INTRODUCTION TO SOCKET PROGRAMMING WITH C

CPSC 441 TUTORIAL – JANUARY 18, 2012

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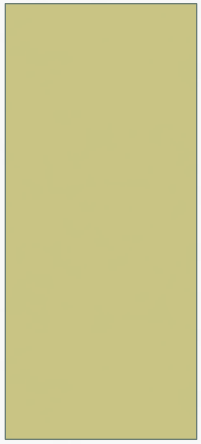
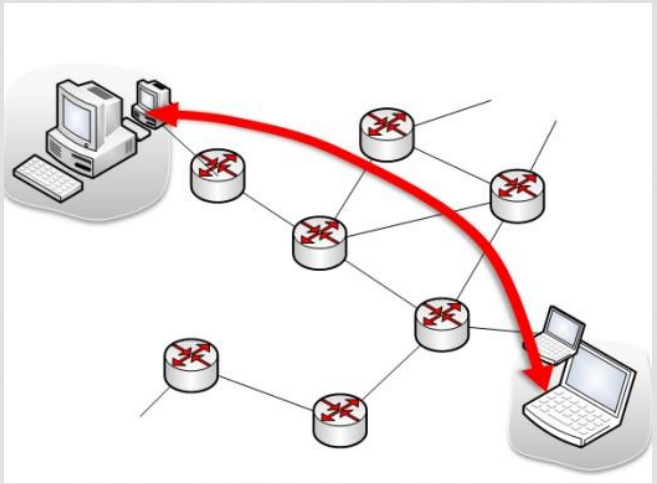


WHAT IS A SOCKET?

- Socket is an interface between application and network (the lower levels of the protocol stack)
  - The application creates a socket
  - The socket *type* dictates the style of communication
    - reliable vs. best effort
    - connection-oriented vs. connectionless



- electric outlet that one can plug into for network services

From: http://www.cs.columbia.edu/~danr/courses/6761/Summer03/intro/6761-1b-sockets.ppt

WHAT IS A SOCKET?

- A host-local, application-created, OS-controlled interface (a "door") into application pro cess
- Once a socket is setup the application can
  - pass data to the socket for network transmission
  - receive data from the socket (transmitted through the network, received from some other host)

