

Network Programming

Concurrent Programming - Threads

Note: This class lecture will be recorded!

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Programs and Threads

- ▶ *Sequential* program
- ▶ *Concurrent* program

- ▶ What is/are the advantage(s) of having multiple threads?

- ▶ What is/are the disadvantage(s) of having multiple threads?

Static Variables

- ▶ What is a static variable?
- ▶ Require care with threads

Thread-safe Functions

- ▶ Not all functions are thread-safe
- ▶ Some have thread-safe alternative

- ▶ `chdir()` vs. `opendir()`

POSIX Threads (pthreads)

- ▶ A popular thread package
- ▶ Process address space shared by all threads

- ▶ pthread_ functions
 - ▶ Return 0 or error number
 - ▶ Use strerror()

- ▶ Thread ID (pthread_t)
 - ▶ pthread_self()
 - ▶ pthread_equal()

Thread Creation

- ▶ `pthread_create()`
- ▶ Data structure(s) - thread ID, stack, PC value
- ▶ May pass one parameter to thread
 - ▶ How would you pass multiple values to a thread?
- ▶ After a thread has been created, how do you know when it will be scheduled to run by the OS?

Thread Create Example

```
pthread_t threads[3];  
int rc, i;  
for (i = 0; i < 3; i++) {  
    printf("Creating thread %d\n", i);  
    rc = pthread_create(&threads[i], NULL, print, (void *) &i);  
    .....  
} // end for loop
```

- What is wrong with this code fragment?
- How can it be corrected?
- Re-write above code to handle this.

Thread Termination

- ▶ Ways pthread may terminate
 - ▶ Return from starting routine
 - ▶ pthread_exit()
 - ▶ Main thread (process) ends
 - ▶ Cancelled by another thread - pthread_cancel()
 - ▶ The thread being cancelled may or may not cancel, depending on its state.

- ▶ When does the process terminate?

Race Conditions

- ▶ What is a Race Condition?
- ▶ `pthread_join()`

Notes on Programming with Threads

- ▶ Local variables
- ▶ Array example
- ▶ Struct example