Introduction to Programming

Week – *8*, Lecture – *1*

Functions in C – Part 2

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What can we do with functions?

Part of a library, or defined by you, we have used functions for many aspects till now, e.g.

- Printing values on screen (using the good old `printf()` function)
- Calculating complex mathematical functions like square root (through the `sqrt()` function)
- Removing leading and trailing spaces from a string (with the `trim()` function we wrote) etc.

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At times, you may need a function to return two or more values

- For such cases, we can use a trick that many programming languages provide

The trick is to pass parameters *by reference* and not *by value*

What is meant by *Pass by Value*?

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These values are copied to “new” memory locations…

- … allocated for the variables that act as formal parameters in the called function

Passing parameters by Value

```
function f()
{
    ...
    a = 10;
    g(a, 5);
    ...
}


function g(int a, int b)
{
    ...
    ...
    ...
}
```

For example, if `f()` is the calling function and `g()` is the called function

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For example, if `f()` is the calling function and `g()` is the called function

Also, `g()` expects two parameters, `a` and `b` (both integers)

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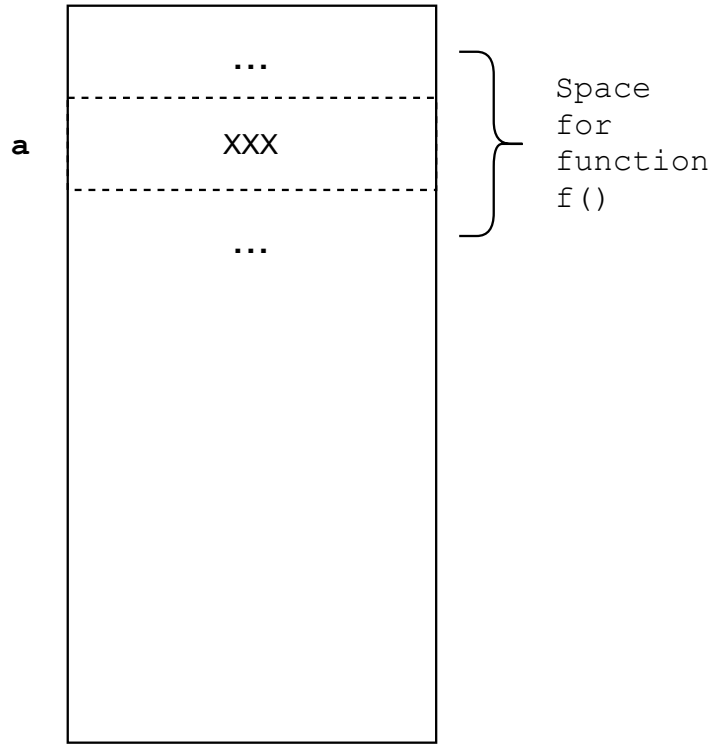
```



Some space in the memory is allocated for execution of `f()`

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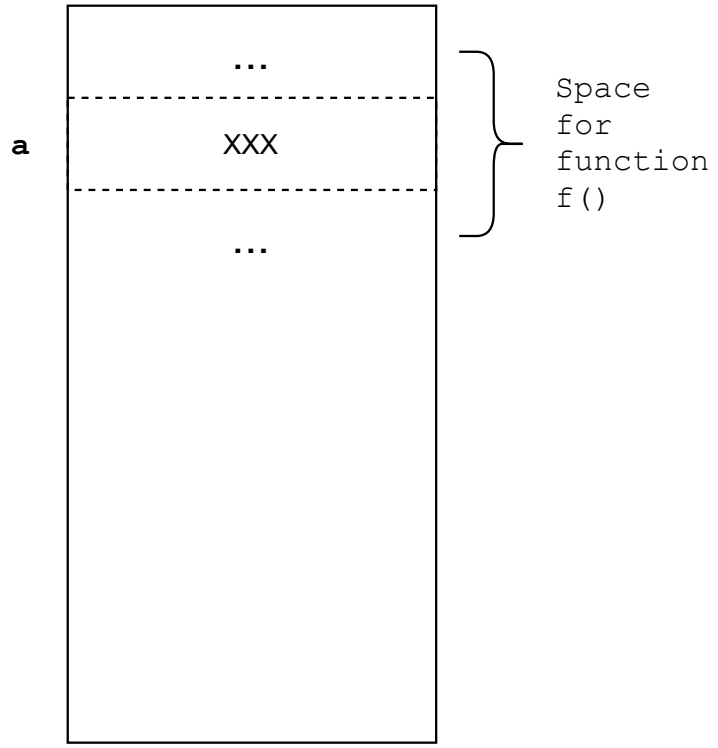

Some space in the memory is allocated for execution of `f()`

The local variable, `a`, is allocated some space in this block

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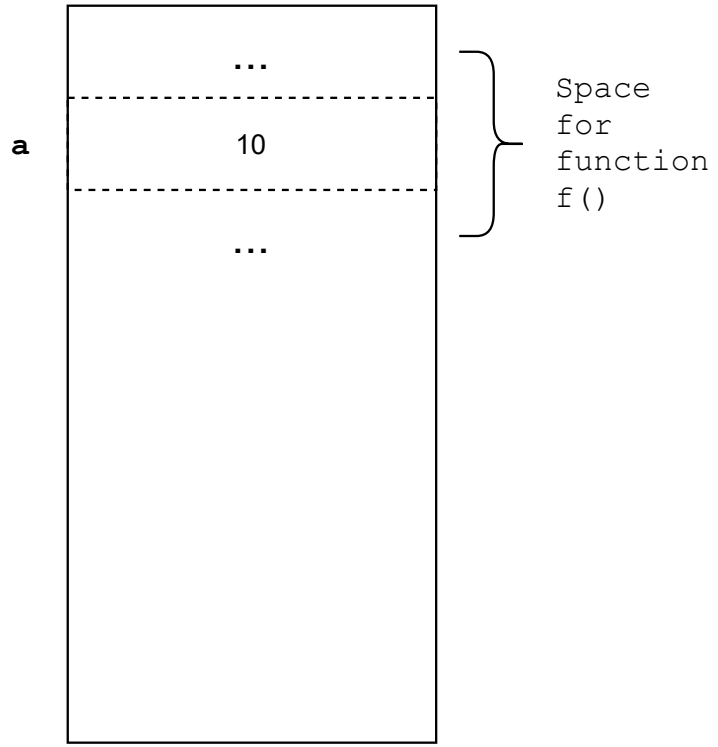

Assume that the ”current” value of `a` is set to `10`

Passing parameters by Value

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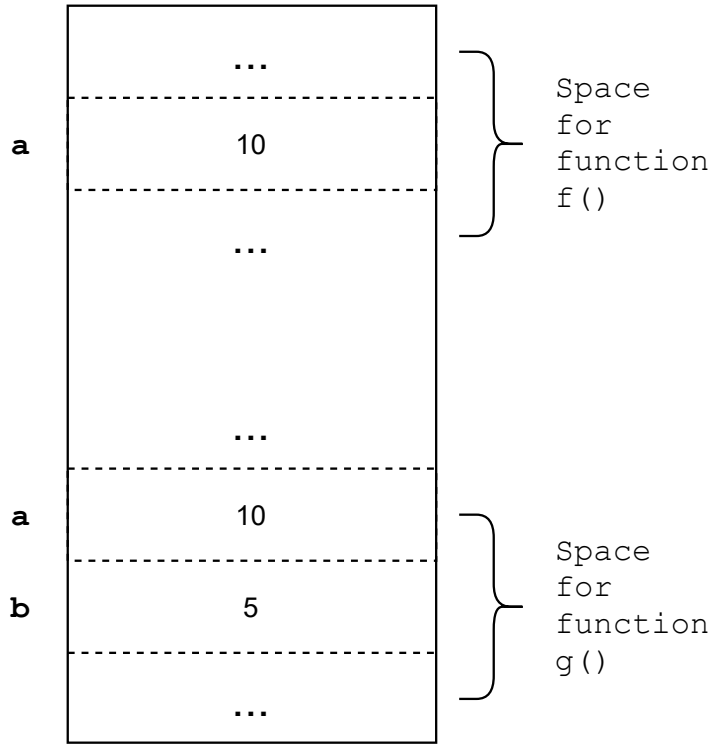

When `g()` is called, some more space is set aside for its execution

