

Week 9 - Friday

Network Programming (cont.)

School of Information Technology and Electrical Engineering
The University of Queensland

Outline

- C Network Programming
 - Concurrent servers – multi process
 - Concurrent servers – multi thread
- Credits:
 - Glass and Ables, "UNIX for Programmers and Users"
 - Bryant and O'Halloran, "Computer Systems: A Programmer's Perspective"
 - Rochkind, "Advanced UNIX Programming"
 - Tanenbaum, "Computer Networks"

3

Iterative Servers

- Iterative servers process one request at a time

4

3 Basic Mechanisms for Creating Concurrent Flows

1. Processes
 - Kernel automatically interleaves multiple logical flows
 - Each flow has its own private address space
2. Threads
 - Kernel automatically interleaves multiple logical flows
 - Each flow shares the same address space
3. I/O multiplexing with `select()`
 - User manually interleaves multiple logical flows
 - Each flow shares the same address space
 - Popular for high-performance server designs

5

Process-Based Concurrent Server

```

...
/* main server loop */
while (1) {
    connfd = accept(listenfd, (struct sockaddr *) &clientaddr,
                    &clientlen);
    if (fork() == 0) {
        close(listenfd); /* child closes its listening socket */
        ... /* Read data from connfd, process, write data etc. */
        close(connfd); /* child is done with this client */
        exit(0); /* child exits */
    }
    close(connfd); /* parent must close connected socket! */
}
...
    
```

6

Process-Based Concurrent Server (cont.)

```

... /* parent must reap children! - set up handler */
struct sigaction sa;
sa.sa_handler = reapchildren;
sa.sa_flags = SA_RESTART | SA_NOCLDSTOP;
sigaction(SIGCHLD, &sa, NULL);...

/* signal handler - reaps children as they terminate */
void reapchildren(int sig) {
    pid_t pid;
    int stat;

    while ((pid = waitpid(-1, &stat, WNOHANG)) > 0) {
        ;
    }
    return;
}
    
```

- Alternatively, set handler to `SIG_IGN` (modern OS's)

7

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Process-based Concurrent Server Example

- Code to be discussed/commented in class

8

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Implementation Issues With Process-Based Designs

- Server should restart `accept` call if it is interrupted by a transfer of control to the `SIGCHLD` handler
 - Not necessary for systems with POSIX signal handling and restart flag is specified
 - Required for portability on some older Unix systems.
- Server must reap zombie children
 - to avoid running out of processes
- Server must close its copy of `connfd`
 - Kernel keeps reference count for each socket
 - After fork, `refcnt(connfd) = 2`
 - Connection will not be closed until `refcnt(connfd)=0`

9

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Thread-Based Concurrent Server

```
... /* main server loop */
while (1) {
    connfd = accept(listenfd, (struct sockaddr *) &clientaddr,
                  &clientlen);
    pthread_create(&threadID, NULL, client_thread, (void*)fd);
    pthread_detach(threadID);
}
...
void* client_thread(void* arg)
{
    int fd;
    fd = (int)arg; /* Retrieve file descriptor from argument */

    ... /* Read data, process, write data etc. */

    close(fd);
    pthread_exit(NULL);
    return NULL;
}
```

12

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Thread-based Concurrent Server Example

- Code to be discussed/commented in class

12

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Pros and Cons of Process Based Designs

- + Handles multiple connections concurrently
- + Simple and straightforward
- Additional overhead for process control
- Nontrivial to share data between processes
 - Requires interprocess communication (IPC) mechanisms
 - FIFO's (named pipes), shared memory and semaphores

Thread based designs

- + Easier to share data between threads (though may need mutexes/semaphores)
- Do have thread overhead

13

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Third option...

- I/O multiplexing with `select()`
 - User manually interleaves multiple logical flows
 - Each flow shares the same address space
 - Popular for high-performance server designs
- Event-based design
- More on this in week 11

14