CSE 333 – SECTION 3

POSIX I/O Functions

Administrivia

- **New TAs!**
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- **HW1 Due Tonight**
- HW2 Due Thursday April 27th
- Midterm on May 5th

- (And regular exercises in between)

Basic File Operations

- Open the file
- Read from the file
- Write to the file
- Close the file / free up resources

System I/O Calls

```
int open(char* filename, int flags, mode_t mode);
```

Returns an integer which is the file descriptor.
Returns -1 if there is a failure.

filename : A string representing the name of the file.
flags : An integer code describing the access.

O_RDONLY -- opens file for read only
O_WRONLY – opens file for write only
O_RDWR – opens file for reading and writing
O_APPEND --- opens the file for appending
O_CREAT -- creates the file if it does not exist
O_TRUNC -- overwrite the file if it exists

mode: File protection mode. Ignored if O_CREAT is not specified.

`[man 2 open]`

System I/O Calls

```
ssize_t read(int fd, void *buf, size_t count);
ssize_t write(int fd, const void *buf, size_t count);
```

fd: file descriptor.

buf: address of a memory area into which the data is read.

count: the maximum amount of data to read from the stream.

The return value is the actual amount of data read from the file.

```
int close(int fd);
```

Returns 0 on success, -1 on failure.

[man 2 read]
[man 2 write]
[man 2 close]

Errors

- When an error occurs, the error number is stored in **errno**, which is defined under <errno.h>
- View/Print details of the error using **perror()** and **errno.**
- POSIX functions have a variety of error codes to represent different errors. Some common error conditions:
  - **EBADF -** *fd* is not a valid file descriptor or is not open for reading.
  - **EFAULT -** *buf* is outside your accessible address space.
  - **EINTR -** The call was interrupted by a signal before any data was read.
  - **EISDIR -** *fd* refers to a directory.
- errno is shared by all library functions and overwritten frequently, so you must read it right after an error to be sure of getting the right code

[man 3 errno]

[man 3 perror]

Reading a file

```
#include <errno.h>
#include <unistd.h>

...

  char *buf = ...;     // buffer has size n
  int bytes_left = n;  // where n is the length of file in bytes
  int result = 0;

  while (bytes_left > 0) {
     result = read(fd, buf + (n-bytes_left), bytes_left);
     if (result == -1) {
       if (errno != EINTR) {
        // a real error happened, return an error result
       }
       // EINTR happened, do nothing and loop back around
       continue;
     }
     bytes_left -= result;
  }
```

Reading a file

```
#include <errno.h>
#include <unistd.h>
#define N 2048

char buf...;  // buffer size unspecified
int bytes_read = 0;
int result = 0;
int fd = open("filename", O_RDONLY);

while (bytes_read < N) {
  // Read from the file
  result = read(fd, buf + bytes_read, N - bytes_read);
  if (result == -1) {
    if (errno != EINTR) {
      // a real error happened, return an error result
    }
    continue;  // EINTR happened, loop back and try again
  }
  bytes_read += result;
}
```

Reading a file

```
#include <errno.h>
#include <unistd.h>
#define N 2048

char buf...;  // buffer size unspecified
int bytes_read = 0;
int result = 0;
int fd = open("filename", O_RDONLY);
// BUG: if filesize < N, infinite loop!
while (bytes_read < N) {
  // BUG: if N >= buf size, buffer overflow!
  result = read(fd, buf + bytes_read, N - bytes_read);
  if (result == -1) {
    if (errno != EINTR) {
      // a real error happened, return an error result
    }
    continue;  // EINTR happened, loop back and try again
  }
  bytes_read += result;
}
```

Again, why are we learning POSIX functions?

