CS354: Machine Organization and Programming

Lecture 40
Monday the December 7th 2015

Section 2
Instructor: Leo Arulraj

Section 2 Class Announcements

Practice Final Exam has been posted.
Good luck with the finals.

Wednesday's (12/09) lecture by Adalbert (Instructor for next semester).

Friday's (12/11) and Monday's (12/14) lectures by Jason (Instructor for Section 1).

Course evaluation: Login to https://aefis.wisc.edu using Net ID and password between Dec 8th through Dec 16th to give course feedback.

Section 2 Lecture Overview

1. Internet Domain Names
2. OSI Model
3. Internet connection
4. Web Basics
5. HTTP Transactions

The following will be handled by Adalbert on Wednesday's lecture.

1. Sockets Interface
2. Echo Client, Server
3. Overview of Tiny Web Server

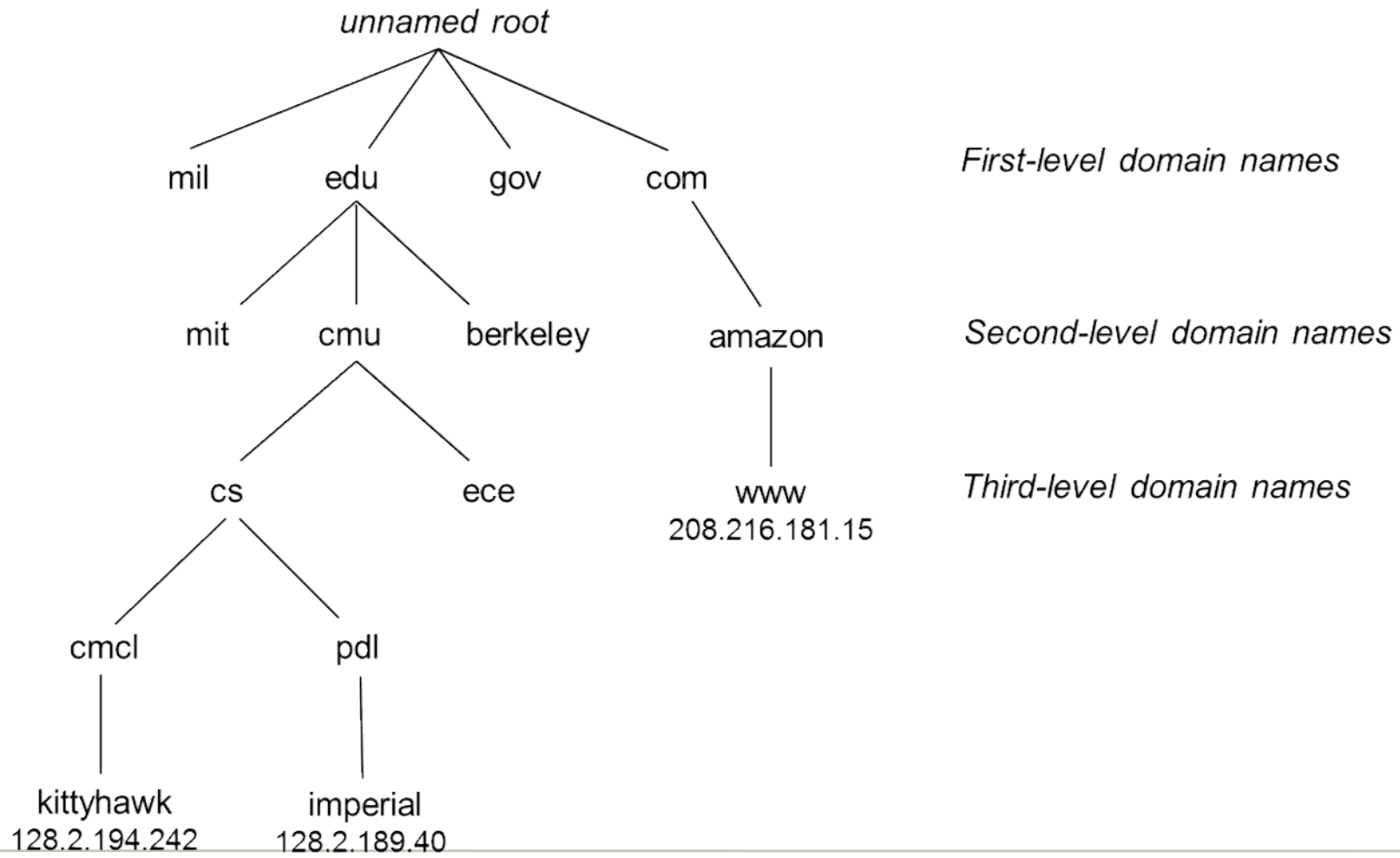
Internet Domain Names

Since large integers are difficult to remember, a human friendly *domain name* is used along with a mechanism that maps domain names to IP addresses.

