C

Come let's see how deep it is!!

Team Emertxe

Functions

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Functions – What?

An activity that is natural to or the purpose of a person or thing.

"bridges perform the function of providing access across water"

A relation or expression involving one or more variables.

"the function (bx + c)"

Source: Google

- In programing languages it can something which performs a specific service
- Generally it can have 3 parameters like
  - Input
  - Operation
  - Output

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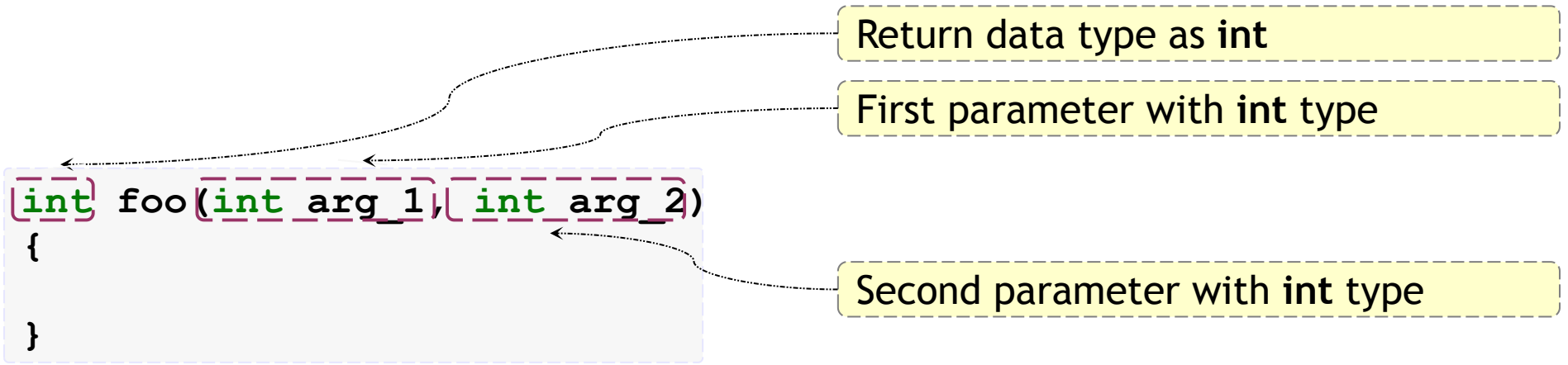
Functions - How to write

Syntax

```
return_data_type function_name(arg_1, arg_2, ..., arg_n)
{
    /* Function Body */
}
```

Example



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Functions - How to write

$$y = x + 1$$

Example

```
int foo(int x)
{
    int ret = 0;

    ret = x + 1;

    return ret;
}
```

Return from function

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Functions - How to call

Example

```c
#include <stdio.h>

int main()
{
    int x, y;

    x = 2;

    y = foo(x);
    printf("y is %d\n", y);

    return 0;
}
```

The function call

```c
int foo(int x)
{
    int ret = 0;

    ret = x + 1;

    return ret;
}
```

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Functions – Why?

- Re usability
  - Functions can be stored in library & re-used
  - When some specific code is to be used more than once, at different places, functions avoids repetition of the code.
- Divide & Conquer
  - A big & difficult problem can be divided into smaller sub-problems and solved using divide & conquer technique
- Modularity can be achieved.
- Code can be easily understandable & modifiable.
- Functions are easy to debug & test.
- One can suppress, how the task is done inside the function, which is called Abstraction

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Functions - A complete look

Example

```c
#include <stdio.h>

int main()
{
    int num1 = 10, num2 = 20;
    int sum = 0;

    sum = add_numbers(num1, num2);
    printf("Sum is %d\n", sum);

    return 0;
}

int add_numbers(int num1, int num2)
{
    int sum = 0;

    sum = num1 + num2;

    return sum;
}
```

The main function

The function call

Actual arguments

Return type

Formal arguments

Function

Return from function

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Functions - Ignoring return value

Example

```c
#include <stdio.h>

int main()
{
    int num1 = 10, num2 = 20;
    int sum = 0;

    add_numbers(num1, num2);
    printf("Sum is %d\n", sum);

    return 0;
}
```

```c
int add_numbers(int num1, int num2)
{
    int sum = 0;

    sum = num1 + num2;

    return sum;
}
```

Ignored the return from function
In C, it is up to the programmer to capture or ignore the return value

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Functions – Parameter Passing Types

Pass by Value	Pass by reference
• This method copies the actual value of an argument into the formal parameter of the function. • In this case, changes made to the parameter inside the function have no effect on the actual argument.	• This method copies the address of an argument into the formal parameter. • Inside the function, the address is used to access the actual argument used in the call. This means that changes made to the parameter affect the argument.

