Functions

Advanced C

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 programming languages it can be something which performs a specific service
- Generally a function has 3 properties
  - Takes Input
  - Perform Operation
  - Generate Output

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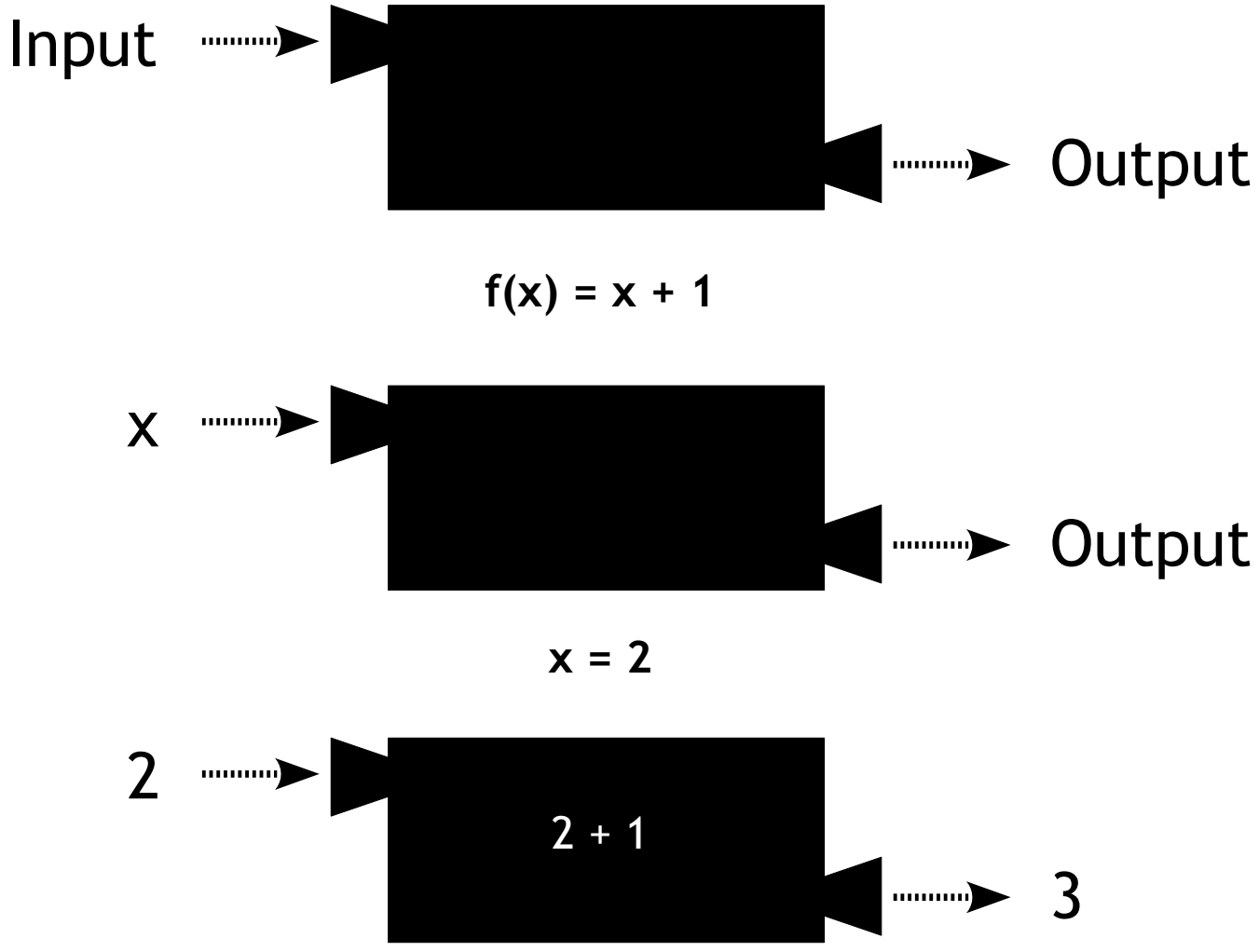
Functions – What?



