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COURSE NAME : 19CST101 PROGRAMMING FOR PROBLEM SOLVING

I YEAR/ I SEMESTER

UNIT-IV FUNCTIONS AND POINTERS

Topic: Pointers

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Pointers

C Pointers

Pointers are powerful features of C and C++ programming. Before we learn pointers, let's learn about addresses in C programming.

Address in C

If you have a variable `var` in your program, `&var` will give you its address in the memory.

We have used address numerous times while using the `scanf()` function.

```
scanf("%d", &var);
```

Pointers

Here, the value entered by the user is stored in the address of `var` variable. Let's take a working example.

```c
#include <stdio.h>
int main()
{
  int var = 5;
  printf("var: %d\n", var);

  // Notice the use of & before var
  printf("address of var: %p", &var);
  return 0;
}
```

Output

```
var: 5
address of var: 2686778
```

Pointers

C Pointers

Pointers (pointer variables) are special variables that are used to store addresses rather than values.

Pointer Syntax

Here is how we can declare pointers.

```
int* p;
```

Here, we have declared a pointer `p` of `int` type.

You can also declare pointers in these ways.

```
int *p1;
int * p2;
```

Pointers

Let's take another example of declaring pointers.

```
int* p1, p2;
```

Here, we have declared a pointer `p1` and a normal variable `p2`.

Pointers

Assigning addresses to Pointers

Let's take an example.

```
int* pc, c;
c = 5;
pc = &c;
```

Here, 5 is assigned to the `c` variable. And, the address of `c` is assigned to the `pc` pointer.

Pointers

Get Value of Thing Pointed by Pointers

To get the value of the thing pointed by the pointers, we use the `*` operator. For example:

```
int* pc, c;
c = 5;
pc = &c;
printf("%d", *pc);    // Output: 5
```

Here, the address of `c` is assigned to the `pc` pointer. To get the value stored in that address, we used `*pc`.

Pointers

Note: In the above example, `pc` is a pointer, not `*pc`. You cannot and should not do something like `*pc = &c;`

By the way, `*` is called the dereference operator (when working with pointers). It operates on a pointer and gives the value stored in that pointer.

Pointers

Changing Value Pointed by Pointers

Let's take an example.

```
int* pc, c;
c = 5;
pc = &c;
c = 1;
printf("%d", c);    // Output: 1
printf("%d", *pc);  // Ouptut: 1
```

We have assigned the address of `c` to the `pc` pointer.

Then, we changed the value of `c` to 1. Since `pc` and the address of `c` is the same, `*pc` gives us 1.

Pointers

Let's take another example.

```
int* pc, c;
c = 5;
pc = &c;
*pc = 1;
printf("%d", *pc);  // Ouptut: 1
printf("%d", c);    // Output: 1
```

We have assigned the address of `c` to the `pc` pointer.

Then, we changed `*pc` to 1 using `*pc = 1;`. Since `pc` and the address of `c` is the same, `c` will be equal to 1.

Example: Working of Pointers

Let's take a working example.

```c
#include <stdio.h>
int main()
{
    int* pc, c;

    c = 22;
    printf("Address of c: %p\n", &c);
    printf("Value of c: %d\n\n", c);  // 22

    pc = &c;
    printf("Address of pointer pc: %p\n", pc);
    printf("Content of pointer pc: %d\n\n", *pc); // 22

    c = 11;
    printf("Address of pointer pc: %p\n", pc);
    printf("Content of pointer pc: %d\n\n", *pc); // 11

    *pc = 2;
    printf("Address of c: %p\n", &c);
    printf("Value of c: %d\n\n", c); // 2
    return 0;
}
```

Output

```
Address of c: 2686784
Value of c: 22

Address of pointer pc: 2686784
Content of pointer pc: 22

Address of pointer pc: 2686784
Content of pointer pc: 11

Address of c: 2686784
Value of c: 2
```

Pointers

Relationship Between Arrays and Pointers

An array is a block of sequential data. Let's write a program to print addresses of array elements.

