Administrivia

HW3 due tomorrow night

HW4 posted by end of week; demo on Friday

Sections tomorrow: network programming

New exercise covering client-side programming posted now, due Monday before class
Today

Network programming
- server-side programming
Servers

Pretty similar to clients, but with additional steps

- there are seven steps:
  1. figure out the address and port on which to listen
  2. create a socket
  3. `bind` the socket to the address and port on which to listen
  4. indicate that the socket is a `listening` socket
  5. `accept` a connection from a client
  6. `read` and `write` to that connection
  7. `close` the connection
Accepting a connection from a client

Step 1. Figure out the address and port on which to listen.

Step 2. Create a socket.

Step 3. **Bind** the socket to the address and port on which to listen.

Step 4. Indicate that the socket is a **listening** socket.
Servers can have multiple IP addresses

- “multihomed”
- usually have at least one externally visible IP address, as well as a local-only address (127.0.0.1)

When you bind a socket for listening, you can:

- specify that it should listen on all addresses
  ‣ by specifying the address “INADDR_ANY” -- 0.0.0.0
- specify that it should listen on a particular address
bind()

The “bind( )” system call associates with a socket:

- an address family
  - AF_INET: IPv4
  - AF_INET6: IPv6
- a local IP address
  - the special IP address **INADDR_ANY** (“0.0.0.0”) means “all local IPv4 addresses of this host”
  - use **in6addr_any** (instead of INADDR_ANY) for IPv6
- a local port number
listen() 

The “listen()” system call tells the OS that the socket is a listening socket to which clients can connect

- you also tell the OS how many pending connections it should queue before it starts to refuse new connections
  ‣ you pick up a pending connection with “accept()”

- when listen returns, remote clients can start connecting to your listening socket
  ‣ you need to “accept()” those connections to start using them
Server socket, bind, listen

see server_bind_listen.cc
Accepting a connection from a client

Step 5. `accept()` a connection from a client.

Step 6. `read()` and `write()` to the client.

Step 7. `close()` the connection.
The "accept()" system call waits for an incoming connection, or pulls one off the pending queue

- it returns an active, ready-to-use socket file descriptor connected to a client
- it returns address information about the peer
  - use inet_ntop() to get the client’s printable IP address
  - use getnameinfo() to do a reverse DNS lookup on the client
Server accept, read/write, close

see server_accept_rw_close.cc
Something to note...

Our server code is not concurrent

- single thread of execution
- the thread blocks waiting for the next connection
- the thread blocks waiting for the next message from the connection

A crowd of clients is, by nature, concurrent

- while our server is handling the next client, all other clients are stuck waiting for it
Exercise 1

Write a program that:

- creates a listening socket, accepts connections from clients
  ‣ reads a line of text from the client
  ‣ parses the line of text as a DNS name
  ‣ does a DNS lookup on the name
  ‣ writes back to the client the list of IP addresses associated with the DNS name
  ‣ closes the connection to the client
Exercise 2

Write a program that:

- creates a listening socket, accepts connections from clients
  - reads a line of text from the client
  - parses the line of text as a DNS name
  - connects to that DNS name on port 80
  - writes a valid HTTP request for “/”
    - see next slide for what to write
  - reads the reply, returns the reply to the client
Exercise 2 continued

Here’s a valid HTTP request to server www.foo.com

- note that lines end with `\r\n`, not just `\n`

```
GET / HTTP/1.0\r\nHost: www.foo.com\r\nConnection: close\r\n\r\n```
See you on Friday!