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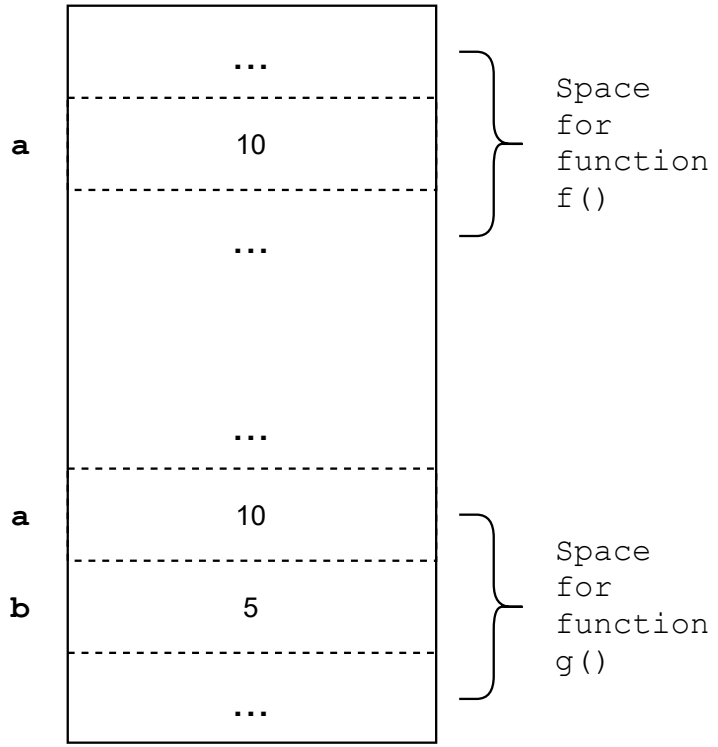

When `g()` is called, some more space is set aside for its execution

Two local variables, `a` and `b` are allocated some space in this block…

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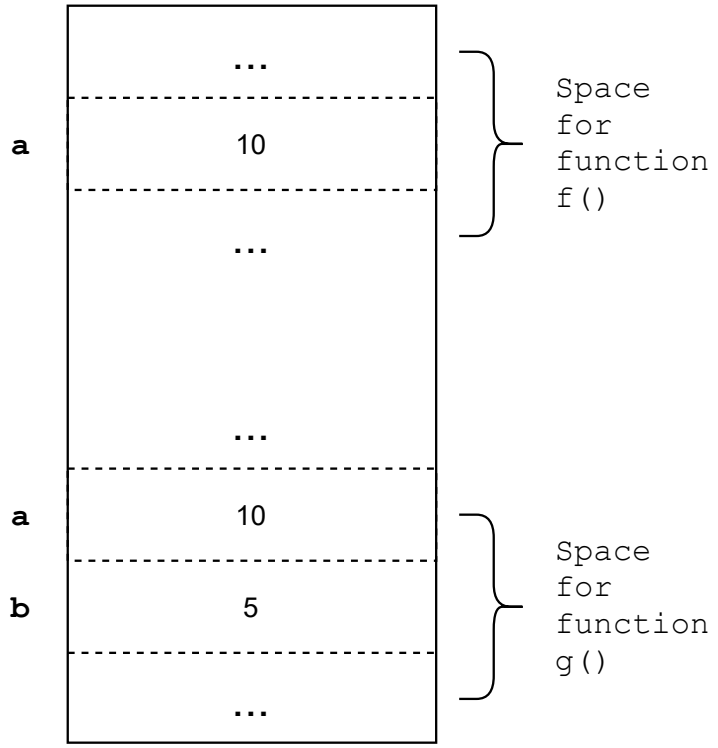

When `g()` is called, some more space is set aside for its execution

Two local variables, `a` and `b` are allocated some space in this block…

… and, they are initialised by copying values of actual parameters (i.e. `10` and `5`)

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This means that the value of the actual parameters “travel” to the called function…

- … even if the passed parameter is a variable, all that matters, is its “current” value

These values are copied to “new” memory locations…

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These memory locations are “active”, till the function executes, and are “freed” when it returns

