CSCI-1680
Sockets and network programming

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Based partly on lecture notes by Rodrigo Fonseca, David Mazières, Phil Levis, John Jannotti

Administrivia

- Container setup: fill out form by TONIGHT
  - Whether or not you have it working

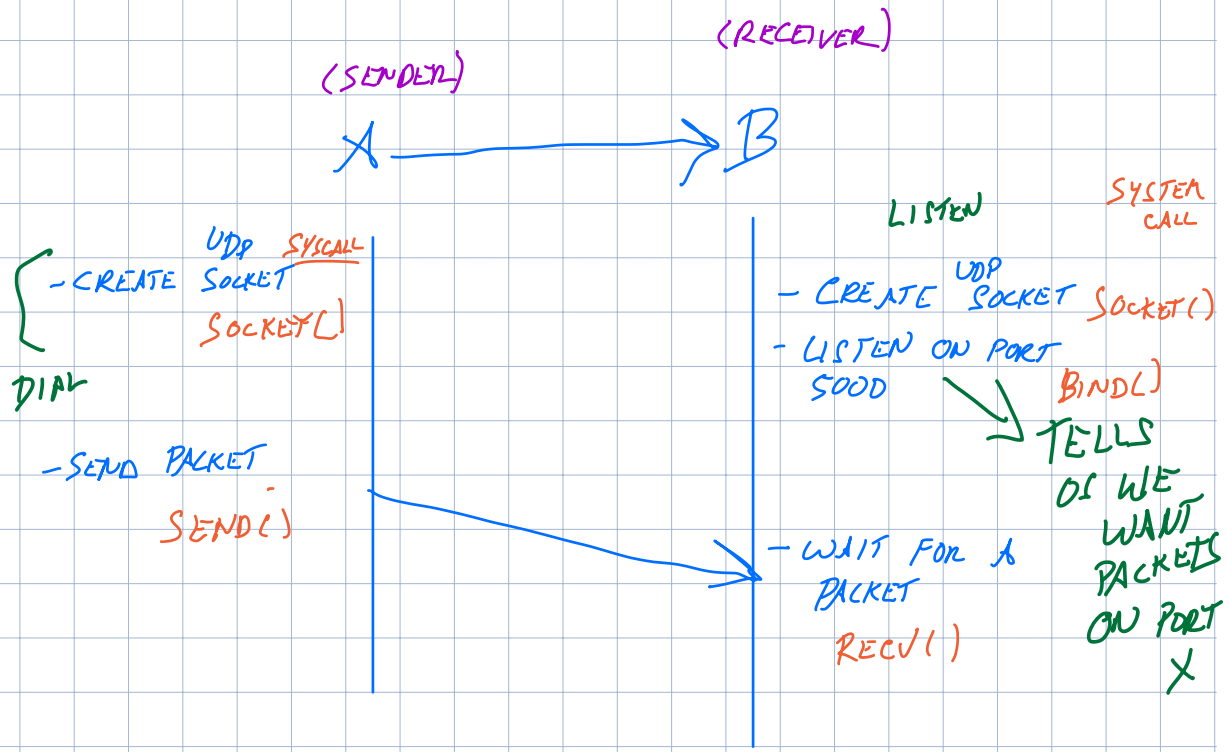
Snowcast is out!

