Introduction to Programming

Week – *9*, Lecture – *2*

File Handling in C – Part 1

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Binary files are a sequence of bytes, whose interpretation is application-specific

- Thus, the binary file created by one class of applications is usually incompatible with other applications

A Differentiating Example

If you store the number `0` in a text file, it occupies just one byte of space

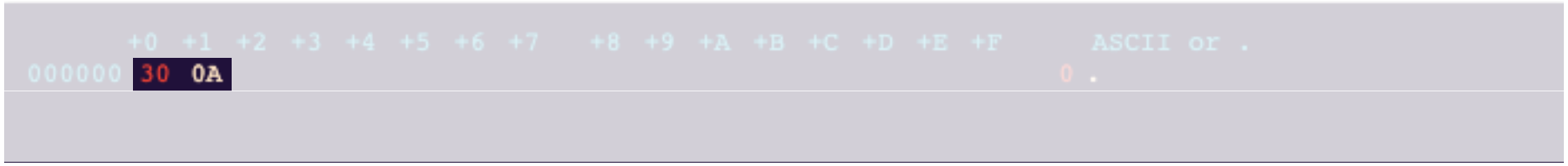
- If the encoding is ASCII, what is stored, is the binary representation of `48` – i.e. `0`'s ASCII code

A Differentiating Example

```
      +0  +1  +2  +3  +4  +5  +6  +7   +8  +9  +A  +B  +C  +D  +E  +F     ASCII or .
000000 30  0A                                                          0 .
```

This is the content of a text file, containing a single character, ‘0’ and a linefeed character

A Differentiating Example



30 in hexadecimal means 48, and 0A is 10 in hexadecimal (the ASCII code for a line feed)

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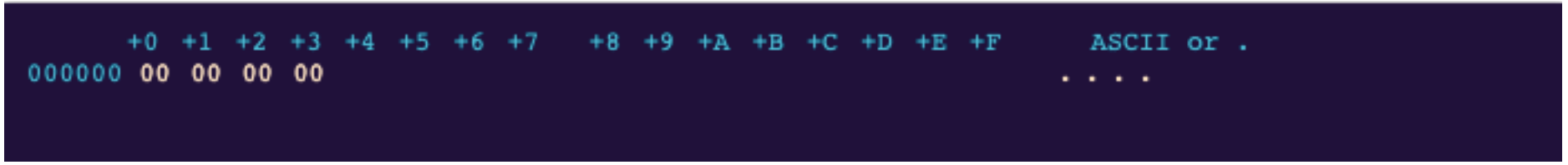
If you store the number `0` in a binary file, say as an integer, it may occupy two or four bytes…

- … depending on the number of bytes that integers take on that machine
- What is stored is the binary representation of `0` in 16 or 32 bits

A Differentiating Example



This is the content of a binary file, containing a single integer 0

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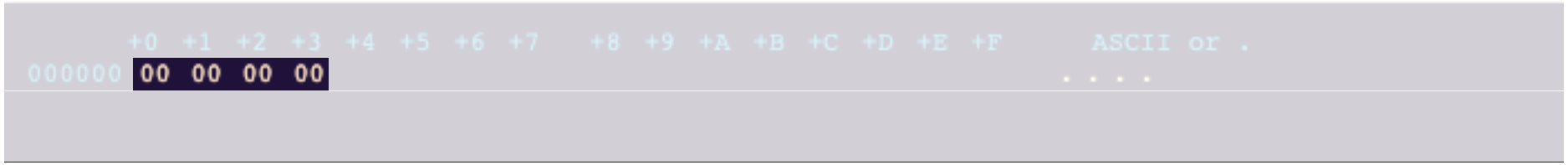

0 is being represented in 4 bytes as well, by “all zeroes”

Accessing files through Programs

When you attempt to work with a file through a program, you should know the type of the file…

- … i.e., text or binary (as well as any related encoding or format)

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- Reading from text files
- Writing to text files
- Reading from binary files
- Writing to binary files

Based on your needs, you must pick the correct set of library resources for your task

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When done, the `FILE` pointer is passed to the `fclose()` function to free up any allocated resources

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Both the functions expect a `FILE` pointer as input, with the file opened in writing mode

If you write a string, they essentially write each character in that string to the file, in that order