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These memory locations are “active”, till the function executes, and are “freed” when it returns

Since only the values travelled to the called function…

- … the memory allocated for (and hence, any variables in,) the calling function remain unaffected

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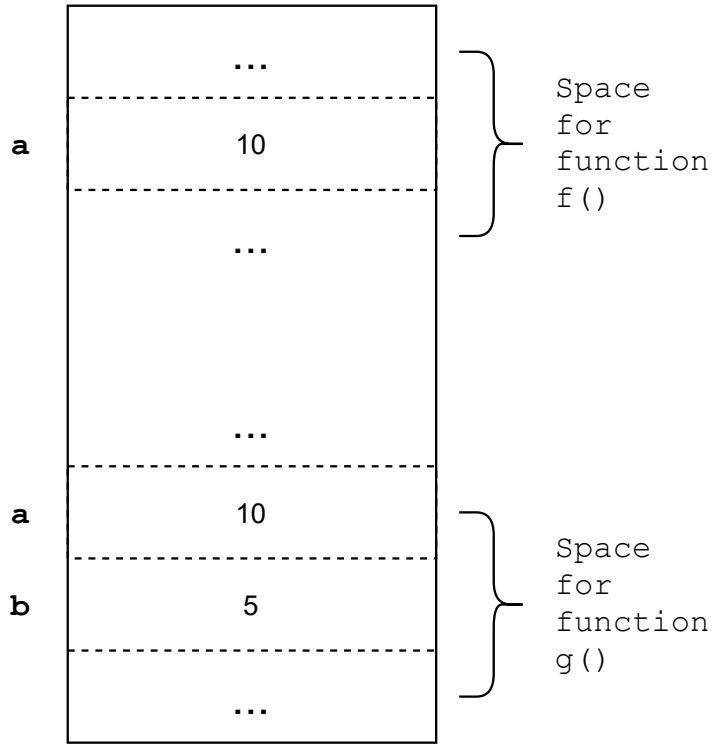

The two a variables here are at different memory locations

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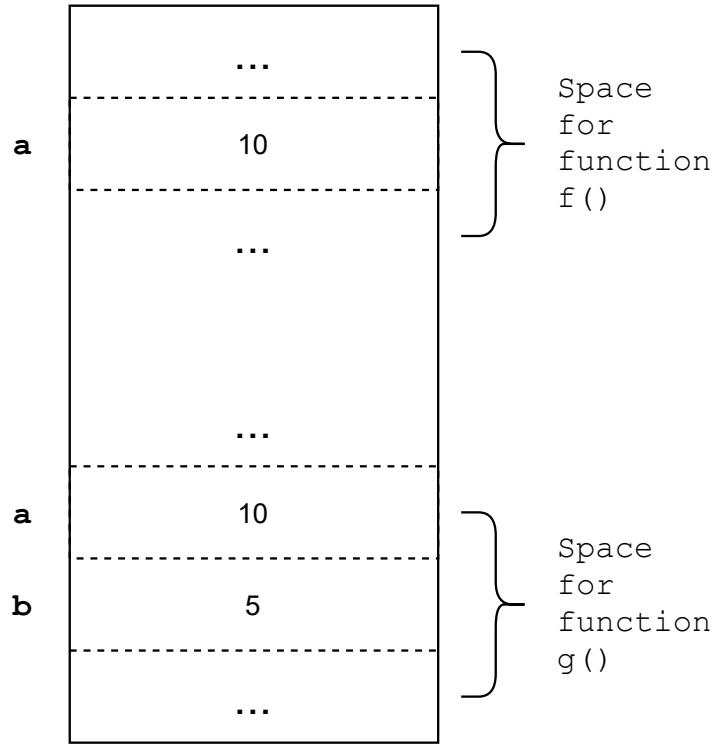

The two `a` variables here are at different memory locations

Thus, a change to `a` in `g()`, does not affect `a` in `f()`

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This involves sending the address of a variable as a parameter value from the calling function…

- … and in the called function, using a pointer variable to store the address

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function f()
{
    ...
    a = 10;
    g(&a, 5);
    ...
}


function g(int *p, int b)
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    ...
    ...
    ...
}
```