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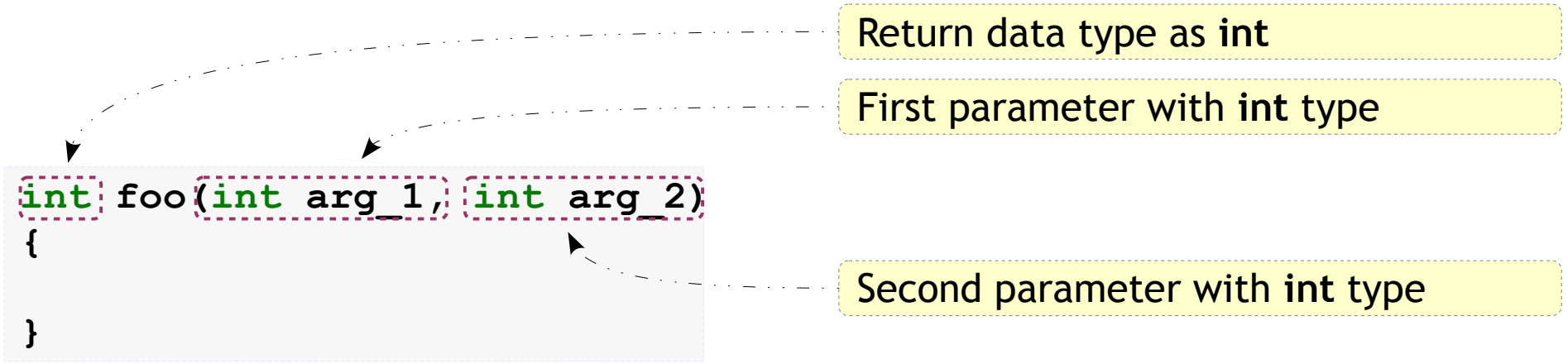
Functions - How to write

Syntax

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

List of function parameters

Example



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Functions - How to write

$$y = x + 1$$

Example

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

    ret = x + 1;

    return ret;
}
```

Return from function

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Functions - How to call

001_example.c

```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

002_example.c

```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

operation

Return result from function and exit

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Functions - Ignoring return value

003_example.c

```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 – DIY

- Write a function to calculate square a number
  - y = x * x
- Write a function to convert temperature given in degree Fahrenheit to degree Celsius
  - C = 5/9 * (F – 32)
- Write a program to check if a given number is even or odd. Function should return TRUE or FALSE

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Function and the Stack

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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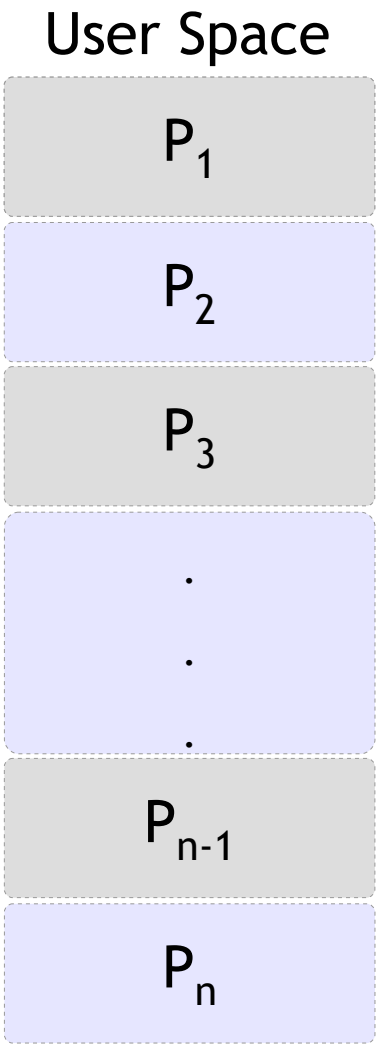
Function and the Stack