Example – Writing a simple string

```c
#include<stdio.h>
#include<string.h>

int main()
{
        char str[102];
        char file_name[22];
        FILE* fptr = NULL;

        printf("Enter a message (up to 100 characters): ");
        fgets(str, 100, stdin);

        printf("Enter the name of the file to store the message (max 20 chars): ");
        fgets(file_name, 20, stdin);
        file_name[strlen(file_name)-1] = '\0'; // To remove the extra \n character

        fptr = fopen(file_name, "w"); //"w" - write

        fprintf(fptr, "%s", str);

        printf("Saved your message in %s. Use the MessageReader program to read it.\n", file_name);

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The first step, as discussed, is to open the file in a writing mode, and obtain a `FILE` pointer to it

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`fprintf()` is exactly like `printf()`, with one additional input – a `FILE` pointer

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Finally, we close the resources associated with the file by calling the `fclose()` function

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```
saurabh@saurabh-VirtualBox:~/C/examples/Week 9$ gcc -o MessageSaver MessageSaver.c
saurabh@saurabh-VirtualBox:~/C/examples/Week 9$ ./MessageSaver
Enter a message (up to 100 characters): This is a sample message
Enter the name of the file to store the message (max 20 chars): message.txt
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The message gets saved as *readable text* in the chosen file

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The obtained `FILE` pointer is required in either case

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The start is fairly similar – getting the `FILE` pointer in the correct access mode

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The read may terminate before 100 characters, if a `\n` character is found

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This is the same string that we wrote to the file

A word about binary files

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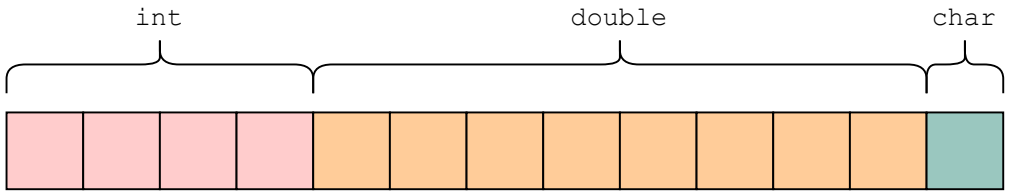
- This will write a total of 13 bytes to the file, in that precise order, as shown



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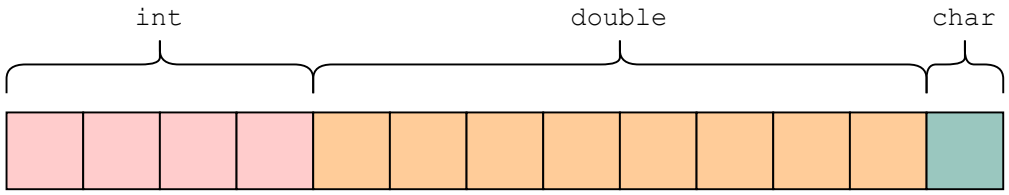

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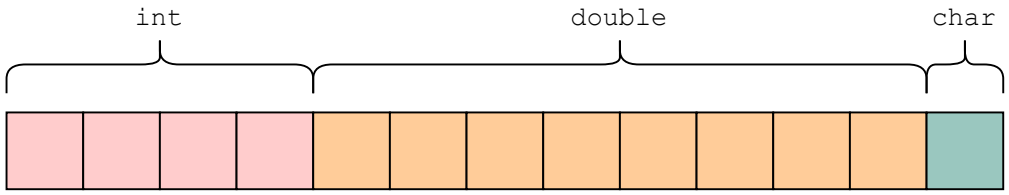
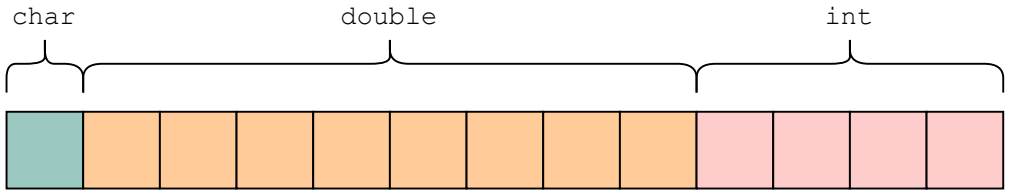


- The file itself will just look like a set of 13 bytes (which can be interpreted in multiple ways)
- While reading, we must be aware of the format used for creating the file, since it can also be interpreted as



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You'll need to provide the following to this function

- The `FILE` pointer, as always
- The size of the data type that you wish to write (e.g. `4` for `int` or `8` for `double`)
- The number of elements to write – this makes sense when you are writing an array; otherwise it is `1`
- A pointer to the data to be written – or the name of the array, if more than one elements are to be written

Example – Writing a list of integers

