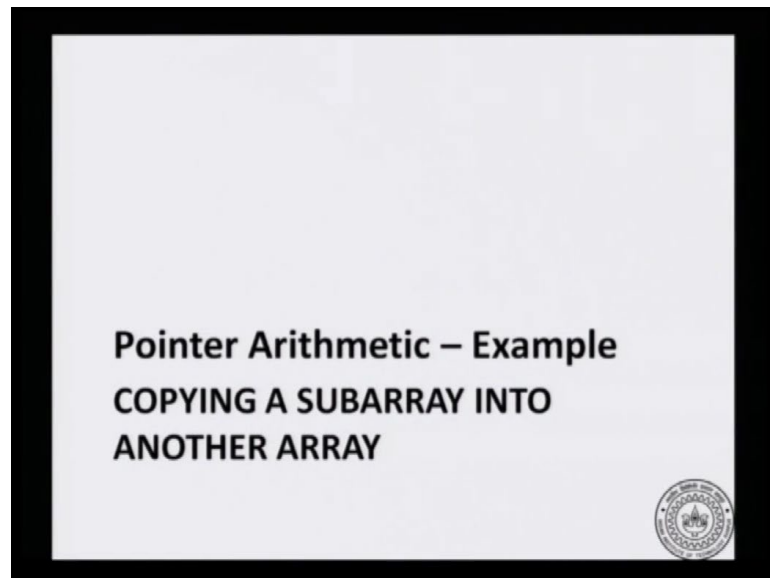


## Introduction to Programming in C Department of Computer Science and Engineering

Since pointer arithmetic is a tricky concept let us solve one more problem to try to get comfortable with that notion.

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So, the problem here is copying a sub array into another array. Now, let us explain what that means?

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The slide has a white background with a black border. It contains several text blocks: a blue box with a description of a function, a black box with C code, a green box with numbered instructions, and a black box with a function signature. A blue question is at the bottom, and a logo is in the bottom right.

I have written a function `copy_array(int a[], int b[], int n)`. It copies `n` successive index elements from `a[]` and puts into `b[]`.

```
int copy_array(int a[], int b[], int n) {
    int i;
    for (i=0; i < n; i =i+1) {
        b[i] = a[i];
    }
    return 0;
}
```

But this is not general !!

1. Suppose there are two arrays `from[]` and `to[]`.
2. I want to copy `n` numbers from the array `from[]` starting at index `i` into the array `to[]` starting at index `j`.
3. I need a declaration like this below.

```
int copy_array_2( int from[], int i,
                 int to [], int j,
                 int n);
```

Can you write this function?

Suppose, I have written a function `copy_array()` which has three arguments an integer array `a[ ]` and integer array `b[ ]` and `n` which is the size, I want to copy `n` successive index

elements from a and put it into b. So, a is 0 through a n - 1 have to be copied to b. I can easily write it in the following function has int copy\_array int a, int b, int n and then I have one variable to keep track of the index and that variable goes from 0 to n, for i = 0, i < n, i = i + 1 and then I simply say b[i] = a[i] within the loop.

So, this would copy whatever a[i] is into the location b[i]. So, once the loop executes, I would have copied n elements from the array a to the array b. But, this is not general and I want to solve the following problem, I have two arrays let us name them from( ) and to( ) and I want to copy n numbers from the array from[ ] to to[ ]. But, I have an additional requirement, I want to copy n elements from index i.

So, the earlier code solve the problem from index 0 in general I want to copy from index i of from[ ] in the elements into the locations starting at index j in to[ ]. So, the earlier function assume that i and j were both 0. In the general function I want arbitrary i and arbitrary j. So, I need a declaration like the following, I have int copy\_array\_2. So, this is the second function I am writing and I have from i to j and then n is the number of elements to copy. So, what I have to do is from i from i + 1. So, on up to from i + n - 1 have to be copied to to[j], to[j+1] so, on up to to[j + n - 1].