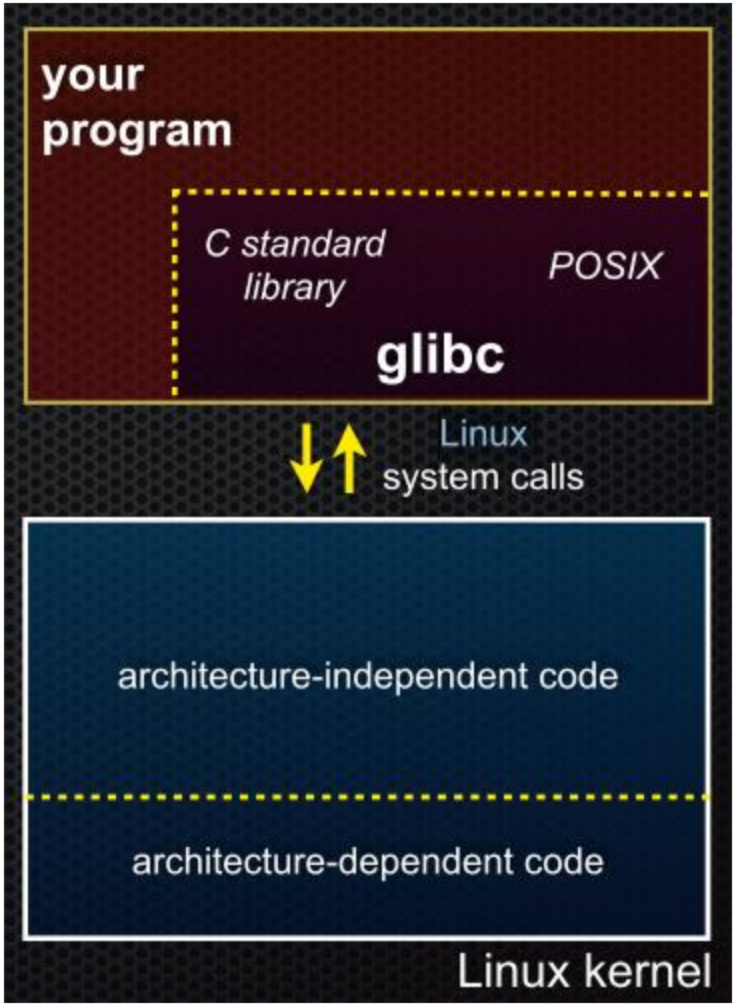
- They are unbuffered. You can implement different buffering/caching strategies on top of read/write.
- More explicit control since read and write functions are system calls and you can directly access system resources.
- There is no standard higher level API for network and other I/O devices.

STDIO vs. POSIX Functions

- User mode vs. Kernel mode.

- STDIO library functions
  - – fopen, fread, fwrite, fclose, etc. use FILE* pointers.

- POSIX functions
  - – open, read, write, close, etc. use integer file descriptors.



Directories

- Accessing directories:
  - Open a directory
  - Iterate through its contents
  - Close the directory
- Opening a directory:

```
DIR *opendir(const char* name);
```

  - Opens a directory given by **name** and provides a pointer **DIR*** to access files within the directory.
- Don’t forget to close the directory when done:

```
int closedir(DIR *dirp);
```

```
[man 0P dirent.h]
[man 3 opendir]
[man 3 closedir]
```

Directories

- Reading a directory file.

```
struct dirent *readdir(DIR *dirp);

struct dirent {
  ino_t          d_ino;    /* inode number for the dir entry */
  off_t          d_off;    /* not necessarily an offset */
  unsigned short d_reclen; /* length of this record */
  unsigned char  d_type;   /* type of file (not what you think);
                            not supported by all file system types */
  char           d_name[NAME_MAX+1] ; /* directory entry name */
};
```

```
[man 3 readdir]
[man readdir]
```

Read the man pages

- **man, section 2: Linux system calls**
  - `man 2 intro`
  - `man 2 syscalls`
  - `man 2 open`
  - `man 2 read`
- …
- **man, section 3: glibc / libc library functions**
  - `man 3 intro`
  - `man 3 fopen`
  - `man 3 fread`
  - `man 3 stdio` for a full list of functions declared in `<stdio.h>`
- …

Section Exercises 1 & 2

Find a partner if you wish.

1. Write a C program that given a directory:

- Prints the names of the entries to stdout
- Analogous to the bash command **ls**

2. Write a C program that given a filename:

- Prints the contents of the file to stdout
- Analogous to the bash command **cat**

You must use POSIX functions! And handle any errors! :)