Client-Side Networking

CSE 333 Autumn 2019

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Poll Everywhere

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About how long did Homework 3 take?

A. 0-12 Hours
B. 13-18 Hours
C. 19-24 Hours
D. 25-30 Hours
E. 31+ Hours
F. I didn't finish / I prefer not to say

Administrivia

- Exercise 15 due Monday
- Canvas updated with late days and HW1 + HW2 grades
  - Let Hannah know if you can't access
- HW3:
  - Extra OH tonight! 4-6pm @ 4th floor breakout
  - 1 late day = 8:59pm tonight; 2 late days = 8:59pm on *Sunday*
- HW4 posted and files will be pushed to repos today
  - Due last Thursday of the quarter (12/5)
  - Only 1 late day allowed for HW4 (hard deadline of 12/6)

Lecture Outline

- Client-side Networking
  - Step 1: Figure out the IP/Port
    - What is a Network Address?
    - Data structures for address information
    - DNS (Domain Name System): finding IP addresses
  - **Step 2: Create a Socket**
  - Step 3: Connect the Socket
  - Step 4: `read`() and `write`() Data
  - Step 5: Close the Socket
- HW4 demo

Step 2: Creating a Socket

- `int socket(int domain, int type, int protocol);`
  - Creating a socket doesn't bind it to a local address or port yet
  - Returns file descriptor or -1 on error

socket.cc

```
#include <arpa/inet.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include <iostream>

int main(int argc, char **argv) {
  int socket_fd = socket(AF_INET, SOCK_STREAM, 0);
  if (socket_fd == -1) {
    std::cerr << strerror(errno) << std::endl;
    return EXIT_FAILURE;
  }
  close(socket_fd);
  return EXIT_SUCCESS;
}
```

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Step 3: Connect to the Server

- The `connect()` system call establishes a connection to a remote host
  - ```
    int connect(int sockfd, const struct sockaddr *addr,
                socklen_t addrlen);
    ```
    - `sockfd`: Socket file description from Step 2
    - `addr` and `addrlen`: Usually from one of the address structures returned by `getaddrinfo` in Step 1 (DNS lookup)
    - Returns `0` on success and `-1` on error
- `connect()` may take some time to return
  - It is a *blocking* call by default
  - The network stack within the OS will communicate with the remote host to establish a TCP connection to it
    - This involves ~2 *round trips* across the network
    ```

Connect Example

- See connect.cc

```
// Get an appropriate sockaddr structure.
struct sockaddr_storage addr;
size_t addrlen;
LookupName(argv[1], port, &addr, &addrlen);

// Create the socket.
int socket_fd = socket(addr.ss_family, SOCK_STREAM, 0);
if (socket_fd == -1) {
  cerr << "socket() failed: " << strerror(errno) << endl;
  return EXIT_FAILURE;
}

// Connect the socket to the remote host.
int res = connect(socket_fd,
                  reinterpret_cast<sockaddr*>(&addr),
                  addrlen);
if (res == -1) {
  cerr << "connect() failed: " << strerror(errno) << endl;
}
```

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- How do we *error check* `read()` and `write()`?

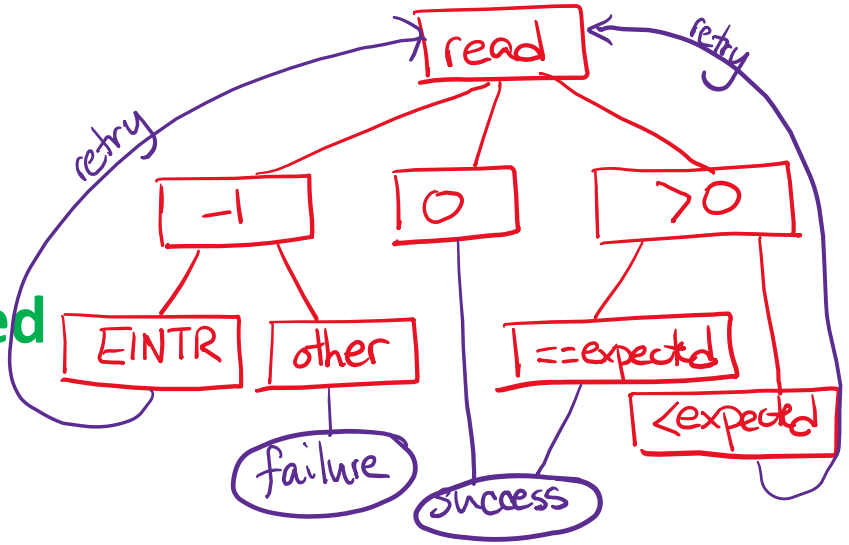
A. `ferror()`

B. Return value less than expected

C. Return value of 0 or NULL

D. Return value of -1

E. I'm not sure…



Step 4: `read()`

- If there is data that has already been received by the network stack, then read will return immediately with it
  - `read()` might return with *less* data than you asked for
- If there is no data waiting for you, by default `read()` will *block* until something arrives
  - How might this cause *deadlock*?
  - Can `read()` return `0`?

Step 4: `write()`

- `write()` queues your data in a send buffer in the OS and then returns
  - The OS transmits the data over the network in the background
  - When `write()` returns, the receiver probably has not yet received the data!

- If there is no more space left in the send buffer, by default `write()` will *block*

Read/Write Example

- See receivesend.cc

```
while (1) {
  int wres = write(socket_fd, readbuf, res);
  if (wres == 0) {
    cerr << "socket closed prematurely" << endl;
    close(socket_fd);
    return EXIT_FAILURE;
  }
  if (wres == -1) {
    if (errno == EINTR)
      continue;
    cerr << "socket write failure: " << strerror(errno) << endl;
    close(socket_fd);
    return EXIT_FAILURE;
  }
  break;
}
```

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Step 5: `close()`

- `int close(int fd);`
  - Nothing special here – it's the same function as with file I/O
  - Shuts down the socket and frees resources and file descriptors associated with it on both ends of the connection

Lecture Outline

- Client-side Networking
  - Roadmap
  - Step 1: Figure out the IP/Port
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- **HW4 demo**

hw4 demo

- Multithreaded Web Server (333gle)
  - Don't worry – multithreading has mostly been written for you
  - `./http333d <port> <static files> <indices+>`
  - Some security bugs to fix, too

Extra Exercise #1

- Write a program that:
  - Reads DNS names, one per line, from `stdin`
  - Translates each name to one or more IP addresses
  - Prints out each IP address to `stdout`, one per line