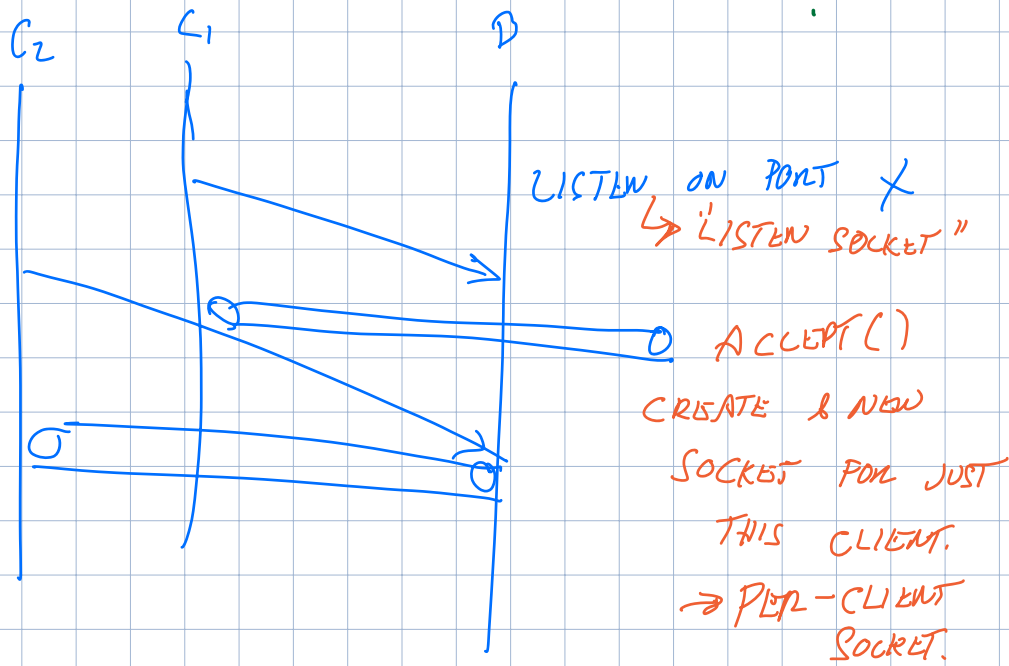
- Gearup Today 9/14 5-7pm CIT368 (+Zoom, recorded)
  - Look at the notes!
- Milestone due by Tuesday, 9/19 by 11:59pm EDT
  - Warmup + design doc

Topics for Today

- Working with sockets
- TCP & UDP
- Building a protocol

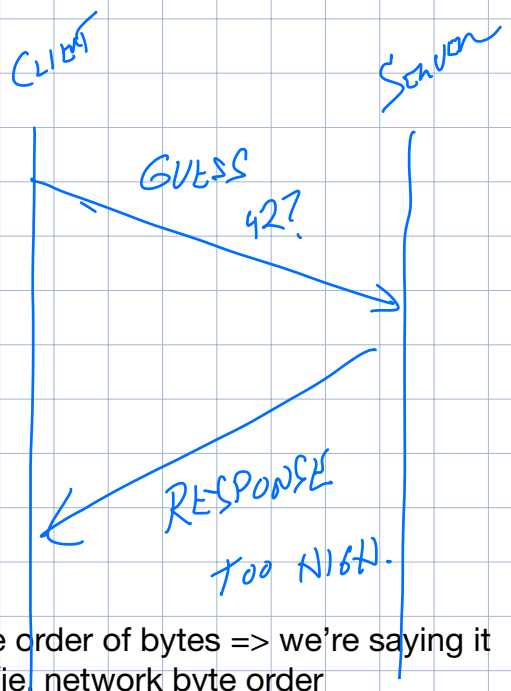
UDP EXAMPLE


(SENDER)
(RECEIVER)
A
B
LISTEN
SYSTEM CALL
UDP SYSCALL
- CREATE SOCKET
SOCKET()
DIAL
- SEND PACKET
SEND()
- CREATE UDP SOCKET SOCKET()
- LISTEN ON PORT 5000
BIND()
TELLS OS WE WANT PACKETS ON PORT X
- WAIT FOR A PACKET
RECV()

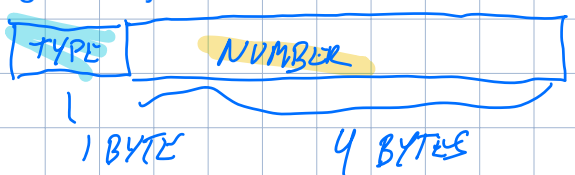

C2
C1
B
LISTEN ON PORT X
↳ "LISTEN SOCKET"
ACCEPT()
CREATE A NEW SOCKET FOR JUST THIS CLIENT.
→ PER-CLIENT SOCKET.