For example, in the previously discussed scenario, we can pass the first parameter by reference as well (the second parameter, here is a constant, so pass by reference is not applicable)

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For example, in the previously discussed scenario, we can pass the first parameter by reference as well (the second parameter, here is a constant, so pass by reference is not applicable)

We pass the address of `a` from `f()` and use a pointer variable `p` to store it in `g()`

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In the called function, we make changes using the address of the passed variable…

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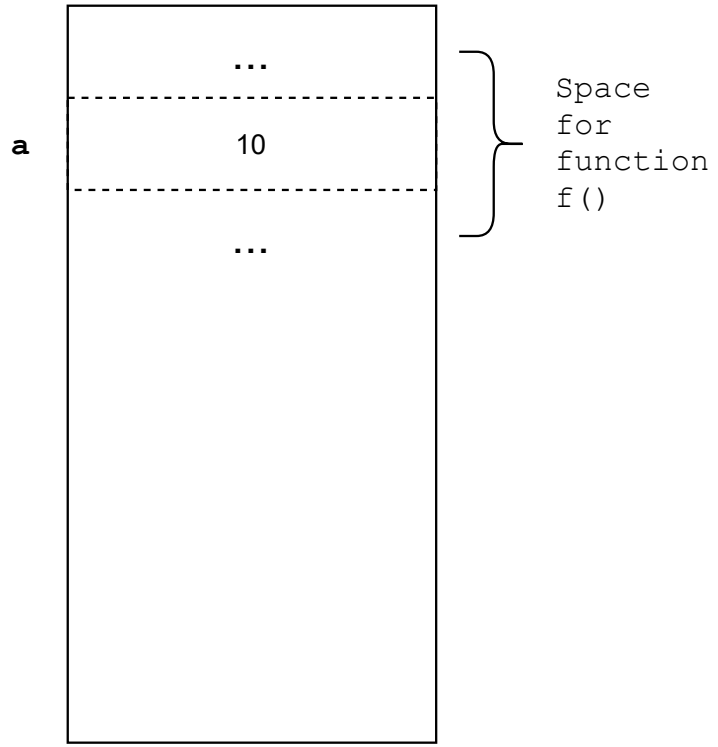

It doesn't matter now, what the current value of `a` is…

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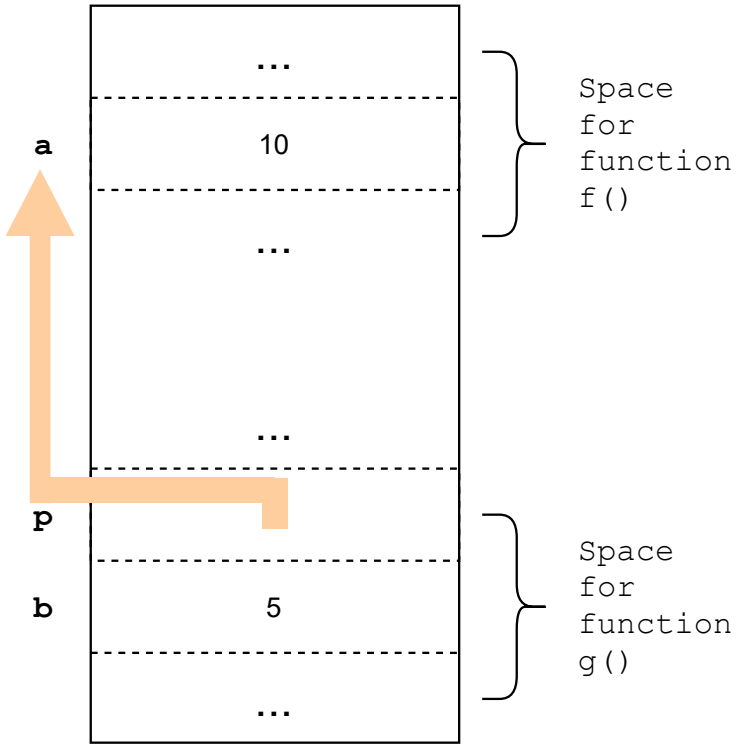

