C Pointers

Difficulty Level : Easy • Last Updated : 23 Mar, 2023

Pointers in C are used to store the address of variables or a memory location. This variable can be of any data type i.e, int, char, function, array, or any other pointer. Pointers are one of the core concepts of C programming language that provides low-level memory access and facilitates dynamic memory allocation.

What is a Pointer in C?

A pointer is a derived data type in C that can store the address of other variables or a memory. We can access and manipulate the data stored in that memory location using pointers.

Syntax of C Pointers

```
datatype * pointer_name;
```

The above syntax is the generic syntax of C pointers. The actual syntax depends on the type of data the pointer is pointing to.

How to Use Pointers?

To use pointers in C, we must understand below two operators:

1. Addressof Operator

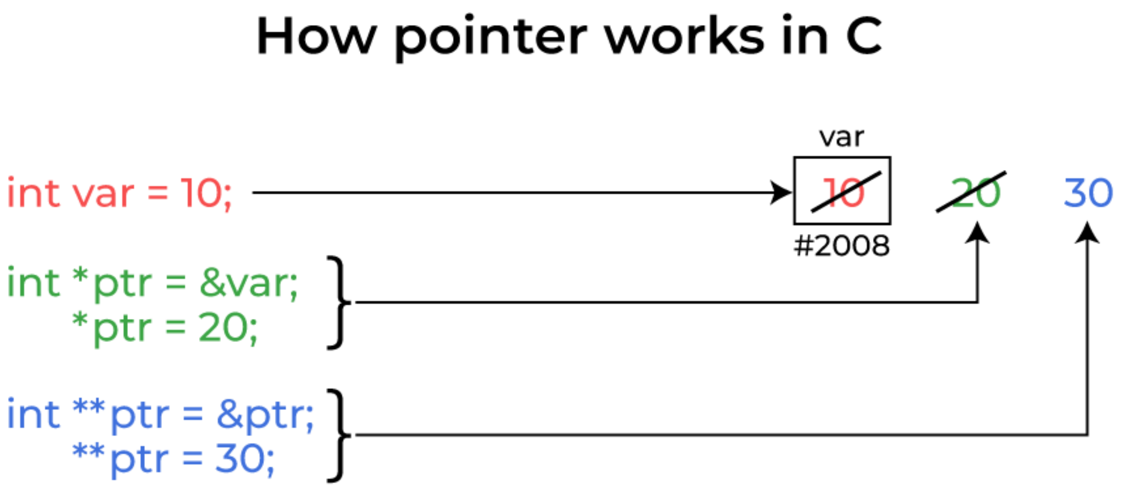
The addressof operator (&) is a unary operator that returns the address of its operand. Its operand can be a variable, function, array, structure, etc.

Syntax of Address of Operator

```
&variable_name;
```

2. Dereferencing Operator

The dereference operator (*), also known as the indirection operator is a unary operator. It is used in pointer declaration and dereferencing.



C Pointer Declaration

In pointer declaration, we only declare the pointer but do not initialize it. To declare a pointer, we use the * dereference operator before its name.

```
data_type * pointer_name;
```

The pointer declared here will point to some random memory address as it is not initialized. Such pointers are also called wild pointers that we will study later in this article.

C Pointer Initialization

When we assign some value to the pointer, it is called Pointer Initialization in C. There are two ways in which we can initialize a pointer in C of which the first one is:

Method 1: C Pointer Definition

```
datatype * pointer_name = address;
```

The above method is called Pointer Definition as the pointer is declared and initialized at the same time.