So, for the purposes of this lecture let us just assume that from[ ] and to[ ] are big enough. So, that you will never ever over suit the arrays by taking i + n -1 and j + n - 1. Can you write this function? Now; obviously, you can write a separate function to solve this. Now, the trick is can you use the copy\_array() function, the copy\_array() functions copied n elements starting from index 0 of a to index n - 1 to the array b starting at index b [0] to b[n - 1]. So, that is what is it means.

And this should be strange, because if you think about it in a mathematical way, you are saying that a general function is being solved in terms of s particular functions. So, you are reducing a general case to a special case at sounds a bit strange. But, we can do this with pointer arithmetic.


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```
int copy_array_2( int from[], int i,
                 int to [], int j,
                 int n);
```

OK! You can write the new function using your own function

```
int copy_array(int a[], int b[], int n) {
    int i;
    for (i=0; i < n; i =i+1) {
        b[i] = a[i];
    }
    return 0;
}
```

```
int copy_array_2( int from[], int i, int to[], int j, int n) {
    copy_array(from+i,to+j,n);
    return 0;
}
```



So, let us try to solve with using our own function, and here is the guess that I am making and then I will justify that this works. So, I will just say here is my function from [ ], i, to [ ], j, n that will be defined as copy\_array(from + i, to + j, n). So, copy\_array() will start from a[0] and copy n elements after wards to b[0] so, on up the b[n-1]. And that function I am calling using the address from + i ,to + j and n, n is the number of elements I want to copy. Now, I will justify that this works.

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**Problem:** Given two int arrays f[] and t[], copy n numbers starting from index i in f[] to index j in t[].  
So  $t[j] = f[i]$ ,  $t[j+1] = f[i+1]$ , ...,  $t[j+n-1] = f[i+n-1]$ .

```
void copy_array( int a[],
                int b[], int n) {
    int i;
    for (i=0; i<n; i =i+1) {
        b[i] = a[i];
    }
    return 0;
}
```

```
int copy_array_2( int f[], int i,
                 int t[], int j, int n) {
    copy_array(f+i,t+j,n);
    return 0;
}
```

State: execution at start of copy\_array\_2

f	f[0]			f[4]			f[8]		f[10]		
	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	
t	1	2	-3	6	-5	4	6	-9	11	81	42
	t[0]	i	2	j	4	5	n	t[7]		t[10]	



So, here is a problem that I have and I want  $t[j] = f[i]$ ,  $t[j + 1] = f[i + 1]$  so, on upto  $t[j + n - 1] = f[i + n - 1]$ . So, let us try to see what happens in this function? Suppose, I call copy\_array\_2() from name, using the arrays f, t, i, j, n and that function nearly calls the

old copy\_array() function, using f + i, t + j and n. So, this state of execution at the start of copy\_array\_2(), let say that f [ ] is an array with say 10 elements and t [ ] is an array with say 10 elements arbitrary and what I want is I also assume that i is 2 and j is 4.

So, I want to copy 5 elements starting from the second location or the third location in f f[2] onwards to the fifth location in t onwards. So, here is what I want to... So, I want to copy this - 1, - 1, - 1, - 1, - 1, to t [4] onwards. So, I will copy them here, so, 5 elements are to be copied.

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**Problem:** Copy n numbers starting from index i in f[] to index j in t[]. So  $t[j] = f[i]$ ,  $t[j+1] = f[i+1]$ , ...,  $t[j+n-1] = f[i+n-1]$ .

