic apps") utilize whatever throughout is available
- **Security?**
  - Some apps require encyption

Internet Transport Protocols

TCP SERVICE

- Connection-oriented
  - Setup required between client and server processes
- Reliable transport between sending and receiving process
- Flow control
  - Sender won't overwhelm receiver
- Congestion control
  - Throttle sender when network overloaded
- Does not provide
  - Timing, minimum throughput guarantees, security

UDP SERVICE

- Unreliable data transfer between sending and receiving process
- Does not provide
  - Connection setup
  - Reliability
  - Flow control
  - Congestion control
  - Timing
  - Throughput guarantee
  - Security

Why bother with UDP then?

Socket Programming

- Goal: learn how to build client/server application that communicate using sockets
- Socket API
  - Introduced in BSD4.1 UNIX, 1981
  - Client/server paradigm
  - Two types of transport services via socket API:
    - UDP
    - TCP

socket

A *application-created*, *OS-controlled* interface (a "door") into which application process can both send and receive messages to/from another application process

Socket Programming Basics

- Server must be running before client can send anything to it
- Server must have a socket (door) through which it receives and sends messages
- Similarly client needs a socket
- Socket is locally identified with a port number
  - *Analogous to the apt # in a building*
- Client needs to know server IP address and socket port number
  - **How do we find this?**

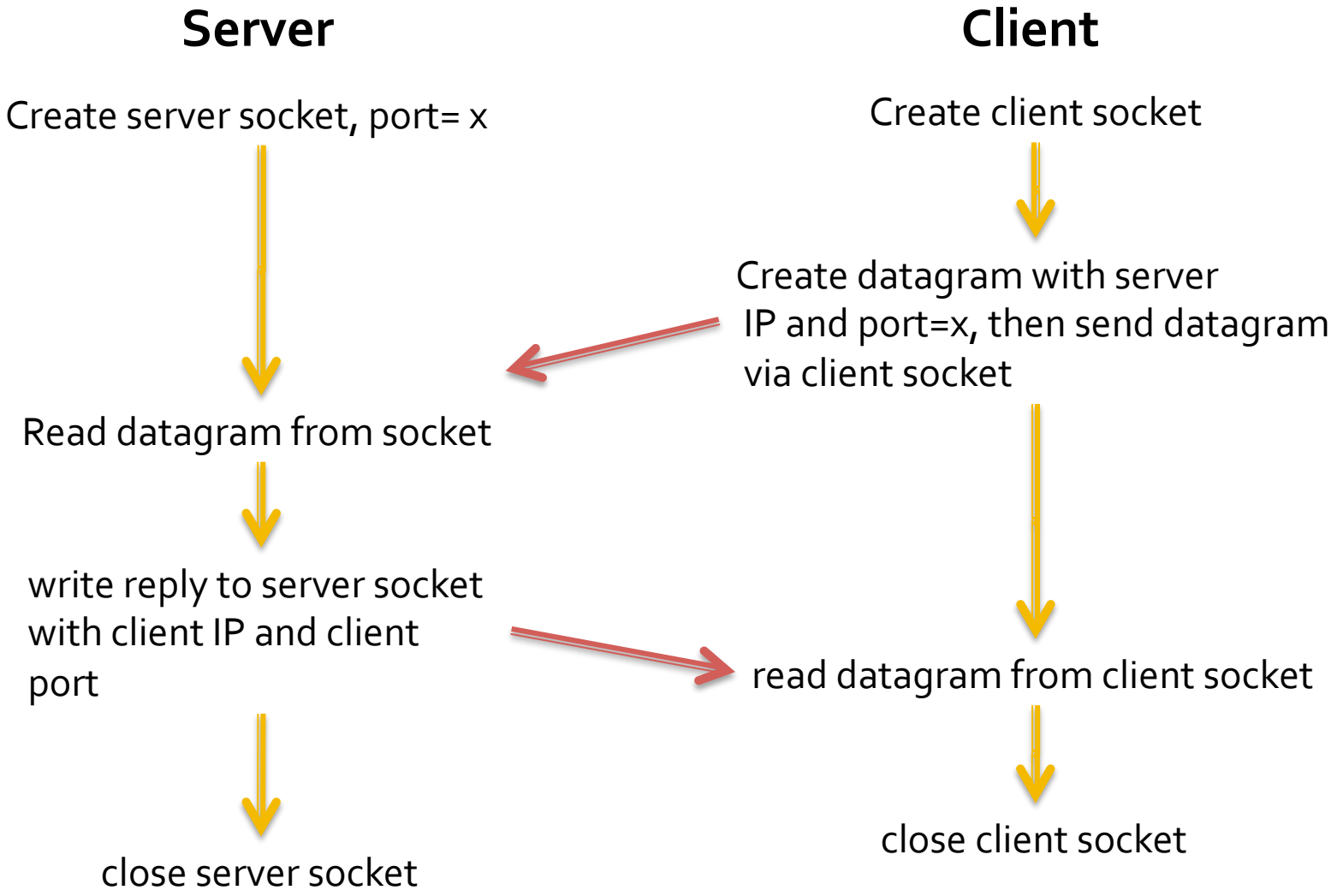
Socket Programming with UDP

- UDP: no "connection" between client and server
  - No handshaking
  - Sender explicitly attaches IP address and port of destination to each message
  - OS attaches IP address and port of sending socket to each segment
  - Server can extract IP address, port of sender from received segment

application viewpoint

UDP provides unreliable transfer of groups of bytes ("datagrams") between client and server

