

Computer Science & Engineering 155E

Computer Science I: Systems Engineering Focus

Lecture – File Processing

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Introduction

- ▶ Up to now, all input/output has been via the standard interface
- ▶ Standard Input: `stdin`, keyboard
- ▶ Standard Output: `stdout`, console
- ▶ Useful to save, load, process data to/from a *file*
- ▶ Actually: `stdout`, `stdin` are files!

Files

- ▶ *Files* are collections of data stored on secondary media (disks)
- ▶ Files can either be text files or data (binary) files
- ▶ Text files contain printable ASCII text characters
- ▶ Binary files contain pure binary data: 0s and 1s
- ▶ Every file has an **EOF** (end of file) marker
- ▶ Files sometimes referred to as *streams*

File Processing

File Pointers

- ▶ C has a built-in file type: `FILE`
- ▶ All functions dealing with `FILE` types are by *reference*
- ▶ Best to only deal with file *pointers*
- ▶ Declaration:

```
FILE *myInputFile = NULL;
FILE *myOutputFile = NULL;
```
- ▶ Best practice: assign a `NULL` value in declaration

Opening Files

- ▶ Open file streams using `fopen`:

```
FILE *fopen(const char *path, const char *mode);
```
- ▶ First argument: string of the *path* of the file
- ▶ Second argument: open mode
- ▶ Return type: a pointer to the file stream

Opening Files

File Path

- ▶ Default: current directory (the directory the program is executed in)
- ▶ Path may be *absolute*:

```
"/home/grad/cbourke/cse150a/program01/file.txt"
```
- ▶ or *relative*:

```
"../file.txt"
"file.txt"
```

Opening Files

Mode

Second argument: string indicating the *mode*

- r** Open text file for reading. The stream is positioned at the beginning of the file.
- r+** Open for reading and writing. The stream is positioned at the beginning of the file.
- w** Truncate file to zero length or create text file for writing. The stream is positioned at the beginning of the file.
- w+** Open for reading and writing. The file is created if it does not exist, otherwise it is truncated. The stream is positioned at the beginning of the file.
- a** Open for appending (writing at end of file). The file is created if it does not exist. The stream is positioned at the end of the file.
- a+** Open for reading and appending (writing at end of file). The file is created if it does not exist. The initial file position for reading is at the beginning of the file, but output is always appended to the end of the file.

Opening Files

Binary Mode

- ▶ Some systems recognize the **b** flag in the mode argument
- ▶ Used to indicate the file will be opened for *binary* read/write
- ▶ Ignored in POSIX systems (used for C89 compatibility)
- ▶ Unnecessary on CSE

Opening Files

Code Snippet

```
1 FILE *myInputFile = NULL;
2 FILE *myOutputFile = NULL;
3 myInputFile = fopen("data.txt", "r");
4 myOutputFile = fopen("results.txt", "w");
```

Opens two files: one for read, one for write, in the current working directory

Opening Files

Handling Problems

- ▶ Opening files can fail
- ▶ File not found, program doesn't have permissions, etc.
- ▶ In the event of failure, `fopen` returns `NULL`
- ▶ Best practice: check for file open failure

```
1 if(myInputFile == NULL)
2 {
3     printf("Opening file, data.txt failed, quitting...\n");
4     exit(-1);
5 }
```

Processing Text Files

- ▶ The standard input/output uses `scanf` and `printf`
- ▶ Processing input/output with files uses `fscanf` and `fprintf`
- ▶ Both process from any given file stream
- ▶ Full function definitions:

```
int fprintf(FILE *stream, const char *format, ...);
int fscanf(FILE *stream, const char *format, ...);
```

Processing Text Files

- ▶ First argument: file stream
- ▶ Second: string representing format
- ▶ Same placeholders and formatting rules as `printf`, `scanf`
- ▶ Followed by list of variables

```
1 fscanf(myInputFile, "%d", &aNumber);
2 fprintf(myOutputFile, "Hey, I read %d! Neato!\n", aNumber);
```