… because the memory location of `a`, is directly accessible to `g()`

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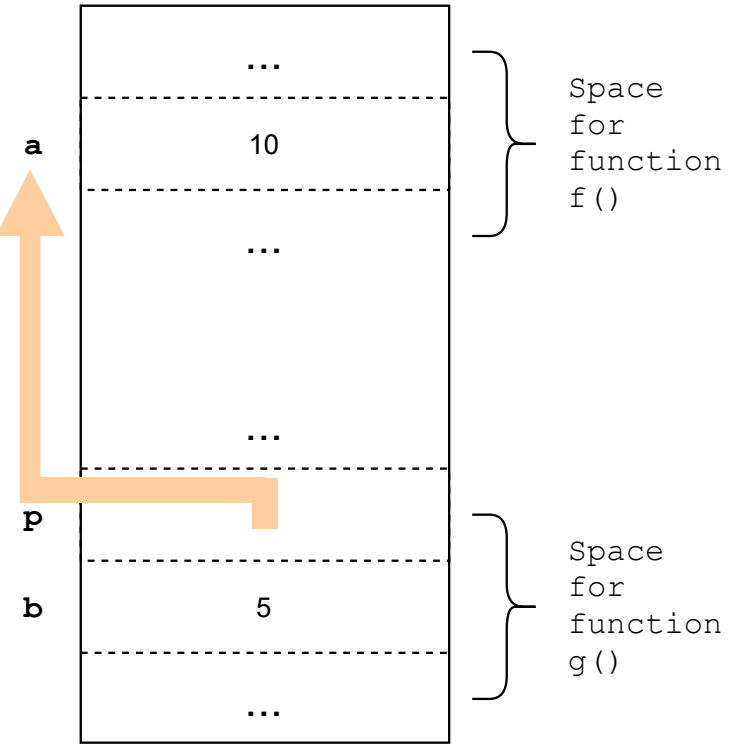

… because the memory location of `a`, is directly accessible to `g()`

Any changes made via this address (by using `*p`) happen directly at the location of `a`, making it visible to `f()` even after `g()` returns

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- Here, side effects mean undesired changes in values of variables in the calling function, after the call
- e.g. in the sample scenario, the value of `a` in `f()` is not affected by any changes to `a` in `g()`

However, sometimes, we may need these side effects

- The most common example, is when we need more than one value to be returned from a function

In this case, a common trick is to *pass one or more parameters* to the function by *reference*

This involves sending the address of a variable as a parameter value from the calling function…

- … and in the called function, using a pointer variable to store the address

In the called function, we make changes using the address of the passed variable…

- … meaning that when the call finishes, the changes made in the function are visible in the calling function

This trick, thus, can be used to get *implicit* outputs from a function, even without returning them

Example – The *im*perfect swapping

```c
#include<stdio.h>

void imperfect_swap(int a, int b)
{
        int temp;
        printf("In function imperfect_swap()\n");
        printf("Before swap...\n");
        printf("a = %d, b = %d\n", a, b);
        printf("Swapping...\n");
        temp = a;
        a = b;
        b = temp;
        printf("After swap...\n");
        printf("a = %d, b = %d\n", a, b);
}

int main()
{
        int a = 5, b =15;
        printf("In function main()\n");
        printf("Before swap...\n");
        printf("a = %d, b = %d\n", a, b);
        printf("Calling the function to swap values...\n");
        imperfect_swap(a, b);
        printf("Call to the function returned\n");
        printf("a = %d, b = %d\n", a, b);
        return 0;
}
```

