CS551
Warm-up Project #1

Bill Cheng

http://merlot.usc.edu/cs551-f12

Do You Know What You Are Sending To The Network?

```
typedef struct tagReqMsg {
    unsigned short MsgType;
    unsigned int Offset;
    unsigned char ServerDelay;
    unsigned int DataLen;
    char *Data;
} ReqMsg;

int SendReq(int n_socket)
{
    ReqMsg request;

    memset(&request, 0, sizeof(ReqMsg));
    /* fill up the request data structure */
    if (write(n_socket, &request, sizeof(ReqMsg)) == sizeof(ReqMsg)) {
        return 0;
    }
    switch (errno) {
    case EINTR: ...
    default:
        fprintf(stderr, "Unrecognized errno %ld in SendReq()\n", errno);
        break;
    }
    return (-1);
}
```

⇨ What does `sizeof()` do?

Memory Layout (Cont...)

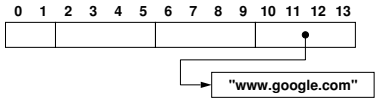
⇨ Is `sizeof(ReqMsg)` 11?

```
typedef struct tagReqMsg {
    unsigned short MsgType;
    unsigned int Offset;
    unsigned char ServerDelay;
    unsigned int DataLen;
    char *Data;
} ReqMsg;
```

⇨ Filling the data structure

```
unsigned short usAddrReqMsgType=(unsigned short)0xfe10;

request.MsgType = usAddrReqMsgType;
request.Offset = 0;
request.ServerDelay = 0;
request.DataLen = strlen("www.google.com");
request.Data = argv[3];
```



- this is incorrect

Memory Layout (Cont...)

- stream abstraction of TCP

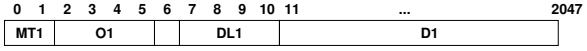
```
int msg_buf_sz=10+strlen("www.google.com")+1;
char *msg_buf=(char*)malloc(msg_buf_sz);

if (msg_buf == NULL) { fprintf(stderr, "malloc() failed\n"); ...
memset(msg_buf, 0, msg_buf_sz);
memcpy(msg_buf, &usAddrReqMsgType, 2); /* is this right? */
memcpy(&msg_buf[2], &request.Offset, 4); /* is this right? */
msg_buf[6] = &request.ServerDelay, 1;
memcpy(&msg_buf[7], &request.DataLen, 4); /* is this right? */
strcpy(&msg_buf[11], request.Data); /* is this right? */
...
send(msg_buf, ...);
```

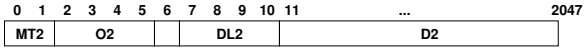
- need to call `htons()/htonl()` before sending and `ntohs()/ntohl()` after receiving
- in order to make sure a data object is 2/4 bytes long, you can use `uint16_t/unit32_t`
- there is really no difference between signed and unsigned
  - except in the context of negative numbers, then you need to watch out for sign extension

TCP's Stream Abstraction

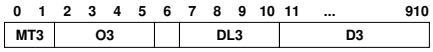
- 1st write: (*Note:* Assuming you can write up to 2048 bytes at a time)



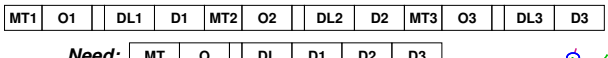
- 2nd write:



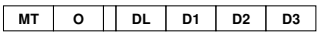
- 3rd write:



- Receiver *concatenates* all bytes received



Need:

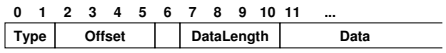


TCP's Stream Abstraction (Cont...)

- for warmup #1 (and warmup #1 only), you must read and write *one byte at a time*
  - this means that if you call `send()` or `write()` with the first argument being a socket descriptor, the 3rd argument must be 1

Warmup Project #1

- 3 request types
  - ADDR → ADR_REQ
  - FILESIZE → FSZ_REQ
  - GET → GET_REQ
- 3 reply types
  - ADR_RPLY
  - FSZ_RPLY
  - GET_RPLY
- other
  - ADR_FAIL
  - FSZ_FAIL
  - GET_FAIL
  - ALL_FAIL
- Client program commandline
  - `client {adr|fsz|get} [-d delay] [-o offset] \ [-m] hostname:port string`
- Message format



  - for requests, Data came from `string` in commandline
- Server program commandline
  - `server [-t seconds] [-m] port`

Examples

- ADDR

```
client adr nunki.usc.edu:6001 www.cs.usc.edu
<TAB>ADDR = 128.125.3.104
```