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Functions - Pass by Value

Example

```c
#include <stdio.h>

int add_numbers(int num1, int num2);

int main()
{
    int num1 = 10, num2 = 20, sum;

    sum = add_numbers(num1, num2);
    printf("Sum is %d\n", sum);

    return 0;
}
```

```c
int add_numbers(int num1, int num2)
{
    int sum = 0;

    sum = num1 + num2;

    return sum;
}
```

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Functions - Pass by Value

Example

```c
#include <stdio.h>

void modify(int num1);

int main()
{
    int num1 = 10;

    printf("Before Modification\n");
    printf("num1 is %d\n", num1);

    modify(num1);

    printf("After Modification\n");
    printf("num1 is %d\n", num1);

    return 0;
}
```

```c
void modify(int num1)
{
    num1 = num1 + 1;
}
```

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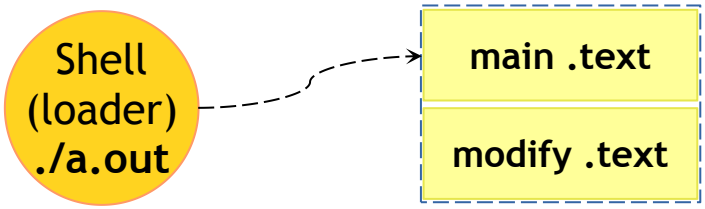
Functions - Pass by Reference

Example

```c
#include <stdio.h>

void modify(int *iptr);

int main()
{
    int num = 10;

    printf("Before Modification\n");
    printf("num1 is %d\n", num);

    modify(&num);

    printf("After Modification\n");
    printf("num1 is %d\n", num);

    return 0;
}
```

```c
void modify(int *iptr)
{
    *iptr = *iptr + 1;
}
```



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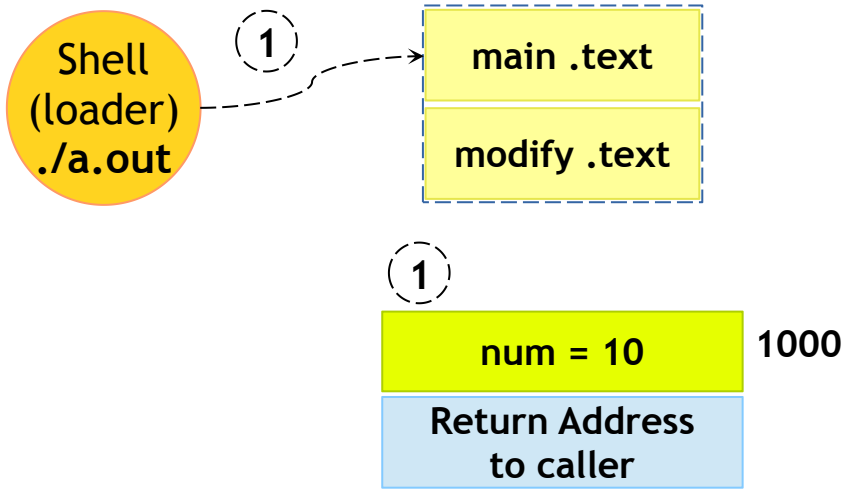
Functions - Pass by Reference

Example

```c
#include <stdio.h>

void modify(int *iptr);

int main()
{
    int num = 10;

    printf("Before Modification\n");
    printf("num1 is %d\n", num);

    modify(&num);

    printf("After Modification\n");
    printf("num1 is %d\n", num);

    return 0;
}
```

```c
void modify(int *iptr)
{
    *iptr = *iptr + 1;
}
```



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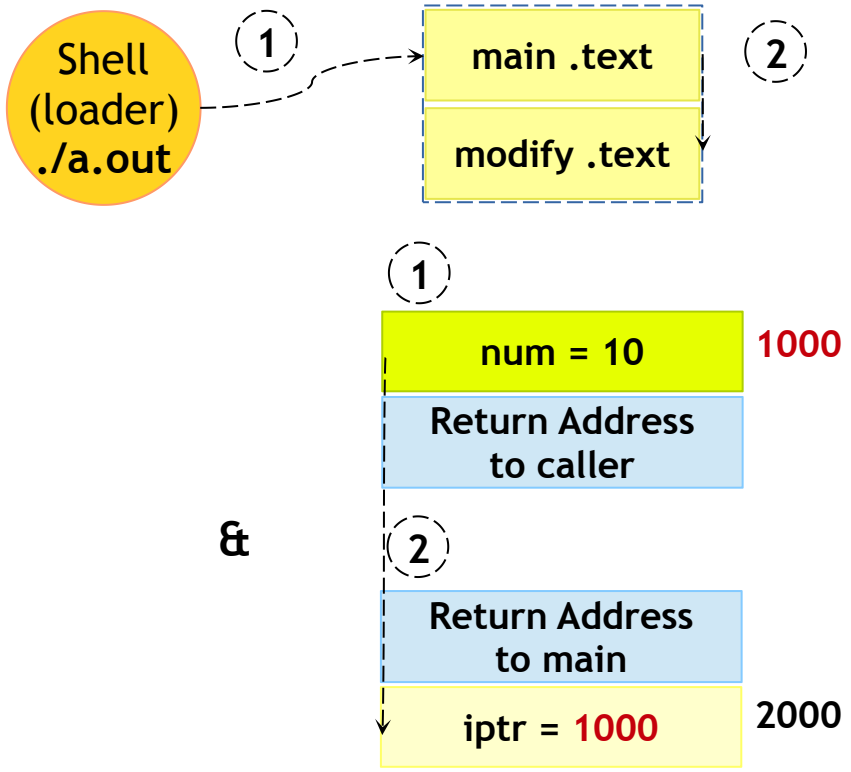
Functions - Pass by Reference