A domain name is a sequence of words separated by periods. E.g. cs.wisc.edu

The set of domain names form a hierarchy and each domain name encodes its position in the hierarchy.

Subset of the Internet Domain Name Hierarchy



Internet Domain Names

First level domain names defined by a nonprofit organization called ICANN (Internet Corporation for Assigned Names and Numbers).

Second level domain names are assigned on a first come first server basis by authorized agents of ICANN.

The mapping between domain names and the set of IP addresses is maintained in a distributed world-wide database know as DNS (Domain Name System).

Internet Domain Names

- The Internet maintains a mapping between IP addresses and domain names in a huge worldwide distributed database called *DNS*

- Conceptually, programmers can view the DNS database as a collection of millions of *host entries.*
  - Each host entry defines the mapping between a set of domain names and IP addresses.
  - In a mathematical sense, a host entry is an equivalence class of domain names and IP addresses.

Internet Domain Names

Each Internet host has the locally defined domain name *localhost* which always maps to the loopback address *127.0.0.1*

Example program that displays the host entry for a input hostname or dotted decimal address.

linux> ./hostinfo cs.wisc.edu

Internet Connections

Internet clients and servers communicate by sending and receiving streams of bytes over connections.

A connections is:

- point-to-point: connects pair of processes
- full-duplex: data can flow in both directions
- reliable: except for some catastrophic failures, the stream of bytes sent by the source is eventually received by the destination in the same order that it was sent.

Internet Connections

A socket is an endpoint of a connection and has a socket address that is denoted by "address:port" consisting of:

1. An Internet address
2. 16 bit integer port

The port in the server's socket is typically a *well-known port* that is associated with the service.

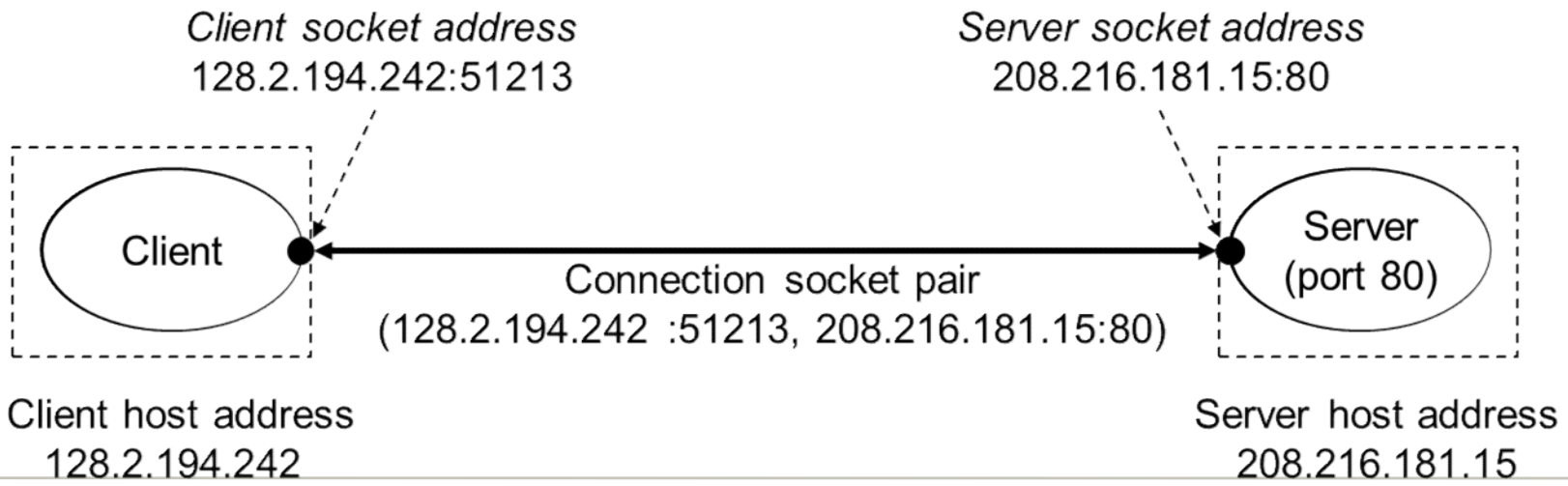
The port in the client's socket is *ephemeral port* and is assigned automatically by the kernel when the client makes a connection request.