- FILE_SIZE

```
client fsz nunki.usc.edu:6001 /etc/passwd
<TAB>FILESIZE = 1030
```

- GET

```
client get nunki.usc.edu:6001 /bin/less
<TAB>FILESIZE = 104908, MD5 = f27df2e0...

client get -o 123 nunki.usc.edu:6001 /bin/less
<TAB>FILESIZE = 104785, MD5 = eccfd764...

openssl md5 /bin/less
MD5(/bin/less)= f27df2e0...
```


Many Requirements

- Please read the spec yourself for details
  - Ex:
    - separate compilation
    - buffer size limit
    - reading and writing one byte at a time
- Be careful with binary data
  - binary file contains binary data
  - MD5 buffer contains binary data
  - write a function to print binary data correctly
    - if you use "`%x`" in `printf()`, the corresponding data is assume to be a signed integer
    - if the most significant bit is 1, will cause sign-extension

Some Major Requirements for *All* Projects

- Severe pentalty for failing `make`
- Severe pentalty for using large memory buffers
- Severe pentalty for any segmentation fault -- you must test your code well
- Severe pentalty for not using separate compilation or for having all your source code in header files -- you must learn to plan how to write your program
- Never do *busy-wait*
  - run "`top`" on nunki
  - don't stay in a tight loop and poll
    - just sleep for 50-100 milliseconds before poll again
  - use blocking I/O and sockets

Separate Compilation

- Break up your code into *modules*
  - *compile the modules separately*, at least one rule per module per rule in the `Makefile`
  - a separate rule to *link* all the modules together
    - if your program requites additional libraries, add them to the link stage
- To receive full credit for separate compilation
  - to create an executable, at a minimum, you must run the compiler at least *twice* and the linker *once*
  - for warmup #1, there are two executables, they can share modules

Code Design - Functional vs. Procedural

- Don't design your program "procedurally"
- You need to learn how to write functions!
  - a function has a well-defined interface
    - what are the meaning of the parameters
    - what does it suppose to return
  - pre-conditions
    - what must be true when the function is entered
    - you assume that these are true
      - you can verify it if you want
  - post-conditions
    - what must be true when the function returns
  - you design your program by making designing a sequence of function calls

Sticky Issues

- Your server must shutdown *gracefully*
  - wait for all child threads/processes to terminate before the server terminates itself
    - must not kill child threads/processes abruptly
    - send signals to child threads/processes
      - a child thread/process must be prepared to handle this and self-terminates
      - a child thread/process should react as soon as possible
      - since we are read the socket one byte as a time, you should check if it's time to quit after reading a byte or if `select()` times out (after ~100ms)
      - since we are writing to the socket one byte as a time, you should check if it's time to quit after writing out a byte

Sticky Issues (Cont...)

- Your server must shutdown *gracefully* (cont...)
  - in order to do this, the server needs to know which child thread/process has terminated
    - keep a list of child thread/process IDs
    - more trickly if you use child processes
      - should handle SIGCHLD explicitly (i.e., need to reap child processes)
      - call `waitpid()` in SIGCHLD handler
      - watch out for a *race condition*

Race Condition

- Race condition (only if you use `fork()`)
  - SIGCHLD handler:

```
void sigchld_handler(...) {
  for (;;) {
    pid = waitpid((pid_t)(-1), &status, WNOHANG);
    if (pid == 0) break; /* == 0 for Linux, <= for Solaris */
    remove_from_list(pid);
  }
}
```

  - server infinite loop:

```
for (;;) {
  newsockfd = accept(nSocket, ...);
  if (newsockfd > 0) {
    int pid=fork();

    if (pid == 0) {
      close(nSocket);
      child_processing(newsockfd);
      exit(0);
    }
    close(newsockfd);
    add_to_list(pid);
  }
```

  - what if `remove_from_list()` happens first?

Race Condition (Cont...)

- Fix for the race condition (only if you use `fork()`)
  - block SIGCHLD until `add_to_list()` is finished

```
for (;;) {
  newsockfd = accept(nSocket, ...);
  if (newsockfd > 0) {
    sigprocmask(SIG_BLOCK, ...);
    int pid=fork();

    if (pid == 0) {
      close(nSocket);
      sigprocmask(SIG_UNBLOCK, ...);
      child_processing(newsockfd);
      exit(0);
    }
    close(newsockfd);
    add_to_list(pid);
    sigprocmask(SIG_UNBLOCK, ...);
  }
}
```

- Maybe it's easier just to use pthread and mutex
  - also warms you up for warmup project #2
  - but you need to learn how to deliver signal to a specific thread - see beginning of Warmup Project #2 slides