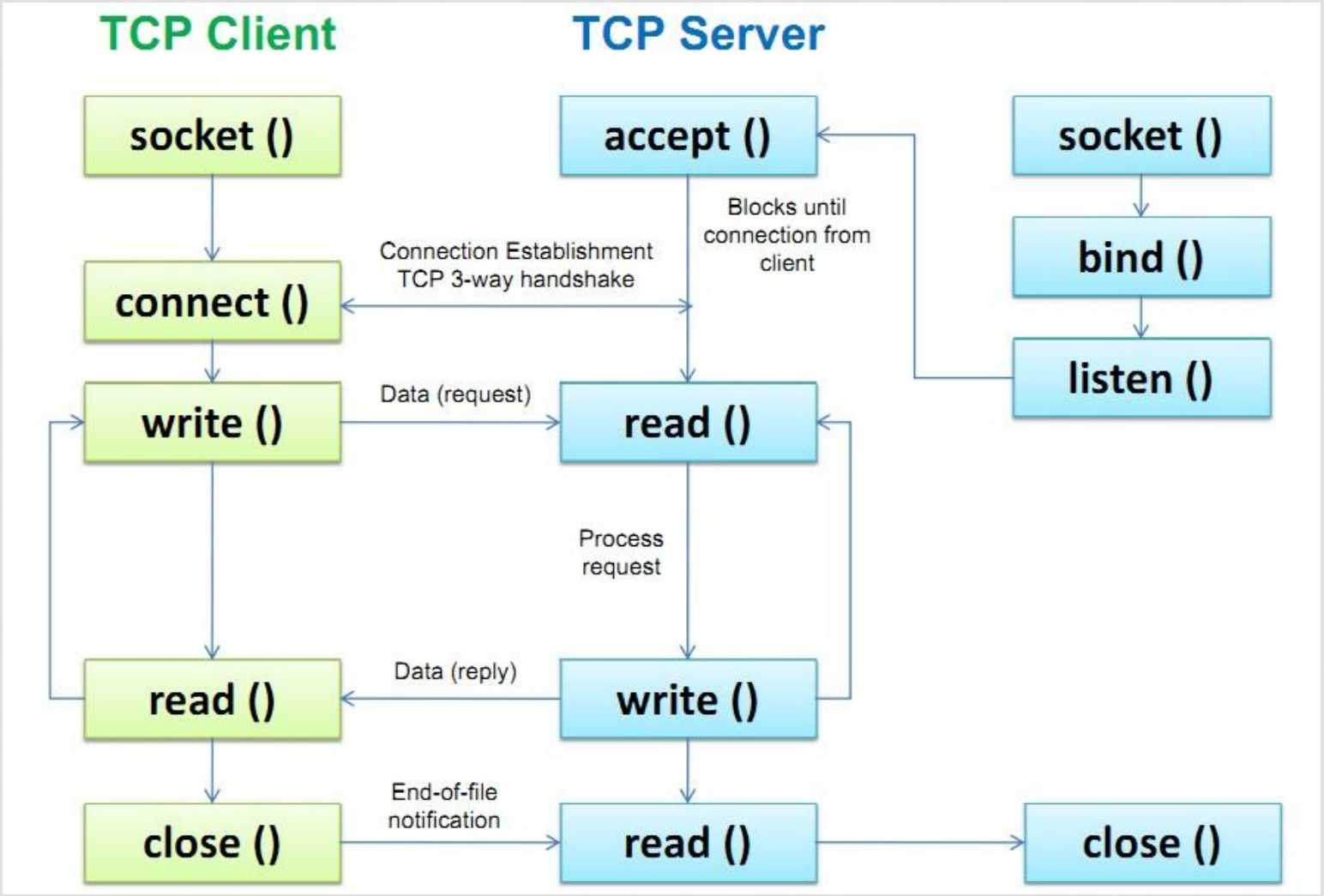
MOST POPULAR TYPES OF SOCKETS

- TCP socket
  - Type: **SOCK_STREAM**
  - reliable delivery
  - in-order guaranteed
  - connection-oriented
  - bidirectional

  We focus on TCP

- UDP socket
  - Type: **SOCK_DGRAM**
  - unreliable delivery
  - no order guarantees
  - no notion of "connection" – app indicates destination for each packet
  - can send or receive

SERVER AND CLIENTS



SOCKET CREATION IN C

- int s = socket(domain, type, protocol);
  - s: socket descriptor, an integer (like a file-handle)
  - domain: integer, communication domain
    - e.g., AF_INET (IPv4 protocol) – typically used
  - type: communication type
    - SOCK_STREAM: reliable, 2-way, connection-based service
    - SOCK_DGRAM: unreliable, connectionless,
    - other values: need root permission, rarely used, or obsolete
  - protocol: specifies protocol (see file /etc/protocols for a list of options) - usually set to 0, 0 is for IP

NOTE: socket call does not specify where data will be coming from, nor where it will be going to - it just creates the interface.

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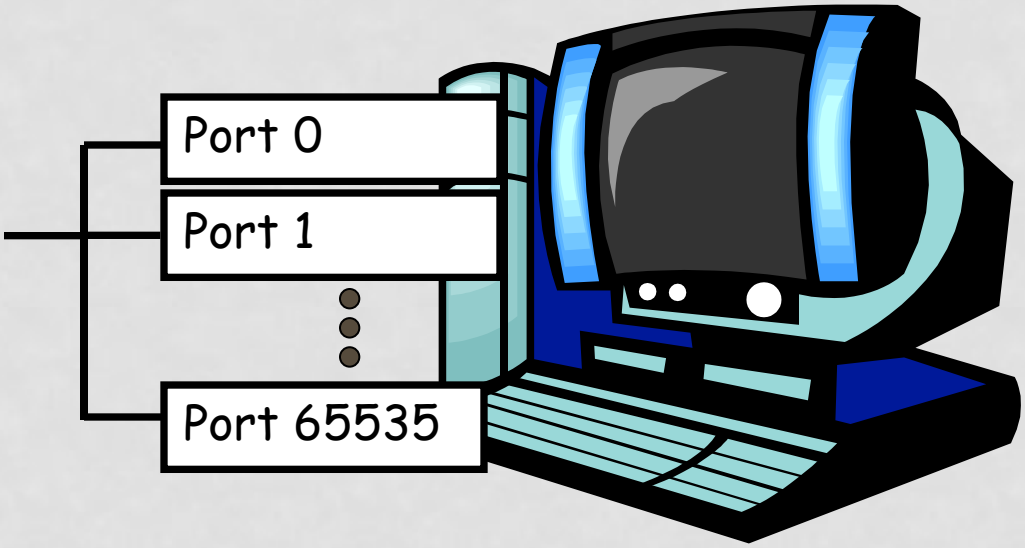
PORTS