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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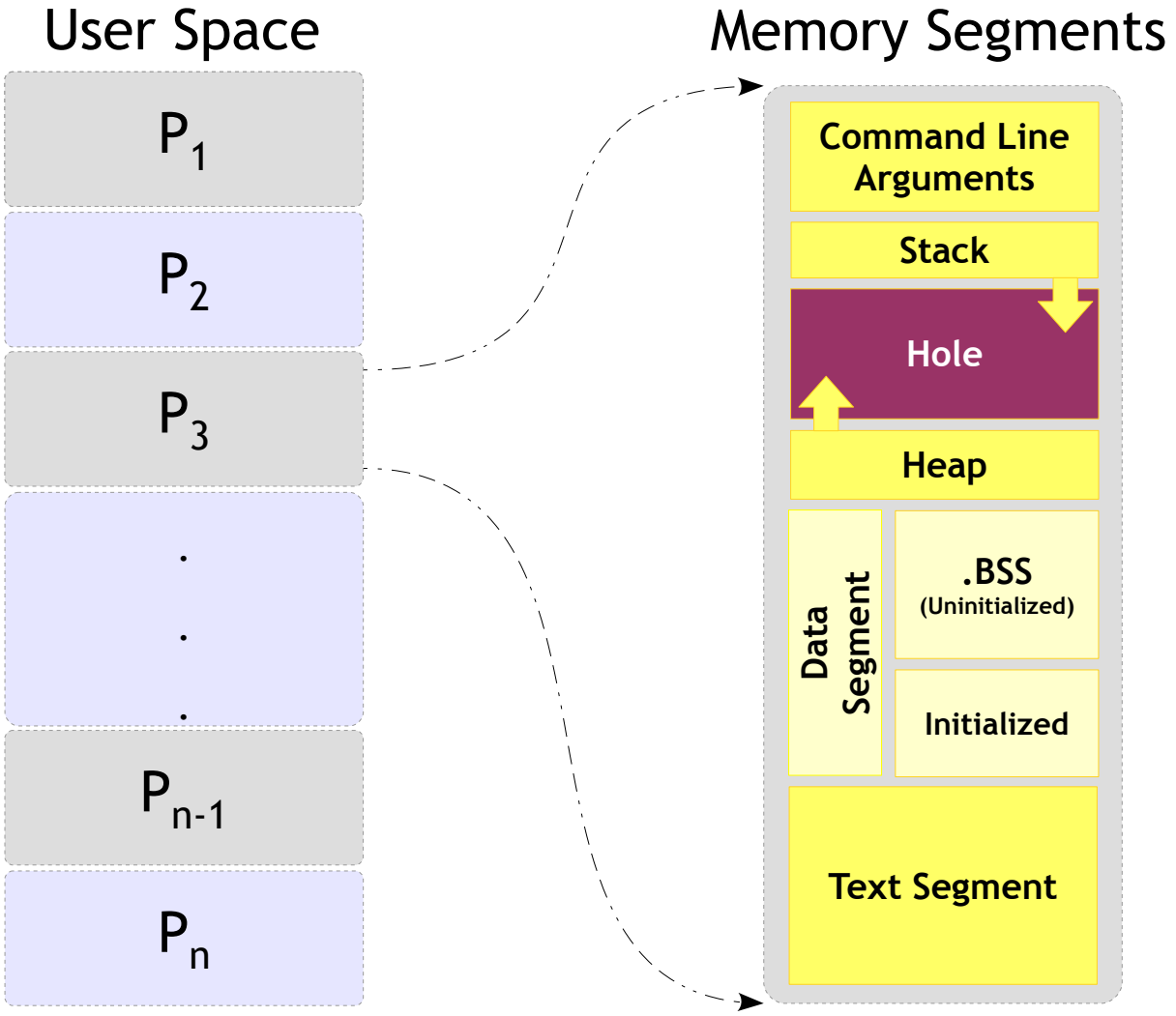
Function and the Stack



The memory segment of a program contains four major areas.

- Text Segment
- Stack
- Data Segment
- Heap

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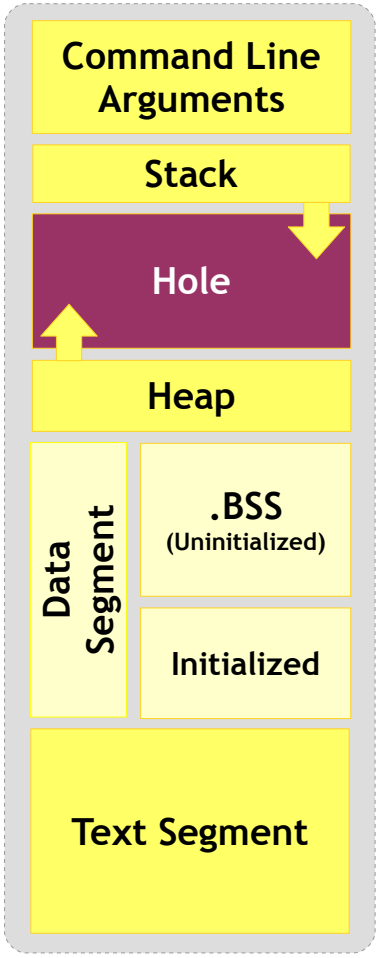
Function and the Stack