Example

```c
#include <stdio.h>

void modify(int *iptr);

int main()
{
    int num = 10;

    printf("Before Modification\n");
    printf("num1 is %d\n", num);

    modify(&num);

    printf("After Modification\n");
    printf("num1 is %d\n", num);

    return 0;
}
```

```c
void modify(int *iptr)
{
    *iptr = *iptr + 1;
}
```



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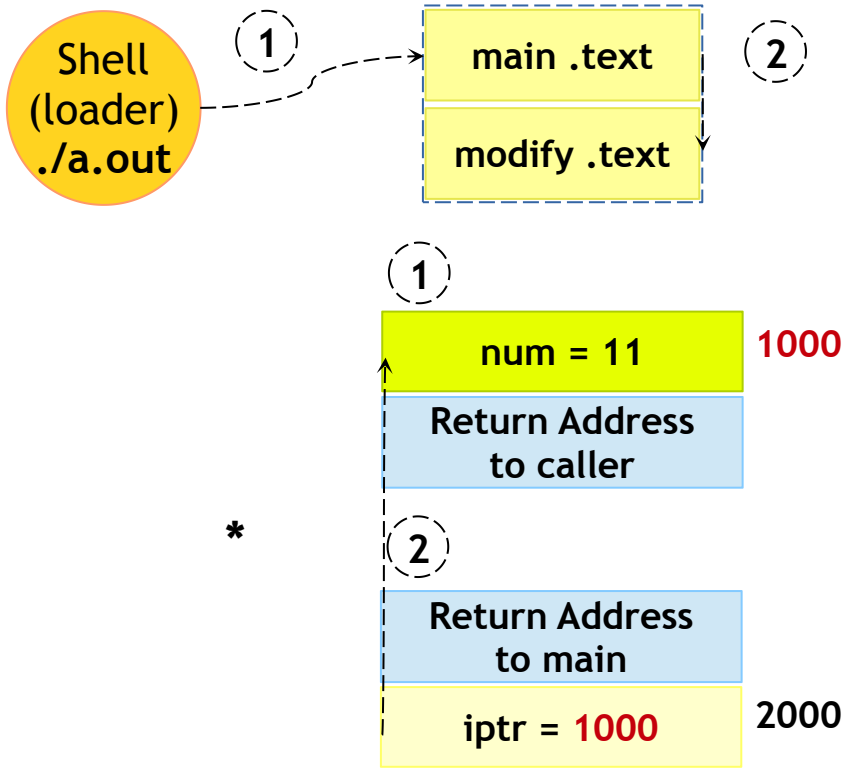
Functions - Pass by Reference

Example

```c
#include <stdio.h>

void modify(int *iptr);

int main()
{
    int num = 10;

    printf("Before Modification\n");
    printf("num1 is %d\n", num);

    modify(&num);

    printf("After Modification\n");
    printf("num1 is %d\n", num);

    return 0;
}
```

```c
void modify(int *iptr)
{
    *iptr = *iptr + 1;
}
```



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Functions – Pass by Reference - Advantages

- Return more than one value from a function

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Functions - Passing Array

Example

```
#include <stdio.h>

void print_array(int array[]);

int main()
{
     int array[5] = {10, 20, 30, 40, 50};

     print_array(array);

     return 0;
}
```

```
void print_array(int array[])
{
     int i;

     for (i = 0; i < 5; i++)
     {
          printf("Index %d has Element %d\n", i, array[i]);
     }
}
```

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Functions - Returning Array

Example

```c
#include <stdio.h>

int *modify_array(int *array, int size);
void print_array(int array[], int size);

int main()
{
     int array[5] = {10, 20, 30, 40, 50};
     int *iptr;

     iptr = modify_array(array, 5);
     print_array(iptr, 5);

     return 0;
}
```

```c
int *modify_array(int *array, int size)
{
     int  i;

     for (i = 0; i < size; i++)
     {
          *(array + i) += 10;
     }

     return array;
}
```

```c
void print_array(int array[], int size)
{
     int  i;

     for (i = 0; i < size; i++)
     {
          printf("Index %d has Element %d\n", i, array[iter]);
     }
}
```