- Each host machine has an IP address (or more!)
- Each host has 65,536 ports ($2^?$)
- Some ports are *reserved* for specific apps
  - 20,21: FTP
  - 23: Telnet
  - 80: HTTP
  - see RFC 1700 (about 2000 ports are reserved)



A socket provides an interface to send data to/from the network through a port

From: http://www.cs.columbia.edu/~danr/courses/6761/Summer03/intro/6761-1b-sockets.ppt

ADDRESSES, PORTS AND SOCKETS

- Like apartments and mailboxes
  - You are the application
  - Your apartment building address is the address
  - Your mailbox is the port
  - The post-office is the network
  - The socket is the key that gives you access to the right mailbox (one difference: assume outgoing mail is placed by you in your mailbox)
- Q: How do you choose which port a socket connects to?

From: http://www.cs.columbia.edu/~danr/courses/6761/Summer03/intro/6761-1b-sockets.ppt

THE BIND FUNCTION

- The bind function associates and (can exclusively) reserves a port for use by the socket
- int status = bind(sockid (struct sockaddr *) &servaddr, size);
  - status: error status, = -1 if bind failed
  - sockid: integer, socket descriptor
  - Sockaddr: the structure with the addresses and the ports
  - We put local IP address and the Port in servaddr

```
servaddr.sin_family = AF_INET; /* IPv4 protocol */
servaddr.sin_addr.s_addr = htonl(INADDR_ANY);
 /*any  interface in server*/
servaddr.sin_port  = htons(13);
 /*well - known daytime port*/
```