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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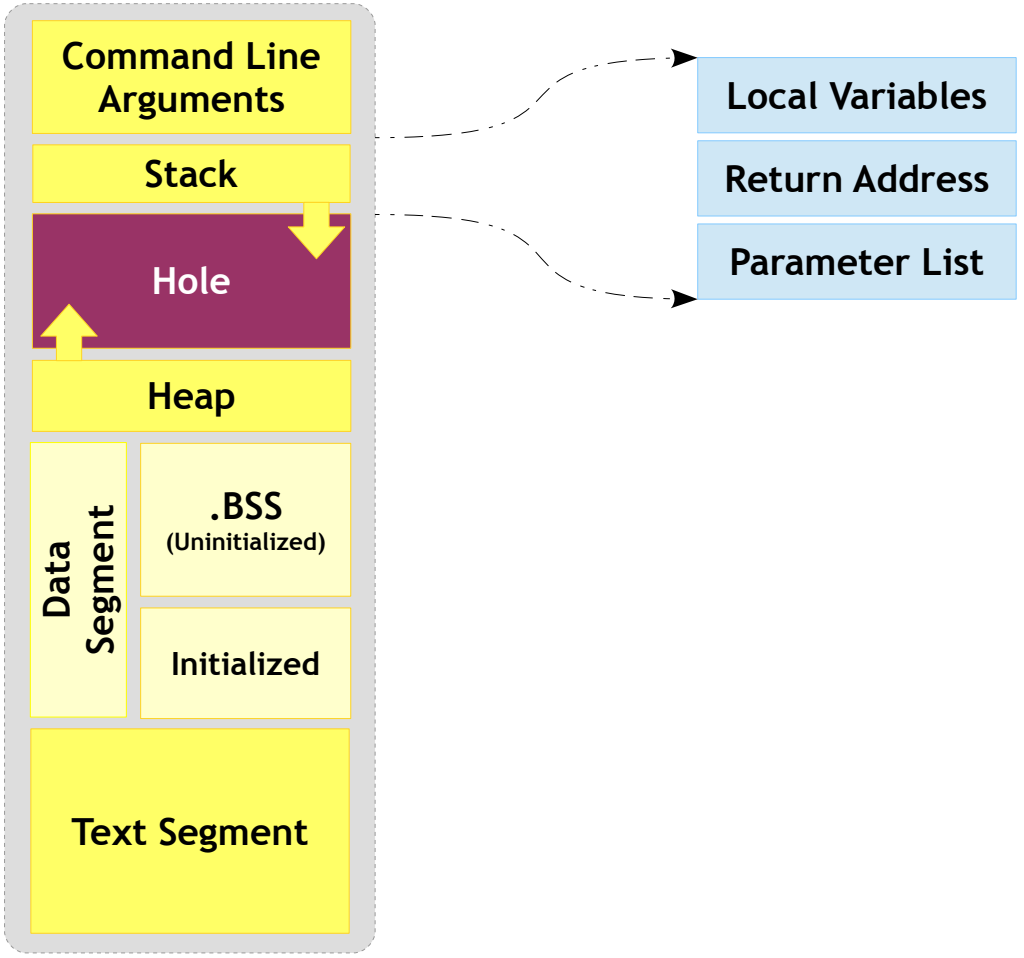
Function and the Stack

