Proxylab

and stuff

15-213: Introduction to Computer Systems
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Section M

Topics

- Summary of malloclab
- News
- Sockets
- Threads
- Proxylab

Malloclab review

- Questions, comments, lessons learned?
- Starting simple and making improvements is a good way to write code
  - Nice because you can have something simple working relatively easily
  - You can test each new optimization alone
- When you write your code, write it so that it can be easily maintained/changed
  - “how can I write my explicit list so that I can change it to seglists later?”

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News

- Last day to turn in malloc is today (if using two late days and taking a late penalty)
- Proxylab was out last Friday

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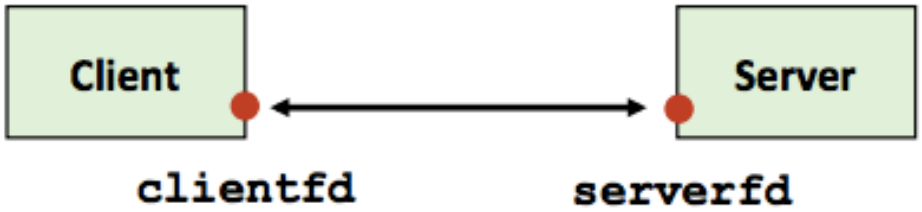
Sockets

- To get a struct hostent for a domain name:
  - struct hostent * gethostbyname(const char *name);
    - not threadsafe, threadsafe version is gethostbyname_r
- What is a socket?
  - To an application, a socket is a file descriptor that lets the application read/write from/to the network
  - (all Unix I/O devices, including networks, are modeled as files)
- Clients and servers communicate with each other by reading from and writing to socket descriptors



- The main difference between regular file I/O and socket I/O is how the application “opens” the socket descriptors

Sockets API

- int socket(int domain, int type, int protocol);
- int bind(int socket, const struct sockaddr *address, socklen_t address_len);
- int listen(int socket, int backlog);
- int accept(int socket, struct sockaddr *address, socklen_t *address_len);
- int connect(int socket, struct sockaddr *address, socklen_t address_len);
- int close(int fd);
- ssize_t read(int fd, void *buf, size_t nbyte);
- ssize_t write(int fd, void *buf, size_t nbyte);

Sockets API

- int socket(int domain, int type, int protocol);
  - used by both clients and servers
  - int sock_fd = socket(PF_INET, SOCK_STREAM, IPPROTO_TCP);
  - Create a file descriptor for network communication
  - One socket can be used for two-way communication

Sockets API

- int bind(int socket, const struct sockaddr *address, socklen_t address_len);
  - used by servers
  - struct sockaddr_in sockaddr;
    memset(&sockaddr, 0, sizeof(sockaddr);
    sockaddr.sin_family = AF_INET;
    sockaddr.sin_addr.s_addr = INADDR_ANY;
    sockaddr.sin_port = htons(listenPort)
    err = bind(sock_fd, (struct sockaddr *) sockaddr, sizeof(sockaddr));
  - sock_fd: file descriptor of socket
  - my_addr: address to bind to, and information about it, like the port
  - addrlen: size of addr struct
  - Associate a socket with an IP address and port number

Sockets API

- int listen(int socket, int backlog);
  - used by servers
  - err = listen(sock_fd, MAX_WAITING_CONNECTIONS);
  - socket: socket to listen on
  - backlog: maximum number of waiting connections
- int accept(int socket, struct sockaddr *address, socklen_t *address_len);
  - used by servers
  - struct sockaddr_in client_addr;
    socklen_t my_addr_len = sizeof(client_addr);
    client_fd = accept(listener_fd, &client_addr, &my_addr_len);
  - socket: socket to listen on
  - address: pointer to sockaddr struct to hold client information after accept returns
  - return: file descriptor