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Functions - Returning Array

Example

```c
#include <stdio.h>

int *return_array(void);
void print_array(int *array, int size);

int main()
{
     int *array_val;

     array_val = return_array();
     print_array(array_val, 5);

     return 0;
}
```

```c
int *return_array(void)
{
     static int array[5] = {10, 20, 30, 40, 50};

     return array;
}
```

```c
void print_array(int *array, int size)
{
     int  i;

     for (i = 0; i < size; i++)
     {
          printf("Index %d has Element %d\n", i, array[i]);
     }
}
```

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Functions – Recursive

- Recursion is the process of repeating items in a self-similar way
- In programming a function calling itself is called as recursive function
- Two steps

Step 1: Identification of base case

Step 2: Writing a recursive case

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Functions - Recursive - Example

Example

```c
#include <stdio.h>

/* Factorial of 3 numbers */

int factorial(int number)
{
    if (number <= 1)
    {
        return 1;
    }
    else
    {
        return number * factorial(number - 1);
    }
}

int main()
{
    int result;

    result = factorial(3);
    printf("Factorial of 3 is %d\n", result);

    return 0;
}
```

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Pointers - Pitfalls - Segmentation Fault

- A segmentation fault occurs when a program attempts to access a memory location that it is not allowed to access, or attempts to access a memory location in a way that is not allowed.

Example

```c
#include <stdio.h>

int main()
{
    int num = 0;

    printf("Enter the number\n");
    scanf("%d", num);

    return 0;
}
```

Example

```c
#include <stdio.h>

int main()
{
    int *num = 0;

    printf("num = %d\n", *num);

    return 0;
}
```

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Pointers - Pitfalls - Wild Pointer

- An uninitialized pointer pointing to a invalid location can be called as an wild pointer.

Example

```c
#include <stdio.h>

int main()
{
    int *iptr_1; /* Wild Pointer */
    static int *iptr_2; / Not a wild pointer */


    return 0;
}
```

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Pointers - Const Qualifier

Example

```c
#include <stdio.h>

int main()
{
    int const *num = NULL;

    return 0;
}
```

The location, its pointing to is constant

Example

```c
#include <stdio.h>

int main()
{
    int * const num = NULL;

    return 0;
}
```

The pointer is constant

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Strings

> A set of things tied or threaded together on a thin cord.
>
> Source: Google

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Strings

- Contiguous sequence of characters
- Easily stores ASCII and its extensions
- End of the string is marked with a special character, the null character '\0'
- '\0' is implicit in strings enclosed with “”
- Example

“You know, now this is what a string is!”

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Strings - Initializations

Examples

```
char char_array[5] = {'H', 'E', 'L', 'L', 'O'};
```
← Character Array

```
char str[6] = {'H', 'E', 'L', 'L', 'O', '\0'};
```
← String

```
char str[] = {'H', 'E', 'L', 'L', 'O', '\0'};
```
← Valid

```
char str[6] = {“H”, “E”, “L”, “L”, “O”};
```
← Invalid

```
char str[6] = {“H” “E” “L” “L” “O”};
```
← Valid

```
char str[6] = {“HELLO”};
```
← Valid

```
char str[6] = “HELLO”;
```
← Valid

```
char str[] = “HELLO”;
```
← Valid

```
char *str = “HELLO”;
```
← Valid

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Strings - Size

Examples

```c
#include <stdio.h>

int main()
{
    char char_array_1[5] = {'H', 'E', 'L', 'L', 'O'};
    char char_array_2[] = "Hello";

    sizeof(char_array_1);
    sizeof(char_array_2);

    return 0;
}
```

The size of the array Is calculated So,

5, 6

```c
int main()
{
    char *str = "Hello";

    sizeof(str);

    return 0;
}
```

The size of pointer is always constant so,

4 (32 Bit Sys)

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Strings - Size

Example

```
#include <stdio.h>

int main()
{
    if (sizeof("Hello" "World") == sizeof("Hello") + sizeof("World"))
    {
        printf("WoW\n");
    }
    else
    {
        printf("HuH\n");
    }


    return 0;
}
```

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Strings – Library Functions

Purpose	Prototype	Return Values
Length	**size_t strlen(const char *str)**	String Length
Compare	**int strcmp(const char *str1, const char *str2)**	str1 < str2 → < 0 str1 > str2 → > 0 str1 = str2 → = 0
Copy	**char *strcpy(char *dest, const char *src)**	Pointer to dest
Check String	**char *strstr(const char *haystack, const char *needle)**	Pointer to the beginning of substring
Check Character	**char *strchr(const char *s, int c)**	Pointer to the matched char else NULL
Merge	**char *strcat(char *dest, const char *src)**	Pointer to dest

