

Data and File Structures Laboratory

Review of C – More Input/Output, File Handling, Header Files, Multi-file Programs

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- 1 More Input/Output
- 2 Enumeration
- 3 Preprocessor Directives
- 4 File Handling
- 5 Header Files
- 6 Multi-file Programs

More on getchar()

Reading a number from input using getchar():

```
if(isdigit(c))  
x = x * 10 + c - '0';
```

More on getchar()

Taking a single character input from the user:

```
int c;  
c = getchar();
```

taking a series of character inputs from the user:

```
int c;  
while ((c = getchar()) != EOF) {  
    ...  
}
```

Enumeration (enum)

We can use `enum` to declare new enumeration types and define their values.

```
enum MONTH{January, February, March, April, May, June,
    July, August, September, October, November, December};
int main(){
    enum MONTH mm;
    mm = August;
    printf("%d", mm);
    return 0;
}
```

Basics

Definition (What is a preprocessor?)

Before a C program is compiled by a compiler, the source code is processed by a program called preprocessor. This process is called preprocessing.

Definition (What are preprocessor directives?)

The commands used in preprocessor are defined as preprocessor directives and they begin with '#' symbol.

#include

This preprocessor directive is used to include system-defined and user-defined files into the current file. There are two different ways of doing this as shown below.

```
#include <filename>
```

This is used to include system header files. It first searches for a file in a list of directories specified by you, then in a standard list of system directories.

```
#include "filename"
```

This is used include user-defined contents. It first searches for a file in the current directory, then in a standard list of system directories.

#define (also known as macros)

There are two different types of macros as listed below.

1 Object-like macros:

```
#define e 2.71828
```

2 Function-like macros:

```
#define COMPARE(x, y) (((x) > (y)) - ((x) < (y)))
```

#define (also known as macros)

What is the output of the following C program?

```
#include<stdio.h>
#define RECIPROCAL(x) 1/x
int main(void){
    int x = 1, y = 2, z;
    z = (x+y) * RECIPROCAL(x+y);
    printf("%d", z);
    return 0;
}
```

#define (also known as macros)

Multi-line macros can be accommodated by inserting line separators at the end of each line.

```
#define ASCII(character) {\n    printf("The ASCII value of ");\n    printf("%c", character);\n    printf(" is ");\n    printf("%d", character);\n}
```

#undef

The definition of a macro can be dropped as follows.

```
#undef COMPARE(x, y)
```

#ifdef

We can check whether a macro is already defined as follows.

```
#ifdef COMPARE(x, y)
    // Code segment
#endif
```

Note: If the definition exists, it will execute the code segment.

#ifndef

We can check whether a macro is not yet defined as follows.

```
#ifndef COMPARE(x, y)
    // code segment
#endif
```

Note: If the definition does not exist, it will execute the code segment.

#if and #endif

```
#if <expression>  
    // code segment  
#endif
```

#else

```
#if <expression>
    // if code segment
#else
    // else code segment
#endif
```

#elif

```
#if expression
    // if code segment
#elif expression
    // elif code segment
#else
    // else code segment
#endif
```

File handling

Opening a file: `fopen(filename, mode);`

filename: String (`char *`) containing name of file

mode: String specifying whether file is to be opened in read/write mode

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- `"r"`, `"w"`, `"a"`: read mode, write mode, append mode
- `"r+"`, `"w+"`, `"a+"`: read/write mode, write/read mode, read/append mode

File handling

Opening a file: `fopen(filename, mode);`

filename: String (`char *`) containing name of file

mode: String specifying whether file is to be opened in read/write mode

- `"r", "w", "a"`: read mode, write mode, append mode
- `"r+", "w+", "a+"`: read/write mode, write/read mode, read/append mode

Example:

```
FILE *fp;  
if((fp = fopen("a.txt", "r")) == NULL)  
    ERR_MESG("Error opening file");
```