```

int copy_array_2(int f[], int i,
                int t[], int j, int n) {
    copy_array(f+i, t+j, n);
    return 0;
}

int copy_array(int a[],
              int b[], int n) {
    int i;
    for (i=0; i<n; i=i+1) {
        b[i] = a[i];
    }
    return 0;
}

```

Diagram details:  
 - i: 2, n: 5, f+2 points to f[2]  
 - f: [-1, -1, -1, -1, -1, -1, -1, -1, -1, -1]  
 - t: [1, 2, -3, 6, -5, 4, 6, -9, 11, 81, 42]  
 - t: t, j: 4, t+4 points to t[4]  
 - State: execution at start of copy\_array\_2

Let see; how our, function is able to do this. So, t + 4 is this location f + 2 is just location. So, what I am calling is the old copy\_array() function with f + i,. So, f is the address of the first location of the array. Therefore, f + 2 using pointer arithmetic is the second integer box after that. So, it is pointing to f[2], similarly t + 4, t + j in this case is pointing to the fourth location after the location pointer 2 by t, t is an array. So, t points to the first location in the array therefore, t + 4 will point to the fifth location in the array.

So, when I say f + 2 f + 2 is a pointer 2 here and t + 4 is a pointer 2 here and I am calling copy\_array() function with these as the arguments and n is the number of elements I want to copy.

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```
int copy_array_2(int f[], int i, int t[], int j, int n) {
    copy_array(f+i, t+j, n);
    return 0;
}

int copy_array(int a[], int b[], int n) {
    int i;
    for(i=0; i<n; i=i+1) {
        b[i] = a[i];
    }
    return 0;
}
```

n: 5  
i: 2  
j: 4

f: [-1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1]  
t: [1, 2, -3, 6, -5, 4, 6, -9, 11, 81, 42]

Annotations:  
- f+2 points to the 4th element of f (index 3).  
- t+1 points to the 2nd element of t (index 1).  
- t+4 points to the 5th element of t (index 4).

Text: "This box has several names: f[3], \*(f+3), (f+2)[1], (f+1)[2] etc." Handwritten: f[i] = \*(f+i), (f+i)[i] = \*(f+i+i)

So, here is the state just before I call, `copy_array()` function. Now, for example, this particular box has several names, the most common name for it will be `f[3]`. But, I can also write it as `*[f + 3]`, this says jump 3 integer boxes after `f` and then dereference that address. Now, if you are comfortable with the notion that let us say `f[i]` is the same as `*[f + i]`.

If you are comfortable with that notion, then you should be easy to see that `(f + 2)[1]` is just `*[f + 2 + 1]`. It is the same formula that I am using and this happens to be `f + 3`, which happens to be `f[3]`. So, `*(f+3)` would be `f[3]` and so, on. So, this formula that `f[i]` is the same as dereferencing the address `f + i`, `f[i] = *(f + i)` is applicable even for more strange looking expressions.

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```
int copy_array_2(int f[], int i, int t[], int j, int n) {  
    copy_array(f+i, t+j, n);  
    return 0;  
}
```