Storage Classes

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Memory Segments

The Linux OS is divided into two major sections

- User Space
- Kernel Space

The user programs cannot access the kernel space. If done will lead to segmentation violation

Let us concentrate on the user space section here

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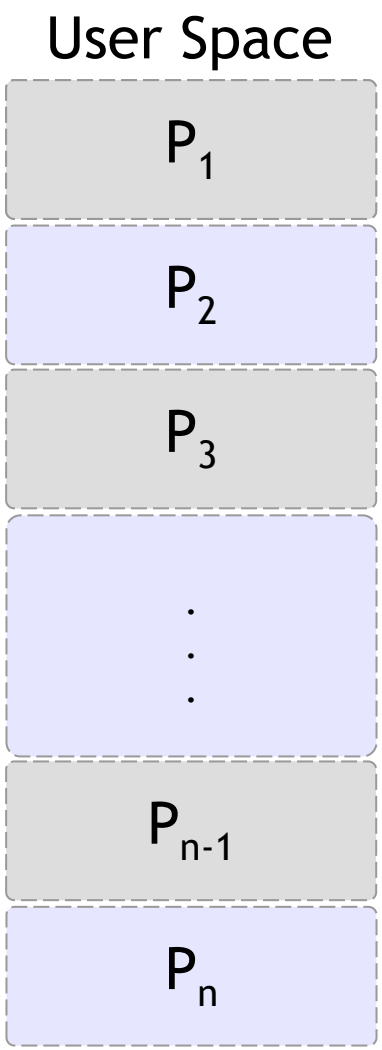
Memory Segments



The User space contains many processes

Every process will be scheduled by the kernel

Each process will have its memory layout discussed in next slide

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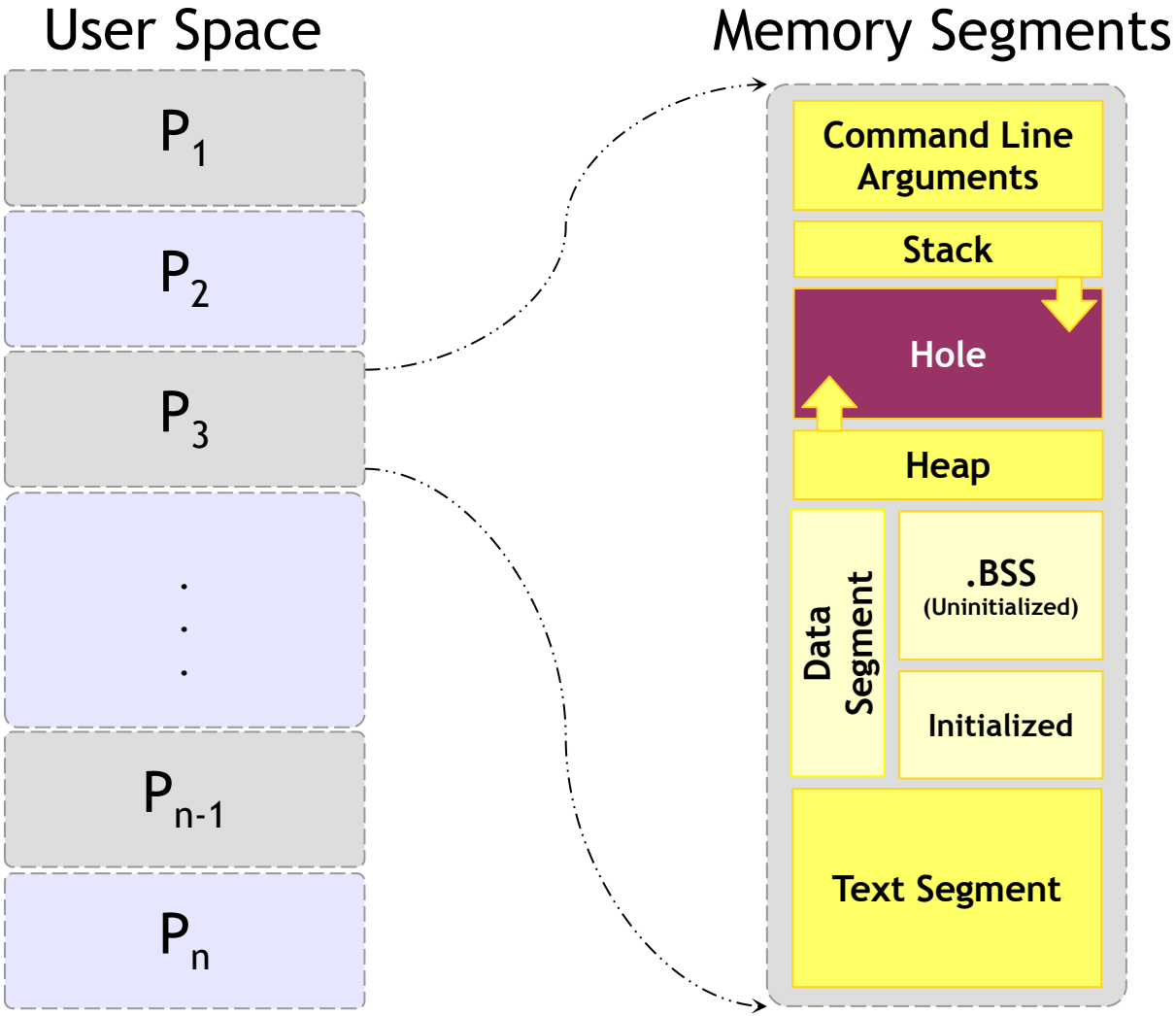
Memory Segments