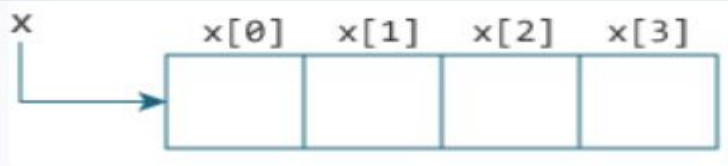
```c
#include <stdio.h>
int main() {
   int x[4];
   int i;

   for(i = 0; i < 4; ++i) {
      printf("&x[%d] = %p\n", i, &x[i]);
   }

   printf("Address of array x: %p", x);

   return 0;
}
```

Output

```
&x[0] = 1450734448
&x[1] = 1450734452
&x[2] = 1450734456
&x[3] = 1450734460
Address of array x: 1450734448
```

Pointers

Notice that, the address of `&x[0]` and `x` is the same. It's because the variable name `x` points to the first element of the array.



From the above example, it is clear that `&x[0]` is equivalent to `x`. And, `x[0]` is equivalent to `*x`.

Similarly,

- `&x[1]` is equivalent to `x+1` and `x[1]` is equivalent to `*(x+1)`.
- `&x[2]` is equivalent to `x+2` and `x[2]` is equivalent to `*(x+2)`.
- ...
- Basically, `&x[i]` is equivalent to `x+i` and `x[i]` is equivalent to `*(x+i)`.

Pointers

Example 1: Pointers and Arrays

```c
#include <stdio.h>
int main() {
  int i, x[6], sum = 0;
  printf("Enter 6 numbers: ");
  for(i = 0; i < 6; ++i) {
  // Equivalent to scanf("%d", &x[i]);
      scanf("%d", x+i);

  // Equivalent to sum += x[i]
      sum += *(x+i);
  }
  printf("Sum = %d", sum);
  return 0;
}
```

When you run the program, the output will be:

```
Enter 6 numbers:  2
 3
 4
 4
 12
 4
Sum = 29
```

Pointers

Example 2: Arrays and Pointers

```c
#include <stdio.h>
int main() {
  int x[5] = {1, 2, 3, 4, 5};
  int* ptr;

  // ptr is assigned the address of the third element
  ptr = &x[2];

  printf("*ptr = %d \n", *ptr);   // 3
  printf("*(ptr+1) = %d \n", *(ptr+1)); // 4
  printf("*(ptr-1) = %d", *(ptr-1));  // 2

  return 0;
}
```

Pointers

When you run the program, the output will be:

```
*ptr = 3
*(ptr+1) = 4
*(ptr-1) = 2
```

In this example, `&x[2]`, the address of the third element, is assigned to the `ptr` pointer. Hence, `3` was displayed when we printed `*ptr`.

And, printing `*(ptr+1)` gives us the fourth element. Similarly, printing `*(ptr-1)` gives us the second element.

Pointer Arithmetic in C

We can perform arithmetic operations on the pointers like addition, subtraction, etc. However, as we know that pointer contains the address, the result of an arithmetic operation performed on the pointer will also be a pointer if the other operand is of type integer.

Following arithmetic operations are possible on the pointer in C

- Increment
- Decrement
- Addition
- Subtraction
- Comparison

Pointer Arithmetic in C

Incrementing Pointer in C

If we increment a pointer by 1, the pointer will start pointing to the immediate next location. This is somewhat different from the general arithmetic since the value of the pointer will get increased by the size of the data type to which the pointer is pointing.

We can traverse an array by using the increment operation on a pointer which will keep pointing to every element of the array, perform some operation on that, and update itself in a loop.

The Rule to increment the pointer is given below:

```
new_address= current_address + i * size_of(data type)
```

Where i is the number by which the pointer get increased.

For 32-bit int variable, it will be incremented by 2 bytes.

For 64-bit int variable, it will be incremented by 4 bytes.