size: the size (in bytes) of the servaddr structure

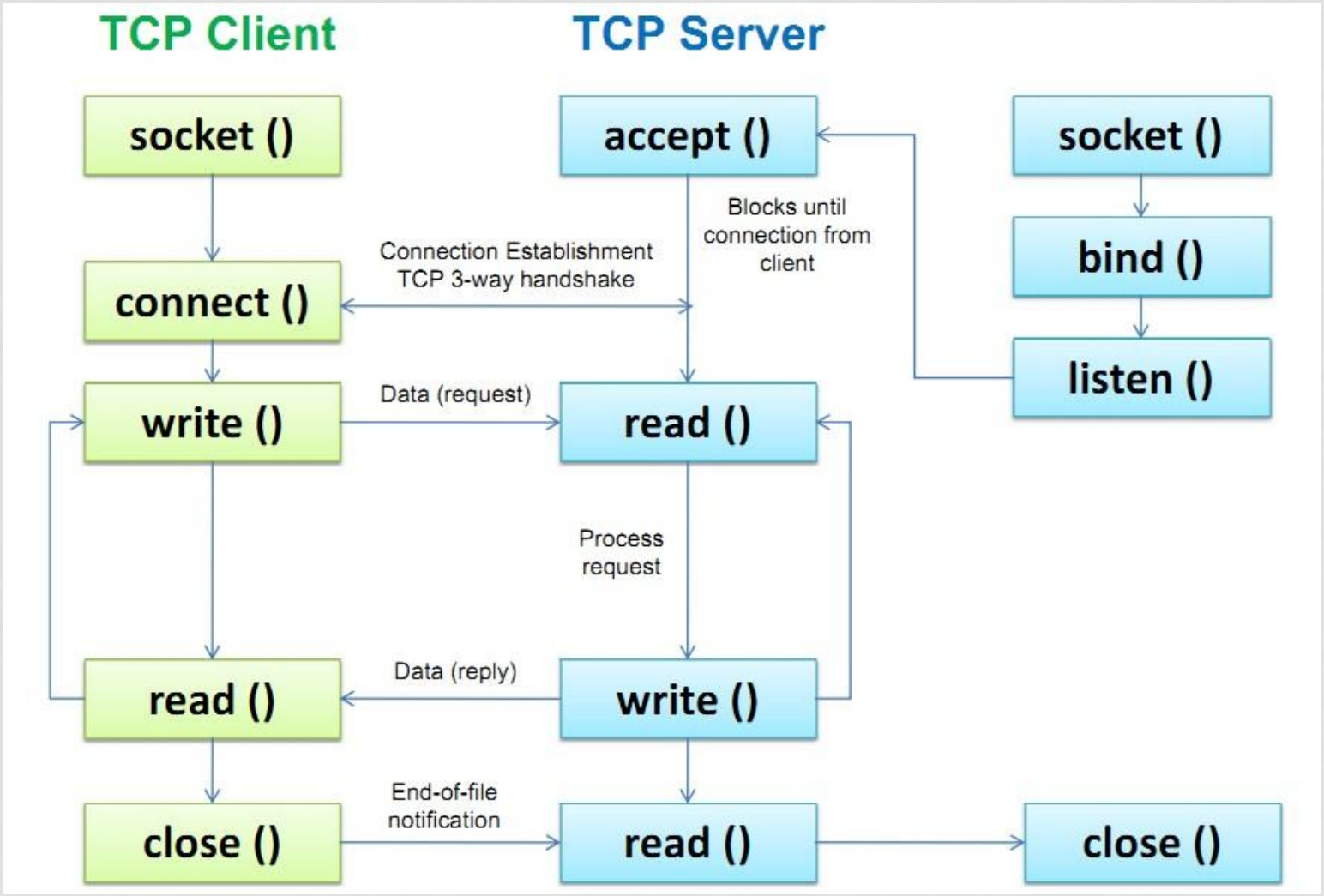
SKIPPING THE BIND

- bind can be skipped, When and why?
- When connecting to another host (i.e., connecting end is the client and the receiving end is the server), the OS automatically assigns a free port for the outgoing connection.
- During connection setup, receiving end is informed of port)
- You can however bind to a specific port if need be.

CONNECTION SETUP

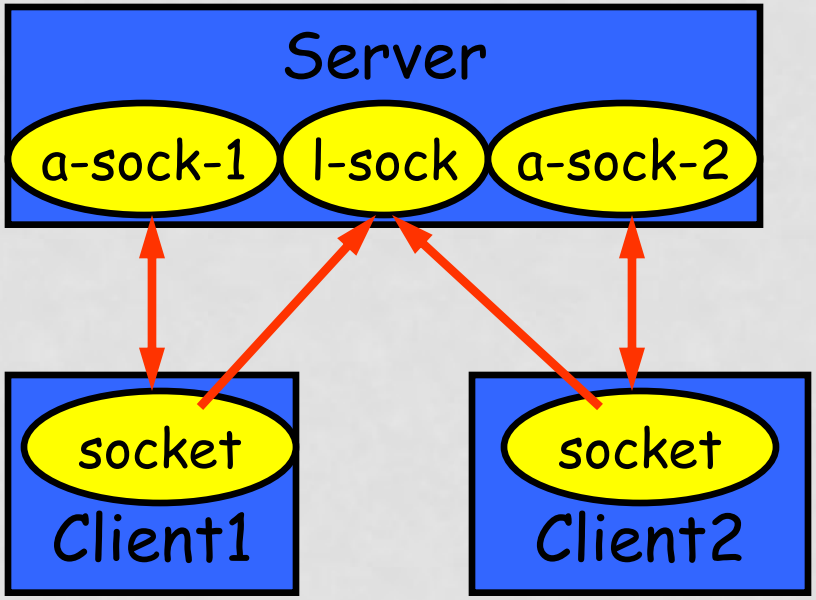
- A connection occurs between two ends
  - Server: waits for an active participant to request connection
  - Client: initiates connection request to passive side
- Once connection is established, server and client ends are "similar"
  - both can send & receive data
  - either can terminate the connection