File handling

Opening a file: `fopen(filename, mode);`

filename: String (`char *`) containing name of file

mode: String specifying whether file is to be opened in read/write mode

- `"r", "w", "a"`: read mode, write mode, append mode
- `"r+", "w+", "a+"`: read/write mode, write/read mode, read/append mode

Example:

```
FILE *fp;  
if((fp = fopen("a.txt", "r")) == NULL)  
    ERR_MESG("Error opening file");
```

Closing a file: `fclose(fp);`

File handling

Reading/writing text:

fgetc(fp): Reads and returns the next character from `fp`, or EOF on end of file or error

Typical usage: `while (EOF != (c = fgetc(fp))) ...`

fgets(s, n, fp): Reads at most `n-1` characters or one line (whichever is shorter), stores input in character array `s` and terminates `s` using `'\0'`;
Returns `s` or `NULL` on end of file (i.e., there is nothing to be read) or error

Typical usage: `while (NULL != fgets(s, n, fp)) ...` _____

fputc(c, fp): Writes `c` to `fp`

fputs(s, fp): Writes string `s` to `fp`

File handling

Reading / writing text line by line:

fread(char **lineptr, n, fp): Reads an entire line (n elements of data) from fp, storing the text (including the newline and a terminating null character) in a buffer and storing the buffer address in *lineptr.
Returns number of elements read.

Note: Before calling `getline()`, you should place in *lineptr the address of a buffer (n bytes long), allocated with `malloc()`. If this buffer is long enough to hold the line, `getline()` stores the line in this buffer.

File handling

Reading / writing data:

`fread((void *) buffer, sz, n, fp)`: Reads `n` elements of data, each of size `sz` bytes from `fp`, stores them in `buffer`;
Returns number of elements read.

`fwrite((void *) buffer, sz, n, fp)`: Writes `n` elements of data from `buffer`, each of size `sz` bytes to `fp`;
Returns number of elements written.

Header files

Contents:

- Preprocessor directives and macros
- Constant declarations
- Type declarations (enum, typedef, struct, union, etc.)
- Function prototype declarations
- Global variable declarations
- Static function definitions (may contain)

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- Static function definitions (may contain)

Example: HelloWorld.h

```
#ifndef _HELLOWORLD_H_
#define _HELLOWORLD_H_
typedef unsigned int my_uint_t;
void printHelloWorld();
int iMyGlobalVar;
...
#endif
```

A bit of memory organization

While compiling and executing a C program, four different regions of memory are created. These are used as follows:

- A memory region that holds the executable code of the program.
- A memory region where global variables are stored.
- Stack: A memory region that holds the local variables, return addresses of function calls, and arguments to functions while a program is in execution. It also holds the CPU's current state.
- Heap: A memory region that is used by the dynamic memory allocation functions at run time.

Multi-file programs

The motivations behind using multi-file programs are as follows:

- 1 Manageability
- 2 Modularity
- 3 Reusability
- 4 Abstraction

Multi-file programs

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- 1 Manageability
- 2 Modularity
- 3 Reusability
- 4 Abstraction

The general abstractions used in multi-file programs are as listed below.

- Header files
- Implementation source files
- Application source file (contains the `main()` function)

Implementation source files

Contents:

- Function body for functions declared in corresponding header files
- Statically defined and inlined functions
- Global variable definitions

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Contents:

- Function body for functions declared in corresponding header files
- Statically defined and inlined functions
- Global variable definitions

Example: HelloWorld.c

```
#include<stdio.h>
#include "HelloWorld.h"
void printHelloWorld(){
    iMyGlobalVar = 20;
    printf("Hello World\n");
    return;
}
```

Application source file

Contents:

- Function body for the `main()` function
- Acts as client for the different modules