The memory segment of a program contains four major areas.

- Text Segment
- Stack
- Data Segment
- Heap

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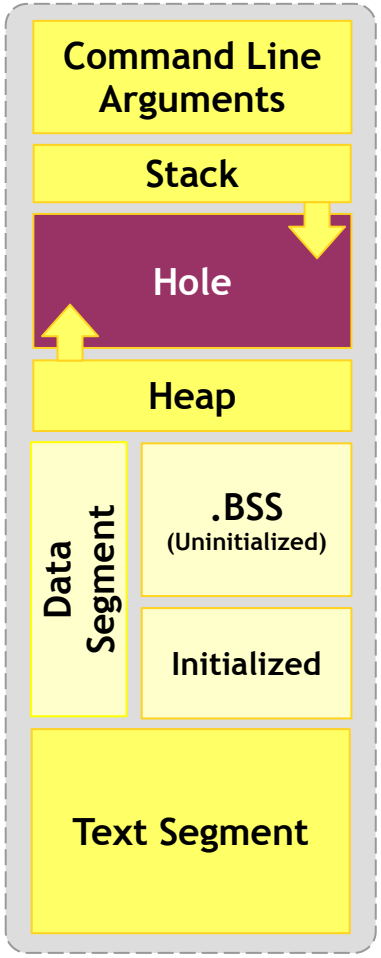
Memory Segments – Text Segment

Memory Segments



- Also referred as Code Segment
- Holds one of the section of program in object file or memory
- In memory, this is place below the heap or stack to prevent getting over written
- Is a read only section and size is fixed

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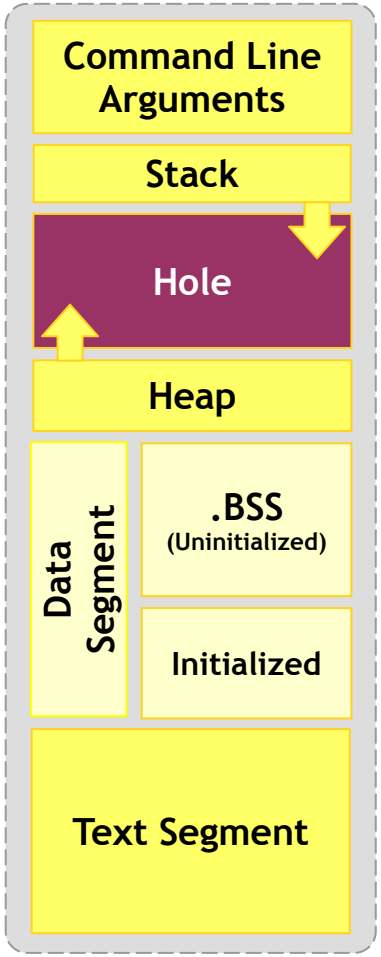
Memory Segments – Data Segment

Memory Segments



- Contains 2 sections as initialized and uninitialized data segments
- Initialized section is generally called as Data Segment
- Uninitialized section is referred as BSS (Block Started by Symbol) usually filled with 0s