```c
int number_of_elements, i;
int* elements = NULL;
FILE* fptr = NULL;
char file_name[22];

printf("Enter the number of integers in your list: ");
scanf("%d", &number_of_elements);

elements = (int*) malloc(sizeof(int) * number_of_elements);
printf("Enter the elements of the list:\n");
for(i = 0; i < number_of_elements; i++)
        scanf("%d", &elements[i]);

clean_stdin();

printf("Enter the name of the file to store the list (max 20 chars): ");
fgets(file_name, 20, stdin);

file_name[strlen(file_name)-1] = '\0'; // To remove the extra \n character

fptr = fopen(file_name, "wb"); //"w" - write, "b" - in binary mode (instead of text)

// Write the size of the list first
fwrite(&number_of_elements, sizeof(int), 1, fptr);

// Now write the list
fwrite(elements, sizeof(int), number_of_elements, fptr);

printf("Saved your list in %s. Use the ListReader program to read it.\n", file_name);

free(elements);
fclose(fptr);
```

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        scanf("%d", &elements[i]);

clean_stdin();

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fgets(file_name, 20, stdin);

file_name[strlen(file_name)-1] = '\0'; // To remove the extra \n character

fptr = fopen(file_name, "wb"); //"w" - write, "b" - in binary mode (instead of text)

// Write the size of the list first
fwrite(&number_of_elements, sizeof(int), 1, fptr);

// Now write the list
fwrite(elements, sizeof(int), number_of_elements, fptr);

printf("Saved your list in %s. Use the ListReader program to read it.\n", file_name);

free(elements);
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```

The starting point is similar, getting the `FILE` pointer…

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file_name[strlen(file_name)-1] = '\0'; // To remove the extra \n character

fptr = fopen(file_name, "wb"); //"w" - write, "b" - in binary mode (instead of text)

// Write the size of the list first
fwrite(&number_of_elements, sizeof(int), 1, fptr);

// Now write the list
fwrite(elements, sizeof(int), number_of_elements, fptr);

printf("Saved your list in %s. Use the ListReader program to read it.\n", file_name);

free(elements);
fclose(fptr);
```

The starting point is similar, getting the `FILE` pointer…

… but with `fopen()`, the suffix `b` needs to be provided in the access mode string

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int number_of_elements, i;
int* elements = NULL;
FILE* fptr = NULL;
char file_name[22];

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elements = (int*) malloc(sizeof(int) * number_of_elements);
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fclose(fptr);
```

Next, we first write the number of integers in the list

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int number_of_elements, i;
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fptr = fopen(file_name, "wb"); //"w" - write, "b" - in binary mode (instead of text)

// Write the size of the list first
fwrite(&number_of_elements, sizeof(int), 1, fptr);

// Now write the list
fwrite(elements, sizeof(int), number_of_elements, fptr);

printf("Saved your list in %s. Use the ListReader program to read it.\n", file_name);

free(elements);
fclose(fptr);
```

Next, we first write the number of integers in the list

Note that `number_of_elements` is an `int` variable, and we have given `1` as the argument for number of elements to write

Example – Writing a list of integers

```
int number_of_elements, i;
int* elements = NULL;
FILE* fptr = NULL;
char file_name[22];

printf("Enter the number of integers in your list: ");
scanf("%d", &number_of_elements);

elements = (int*) malloc(sizeof(int) * number_of_elements);
printf("Enter the elements of the list:\n");
for(i = 0; i < number_of_elements; i++)
        scanf("%d", &elements[i]);

clean_stdin();

printf("Enter the name of the file to store the list (max 20 chars): ");
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file_name[strlen(file_name)-1] = '\0'; // To remove the extra \n character

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// Now write the list
fwrite(elements, sizeof(int), number_of_elements, fptr);

printf("Saved your list in %s. Use the ListReader program to read it.\n", file_name);

free(elements);
fclose(fptr);
```

Then, we write the list itself

Example – Writing a list of integers

```
int number_of_elements, i;
int* elements = NULL;
FILE* fptr = NULL;
char file_name[22];

printf("Enter the number of integers in your list: ");
scanf("%d", &number_of_elements);

elements = (int*) malloc(sizeof(int) * number_of_elements);
printf("Enter the elements of the list:\n");
for(i = 0; i < number_of_elements; i++)
        scanf("%d", &elements[i]);

clean_stdin();

printf("Enter the name of the file to store the list (max 20 chars): ");
fgets(file_name, 20, stdin);

file_name[strlen(file_name)-1] = '\0'; // To remove the extra \n character

fptr = fopen(file_name, "wb"); //"w" - write, "b" - in binary mode (instead of text)

// Write the size of the list first
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// Now write the list
fwrite(elements, sizeof(int), number_of_elements, fptr);

printf("Saved your list in %s. Use the ListReader program to read it.\n", file_name);

free(elements);
fclose(fptr);
```