Pointer Arithmetic in C

Let's see the example of incrementing pointer variable on 64-bit architecture.

```
#include<stdio.h>
int main(){
int number=50;
int *p;//pointer to int
p=&number;//stores the address of number variable
printf("Address of p variable is %u \n",p);
p=p+1;
printf("After increment: Address of p variable is %u \n",p); // in our case, p will get incremented by 4 bytes.
return 0;
}
```

Output

```
Address of p variable is 3214864300
After increment: Address of p variable is 3214864304
```

Pointer Arithmetic in C

Traversing an array by using pointer

```c
#include<stdio.h>
void main ()
{
   int arr[5] = {1, 2, 3, 4, 5};
   int *p = arr;
   int i;
   printf("printing array elements...\n");
   for(i = 0; i< 5; i++)
   {
      printf("%d  ",*(p+i));
   }
}
```

Output

```
printing array elements...
1  2  3  4  5
```

Pointer Arithmetic in C

Decrementing Pointer in C

Like increment, we can decrement a pointer variable. If we decrement a pointer, it will start pointing to the previous location. The formula of decrementing the pointer is given below:

```
new_address= current_address - i * size_of(data type)
```

For 32-bit int variable, it will be decremented by 2 bytes.

For 64-bit int variable, it will be decremented by 4 bytes.

Pointer Arithmetic in C

Let's see the example of decrementing pointer variable on 64-bit OS.

```
#include <stdio.h>
void main(){
int number=50;
int *p;//pointer to int
p=&number;//stores the address of number variable
printf("Address of p variable is %u \n",p);
p=p-1;
printf("After decrement: Address of p variable is %u \n",p); // P will now point to the immidiate previous location.
}
```

Output

```
Address of p variable is 3214864300
After decrement: Address of p variable is 3214864296
```

Pointer Arithmetic in C

C Pointer Addition

We can add a value to the pointer variable. The formula of adding value to pointer is given below:

```
new_address= current_address + (number * size_of(data type))
```

32-bit

For 32-bit int variable, it will add 2 * number.

64-bit

For 64-bit int variable, it will add 4 * number.

Pointer Arithmetic in C

Let's see the example of adding value to pointer variable on 64-bit architecture.

```
#include<stdio.h>
int main(){
int number=50;
int *p;//pointer to int
p=&number;//stores the address of number variable
printf("Address of p variable is %u \n",p);
p=p+3;   //adding 3 to pointer variable
printf("After adding 3: Address of p variable is %u \n",p);
return 0;
}
```

Output

```
Address of p variable is 3214864300
After adding 3: Address of p variable is 3214864312
```

As you can see, the address of p is 3214864300. But after adding 3 with p variable, it is 3214864312, i.e., 4*3=12 increment.

Pointer Arithmetic in C

C Pointer Subtraction

Like pointer addition, we can subtract a value from the pointer variable. Subtracting any number from a pointer will give an address. The formula of subtracting value from the pointer variable is given below:

```
new_address= current_address - (number * size_of(data type))
```

32-bit

For 32-bit int variable, it will subtract 2 * number.

64-bit

For 64-bit int variable, it will subtract 4 * number.

Pointer Arithmetic in C

Let's see the example of subtracting value from the pointer variable on 64-bit architecture.

```
#include<stdio.h>
int main(){
int number=50;
int *p;//pointer to int
p=&number;//stores the address of number variable
printf("Address of p variable is %u \n",p);
p=p-3; //subtracting 3 from pointer variable
printf("After subtracting 3: Address of p variable is %u \n",p);
return 0;
}
```

Output

```
Address of p variable is 3214864300
After subtracting 3: Address of p variable is 3214864288
```

You can see after subtracting 3 from the pointer variable, it is 12 (4*3) less than the previous address value.

Pointers and Functions

In C programming, it is also possible to pass addresses as arguments to functions.

To accept these addresses in the function definition, we can use pointers. It's because pointers are used to store addresses. Let's take an example:

Example: Pass Addresses to Functions

```c
#include <stdio.h>
void swap(int *n1, int *n2);

int main()
{
    int num1 = 5, num2 = 10;

    // address of num1 and num2 is passed
    swap( &num1, &num2);

    printf("num1 = %d\n", num1);
    printf("num2 = %d", num2);
    return 0;
}

void swap(int* n1, int* n2)
{
    int temp;
    temp = *n1;
    *n1 = *n2;
    *n2 = temp;
}
```

When you run the program, the output will be:

```
num1 = 10
num2 = 5
```


Thank You!