Memory Segments



Stack Frame

A stack frame contain at least of a return address

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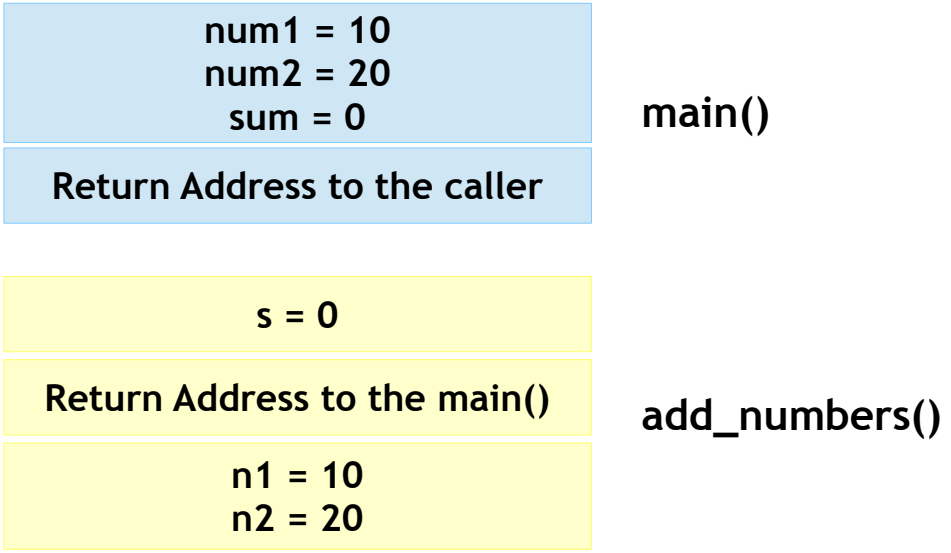
Function and the Stack - Stack Frames

002_example.c

```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;
}
```

```c
int add_numbers(int n1, int n2)
{
    int s = 0;

    s = n1 + n2;

    return s;
}
```

Stack Frame(s)



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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

002_example.c

```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

004_example.c

```c
#include <stdio.h>

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

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;
}
```

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Functions - Pass by Value

Are you sure you understood the previous problem?

Are you sure you are ready to proceed further?

Do you know the prerequisite to proceed further?

If no let's get it cleared

Advanced C

Functions - Pass by Reference

005_example.c

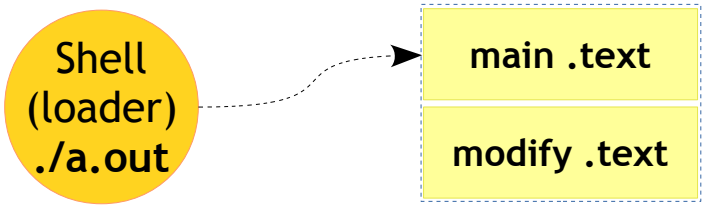
```c
#include <stdio.h>

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

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;
}
```

Advanced C

Functions - Pass by Reference

005_example.c

```c
#include <stdio.h>

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

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;
}
```

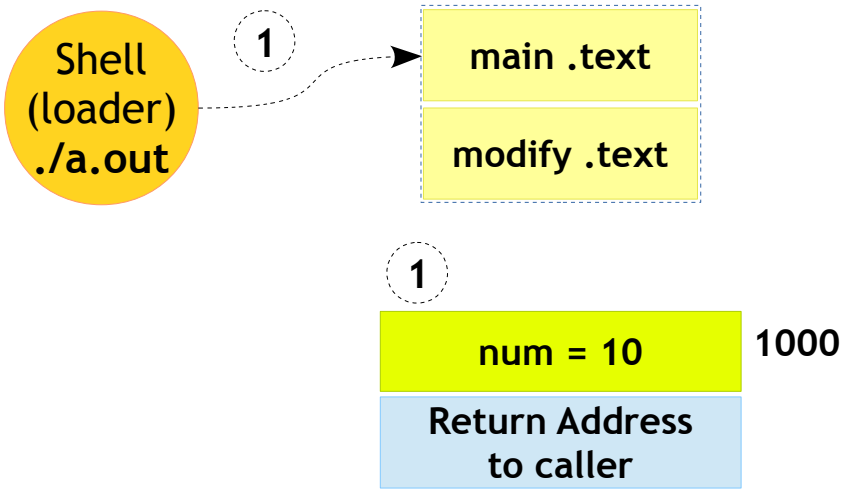


Advanced C

Functions - Pass by Reference

005_example.c