Client-server example: Guessing game

Server picks a random number
Clients connect and can guess numbers
Server responds with too high, too low, or correct
First client to respond wins, restarts game



As the designers, we get to decide on the format for how messages are exchanged
Here's our format. In this version, every message is 5 bytes:

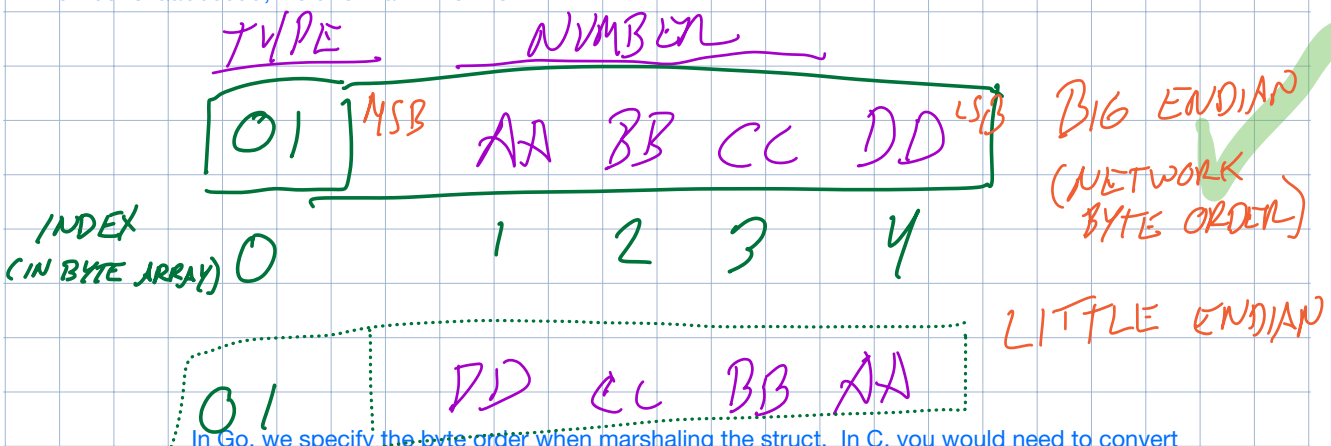


Protocol must give the order of bytes => we're saying it should be big endian (ie, network byte order

GUESS
TYPE = 0
NUMBER = GUESS

RESPONSE:
TYPE = 1
NUMBER = { 1 TOO HIGH
0 CORRECT!
-1 TOO LOW

When we format the message as a byte array, we order each field as in the picture above: first the type, then the number. For multi-byte data like integers, our protocol needs to specify the byte order (ie, the endianness) used to send the data "over the wire". In our protocol, we'll use big endian, or "network byte order." If our guess were the number 0xaabbccdd, we'd format it like this:



In Go, we specify the byte order when marshaling the struct. In C, you would need to convert the fields of your struct using helpers like ntohs(), htons(), etc, before casting your struct to a byte array and sending it.

Sockets: Communication Between Machines

- Network sockets are file descriptors too
- Datagram sockets (eg. UDP): unreliable message delivery
  - Send atomic messages, which may be reordered or lost
- Stream sockets (TCP): bi-directional pipes
  - *Stream* of bytes written on one end, read on another
  - Reads may not return full amount requested, must re-read

System calls for using TCP

Client

`socket` – make socket

`bind*` – assign address

`connect` – connect to listening socket

Server

`socket` – make socket

`bind` – assign address, port

`listen` – listen for clients

`accept` – accept connection

- This call to bind is optional, connect can choose address & port.

Socket Naming

- TCP & UDP name *communication endpoints*
  - IP address specifies host (128.148.32.110)
  - 16-bit port number demultiplexes within host
  - Well-known services listen on standard ports (*e.g.* ssh – 22, http – 80, mail – 25)
  - Clients connect from arbitrary ports to well known ports

- A connection is named by 5 components
  - Protocol, local IP, local port, remote IP, remote port

Dealing with Data

- Many messages are binary data sent with precise formats

- Data usually sent in Network byte order (Big Endian)
  - Remember to always convert!
  - In C, this is htons(), htonl(), ntohs(), ntohl()