

Socket Programming

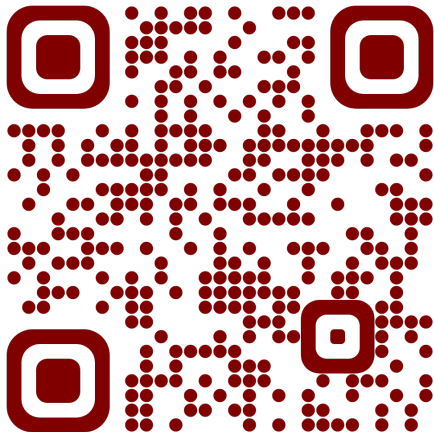
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<https://ratcoinc.github.io/Networks/>



WEB PAGE

Dealing with Partial Sends

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- Due to circumstances beyond our control, the kernel may decide not to send all the data
- The unsent data still resides in our buffer space
- It is now our responsibility to send the remaining data

Dealing with Partial Sends

One can write a small wrapper function¹:

```
int sendall(int sd, char *buf, int len) {
    int total = 0;          // how many bytes we've sent
    int bytesleft = len;   // how many we have left to send

    while(bytesleft > 0) {
        int n = send(sd, buf+total, bytesleft, 0);
        if (n < 0) { break; } // ERROR sendall failed
        total += n;
        bytesleft -= n;
    }

    return total; // return the actual number of bytes sent
}
```

¹Adapted from: <https://beej.us/guide/bgnet/html/index-wide.html#sendall>

Dealing with Partial Sends

A typical usage¹ of our wrapper method:

```
char buf[1024];  
.  
.  
.  
int len = strlen(buf);  
int n = sendall(sd, buf, len);  
if (n < len) {  
    perror("ERROR in sendall");  
    printf("We only sent %d bytes!\n", n);  
}
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How does the receiver know when one packet ends and another begins?
Data often needs to be *encapsulated*² in case of variable sized packets

¹Adapted from: <https://beej.us/guide/bgnet/html/index-wide.html#sendall>

²Data Encapsulation: <https://beej.us/guide/bgnet/html/index-wide.html#sonofdataencap>

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- Multiple processes are harder to coordinate, consume more resources, and sharing data also requires special treatments¹

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- What about using a non-blocking socket
`fcntl(sockfd, F_SETFL, O_NONBLOCK);`^{2,3}

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- Write an infinite loop, poll every socket for data, if no data is available we get -1

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- Write an infinite loop, poll every socket for data, if no data is available we get -1
- This is a bad idea! Program doing *busy-wait* consumes CPU time

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Monitoring Multiple Sockets

- A more elegant solution for monitoring multiple sockets is provided by `poll()`¹ and `select()`² APIs
- The OS does all the dirty work and lets us know when a socket is ready for I/O, while our process can sleep, saving system resources

¹Synchronous I/O Multiplexing: <https://beej.us/guide/bgnet/html/index-wide.html#poll>

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- A structure called `pollfd` is used with `poll()` API³

```
struct pollfd {    // defined in poll.h
    int fd;        // the socket descriptor to monitor
    short events;  // bitmap of events we want to monitor
    short revents; // returned bitmap of events that occurred
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- Two common events are `POLLIN` (socket is ready to be read)
`POLLOUT` (socket is ready for writing)

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The poll() API

```
#include <poll.h>
int poll(struct pollfd *fds, nfds_t nfds, int timeout);
```

waits for one of a given set of file descriptors to become ready for I/O

Return value: On success, returns a nonnegative value denoting the number of file descriptors on which some event (I/O or error) has happened. 0 is returned in case of a time-out. On error, -1 is returned.

Parameters:

fds: set of file descriptors to be monitored, negative fds are ignored

nfds: number of items in the **fds** array

timeout: the number of milliseconds that **poll()** should block waiting until either (1) a fd becomes ready, (2) interrupted by a signal handler, or (3) the timeout expires; a negative timeout waits forever

¹<https://man7.org/linux/man-pages/man2/poll.2.html>

²Note that, a monitored socket also returns 'ready to read' status (POLLIN) when a new incoming connection is ready to be accepted

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- List can be dynamically resized with `realloc()`- doubling/halving

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A Simple Poll Server

Run `server4.c`, then do two or more `telnet` to it
(message from one client is sent to all others)

Sending Data to Multiple Hosts

- **Broadcasting** sends the data to all hosts in the same local network
- For broadcast we need to use UDP (not TCP) and IPv4
- `SO_BROADCAST` needs to be enabled via `setsockopt()`¹
- The message can be sent to a specific subnet's broadcast address (e.g. 192.168.1.255 for subnet 192.168.1.0/24) or to the global broadcast address 255.255.255.255, aka `INADDR_BROADCAST`
- Avoid broadcast if possible, instead use multicast

¹<https://beej.us/guide/bgnet/html/index-wide.html#broadcast-packetshello-world>

Sending Data to Multiple Hosts

- **Multicasting** sends the data to a group of hosts in the same local network
- Here `IP_MULTICAST_IF` needs to be enabled via `setsockopt()`
- A multicast group is maintained using `IP_ADD_MEMBERSHIP` and `IP_DROP_MEMBERSHIP` through `setsockopt()`
- A class D address (224.0.0.0 to 239.255.255.255) is used as a multicast address
- A host can be part of multiple groups⁴

¹<http://www.cs.unc.edu/~jeffay/dirt/FAQ/comp249-001-F99/mcast-socket.html>

²<https://www.ibm.com/docs/en/aix/7.3?topic=sockets-ip-multicasts>

³https://docs.oracle.com/cd/E26502_01/html/E35299/sockets-137.html

⁴<https://stackoverflow.com/questions/9243292/subscribing-to-multiple-multicast-groups-on-one-socket>

A Simple Multicast Program

`server5.c`, `client5.c`

run the server in one terminal

run the client in two or more terminals

type strings in server, all client prints the message

¹Adapted from: <https://web.cs.wpi.edu/~claypool/courses/4514-B99/samples/multicast.c>