Internet Connections

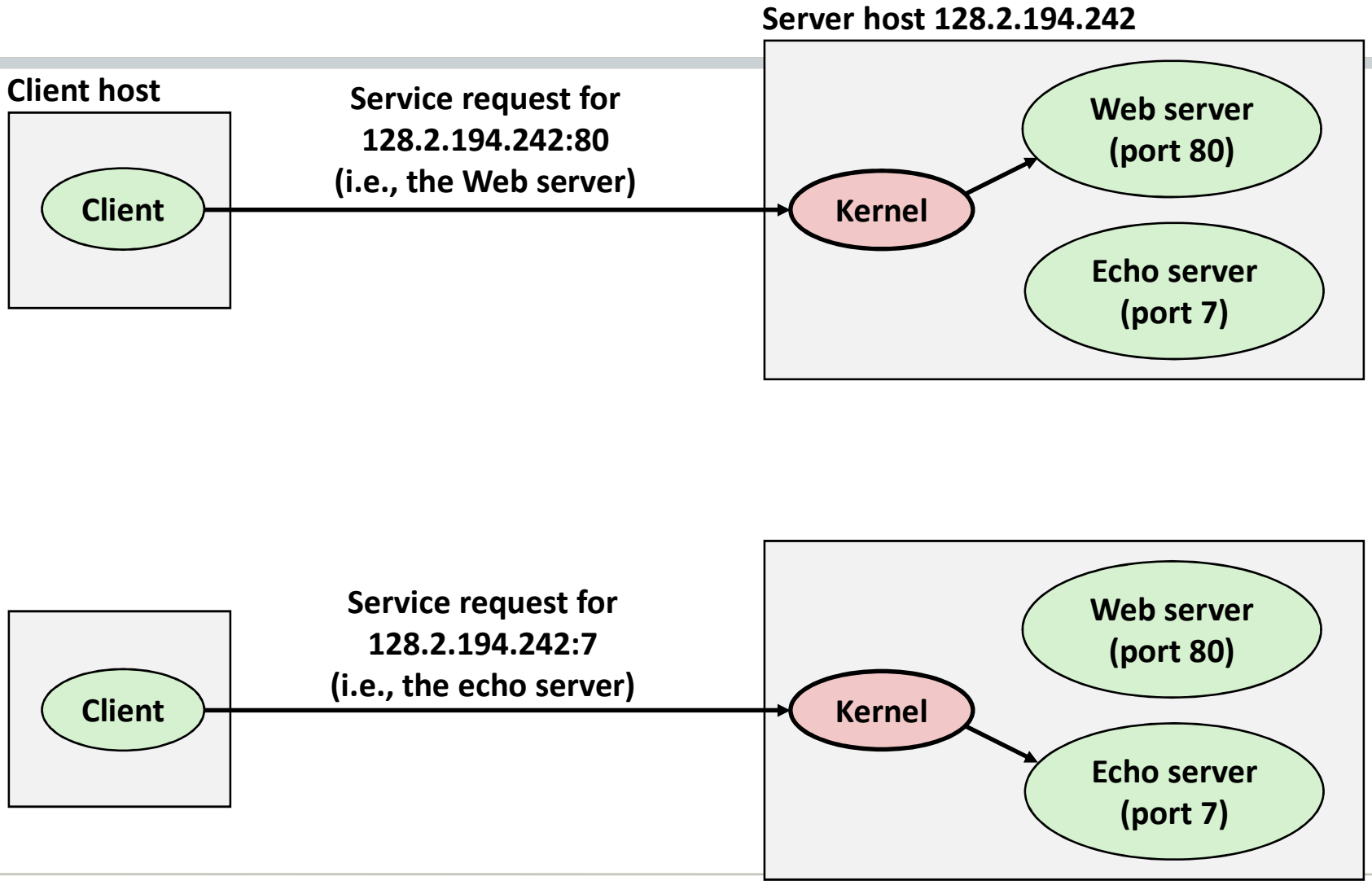
- Popular services have permanently assigned *well-known ports and* corresponding *well-known service names*:
  - echo server: 7/echo
  - ssh servers: 22/ssh
  - email server: 25/smtp
  - Web servers: 80/http
- Mappings between well-known ports and service names is contained in the file `/etc/services` on each Linux machine.