Processing Text Files

End of File

- ▶ The special EOF (end-of-file) character lets you know when the end of the file has been reached
- ▶ `fscanf` either returns the number of successfully matched placeholders or EOF
- ▶ Useful when processing to the end of a file

```
1 /* read in the first integer: */
2 int nums[100], i = 0;
3 int status = fscanf(myInputFile, "%d", &nums[i]);
4 while(status != EOF) {
5     i++;
6     /* status is number of successful items read */
7     status = fscanf(myInputFile, "%d", &nums[i]);
8 }
```

Closing Files

Close a file using `fclose` (file close)

```
1 fclose(myInputFile);
2 fclose(myOutputfile);
```

Failure to close may result in corrupted files.

File Formats

- ▶ Reading files essentially requires you to know in advance what format they are
- ▶ Assumption: the file actually follows the format
- ▶ If formats are not followed, undefined behavior?
- ▶ No program can handle every possible contingency
- ▶ Other, more complex solutions exist

Misc

- ▶ You can think of a file stream as simply another output/input device
- ▶ In fact, `stdin`, `stdout` are also technically file streams
- ▶ Everything in a unix system is a file!
- ▶ The following have the same effect:
`printf("Standard output via printf!\n");`
`fprintf(stdout, "Standard output via fprintf!\n");`

Binary Files

- ▶ *Binary* files are files that have no encoding: strictly 0s and 1s
- ▶ Less resource intensive
- ▶ No delimiters necessary
- ▶ Input/output streams are declared exactly the same:
`FILE *binaryOutputFile = fopen("file.dat", "w");`

Binary File Processing I

- ▶ For binary files, we use `fread` and `fwrite` instead of `fscanf`/`fprintf`
- ▶ Full function definitions:

```
1 size_t fread(void *ptr,
2             size_t size,
3             size_t nmemb,
4             FILE *stream);
5 size_t fwrite(const void *ptr,
6             size_t size,
7             size_t nmemb,
8             FILE *stream);
```

Binary File Processing II

► Arguments:

1. `*ptr` is a pointer to the item that is being read/written
2. `size` is the number of bytes that the item `ptr` is pointing to requires.
3. `nmemb` is the number of items to be written/read
4. `stream` is the file stream to be read from/written to

► Return value: number of successfully read/written items

Binary File Processing

Example

```
1 int aNumber;
2 fread(&aNumber, sizeof(int), 1, binaryInputFile);
3 fwrite(&aNumber, sizeof(int), 1, binaryOutputFile);
```

The formatting of a file must be consistent if it is ever to be read properly again.

Binary versus Text: A demonstration I

```
1 #include<limits.h>
2 #include<stdlib.h>
3 #include<stdio.h>
4
5 int main(void) {
6     /* 2^31 = 2147483647 is the maximum value a signed
7     integer can take; confirm this using limits.h:
8     it defines a macro, INT_MAX, that holds the
9     maximum value a signed integer can take
10    */
11    printf("int's maximum value = %d\n", INT_MAX);
12    printf("int's take %d bytes to store\n", sizeof(int));
13    int a = 2147483647;
14    printf("a = %d\n", a);
15
16    /* */
```

Binary versus Text: A demonstration II

```
17 /* now output this to a regular file */
18 FILE *myStringInteger = fopen("aNumber.txt", "w");
19 fprintf(myStringInteger, "%d", a);
20 fclose(myStringInteger);
21
22 /* now output this to a *binary* file */
23 FILE *myBinaryInteger = fopen("aNumber.bin", "wb");
24 fwrite(&a, sizeof(int), 1, myBinaryInteger);
25 fclose(myBinaryInteger);
26
27 /* How big is each file and why? */
28 }
```

Exercise: File Adder I

Write a program that opens a plain-text file (read as an argument from the command line) containing integers delimited by white space. Echo the sum to the standard output and also store it in a file called `sum.txt`

Exercise: Book

Do Programming project 6 from Chapter 12