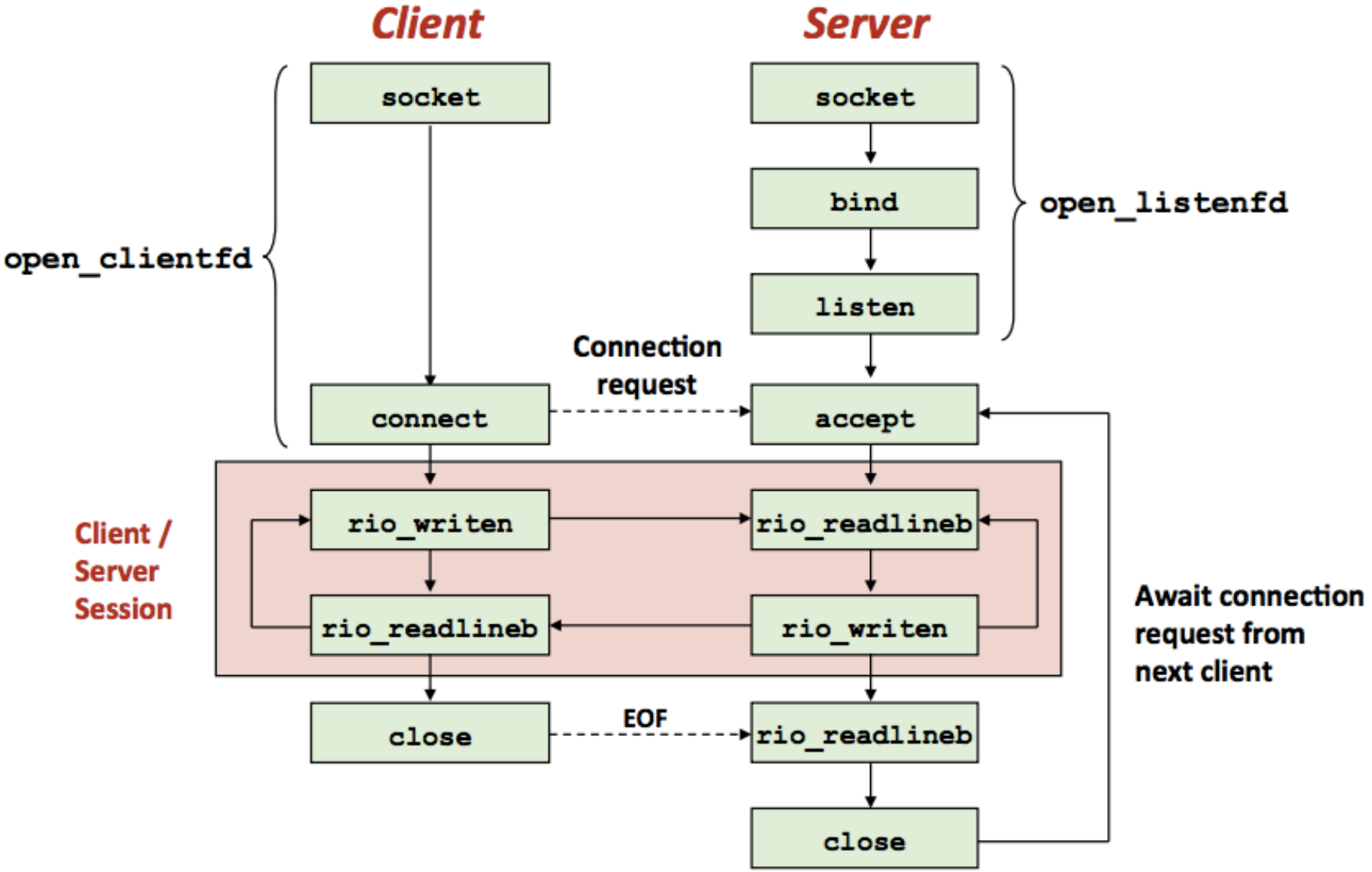
Sockets API

- int connect(int socket, struct sockaddr *address, socklen_t address_len);
  - used by clients
  - attempt to connect to the specified IP address and port described in **address**
- int close(int fd);
  - used by both clients and servers
  - (also used for file I/O)
  - fd: socket fd to close

