

Issues in Client/Server Programming

Refs: Chapter 27

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Issues in Client Programming

- Identifying the Server.
- Looking up a IP address.
- Looking up a well known port name.
- Specifying a local IP address.
- UDP client design.
- TCP client design.

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Identifying the Server

- Options:
 - hard-coded into the client program.
 - require that the user identify the server.
 - read from a configuration file.
 - use a separate protocol/network service to lookup the identity of the server.

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Identifying a TCP/IP server.

- Need an IP address, protocol and port.
 - We often use *host names* instead of IP addresses.
 - usually the protocol (UDP vs. TCP) is not specified by the user.
 - often the port is not specified by the user.

 Can you name one common exception ?

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Services and Ports

- Many services are available via “well known” addresses (names).
- There is a mapping of service names to port numbers:


```
struct *servent getservbyname(  
    char *service, char *protocol );
```
- `servent->s_port` is the port number in network byte order.

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Specifying a Local Address

- When a client creates and binds a socket it must specify a local port and IP address.
- Typically a client doesn't care what port it is on:



```
haddr->port = htons(0);
```

give me any available port !

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Local IP address

- A client can also ask the operating system to take care of specifying the local IP address:

```
haddr->sin_addr.s_addr=  
    htonl(INADDR_ANY);
```


Give me the appropriate address

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UDP Client Design

- Establish server address (IP and port).
- Allocate a socket.
- Specify that any valid local port and IP address can be used.
- Communicate with server (send, recv)
- Close the socket.

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Connected mode UDP

- A UDP client can call `connect()` to establish the address of the server.
- The UDP client can then use `read()` and `write()` or `send()` and `recv()`.
- A UDP client using a connected mode socket can only talk to one server (using the connected-mode socket).

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TCP Client Design

- Establish server address (IP and port).
- Allocate a socket.
- Specify that any valid local port and IP address can be used.
- Call connect()
- Communicate with server (read,write).
- Close the connection.

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Closing a TCP socket

- Many TCP based application protocols support multiple requests and/or variable length requests over a single TCP connection.
- How does the server know when the client is done (and it is OK to close the socket) ?

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Partial Close

- One solution is for the client to shut down only it's writing end of the socket.
- The `shutdown()` system call provides this function.
`shutdown(int s, int direction);`
 - direction can be 0 to close the reading end or 1 to close the writing end.
 - shutdown sends info to the other process!

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TCP sockets programming

- Common problem areas:
 - null termination of strings.
 - reads don't correspond to writes.
 - synchronization (including close()).
 - ambiguous protocol.

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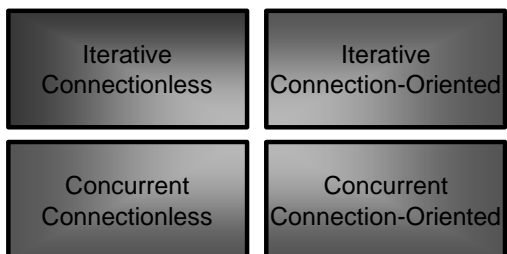
TCP Reads

- Each call to read() on a TCP socket returns any available data (up to a maximum).
- TCP buffers data at both ends of the connection.
- *You must be prepared to accept data 1 byte at a time from a TCP socket!*

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Server Design



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Concurrent vs. Iterative

Concurrent

Large or variable size requests
Harder to program
Typically uses more system resources

Iterative

Small, fixed size requests
Easy to program

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Connectionless vs. Connection-Oriented

Connection-Oriented

EASY TO PROGRAM
transport protocol handles the tough stuff.
requires separate socket for each connection.

Connectionless

less overhead
no limitation on number of clients

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Statelessness

- *State*: Information that a server maintains about the status of ongoing client interactions.
- Connectionless servers that keep state information must be designed carefully!

Messages can be duplicated!

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The Dangers of Statefulness

- Clients can go down at any time.
- Client hosts can reboot many times.
- The network can lose messages.
- The network can duplicate messages.

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Concurrent Server Design Alternatives

One child per client

Spawn one thread per client

Preforking multiple processes

Prethreaded Server

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One child per client

- Traditional Unix server:
 - TCP: after call to `accept()`, call `fork()`.
 - UDP: after `recvfrom()`, call `fork()`.
 - Each process needs only a few sockets.
 - Small requests can be serviced in a small amount of time.
- Parent process needs to clean up after children!!!! (call `wait()`).

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One thread per client

- Almost like using fork - call `pthread_create` instead.
- Using threads makes it easier (less overhead) to have sibling processes share information.
- Sharing information must be done carefully (use `pthread_mutex`)

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Pre**fork**()'d Server

- Creating a new process for each client is expensive.
- We can create a bunch of processes, each of which can take care of a client.
- Each child process is an iterative server.

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Pre**fork**()'d TCP Server

- Initial process creates socket and binds to well known address.
- Process now calls `fork`() a bunch of times.
- All children call `accept`() .
- The next incoming connection will be handed to one child.

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Preforking

- As the book shows, having too many preforked children can be bad.
- Using dynamic process allocation instead of a hard-coded number of children can avoid problems.
- The parent process just manages the children, doesn't worry about clients.

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Sockets library vs. system call

- A preforked TCP server won't usually work the way we want if *sockets* is not part of the kernel:
 - calling `accept()` is a library call, not an atomic operation.
- We can get around this by making sure only one child calls `accept()` at a time using some locking scheme.

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Prethreaded Server

- Same benefits as preforking.
- Can also have the main thread do all the calls to `accept()` and hand off each client to an existing thread.

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What's the best server design for my application?

- Many factors:
 - expected number of simultaneous clients.
 - Transaction size (time to compute or lookup the answer)
 - Variability in transaction size.
 - Available system resources (perhaps what resources can be required in order to run the service).

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Server Design

- It is important to understand the issues and options.
- Knowledge of queuing theory can be a big help.
- You might need to test a few alternatives to determine the best design.

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