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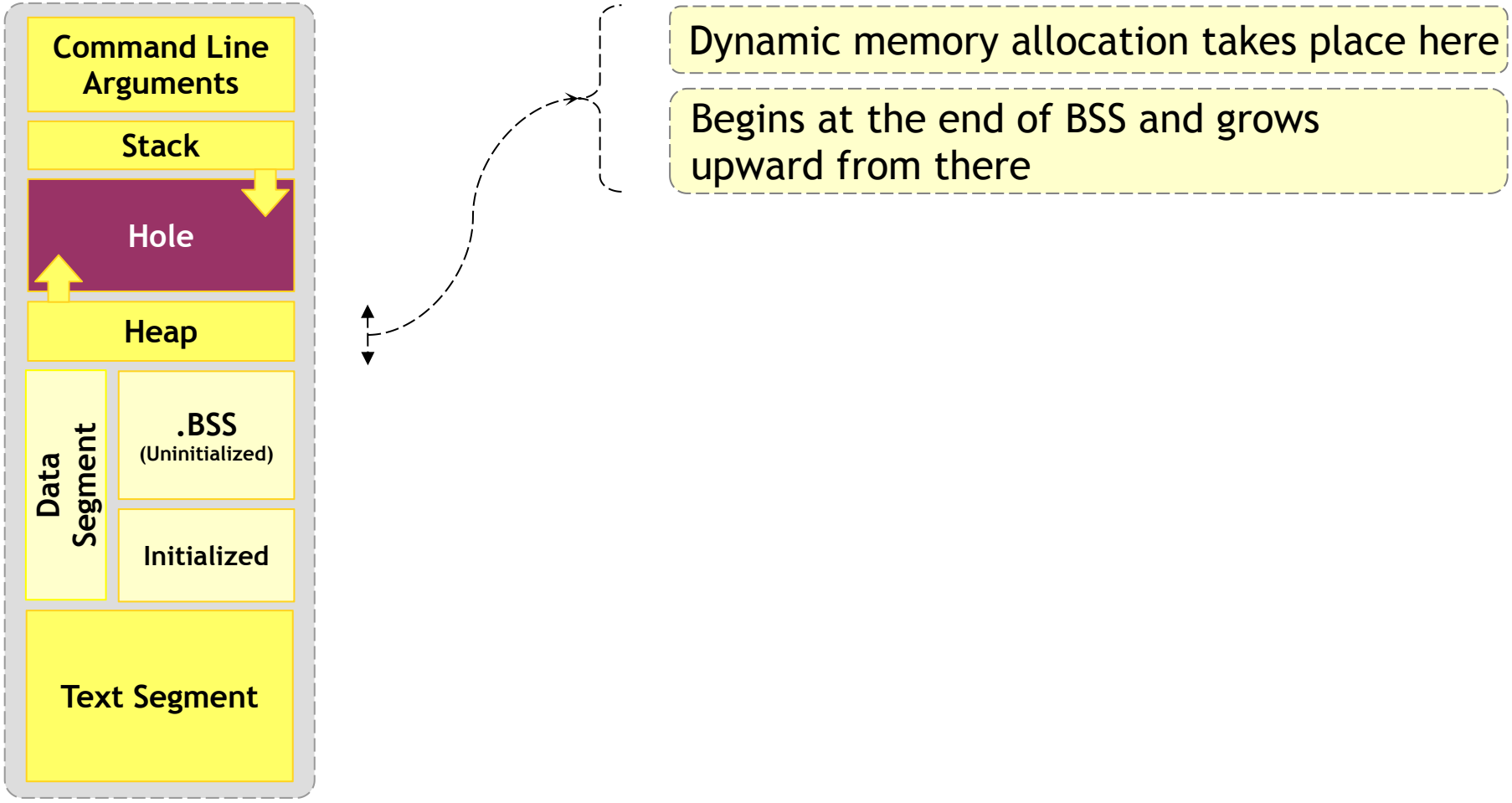
Memory Segments - Heap

Memory Segments



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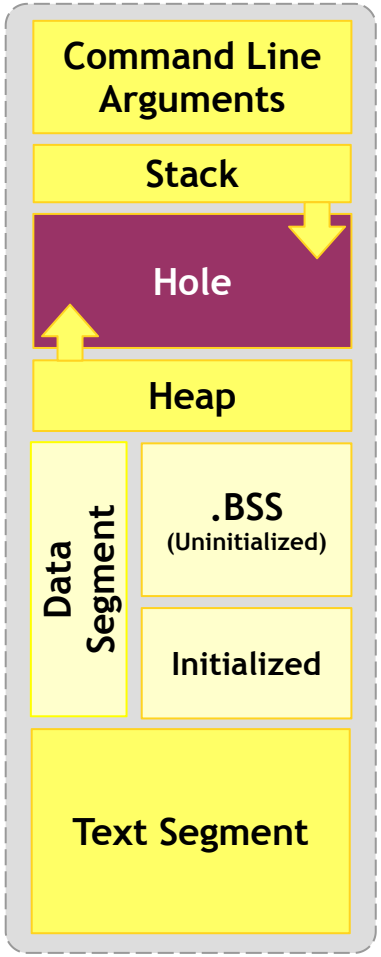
Memory Segments – Stack Segment

Memory Segments



- Adjoins the heap area and grow in opposite area of heap when stack and heap pointer meet (Memory Exhausted)
- Typically loaded at the higher part of memory
- A “stack pointer” register tracks the top of the stack; it is adjusted each time a value is “pushed” onto the stack
- The set of values pushed for one function call is termed a “stack frame”