Sockets API

- ssize_t read(int fd, void *buf, size_t nbyte);
  - used by both clients and servers
  - (also used for file I/O)
  - fd: (socket) fd to read from
  - buf: buffer to read into
  - nbytes: buf length
- ssize_t write(int fd, void *buf, size_t nbyte);
  - used by both clients and servers
  - (also used for file I/O)
  - fd: (socket) fd to write to
  - buf: buffer to write
  - nbytes: buf length

Overview of the Sockets Interface



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Threads

- Similarities to processes
  - each thread has its own logical control flow (its own registers, so its own eip and stuff)
  - multiple threads can be in the middle of running at the same time, possibly on different cores
  - the kernel decides when to context switch to and from a thread (or a thread can voluntarily give up its share of cpu time by calling sleep, pause, sigsuspend, or something similar)
- Differences with processes
  - threads share code and data; processes generally don't
  - threads are less expensive to make than processes (processes are about 2x more expensive to create and reap)

Threads

- Each thread has its own stack/registers, including stack pointer and program counter (imagine what would happen otherwise)
- Processes start out as having one thread, and they also have code, data, page directory/table, file descriptors, and some other things associated with them

Threads: pthreads interface

- Creating/reaping threads
  - pthread_create
  - pthread_join
- To get your thread ID
  - pthread_self
- Terminating threads
  - pthread_cancel
  - pthread_exit
- synchronizing access to shared variables
  - pthread_mutex_init
  - pthread_mutex_[un]lock
  - pthread_rwlock_init
  - pthread_rwlock_[wr]rdlock

Threads

- A thread terminates *implicitly* when its top-level thread routine returns
- A thread terminates *explicitly* by calling pthread_exit(NULL)
- pthread_exit(NULL) only terminates the current thread, **NOT** the process
- exit(0) terminates **ALL** the threads in the process (meaning the whole process terminates
- pthread_cancel(tid) terminates the thread with id equal to tid

Threads

- Joinable threads can be reaped and killed by other threads
  - must be reaped with pthread_join to free memory and resources
- Detached threads cannot be reaped or killed by other threads
  - resources are automatically reaped on termination
- Default state is joinable
  - use pthread_detach(pthread_self()) to make detached

Multithreaded Hello World

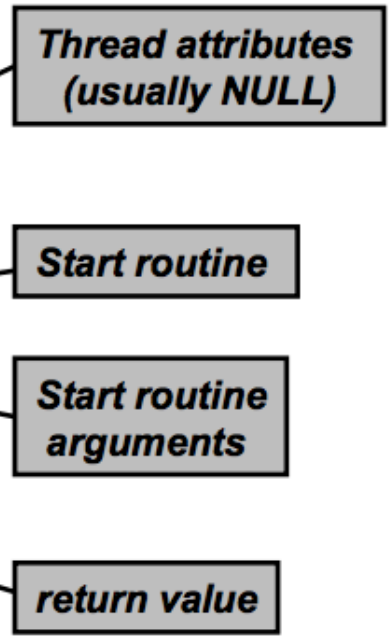
```
/* hello.c - Pthreads "hello, world" program */

#include "csapp.h"

void *thread(void *vargp);

int main() {
  pthread_t tid;
  int i;
  for(i = 0; i < 42; ++i) {
    pthread_create(&tid, NULL, thread, NULL);
    pthread_join(tid, NULL);
  }
  exit(0);
}

/* thread routine */
void *thread(void *vargp) {
  printf("Hello, world!\n");
  return NULL;
}
```