Internet Connection

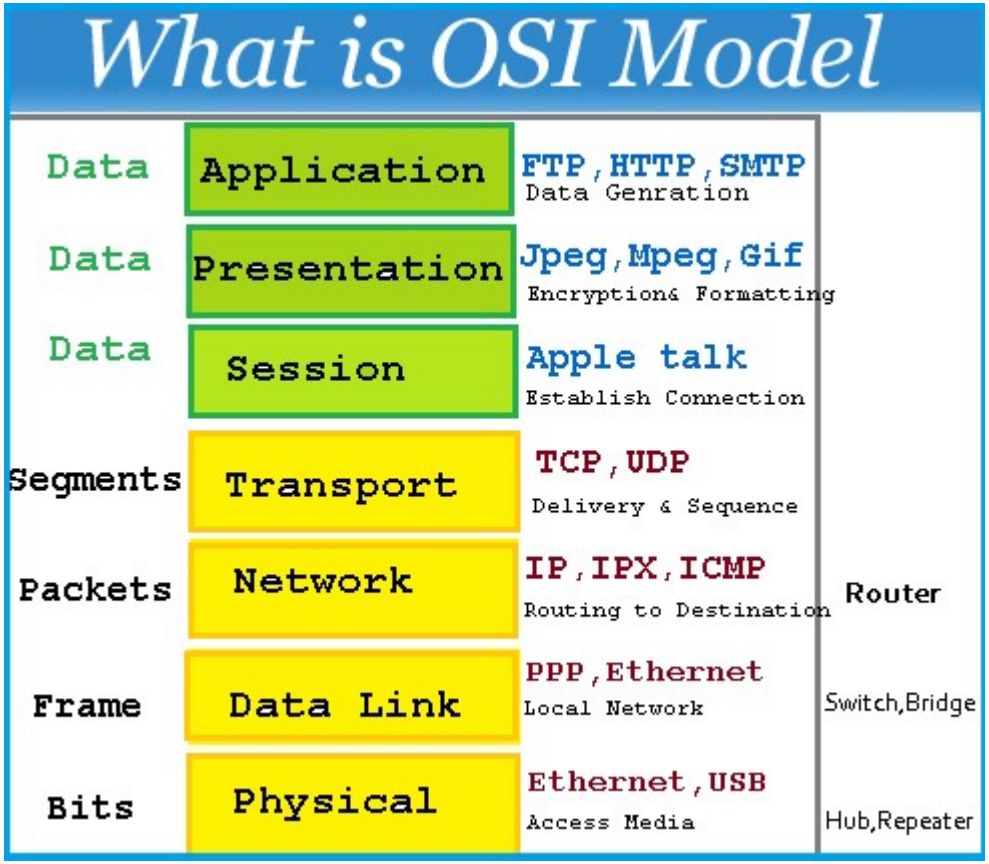
A connection is uniquely identified by the socket addresses of its two end-points.