```c
#include <stdio.h>

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

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;
}
```



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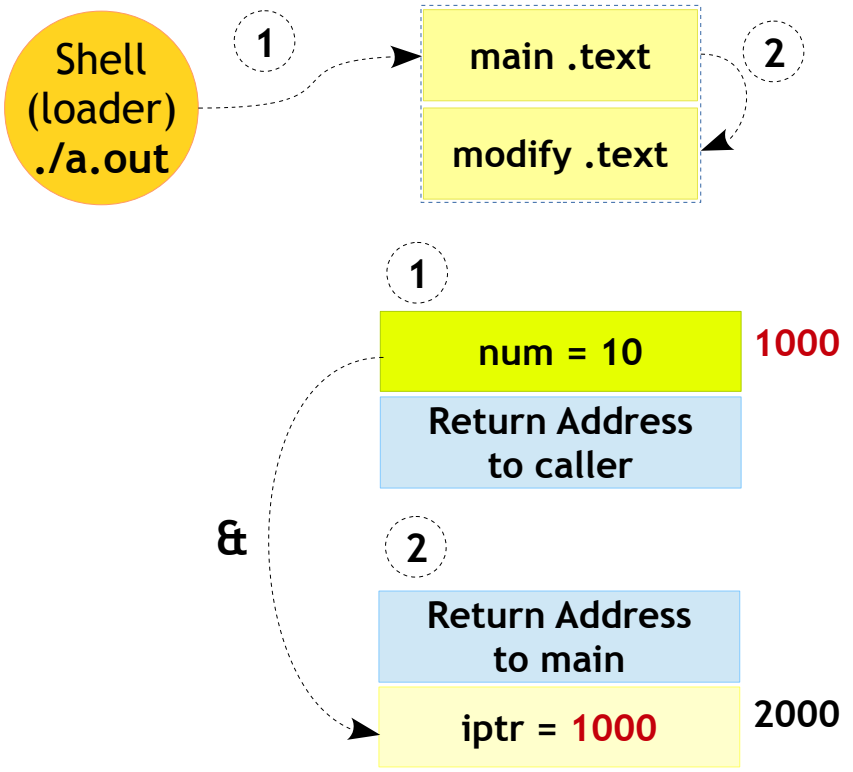
Advanced C

Functions - Pass by Reference

005_example.c

```c
#include <stdio.h>

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

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;
}
```



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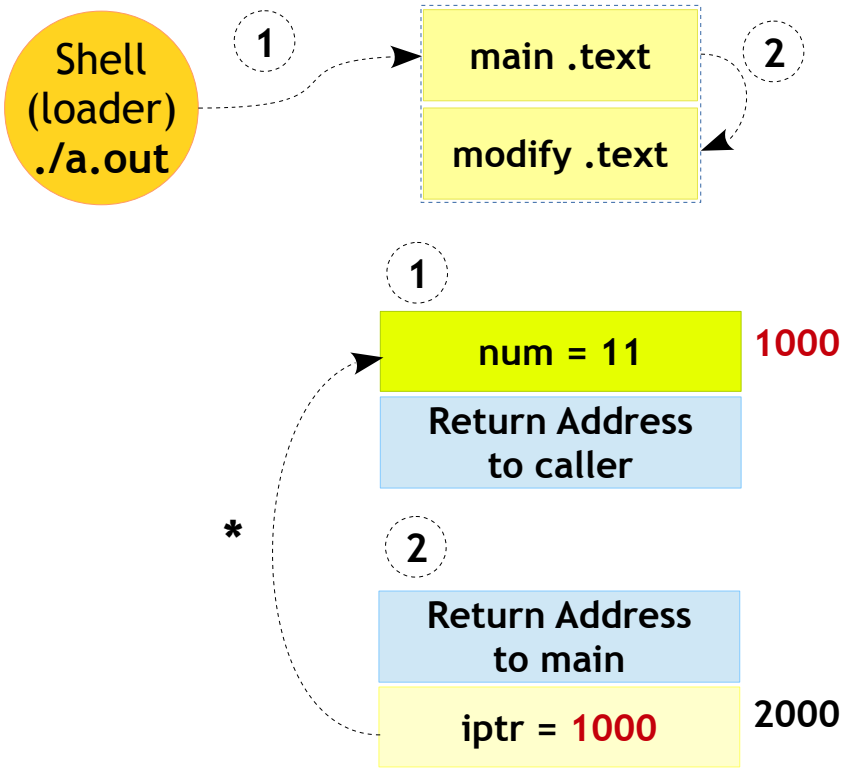
Functions - Pass by Reference

005_example.c

```c
#include <stdio.h>

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

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;
}
```



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Functions – Pass by Reference - Advantages

- Return more than one value from a function
- Copy of the argument is not made, making it fast, even when used with large variables like arrays etc.
- Saving stack space if argument variables are larger (example – user defined data types)

Advanced C

Functions – DIY (pass-by-reference)

- Write a program to find the square and cube of a number
- Write a program to swap two numbers
- Write a program to find the sum and product of 2 numbers
- Write a program to find the square of a number

Advanced C

Functions - Implicit int rule

006_example.c

