C

Preset:

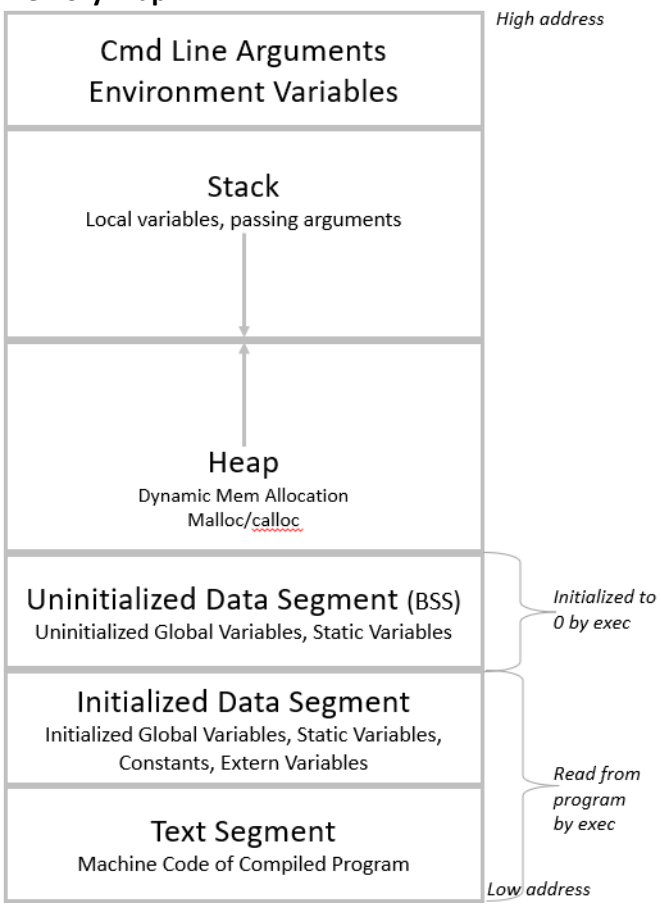
- Invented by Dennis Ritchie, 1972, Bell Labs to write Unix OS
- General Purpose, modular and portable
- Low-level memory access
- C-Standards: C89/90 (1989/90), C99 (1999), C11 (2011), C18(2018)

Structure of C Program:

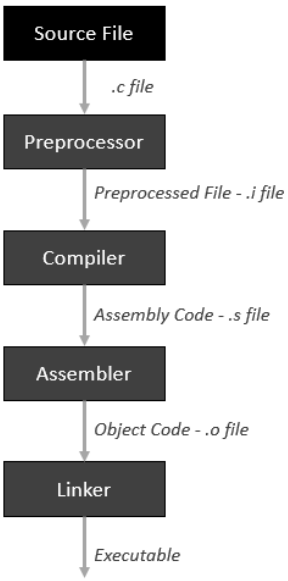
Header	#include <stdio.h>
main()	int main() {
Variable Declaration	int a = 10;
Body	printf("%d", a");
Return	return 0; }

- Header Files inclusion: Contains C function declarations and macro definitions to be shared between source files.
- Main Method: Execution starts from this function.
- Variable Declaration: Variables that are to be used in the function. No variables can be used without being declared.
- Body: Refers to operations that are performed in the functions.
- Return: Depending on return type of the function, the return refers to the returning values from a function

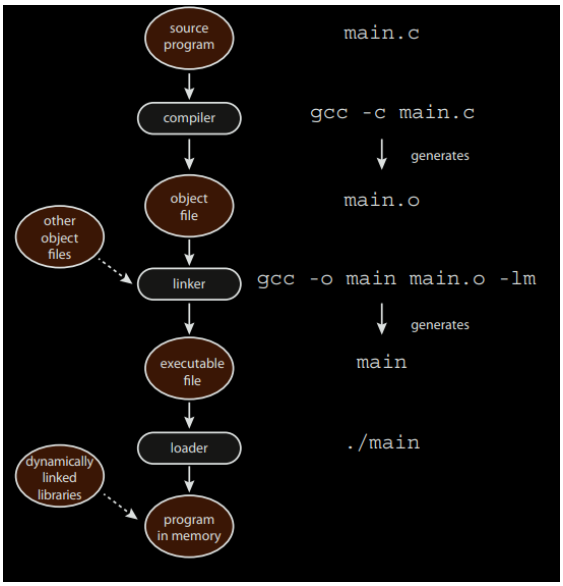
Memory Map:



Compilation: Process of converting the source code of C lang into machine code.



