

CSE 333 Section 3 - POSIX I/O Functions

Welcome back to section! We're glad that you're here :)

Usage

POSIX has similar file I/O operations as the C stdio library, but unbuffered by default, including:

```
int open(char *name, int flags);
```

- *name* is a string representing the name of the file. Can be relative or absolute.
- *flags* is an integer code describing the access. Some common flags are listed below:
 - ◆ `O_RDONLY` - Open the file in read-only mode.
 - ◆ `O_WRONLY` - Open the file in write-only mode.
 - ◆ `O_RDWR` - Open the file in read-write mode.
 - ◆ `O_APPEND` - Append new information to the end of the file.

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

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

→ *fd* is the file descriptor (as returned by `open()`).

★ Returns 0 on success, -1 on failure.

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

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

- *fd* is the file descriptor (as returned by `open()`).
- *buf* is the address of a memory area into which the data is read or written.
- *count* is the maximum amount of data to read from or write to the stream.
- ★ Returns the *actual* amount of data read from or written to the file.

POSIX and Errors

Unfortunately, errors are not handled as nicely for the user as they are in the C stdio library. So it is important to make sure your code handles errors gracefully. Note that:

- When an error occurs, the error number is stored in `errno` (defined in `<errno.h>`).
- You can use `perror()` to print out a message based on `errno`.
- Remember that `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.

POSIX functions have a variety of error codes to represent different errors. Some common error conditions include:

- ◆ `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.
- ◆ `EAGAIN` - *fd* refers to a file other than a socket and has been marked nonblocking, and the read/write blocks.
- ◆ `EISDIR` - *fd* refers to a directory.

`EAGAIN` and `EINTR` are recoverable errors, unlike the rest.

Exercise 1:

A common use of the POSIX I/O function is to **write** to a file; fill in the code skeleton below that writes all of the contents of a string `buf` to the file `333.txt`.

```
int fd = _____; // open 333.txt
int n = ....;
char *buf = ..... ; // Assume buf initialized with size n
int result;

_____ ; // initialize variable for loop

... // code that populates buf happens here

while ( _____ ) {
    result = write( _____ );
    if (result == -1) {
        if (errno != EINTR && errno != EAGAIN) {
            // a real error happened, return an error result
            _____ ; // cleanup
            perror("Write failed");
            return -1;
        }
        continue; // EINTR or EAGAIN happened, so loop and try again
    }
    _____ ; // update loop variable
}
_____ ; // cleanup
```

Follow-up Questions

Why is it important to store the return value from the `write()` function? Why do we not check for a return value of 0 like we do for `read()`?

Why is it important to remember to call the `close()` function once you have finished working on a file?

POSIX and directories

POSIX calls can also be used to access directories. This is because in Linux, directories are nothing more than special files. An example workflow might be: open a directory, iterate through directory contents, close the directory.

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

→ *name is the directory to open. Accepts relative and absolute paths. Can end with '/', but is not necessary.*

★ Returns a pointer `DIR*` to the directory stream or `NULL` on error (with `errno` set).

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

→ *dirp is the directory stream to close.*

★ Returns 0 on success or -1 on error (with `errno` set).

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

→ *dirp is the directory stream to process.*

★ Returns a pointer to a `dirent` structure representing the next directory entry in the directory stream or returns `NULL` on error or reaching the end of the directory stream.

On Linux, the `dirent` structure is defined as follows:

```
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 */
};
```

Exercise 2:

Given the name of a directory, write a C program that is analogous to `ls`, *i.e.* prints the names of the entries of the directory to `stdout`. Be sure to handle any errors!

Example usage: `./dirdump <path>` where `<path>` can be absolute or relative.

```
int main(int argc, char** argv) {
    /* 1. Check to make sure we have a valid command line arguments */

    /* 2. Open the directory, look at opendir() */

    /* 3. Read through/parse the directory and print out file names
       Look at readdir() and struct dirent */

    /* 4. Clean up */

}
```

Bonus Exercise

Given the name of a file as a command-line argument, write a C program that is analogous to `cat`, *i.e.* one that prints the contents of the file to `stdout`. Handle any errors!

Example usage: `./filedump <path>` where `<path>` can be absolute or relative.

```
int main(int argc, char** argv) {
    /* 1. Check to make sure we have valid command line arguments */

    /* 2. Open the file, use O_RDONLY flag */

    /* 3. Read from the file and write it to standard out. Try doing
       this without using printf() and instead have write() pipe to
       stdout (take a look at STDOUT_FILENO). It might be helpful to
       initialize a buffer variable (of size 1024 bytes should be
       fine) to pass in to read() and write(). */

    /*4. Clean up */

}
```