```c
#include <stdio.h>

int main()
{
    dummy(20);

    return 0;
}

/* minimum valid function */
dummy()
{

}
```

- Compilers can assume that return and function parameter types are integers
- The rule was introduced in C89/90
- This rule is discontinued in C99
- But, compilers still follow the above rule to maintain backward compatibility

Advanced C

Functions - Prototype - What?

- Function prototype is signature of function specifying
  - Number of function parameters and their types
  - Return type of function

Advanced C

Functions – Prototype – Why?

- Need of function prototype –
  - Functions can be used in many files
  - Functions can be compiled and added to library for reuse purpose
  - Compiler needs to know the signature of function before it comes across the invocation of function
  - In absence of prototype, compilers will apply “Implicit int rule” which might lead to discrepancy with function parameters and return type in actual definition

Advanced C

Functions – Passing Array

- As mentioned in previous slide passing an array to function can be faster
- But before you proceed further it is expected you are familiar with some pointer rules
- If you are OK with your concepts proceed further, else please know the rules first

Advanced C

Functions - Passing Array

007_example.c

```c
#include <stdio.h>

void print_array(int array[]);

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

    print_array(array);

    return 0;
}
```

```c
void print_array(int array[])
{
    int iter;

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

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Advanced C

Functions - Passing Array

008_example.c

```c
#include <stdio.h>

void print_array(int *array);

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

    print_array(array);

    return 0;
}
```

```c
void print_array(int *array)
{
    int iter;

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

Advanced C

Functions - Passing Array

009_example.c

```c
#include <stdio.h>

void print_array(int *array, int size);

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

    print_array(array, 5);

    return 0;
}
```

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

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

Advanced C

Functions - Returning Array

010_example.c

```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 *new_array_val;

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

     return 0;
}
```

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

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

     return array;
}
```

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

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

Advanced C

Functions - Returning Array

011_example.c

```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  iter;

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

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Functions – DIY

- Write a program to find the average of 5 array elements using function
- Write a program to square each element of array which has 5 elements

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Functions - Local Return

012_example.c

```c
#include <stdio.h>

int *func(void)
{
    int a = 10;

    return &a;
}

int main()
{
    int *ptr;

    ptr = func();

    printf("Hello World\n");

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

    return 0;
}
```

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Functions - Void Return

013_example.c

```c
#include <stdio.h>

void func(void)
{
    printf("Welcome!\n");

    return; // Use of return is optional
}

int main()
{
    func();

    return 0;
}
```

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Functions - Void Return

014_example.c

```c
#include <stdio.h>

int main()
{
    printf("%s\n", func()); // Error, invalid use of a function returning void

    return 0;
}


void func(void)
{
    char buff[] = "Hello World";

    return buff; // some compilers might report error in this case
}
```

Recursive Function

Advanced C

Functions

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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

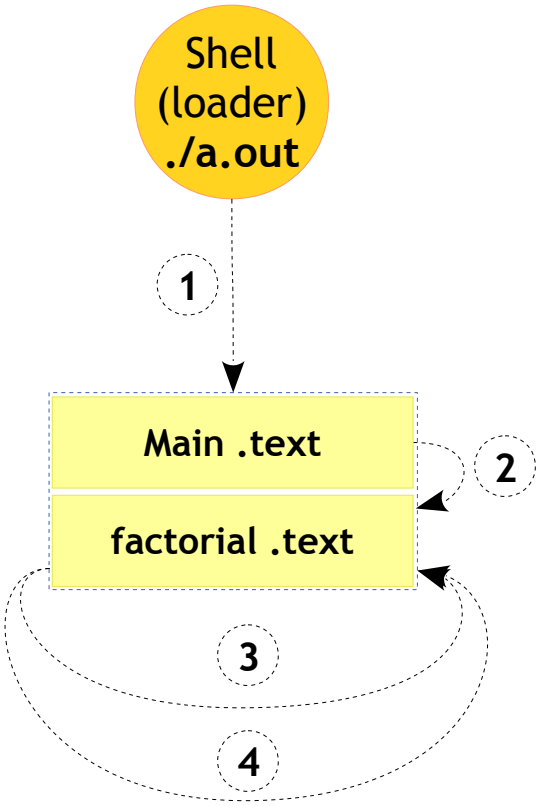
015_example.c