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Storage Classes

Storage Class	Scope	Lifetime	Memory Allocation
auto	Within the block / Function	Till the end of the block / function	Stack
register	Within the block / Function	Till the end of the block / function	Register
static local	Within the block / Function	Till the end of the program	Data Segment
static global	File	Till the end of the program	Data segment
extern	Program	Till the end of the program	Data segment

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Storage Classes

Example

```c
#include <stdio.h>

int global_1;
int global_2 = 10;

static int global_3;
static int global_4 = 10;

int main()
{
    int local_1;
    static int local_2;
    static int local_3 = 20;

    register int i;
    for (i = 0; i < 0; i++)
    {
        /* Do Something */
    }

    return 0;
}
```

Variable	Storage Class	Memory Allocation
global_1	Global	.BSS
global_2	Global	Initialized data segment
global_3	Static global	.BSS
global_4	Static global	Initialized data segment
local_1	auto	stack
local_2	Static local	.BSS
local_3	Static local	Initialized data segment
iter	Register	Registers

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Declaration

```
extern int num1;
extern int num1;

int main();

int main()
{
    int num1, num2;
    char short_opt;

    ...
}
```

Declaration specifies type to the variables

Its like an announcement and hence can be made 1 or more times

Declaration about num1

Declaration about num1 yet again!!

Declaration about main function

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Storage Classes - extern

file1.c

```c
#include <stdio.h>

int num;

int main()
{
    while (1)
    {
        num++;
        func_1();
        sleep(1);
        func_2();
    }

    return 0;
}
```

file2.c

```c
#include <stdio.h>

extern int num;

int func_1()
{
    printf("num is %d from file2\n", num);

    return 0;
}
```

file3.c

```c
#include <stdio.h>

extern int num;

int func_2()
{
    printf("num is %d from file3\n", num);

    return 0;
}
```


Preprocessor

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Preprocessor – Header Files

- A header file is a file containing C declarations and macro definitions to be shared between several source files.
- Has to be included using C preprocessing directive '**#include**'
- Header files serve two purposes.
  - Declare the interfaces to parts of the operating system by supplying the definitions and declarations you need to invoke system calls and libraries.
  - Your own header files contain declarations for interfaces between the source files of your program.

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Preprocessor – Header Files vs Source Files

VS

- Declarations
- Sharable/reusable
  - #defines
  - Datatypes
- Used by more than 1 file

- Function and variable definitions
- Non sharable/reusable
  - #defines
  - Datatypes

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Preprocessor – Header Files - Syntax

Syntax

```
#include <file.h>
```

- System header files
- It searches for a file named ***file*** in a standard list of system directories

Syntax

```
#include "file.h"
```

- Local (your) header files
- It searches for a file named ***file*** first in the directory containing the current file, then in the quote directories and then the same directories used for <file>

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Preprocessor - Header Files - Once-Only

- If a header file happens to be included twice, the compiler will process its contents twice causing an error
- E.g. when the compiler sees the same structure definition twice
- This can be avoided like

Example

```
#ifndef NAME
#define NAME

/* The entire file is protected */

#endif
```

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Preprocessor - Macro - Object-Like

- An object-like macro is a simple identifier which will be replaced by a code fragment
- It is called object-like because it looks like a data object in code that uses it.
- They are most commonly used to give symbolic names to numeric constants

Syntax

```
#define SYMBOLIC_NAME      CONSTANTS
```

Example

```
#define BUFFER_SIZE        1024
```

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Preprocessor - Macro - Arguments

- Function-like macros can take arguments, just like true functions
- To define a macro that uses arguments, you insert parameters between the pair of parentheses in the macro definition that make the macro function-like

Example

```
#include <stdio.h>

#define SET_BIT(num, pos)      (num | (1 << pos))

int main()
{
    SET_BIT(0, 2);

    return 0;
}
```

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Preprocessor - Macro - Multiple Lines

- You may continue the definition onto multiple lines, if necessary, using backslash-newline.
- When the macro is expanded, however, it will all come out on one line

Example

```
#include <stdio.h>

#define SWAP(a, b)                  \
{                                   \
    int temp = a;                   \
    a = b;                          \
    b = temp;                       \
}

int main()
{
    int num1 = 10, num2= 20;

    SWAP(num1, num2);

    printf("%d %d\n", num1, num2);

    return 0;
}
```

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Preprocessor – Macro – Standard Predefined

- Several object-like macros are predefined; you use them without supplying their definitions.
- Standard are specified by the relevant language standards, so they are available with all compilers that implement those standards

Example

```
#include <stdio.h>

int main()
{

    printf("Program: \"%s\" ", __FILE__);
    printf("was compiled on %s at %s. ", __DATE__, __TIME__);
    printf("This print is from Function: \"%s\" at line %d\n", __func__, __LINE__);

    return 0;
}
```

Hope you enjoyed the session.
Thank You