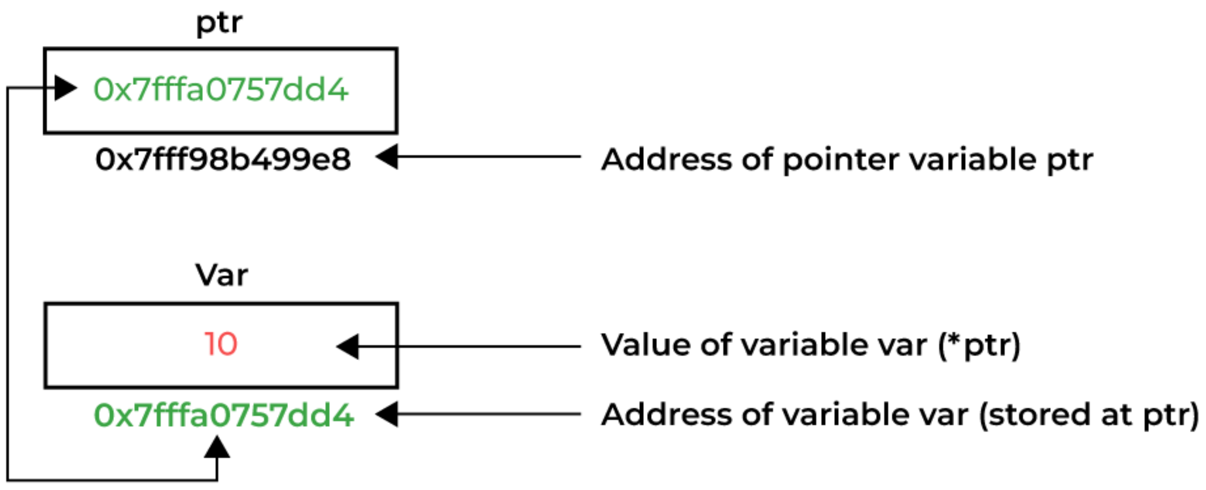
Method 2: Initialization After Declaration

The second method of pointer initialization in C the assigning some address after the declaration.

```
datatype * pointer_name;
pointer_name = addresss;
```

Dereferencing a C Pointer

Dereferencing is the process of accessing the value stored in the memory address specified in the pointer. We use dereferencing operator for that purpose.


ptr
0x7fffa0757dd4
0x7fff98b499e8
Address of pointer variable ptr
Var
10
Value of variable var (*ptr)
0x7fffa0757dd4
Address of variable var (stored at ptr)

Dereferencing a Pointer in C

Example: C Program to demonstrate how to use pointers in C.

C

```
// C program to illustrate Pointers
#include <stdio.h>

void geeks()
{
    int var = 20;

    // declare pointer variable
    int* ptr;

    // note that data type of ptr and var must be same
    ptr = &var;

    // assign the address of a variable to a pointer
    printf("Value at ptr = %p \n", ptr);
    printf("Value at var = %d \n", var);
    printf("Value at *ptr = %d \n", *ptr);
}

// Driver program
int main()
{
    geeks();
    return 0;
}
```

Output

```
Value at ptr = 0x7ffd15b5deec
Value at var = 20
Value at *ptr = 20
```

Types of Pointers

Pointers can be classified into many different types based on the parameter on which we are defining their types. If we consider the type of variable stored in the memory location pointed by the pointer, then the pointers can be classified into the following types:

1. Integer Pointers

As the name suggests, these are the pointers that point to the integer values.

Syntax of Integer Pointers

```
int *pointer_name;
```

These pointers are pronounced as Pointer to Integer.

Similarly, a pointer can point to any primitive data type. The syntax will change accordingly. It can point also point to derived data types such as arrays and user-defined data types such as structures.

2. Array Pointer

Pointers and Array are closely related to each other. Even the array name is the pointer to its first element. They are also known as Pointer to Arrays. We can create a pointer to an array using the given syntax.

Syntax of Array Pointers

```
char *pointer_name = &array_name;
```

Pointer to Arrays exhibits some interesting properties which we discussed later in this article.

3. Structure Pointer

The pointer pointing to the structure type is called Structure Pointer or Pointer to Structure. It can be declared in the same way as we declare the other primitive data types.

Syntax of Structure Pointer

```
struct struct_name *pointer_name;
```

4. Function Pointers

Function pointers point to the functions. They are different from the rest of the pointers in the sense that instead of pointing to the data, they point to the code. Let's consider a function prototype – **int func (int, char)**, the function pointer for this function will be

Syntax of Function Pointer

```
int (*pointer_name)(int, int);
```

Keep in mind that the syntax of the function pointers changes according to the function prototype.