Then, we write the list itself

Note that `elements` is an `int` array, and we have given `number_of_elements` as the argument for number of elements to write

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int number_of_elements, i;
int* elements = NULL;
FILE* fptr = NULL;
char file_name[22];

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elements = (int*) malloc(sizeof(int) * number_of_elements);
printf("Enter the elements of the list:\n");
for(i = 0; i < number_of_elements; i++)
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free(elements);
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```

Then, we write the list itself

Note that `elements` is an `int` array, and we have given `number_of_elements` as the argument for number of elements to write

In essence, this is our *format* for the binary file – number of elements in the list, followed by the list itself

Example – Writing a list of integers

```
saurabh@saurabh-VirtualBox:~/C/examples/Week 9$ gcc -o ListSaver ListSaver.c
saurabh@saurabh-VirtualBox:~/C/examples/Week 9$ ./ListSaver
Enter the number of integers in your list: 5
Enter the elements of the list:
7
11
3
29
23
Enter the name of the file to store the list (max 20 chars): list.bin
Saved your list in list.bin. Use the ListReader program to read it.
saurabh@saurabh-VirtualBox:~/C/examples/Week 9$
```

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Enter the number of integers in your list: 5
Enter the elements of the list:
7
11
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29
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Enter the name of the file to store the list (max 20 chars): list.bin
Saved your list in list.bin. Use the ListReader program to read it.
saurabh@saurabh-VirtualBox:~/C/examples/Week 9$
```

This extension `.bin` or `.dat` are commonly used to signify binary data

Reading *Bytes* from binary files

Again, the `b` suffix is required with `fopen()`, to open a file in binary mode

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The parameters to `fread()` are also similar to `fwrite()`

- The `FILE` pointer

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- A pointer to a variable or array, in which the data will be read
  - You remember the use of call-by-reference to take outputs from a function? This is another example of that…

Example – Reading a list of integers

```c
int number_of_elements, i;
int temp;
FILE* fptr = NULL;
char file_name[22];

printf("Enter the name of the file containing the list (max 20 chars): ");
fgets(file_name, 20, stdin);

file_name[strlen(file_name)-1] = '\0'; // To remove the extra \n character

fptr = fopen(file_name, "rb"); //"r" - read, "b" - in binary mode (instead of text)

// Read the number of elements in the list
fread(&number_of_elements, sizeof(int), 1, fptr);

printf("This is what I read:\n");
// Now read the list
for(i = 0; i < number_of_elements; i++)
{
        fread(&temp, sizeof(int), 1, fptr);
        printf("%d\n", temp);
}

fclose(fptr);
```

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```

The suffix `b` is important here

Example – Reading a list of integers

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{
        fread(&temp, sizeof(int), 1, fptr);
        printf("%d\n", temp);
}

fclose(fptr);
```

As per the expected format, we read an integer from the file first, and expect that this is the size of the list

Example – Reading a list of integers

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for(i = 0; i < number_of_elements; i++)
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        fread(&temp, sizeof(int), 1, fptr);
        printf("%d\n", temp);
}

fclose(fptr);
```

Then, we read *the expected* number of integers from the file, and show it as the stored list

Example – Reading a list of integers

```
saurabh@saurabh-VirtualBox:~/C/examples/Week 9$ gcc -o ListReader ListReader.c
saurabh@saurabh-VirtualBox:~/C/examples/Week 9$ ./ListReader
Enter the name of the file containing the list (max 20 chars): list.bin
This is what I read:
7
11
3
29
23
saurabh@saurabh-VirtualBox:~/C/examples/Week 9$
```

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This is what I read:
7
11
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saurabh@saurabh-VirtualBox:~/C/examples/Week 9$
```

This is the same list that we wrote

Homework !!

Appending, is a type of writing, with some major differences

- Find out the differences

There are several options at your disposal, when you open a file with `fopen()`

- Read the man page for `fopen()` to know about all of the possibilities (use the command `man fopen`)
- A summary with some sample usage is also provided here: https://www.geeksforgeeks.org/c-fopen-function-with-examples/