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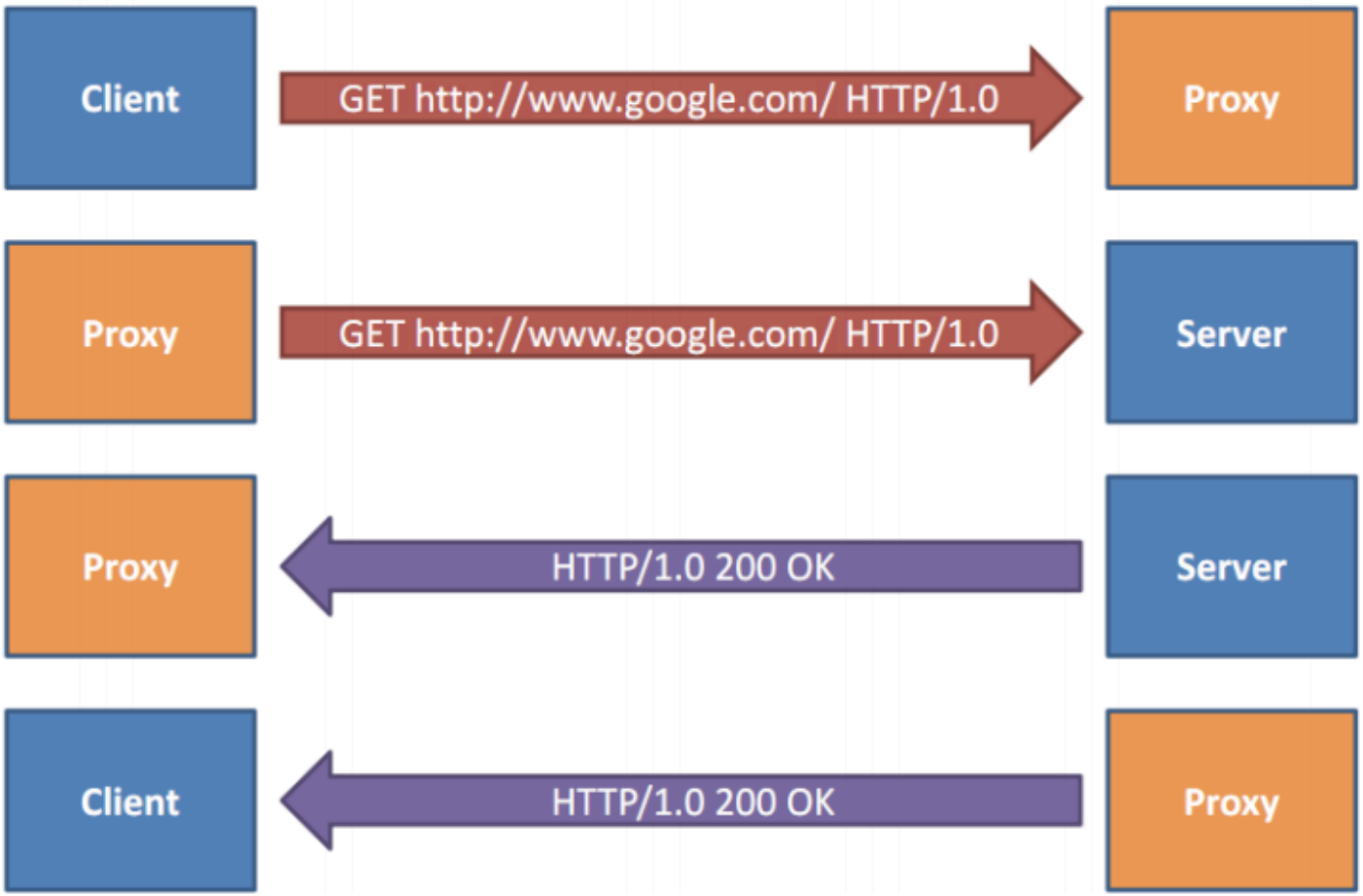
Proxylab: what a proxy is??

- intermediary between client and server



Proxylab

- write a web proxy
  - multi-threaded
  - caching
- should work for most sites (not https connections though)
  - cnn.com
  - google.com
  - youtube.com
  - (not facebook.com)
- Forwards requests from the client to the server
  - acts as a server to the client, but as a client to the server the client is asking you to read from

Proxylab: recommended progress

- implement a sequential proxy
  - this proxy will be very slow in loading webpages
- upgrade to multithreaded proxy
  - should be decently fast
- add caching
  - this involves some multithreading issues we'll talk about solving next week

- You are not given any tests, so make sure you test your proxy well on your own!

Questions?

(sockets, proxylab, what a proxy is??)

(come to office hours if you need help)