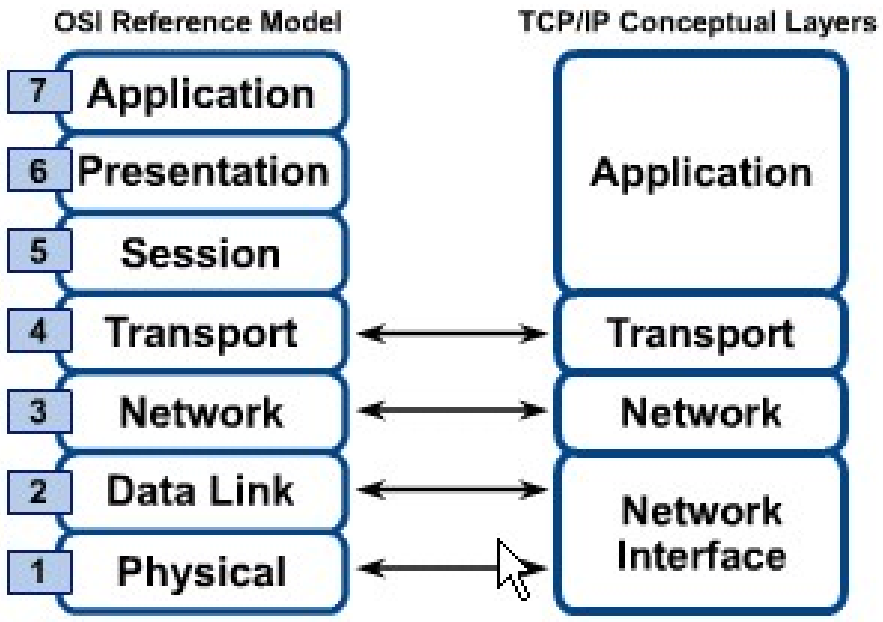
Using Ports to Identify Services



OSI Model


What is OSI Model
Data
Application
FTP, HTTP, SMTP
Data Genration
Data
Presentation
Jpeg, Mpeg, Gif
Encryption& Formatting
Data
Session
Apple talk
Establish Connection
Segments
Transport
TCP, UDP
Delivery & Sequence
Packets
Network
IP, IPX, ICMP
Routing to Destination
Router
Frame
Data Link
PPP, Ethernet
Local Network
Switch,Bridge
Bits
Physical
Ethernet, USB
Access Media
Hub,Repeater

OSI Model



Higher layers often combined together.

OSI Model

- **Application Layer:** High-level APIs, including resource sharing, remote file access, directory services and virtual terminals.
  E.g. HTTP, FTP, SMTP, SSH, TELNET
- **Presentation Layer:** Translation of data between a networking service and an application; including character encoding, data compression and encryption/decryption.
  E.g. HTML, CSS, GIF.
- **Session Layer:** Managing communication sessions, i.e. continuous exchange of information in the form of multiple back-and-forth transmissions between two nodes.
  E.g. RPC, PAP, SSL, SQL

