Week 11 - Friday

Network Programming (cont.)

School of Information Technology and Electrical Engineering
The University of Queensland

CSSE2310 7231

Outline

- C Network Programming
  - Concurrent servers – single process (`select()` function)
  - UDP Example
- 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"

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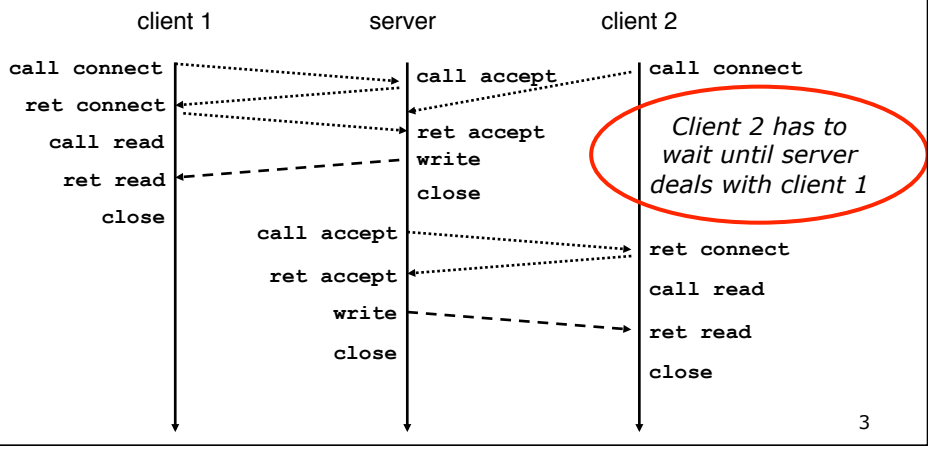
Iterative Servers

- Iterative servers process one request at a time



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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

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Event-Based Concurrent Servers Using I/O Multiplexing

- Maintain a set of connected descriptors and service each as new data arrives
- Repeat the following forever:
  - Use the Unix `select()` function to block until:
    (a) New connection request arrives on the listening descriptor, or
    (b) New data arrives on an existing connected descriptor
  - If (a), add the new connection to the pool of connections
  - If (b), read any available data from the connection
    - Close connection on EOF and remove it from the set

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The `select()` Function

- `select()` sleeps until one or more file descriptors in the set `readset` are ready for reading

```
#include <sys/select.h>

int select(int maxfdp1, fd_set *readset, NULL, NULL, NULL);
```

- `readset`
  - Opaque bit vector (max FD_SETSIZE bits) that indicates membership in a *descriptor set*
  - If bit k is 1, descriptor k is a member of the descriptor set
- `maxfdp1`
  - Maximum descriptor in descriptor set plus 1
  - Tests descriptors 0, 1, 2, ..., maxfdp1 - 1 for set membership
- `select()` returns number of ready descriptors and sets each bit of `readset` to indicate the ready status of corresponding descriptor

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Macros for Manipulating Set Descriptors

- `void FD_ZERO(fd_set *fdset);`
  - Turn off all bits in `fdset`
- `void FD_SET(int fd, fd_set *fdset);`
  - Turn on bit `fd` in `fdset`
- `void FD_CLR(int fd, fd_set *fdset);`
  - Turn off bit `fd` in `fdset`
- `int FD_ISSET(int fd, *fdset);`
  - Is bit `fd` in `fdset` turned on?

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Sample `select()` Server Code

- *To be discussed in class*

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Other options

- `poll()`
  - Does the same thing as select, but different interface
- `pselect(), ppoll()`
  - Can wait for a signal also

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UDP Example Code

- *To be discussed in class*

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Pro and Cons of Event-Based Designs

+ One logical control flow
+ Can single-step with a debugger
+ No process or thread control overhead
– More complex to code than process or thread-based designs
– Can be vulnerable to denial of service attack
  - How?

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Resources

- Beej's Guide to Network Programming
  - http://beej.us/guide/bgnet/ (section 7.2)
- Manual pages
  - On moss: `man <name>` or `man -s 2 <name>`
  - where `<name>` is socket, bind, connect, listen, accept, recv, send, …
  - Try `man select_tut`
- Glass & Ables, "UNIX for Programmers and Users"
- Rochkind, "Advanced UNIX Programming"
- Bryant and O'Halloran, "Computer Systems: A Programmer's Perspective"
- Other UNIX Programming books…
  - See Reference text list in course profile

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