SERVER AND CLIENTS



CONNECTION SETUP STEPS

- Client end:
  - step 2: request & establish connection
  - step 4: send/recv
- Server end:
  - step 1: listen (for incoming requests)
  - step 3: accept (a request)
  - step 4: send/recv



- The accepted connection is on a new socket
- The old socket continues to listen for other active participants

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SERVER SOCKET: LISTEN & ACCEPT

Called on server side:

- int status = listen(sock, queuelen);
  - status: 0 if listening, -1 if error
  - sock: integer, socket descriptor
  - queuelen: integer, # of active participants that can "wait" for a connection
  - listen is **non-blocking**: returns immediately

- int s = accept(sock, (struct sockaddr *) NULL, NULL);
  - s: integer, the new socket (used for data-transfer)
  - sock: integer, the orig. socket (being listened on)
  - struct sockaddr, address of the active participant
  - If so, accept() returns a NEW SOCKET DESCRIPTOR ! Why ? B ecause the old socket descriptor (sock) is still queuing requ est from the network !
  - accept is **blocking**: waits for connection before returning

From: http://www.cs.columbia.edu/~danr/courses/6761/Summer03/intro/6761-1b-sockets.ppt

CONNECT

- int status = connect(sock, (sockaddr *) &servaddr, sizeof(servaddr));
  - status: 0 if successful connect, -1 otherwise
  - sock: integer, socket to be used in connection
  - servaddr :address of passive participant
  - sizeof(servaddr): integer
- connect is **blocking**

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SENDING / RECEIVING DATA

- int count = send(sock, &buf, len, flags);
  - count: # bytes transmitted (-1 if error)
  - buf: char[], buffer to be transmitted
  - len: integer, length of buffer (in bytes) to transmit
  - flags: integer, special options, usually just 0
- int count = recv(sock, &buf, len, flags);
  - count: # bytes received (-1 if error)
  - buf: void[], stores received bytes
  - len: # bytes received
  - flags: integer, special options, usually just 0

- Calls are **blocking** [returns only after data is sent (to socket buf) / received]

From: http://www.cs.columbia.edu/~danr/courses/6761/Summer03/intro/6761-1b-sockets.ppt

CLOSE

- When finished using a socket, the socket should be closed:

- status = close(s);
  - status: 0 if successful, -1 if error
  - s: the file descriptor (socket being closed)

- Closing a socket
  - closes a connection
  - frees up the port used by the socket

From: http://www.cs.columbia.edu/~danr/courses/6761/Summer03/intro/6761-1b-sockets.ppt

THE STRUCT SOCKADDR

- The Internet-specific:

```
struct sockaddr_in {
    short sin_family;
    u_short sin_port;
    struct in_addr sin_addr;
    char sin_zero[8];
};
```

- sin_family = AF_INET // Specifies the address family
- sin_port: // Specifies the port # (0-65535)
- sin_addr: // Specifies the IP address
- sin_zero: unused // unused!

From: http://www.cs.columbia.edu/~danr/courses/6761/Summer03/intro/6761-1b-sockets.ppt

FAQ 1

- Sometimes, an ungraceful exit from a program (e.g., ctrl-c) does not properly free up a port
- Eventually (after a few minutes), the port will be freed
- You can kill the process, or
- To reduce the likelihood of this problem, include the following code:
  - In header include:

```
#include <signal.h>
void cleanExit(){exit(0);}
```

  - In socket code:

```
signal(SIGTERM, cleanExit);
signal(SIGINT, cleanExit);
```

From: http://www.cs.columbia.edu/~danr/courses/6761/Summer03/intro/6761-1b-sockets.ppt

FAQ 2

- Make sure to #include the header files that define used functions
- Check Beej's Guide to Network Programming Using Internet Sockets
  http://beej.us/guide/bgnet/output/html/multipage/index.html
- Search the specification for the function you need to use for more info, or check the main pages.

LETS WRITE SOME CODE!

- Sample socket program:
  - Client/server example.

REFERENCES

- These are good references for further study of Socket programming with C:

  - Beej's Guide to Network Programming Using Internet Sockets http://beej.us/guide/bgnet/output/html/multipage/index.html

  - http://www.cs.columbia.edu/~danr/courses/6761/Summer03/intro/6761-1b-sockets.ppt

TIPS FOR THE ASSIGNMENT 1