1. Source File: Create a c program using an editor and save the file as filename.c
2. Pre-processor: This phase includes the following and produces filename.i
    a. Removal of comments
    b. Expansion of Macros
    c. Expansion of Included files
    d. Conditional Compilation
3. Compiling: Compiles filename.i and produces filename.s which includes assembly-level instructions.
4. Assembler: Takes filename.s as output and produces filename.o – object code. Existing code is converted into machine language.
5. Linking: All function calls linked, adds extra code to mark delimiters of each block and forms a executable file.
6. Loading: Loading the process to main memory



$gcc -Wall -save-temps filename.c –o filename // To save all intermediate files during compilation.

Comments and Line Splicing:
Single Line: //
Multi Line: /* */

```
#include <stdio.h>
int main()
{
```

```
    // Line Splicing\
    printf("Hello GFG\n");
    printf("welcome\n");
    /* Below lines will be printed*/ \
    printf("Hello\t");
    printf("World");
    return (0);
}
/* Output
welcome
Hello World
*/
```

Prefer using Multi Line Comments every where

Tokens:

- Keywords
- Identifiers
- Constants/Literals: Variables with fixed values. *const a=19;*
- Strings: Array of chars with a null char at end. *char string[] = "ravikumar";*
- Special Symbols: []({},:;*=#.~
- Operators:

Assignment	=, +=, -=, *=, /=, %=, &=, |=, ^=, >>=, <<=
Arithmetic	+ , - , * , / , % , ++ , --
Relational	==, !=, >, <, >=, <=
Logical	&&, ||, !
Bitwise	&, |, ^
Ternary	Condition? True : False;
Pointer	&, *
Misc	sizeof(), . (obj.val), &(ptr), *(access)

Keywords: Predefined and reserved words that special meanings to compiler

auto	*break*	*case*	*char*
double	*else*	*enum*	*extern*
int	*long*	*register*	*return*
struct	*switch*	*typedef*	*Union*
const	*continue*	*default*	*do*
float	*for*	*goto*	*if*
short	*signed*	*sizeof*	*static*
unsigned	*void*	*volatile*	*while*

Identifiers - Variables and Constants:

- Named location which has some memory allocated to it.
- Always start with letter/_, only alphanumeric, no whitespace, no keywords.

Types of variables:

- Local Variables: Declared inside a function or block of code
- Global Variables: When we have same name for local and global variable, local variable will be given preference over the global variable by the compiler. For accessing global variable in this case:

```c
#include <stdio.h>

// Global variable x
int x = 50;

int main()
{
    // Local variable x
    int x = 10;
    {
        extern int x;
        printf("Global x: %d\n", x);
    }
    printf("Local x: %d\n", x);
    return 0;
}
/* Output:
    Global x: 50
    Local x: 10 */
```

- Automatic Variables: All local variables are local by default. Scope is local and their life time is till the end of the block
- Extern Variables: To share variables between multiple C files.

```c
//----------myfile.h------------
  extern int x=10;  //external variable (also global)


// ----------pgm1.c----------
  #include "myfile.h"
  #include <stdio.h>
  void printValue(){
  printf("X: %d", x);
  }
```

- Static Variables: Retains its value between multiple function calls.

```c
#include <stdio.h>
void function()
{
    int x = 20;        // local variable
    static int y = 30; // static variable
    x = x + 10;
    y = y + 10;
    printf("\n%d,%d", x, y);
}
int main()
{
    function();
    function();
    function();
    return 0;
}
/* Output:
30,40
30,50
30,60 */
```

- Register Variables: Stored in CPU register instead of conventional storage (RAM).

```c
register int var = 20;
```

Type Qualifiers:

const	Variables of type const cannot be changed by program. They can only be given an initial value.
volatile	Variable's value may be changed in ways not explicitly specified by the program. Global variable which is passed to the OS's clock routine is a good example. Most compilers do not expect such changes and look for assignment operators for changes.
restrict	Applied to pointer declarations. Object

Storage Class Specifiers:

- **extern:** Used to specify that an object is declared with external linkage elsewhere in the program.