Application source file

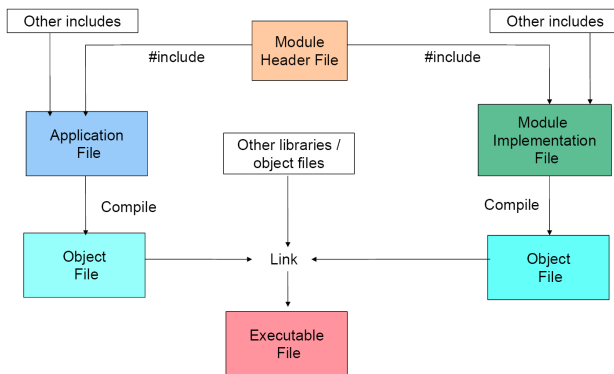
Contents:

- Function body for the main() function
- Acts as client for the different modules

Example: app.c

```
#include<stdio.h>
#include "HelloWorld.h"
int main(){
    iMyGlobalVar = 10;
    printf("%d\n", iMyGlobalVar);
    printHelloWorld();
    printf("%d\n", iMyGlobalVar);
    return 0;
}
```

Associativity between different components



Compiling a simple multi-file program

Syntax:

```
gcc <file1.c> <file2.c> ... -o filename
```

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Syntax:

```
gcc <file1.c> <file2.c> ... -o filename
```

```
user@ws$ gcc HelloWorld.c app.c -o my_app
```

```
user@sw$ ./my_app
```

```
10
```

```
Hello World
```

```
20
```

```
user@ws$
```

Compiling a simple multi-file program

Syntax:

```
gcc <file1.c> <file2.c> ... -o filename
```

```
user@ws$ gcc HelloWorld.c app.c -o my_app
```

```
user@sw$ ./my_app
```

```
10
```

```
Hello World
```

```
20
```

```
user@ws$
```

Note: Source files are directly converted into executables.

Compiling a simple multi-file program

Syntax:

```
gcc -c <filename(s).c>
```

```
gcc <filename1.o> <filename2.o> [-o output]
```

Compiling a simple multi-file program

Syntax:

```
gcc -c <filename(s).c>
```

```
gcc <filename1.o> <filename2.o> [-o output]
```

```
user@ws$ gcc -c HelloWorld.c
```

```
user@ws$ gcc -c app.c
```

```
user@ws$ gcc HelloWorld.o app.o -o my_app
```

```
user@sw$ ./my_app
```

```
10
```

```
Hello World
```

```
20
```

```
user@ws$
```

Compiling a simple multi-file program

Syntax:

```
gcc -c <filename(s).c>
```

```
gcc <filename1.o> <filename2.o> [-o output]
```

```
user@ws$ gcc -c HelloWorld.c
```

```
user@ws$ gcc -c app.c
```

```
user@ws$ gcc HelloWorld.o app.o -o my_app
```

```
user@sw$ ./my_app
```

```
10
```

```
Hello World
```

```
20
```

```
user@ws$
```

Note: Source files are compiled into object files and multiple object files are linked to executables.

Problems – Day 4

- 1 Suppose you are playing a game in turn with the computer. Total 11 sticks are to be picked up but no more than 3 can be picked up at a time. Whoever picks the last one loses the game. Write a program to let the following happen.
 - 1 The computer wins if it has the first turn.
 - 2 The computer wins optimally irrespective of the turn.
- 2 Without using the `getpass()` function, write a program to take a password from the user and verify its strength. Mask the password text with character '?'.
 - If the counts of lowercase alphabets, uppercase alphabets, digits, and special characters contained in this is a prime number, then return **STRONG**.
 - Otherwise, return **WEAK**.

Problems – Day 4

- 3 Write macros to define the following operations:
 - Evaluates the value of “x implies y”
 - Swaps the values of x and y
 - Finds the minimum of x and y
 - Finds the maximum of x and y
 - Runs an infinite loop over a print statement
 - Finds the least significant bit of x
- 4 Write a program that will count the number of preprocessor lines used in its source code. Note that, the source code might contain multi-line macros.
- 5 Write a header file for the ease of dynamic memory allocation, deallocation and reallocation for one-dimensional and multi-dimensional arrays. Use it to write a program for swapping the contents of two files without using any additional file.