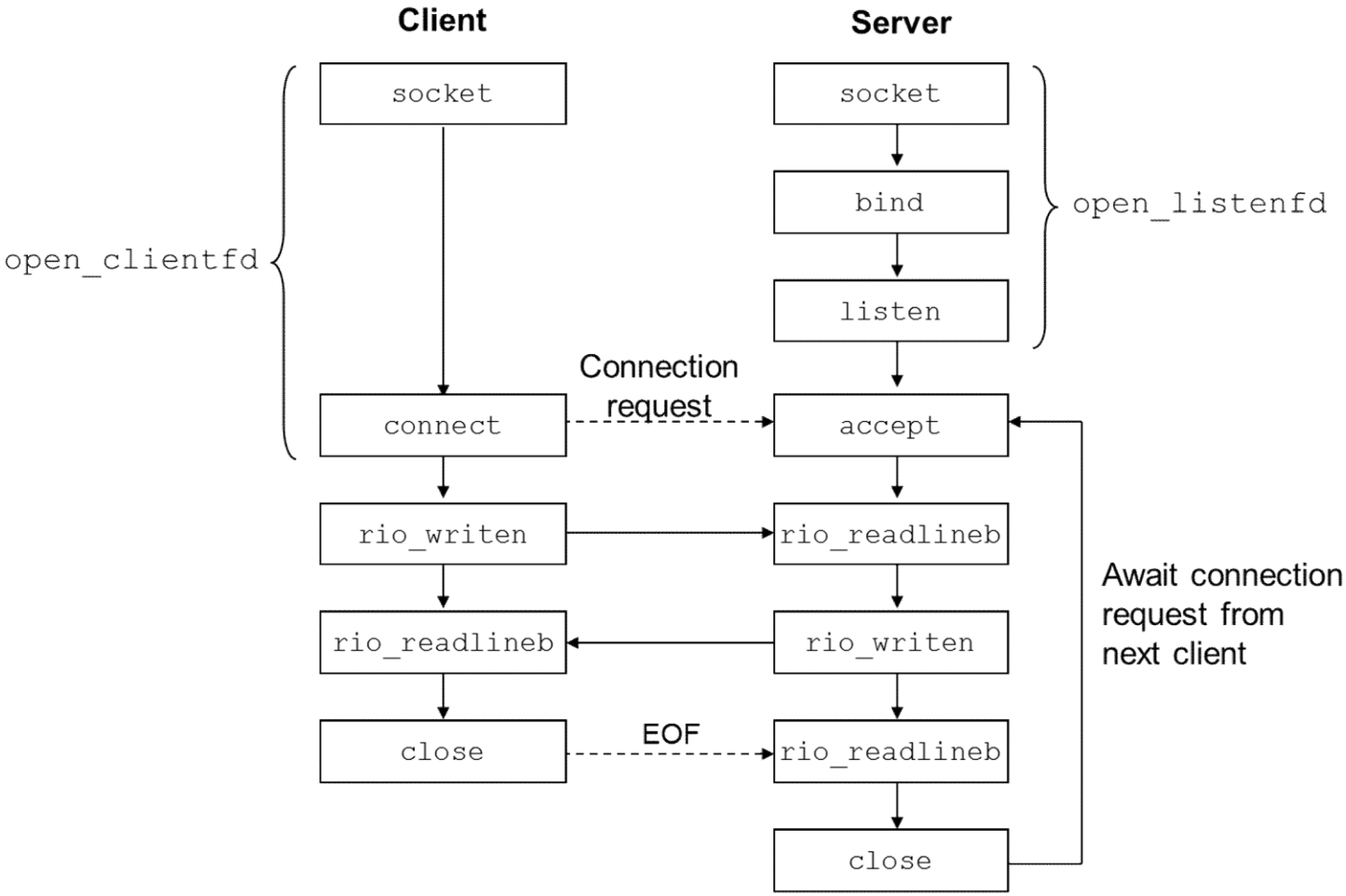
OSI Model

- **Transport Layer:** Reliable transmission of data segments between points on a network, including segmentation, acknowledgement and multiplexing.
  E.g. TCP, UDP, NETBEUI
  Data Unit: Segments/Datagram
- **Network Layer:** Structuring and managing a multi-node network, including addressing, routing and traffic control.
  E.g. IPv4, IPv6, IPsec, AppleTalk, ICMP
  Data Unit: Packet

OSI Model

- **Data Link Layer:** Reliable transmission of data frames between two nodes connected by a physical layer.
  E.g. PPP, IEEE 802.2, L2TP, MAC, LLDP
  Data Unit: Frame
- **Physical Layer:** Transmission and reception of raw bit streams over a physical medium Ethernet physical layer.
  E.g. DSL, USB, ISDN, DOCSIS
  Data Unit: Bit

Overview of the sockets interface



Web Basics

Client server interact through text based application level protocol known as HTTP (Hypertext Transfer Protocol)

Web content written in HTML language.

(Hypertext Markup Language)

HTML contains instructions on how to display content on browser. Eg. Make me bold

HTML pages can contain pointers (hyperlinks) to content stored on any Internet host.

Web Content

Web content is a sequence of bytes with an associated MIME type.

MIME -> Multipurpose Internet Mail Extensions

E.g. text/html -> HTML page.

text/plain -> unformatted text.

image/gif -> Binary image encoded in GIF format.

Each file has a unique name known as a URL (Universal Resource Locator)

E.g. http://pages.cs.wisc.edu/~cs354-1/index.html

Web Content

Two types of web content:

Static: Fetch a disk file and return its contents to client.

- Fastest and most efficient way to deliver content
- More secure because no executable

Dynamic: Run an executable file and return its output to client.

- Suitable for displaying user specific content

HTTP Requests

HTTP Request is a request line followed by zero or more request headers followed by empty text line.

Request line is of the form: <method> <uri> <version>

HTTP support many different methods: GET, POST, OPTIONS, HEAD, PUT, DELETE, TRACE

Our focus: GET method which instructs server to generate and return the content identified by the URI (Uniform resource Identifier)

URI is the suffix of the URL that contains the file name and optional arguments.

Version field specifies which HTTP version to which request conforms.

HTTP Requests

Request headers provide additional information to the server such as:

Brand name of the browser

MIME types that the browser understands

Request headers are of the form:

<header name>: <header data>

E.g. Host: www.aol.com

HTTP Responses

Http response is a response line followed by zero or more response headers, followed by an empty line that terminates the headers, followed by the response body.

Response line is of the form: <version> <status code> <status message>

Status code is a three digit positive integer and some common status codes are:

200 -> OK, 404 -> Not found, 505 -> HTTP version not supported

Status message gives the English equivalent of the status code.

Common Response headers are: Content-Type: text/html, Content-Length: 42092

Serving dynamic content

Passing arguments to the server:

"?" separates file name and arguments.

"&" separates multiple arguments.

E.g. Http request: GET /cgi-bin/adder?150&213 HTTP/1.1

Passing arguments to child process by Web Server:

Using environment variables.

Child sets environment variable QUERY_STRING to "150&213" before calling execve.

Child also perform output redirection using dup2 to capture the results.