- **static:** These are permanent variables within their own function or file. They maintain their values between function calls. Types: static Local variables and static Global variables
- **register:** Variables declared with register are stored in CPU registers instead of RAM for faster access. If arrays or any data structures are being declared with register keyword will receive a preferential treatment by the compiler as they can't be stored in registers due to their large size

Constants/Literals:

They refer to fixed values that the program may not alter. Types include integers, hexadecimal, octal, string, backslash character constants

Scope Rules:

Scope	Meaning
File Scope	Starts at beginning of the file and ends with end of the file
Block Scope	Starts at the opening of { and ends at }
Function prototype scope	Identifiers declared in a func prototype; visible within the prototype
Function Scope	Starts at the opening of { of a function and ends at } of a function

Escape Sequences:

\a	Alarm or Beep
\b	Backspace
\f	Form Feed
\n	New Line
\r	Carriage Return
\t	Tab (Horizontal)
\v	Tab (Vertical)
**	Backslash
\'	Single Quote
\"	Double Quote
\?	Question Mark
\ooo	Octal Number
\xhh	Hexadecimal number
\0	Null

Macros and Preprocessors:
All lines that start with **#** are processed by preprocessor; the functionality is processed prior to other statements in the program.

- When we use *include* directive, the contents of included header file are copied to the current file. Angulars **<** and **>** indicate preprocessor to look in the standard folder where all header files are held. Double Quotes **"** and **"** indicate it to look into the current folder.
- When we use *define* for a constant, the preprocessor produces a C program where the defined constant is searched and matching tokens are replaced with the given expression.
- Macros can take full function like args and args are not checked for data type.

```
#define INC(x) x++;
```

- Macro args are not evaluated before macro expansion.

```
#include <stdio.h>
#define MULTIPLY(a, b) a* b
int main()
{
    // The macro is expanded as 2 + 3 * 3 + 5, not as 5*8
    printf("%d", MULTIPLY(2 + 3, 3 + 5));
    return 0;
}
// Output: 16
```

- Tokens passed to macros can be concatenated using **##**

```
#define concat(a,b) a##b
```

- A token passed to macro can be converted to a string literal by using # before it

```
#define conv_str(a) #a
```

- The macros can be written in multiple lines:

```
#define PRINT(i, limit)       \
    while (i < limit) {       \
        printf("Ravi ");      \
        i++;                  \
    }
```

- It's better to avoid macros with arguments and inline functions should be preferred as they have type checking.
- Preprocessors also support if-else directives: #if, #else, #endif, #ifdef, #ifndef, #undef
- Standard Macros:

```
#include <stdio.h>

int main() {
    printf("File: %s\n", __FILE__);
    printf("Function: %s\n", __FUNCTION__);
    printf("Line: %d\n", __LINE__);
    printf("Date: %s\n", __DATE__);
    printf("Time: %s\n", __TIME__);
    return 0;
}
/* Output:
File: test.c
Function: main
Line: 6
Date: Feb  6 2024
Time: 11:53:41
*/
```

void main() or main(): In C, void main() has no defined(legit) usage, and it can sometimes throw garbage results or an error. However, main() is used to denote the main function which takes no arguments and returns an integer data type. To summarize the above, it is never a good idea to use void main() or simply, main() as it doesn't confirm standards. It may be allowed by some compilers though.

int main() and int main(void): In C, if a function signature doesn't specify any argument, it means that the function can be called with any number of parameters or without any parameters.

Program Error Signals:

SIGFPE	Arithmetic Error	Division by zero, Floating point error etc.
SIGILL	Illegal Instruction: Instruction with no privilege to get executed, got executed.	Stack overflow, Object file corrupted
SIGSEGV	Segmentation fault: Process trying to access a mem location not allocated to it.	De-referencing a wild pointer, Programs gets far from its mem space
SIGBUS	Bus error. Invalid memory is accessed (not existing mem accessed)	De-referencing memory location out of mem space
SIGABRT	Internal Error	General used in assert function
SIGSYS	System Call error	Invalid arg passed to a sys call
SIGTRAP	Exception Occurred, debugger to be informed	Variable changes its value.

Data Types:

Type	Bits	Range
char	8	-127 to 127
unsigned char	8	0 to 255
signed char	8	-127 to 127
int	16/32	-32767 to 32767
unsigned int	16/32	0 to 65535
signed int	16/32	-32767 to 32767

short int	16	-32767 to 32767
unsigned short int	16	0 to 65535
signed short int	16	-32767 to 32767
long int	32	-2^31-1 to 2^31
long long int	64	-2^63-1 to 2^63
signed long int	32	-2^31-1 to 2^31
unsigned long int	32	0 to 2^31
unsigned long long int	64	2^64 - 1
float	32	0 to 2^31
double	64	2^64 - 1
long double	80	2^80 – 1
bool		stdbool.h
float_complex		complex.h
float_imaginary		complex.h
double_complex		complex.h
double_imaginary		complex.h
long double_complex		complex.h
long double_imaginary		complex.h

INT_MIN and INT_MAX in limits.h give the limits of an integer