```c
#include <stdio.h>

/* Factorial of 3 numbers */

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

int main()
{
    int ret;

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

    return 0;
}
```

n	!n
0	1
1	1
2	2
3	6
4	24

Embedded C

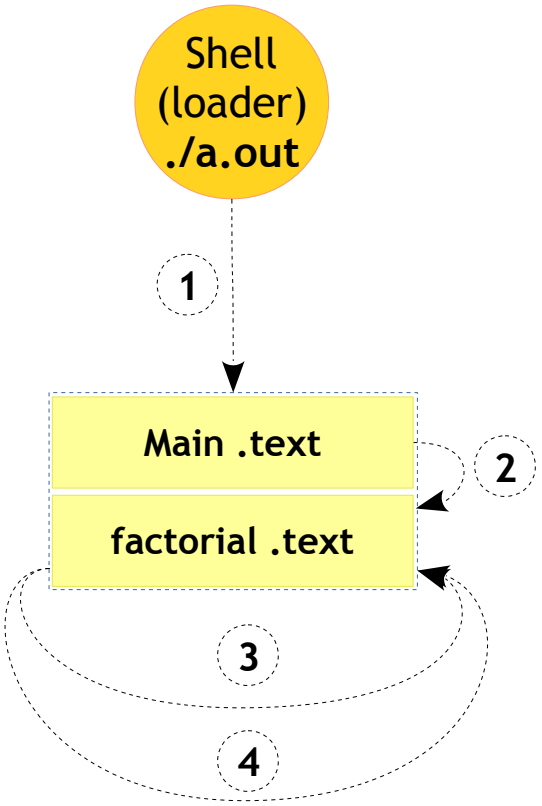
Functions - Recursive - Example Flow



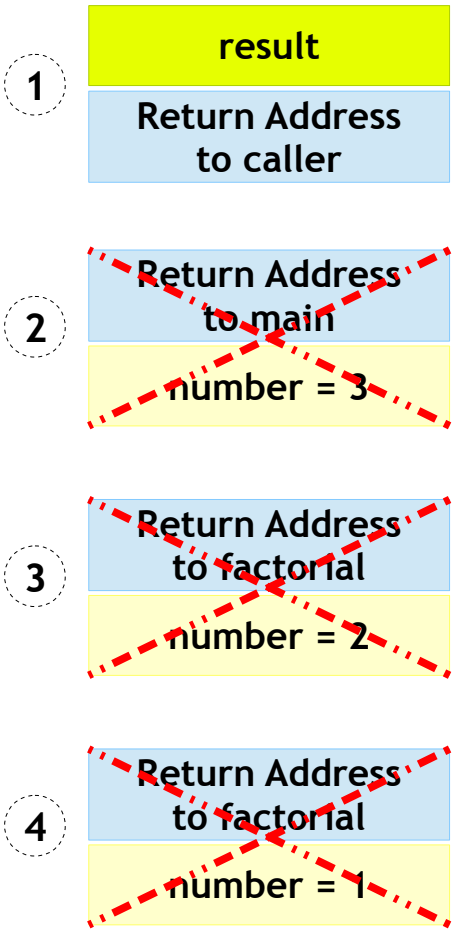
	Stack Frames	Value with calls
1	result Return Address to caller	factorial(3)
2	Return Address to main number = 3	number != 1 number * factorial(number -1) 3 * factorial(3 -1)
3	Return Address to factorial number = 2	number != 1 number * factorial(number -1) 2 * factorial(2 -1)
4	Return Address to factorial number = 1	number == 1

Embedded C

Functions - Recursive - Example Flow



Stack Frames



Results with return

Gets 6 a value

Returns 3 * 2 to the caller

Returns 2 * 1 to the caller

returns 1 to the caller

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Functions – DIY

- Write a program to find the sum of sequence of N numbers starting from 1
- Write a program to find x raise to the power of y (x^y)
  - Example : $2^3 = 8$
- Write a program to find the sum of digits of a given number
  - Example : if given number is 10372, the sum of digits will be 1+0+3+9+2 = 15

Standard I/O Functions