```
int copy_array(int a[], int b[], int n) {  
    int i;  
    for(i=0; i<n; i = i+1) {  
        b[i] = a[i];  
    }  
    return 0;  
}
```

n 5  
i 2  
f f[0] f[1] f[2] f[3] f[4] f[5] f[6] f[7] f[8] f[9] f[10]  
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1  
t t[0] t[1] t[2] t[3] t[4] t[5] t[6] t[7] t[8] t[9] t[10]  
1 2 -3 6 -5 4 6 -9 11 81 42  
j 4  
f+2 This box has several names: f[3], \*(f+3), (f+2)[1], (f+1)[2] etc.  
t+4  
f[i] = \*(f+i)  
i[f] = \*(i+f)

Now, here is a trivia about c, that because of the way it is defined. So, if you say that  $f[i]$  is the same as  $*(f+i)$ , then you could think that this is the same as  $*(i+f)$ . So, I can write this as  $i$  of  $f$  never do this, but it will actually work. So,  $f[i]$  you can also write it as  $i$  of  $f$ . For example, 3 of  $f$  and it will also work, because internally c translates it to  $*(f+i)$  and we know that  $*(f+i)$  is a same as  $*(i+f)$ . So, never do this, but this helps you to understand that  $f[i]$  is being translated by c into this format.

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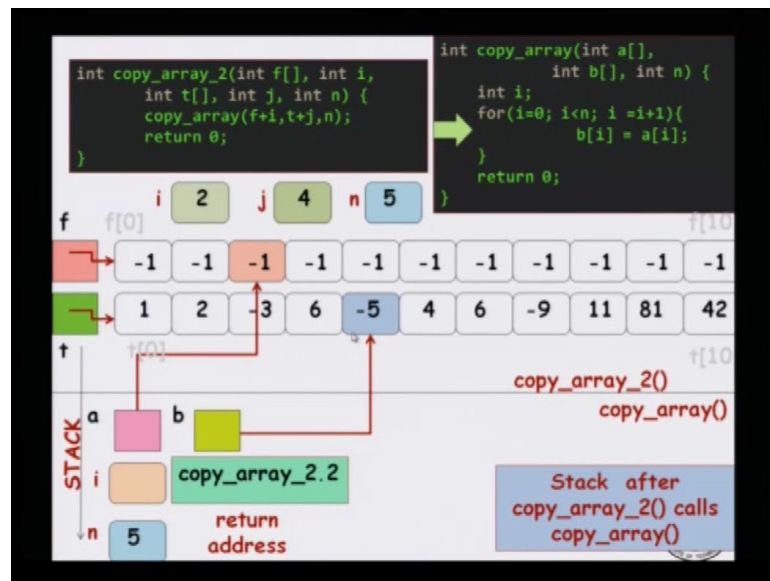
```
int copy_array_2(int f[], int i, int t[], int j, int n) {  
    copy_array(f+i, t+j, n);  
    return 0;  
}
```