To see its relevance, let us see this “incorrect” attempt to use a function to swap values of two integer variables

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        return 0;
}
```

To see its relevance, let us see this “incorrect” attempt to use a function to swap values of two integer variables

In the first attempt, we are trying to do so, by passing the parameters by value

Example – The *im*perfect swapping

```
saurabh@saurabh-VirtualBox:~/C/examples/Week 8$ gcc ImperfectSwap.c
saurabh@saurabh-VirtualBox:~/C/examples/Week 8$ ./a.out
In function main()
Before swap...
a = 5, b = 15
Calling the function to swap values...
In function imperfect_swap()
Before swap...
a = 5, b = 15
Swapping...
After swap...
a = 15, b = 5
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While the values change in the called function…

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```

While the values change in the called function…

... they remain the same in the calling function

Example – The perfect swapping

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In the second attempt, we change the type of parameter passing to reference

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So, we now use two pointer variables to perform the swapping

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Now, the changes made in the called function…

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```

Now, the changes made in the called function…

... are also visible in the calling function

Some additional points

We can use the same concept while returning values as well…

- … i.e., instead of returning a value, we can also return an address

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- So, returning the address to such a variable can be disastrous !!

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- A good candidate for returning the address, is of any memory block allocated via `malloc()`

Arrays are always passed by reference in C

- This follows from the fact that array names are, in fact, pointer constants
- Remember: the expression `arr` (where `arr` is an array’s name) is equivalent to `&arr[0]`

Example – The `trim()` function… again

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

void trim(char str[])
{
        int len = strlen(str), beg = 0, end = len-1, ctr = 0;
        while(beg <= end && str[beg] == ' ')
                beg++;
        while(end >= beg && str[end] == ' ')
                end--;
        for(ctr = 0; beg <= end; ctr++, beg++)
                str[ctr] = str[beg];
        str[ctr] = '\0';
}

int main()
{
        char str[] = "  Hello  ";
        printf("The initial array is \"%s\"\n", str);
        trim(str);
        printf("The array after trimming is \"%s\"\n", str);
}
```

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Even though we don't pass any addresses here explicitly…

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```

Even though we don't pass any addresses here explicitly…

… the changes made in the called function can be observed in the calling function

Example – The `trim()` function… again

```
saurabh@saurabh-VirtualBox:~/C/examples/Week 8$ gcc TrimString.c
saurabh@saurabh-VirtualBox:~/C/examples/Week 8$ ./a.out
The initial array is "  Hello  "
The array after trimming is "Hello"
saurabh@saurabh-VirtualBox:~/C/examples/Week 8$
```

Example – The `trim()` function… again

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The initial array is "  Hello  "
The array after trimming is "Hello"
saurabh@saurabh-VirtualBox:~/C/examples/Week 8$
```

Now, the changes made in the called function…

Some additional points

We can use the same concept while returning values as well…

- … i.e., instead of returning a value, we can also return an address

However, the returned address must be “accessible” for it to make any sense

- Remember, local variables in the called function will vanish, after the call returns
- So, returning the address to such a variable can be disastrous !!
- A good candidate for returning the address, is of any memory block allocated via `malloc()`

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If you are coming from C++ background, you may find the terminology a little confusing

- In C++, whatever we studied, is known as *pass by pointers*, whereas *pass by reference* is something else
- But in C, there is no concept of a reference, thus, pass by pointers is *a way to emulate* pass by reference

Homework !!

The terminology problem does not really have a perfect answer…

- It is true that C only allows passing parameters by value, and thus, using pointers, is kind of a hack
- But that doesn't mean that it cannot by called "pass by reference"
- Read the discussions on this interesting thread: https://stackoverflow.com/questions/59048556/no-call-by-reference-in-c