Client/Server Socket Interaction with UDP



UDP Question

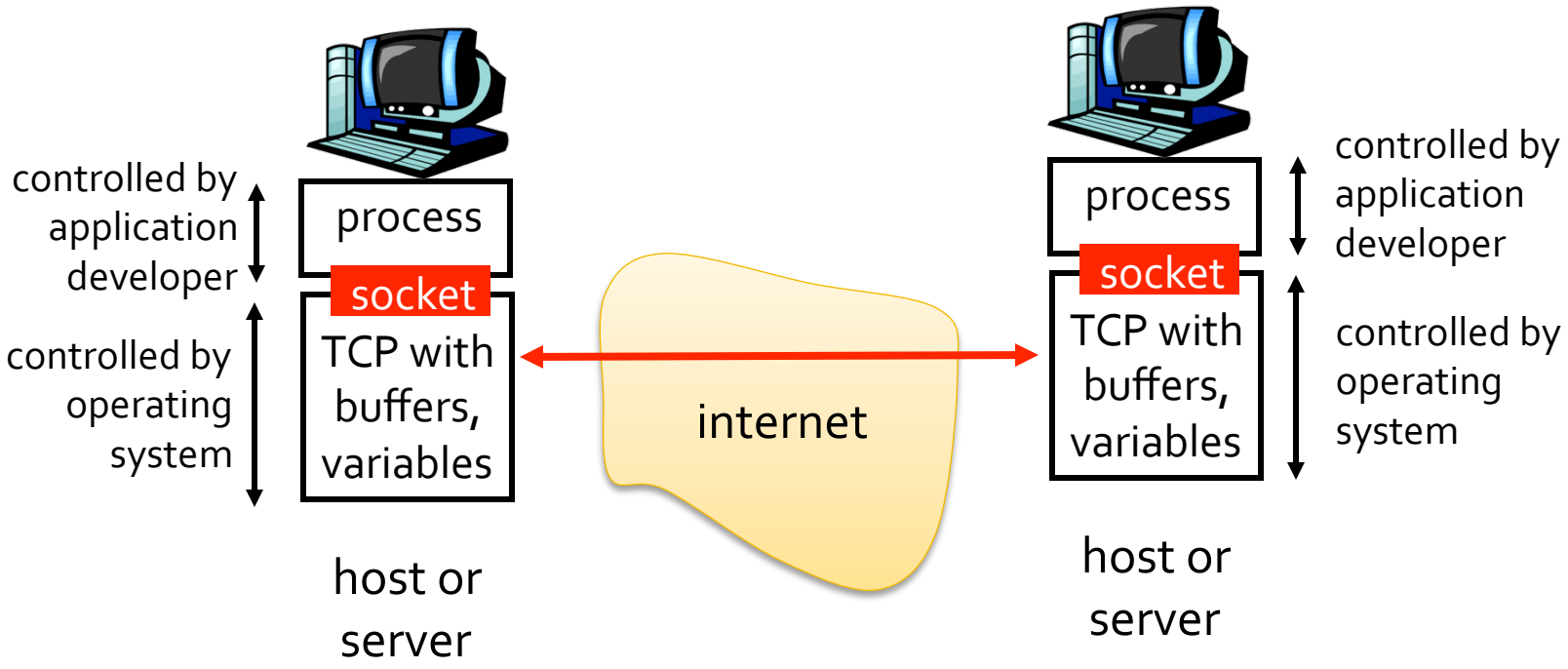
- **Can the client send a segment to server without knowing the server's IP address and port number?**
- Could use **broadcast IP address** of the subnet to get around lack of IP address knowledge…
- No way to avoid knowing port number…

UDP Observation

- Each UDP message is self-contained and complete
- Each time you read from a UDP socket, you get a complete message as sent by the sender
  - *That is, assuming it wasn't lost in transit!*
- Think of UDP sockets as putting a stamp on a letter and sticking it in the mail

Socket Programming using TCP

TCP service: reliable transfer of bytes from one process to another



Socket Programming *with TCP*

Client must contact server

- Server process must first be running
- Server must have created socket (door) that welcomes client's contact

Client contacts server by:

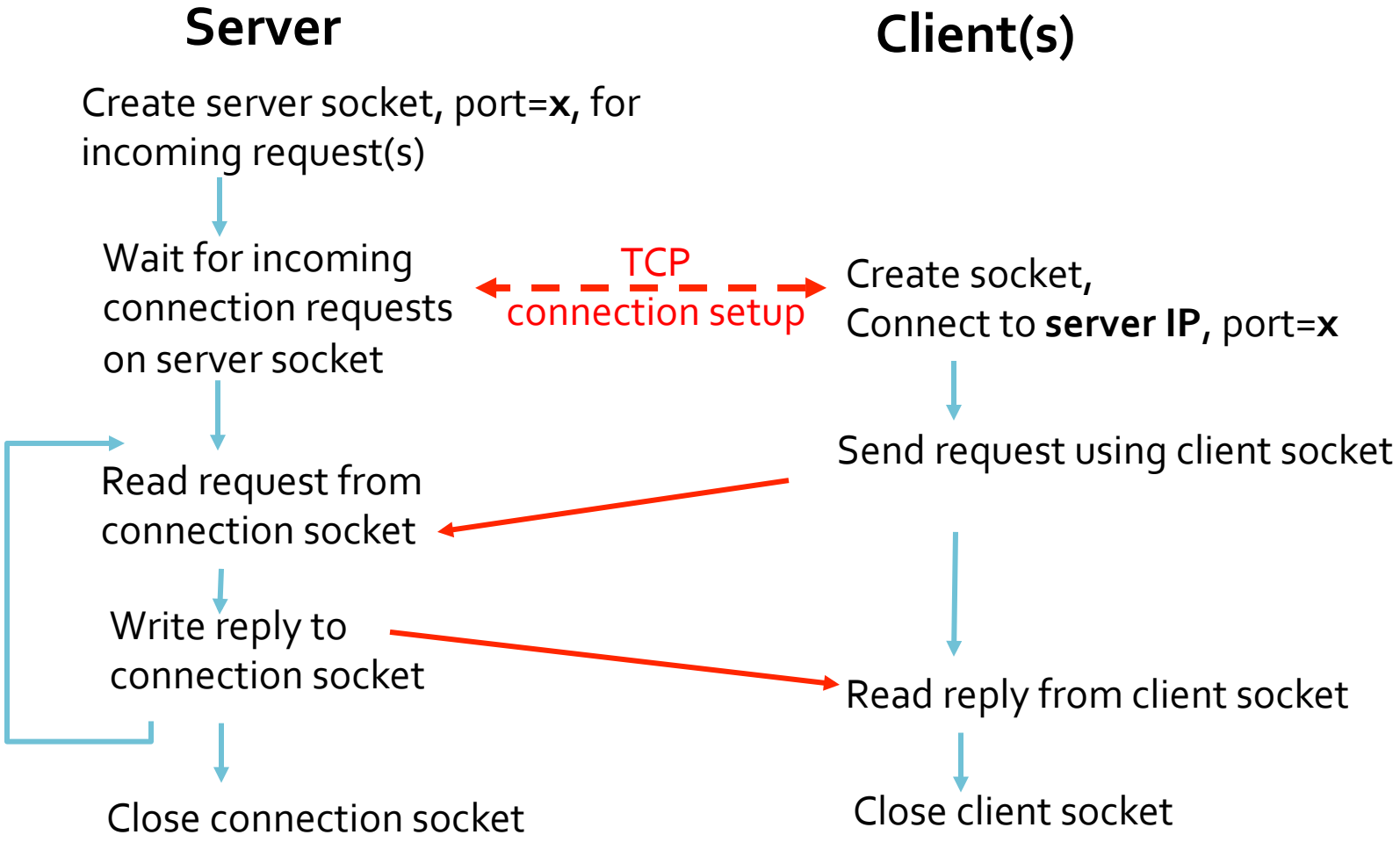
- Creating client-local TCP socket
- Specifying IP address, port number of server process
- When client creates socket: client TCP establishes connection to server TCP

- When contacted by client, server TCP creates new socket for server process to communicate with client
  - allows server to talk with multiple clients
  - source port numbers used to distinguish clients

application viewpoint

TCP provides reliable, in-order transfer of bytes ("pipe") between client and server

Client/Server Socket Interaction with TCP



What is a Stream?

- A **stream** is a sequence of characters that flow into or out of a process.
- An **input stream** is attached to some input source for the process, e.g., keyboard or socket.
- An **output stream** is attached to an output source, e.g., monitor or socket.

TCP Observations

- TCP sockets are **stream** based
  - At the receiver, each read on a UDP socket is **not** guaranteed to produce the same number of bytes as were sent by the transmitter
  - All you know is that you'll get the **next** set of bytes
    - Keep reading, and eventually you'll get them all
  - Your **application** has to have some way to separate a stream of bytes into discrete messages
- Server has two types of sockets
  - One that listens for incoming connections
  - One on a per-client basis after a connection is opened

Upcoming Events

- **Class**
  - Topics for next week: Transport Layer operation (TCP and UDP in detail)
- **Homework 2**
  - Assigned **next Tuesday**
  - Due in one week