```
int copy_array(int a[], int b[], int n) {  
    int i;  
    for(i=0; i<n; i = i+1) {  
        b[i] = a[i];  
    }  
    return 0;  
}
```

n 5  
i 2  
f f[0] f[1] f[2] f[3] f[4] f[5] f[6] f[7] f[8] f[9] f[10]  
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1  
t t[0] t[1] t[2] t[3] t[4] t[5] t[6] t[7] t[8] t[9] t[10]  
1 2 -3 6 -5 4 6 -9 11 81 42  
j 4  
f+2 This box has several names: f[3], \*(f+3), (f+2)[1], (f+1)[2] etc.  
t+4  
\*(t+4) is same as (t+4)[0], etc..

So, now, that we know this, similarly you can argue about  $*(t+4)$  and  $(t+4)[0]$  and. So, on all of them refer to the same box.

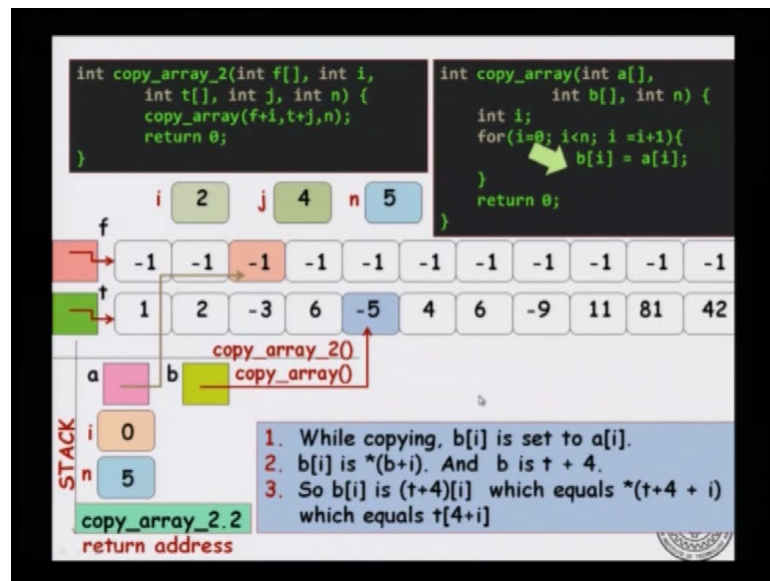
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Now, let us see what happens when we call `copy_array()`. So, we have the stack space for `copy_array_2()` and `copy_array_2()` calls `copy_array()`. The formal parameters are `a` and `b`, `a` copies the address it was passed to, it was passed the address `f + i`. So, `a` points to `f + 2`, similarly `b` points to `t + 4`. So, `b` points to this. Now, as for as `copy_arrays` concerned it is not too bothered by the fact that, it was not passed the absolute first address of the array. It will think that whatever address it has been passed is the start of an array and it will work from there.

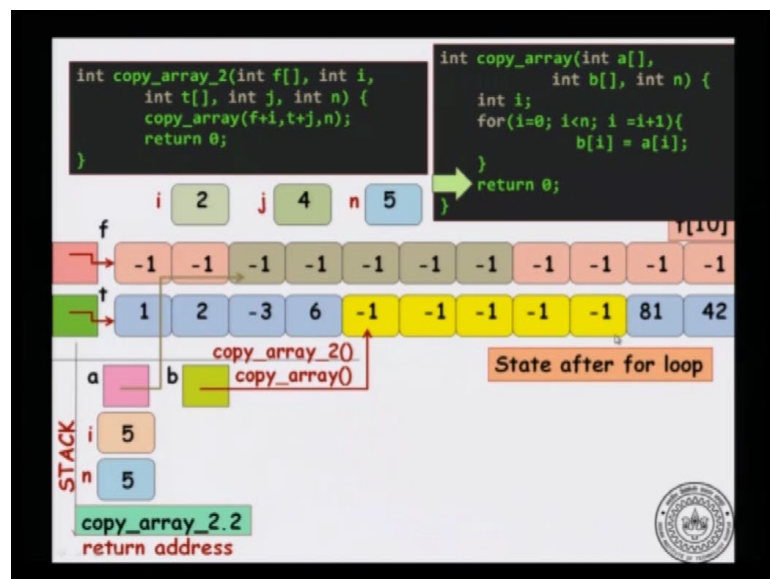
So, `copy_array()` does not bother the fact that, I was given the second element of the array, rather than the first element of the array and so, on, it will work as though the array started from there. And here is where we are exploiting that fact so, you now copy `n` elements from this location to this array, so, `n` is 5.

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Now, when you execute that you will have `copy_array_2()`, should copy 5 elements starting from here to 5 locations here. So, that is what it will actually do.

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And when you execute the loop, it will start from this location copied to `t + j` then `f + i + 1` will be copied to `t + j + 1` and so, on. So, it will copy these five locations to here in the `t` array.

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```
int copy_array_2(int f[], int i,
                int t[], int j, int n) {
    copy_array(f+i, t+j, n);
    return 0;
}

int copy_array(int a[],
              int b[], int n) {
    int i;
    for(i=0; i<n; i=i+1){
        b[i] = a[i];
    }
    return 0;
}
```

copy\_array\_2() i 2 j 4 n 5

f → [-1, -1, -1, -1, -1, -1, -1, -1, -1, -1, -1]

t → [1, 2, -3, 6, -1, -1, -1, -1, -1, 81, 42]

copy\_array() returns.

Changes made to b[] by copy\_array() is reflected in t[] of copy\_array\_2().

And after you do this copy\_array() returns and every variable that was allocated to copy\_array() is erased. But, then because of pointers it was actually working with the arrays in copy\_array\_2(). So, even when you erase all the memory allocated to copy\_array(), once you return these arrays would have been changed. These five locations starting from f + 2 have been copied to these five locations starting from t + 4. So, changes made to b[] by copy\_array(), is still maintained after you returns to the calling function copy\_array\_2().