5. Double Pointers

In C language, we can define a pointer that stores the memory address of another pointer. Such pointers are called double-pointers or pointers-to-pointer. Instead of pointing to a data value, they point to another pointer.

Syntax of Double Pointer in C

```
datatype ** pointer_name;
```

Dereferencing in Double Pointer

```
*pointer_name; // get the address stored in the inner level pointer
**pointer_name; // get the value pointed by inner level pointer
```

***Note:** In C, we can create multi-level pointers with any number of levels such as – ***ptr3, ****ptr4, ******ptr5 and so on.*

6. NULL Pointer

The Null Pointers are those pointers that do not point to any memory location. They can be created by assigning a NULL value to the pointer. A pointer of any type can be assigned the NULL value.

Syntax of NULL Pointer in C

```
data_type *pointer_name = NULL;
        or
pointer_name = NULL
```

It is said to be good practice to assign NULL to the pointers currently not in use.

7. Void Pointer

The Void pointers in C are the pointers of type void. It means that they do not have any associated data type. They are also called **generic pointers** as they can point to any type and can be typecasted to any type.

Syntax of Void Pointer

```
void * pointer_name;
```

One of the main properties of void pointers is that they cannot be dereferenced.

8. Wild Pointers

The Wild Pointers are pointers that have not been initialized with something yet. These types of C-pointers can cause problems in our programs and can eventually cause them to crash.

Example of Wild Pointers

```
int *ptr;
char *str;
```

9. Constant Pointers

In constant pointers, the memory address stored inside the pointer is constant and cannot be modified once it is defined. It will always point to the same memory address.

Syntax of Constant Pointer

```
const data_type * pointer_name;
```

10. Pointer to Constant

The pointers pointing to a constant value that cannot be modified are called pointers to a constant. Here we can only access the data pointed by the pointer, but cannot modify it. Although, we can change the address stored in the pointer to constant.

Syntax to Pointer to Constant

```
data_type * const pointer_name;
```

Other Types of Pointers in C:

There are also the following types of pointers available to use in C apart from those specified above:

- **Far pointer:** A far pointer is typically 32-bit that can access memory outside the current segment.
- **Dangling pointer:** A pointer pointing to a memory location that has been deleted (or freed) is called a dangling pointer.
- **Huge pointer:** A huge pointer is 32-bit long containing segment address and offset address.
- **Complex pointer:** Pointers with multiple levels of indirection.
- **Near pointer:** Near pointer is used to store 16-bit addresses means within the current segment on a 16-bit machine.
- **Normalized pointer:** It is a 32-bit pointer, which has as much of its value in the segment register as possible.
- **File Pointer:** The pointer to a FILE data type is called a stream pointer or a file pointer.

Size of Pointers in C

The size of the pointers in C is equal for every pointer type. The size of the pointer does not depend on the type it is pointing to. It only depends on the operating system and CPU architecture. The size of pointers in C is

- **8 bytes** for a **64-bit System**
- **4 bytes** for a **32-bit System**

The reason for the same size is that the pointers store the memory addresses, no matter what type they are. As the space required to store the addresses of the different memory locations is the same, the memory required by one pointer type will be equal to the memory required by other pointer types.

How to find the size of pointers in C?

We can find the size of pointers using the **sizeof** operator as shown in the following program:

Example: C Program to find the size of different pointer types.

C

```c
// C Program to find the size of different pointers types
#include <stdio.h>

// dummy structure
struct str {
};

// dummy function
void func(int a, int b){};

int main()
{
    // dummy variables definitions
    int a = 10;
    char c = 'G';
    struct str x;

    // pointer definitions of different types
    int* ptr_int = &a;
    char* ptr_char = &c;
    struct str* ptr_str = &x;
    void (*ptr_func)(int, int) = &func;
    void* ptr_vn = NULL;

    // printing sizes
    printf("Size of Integer Pointer  \t:\t%d bytes\n",
           sizeof(ptr_int));
    printf("Size of Character Pointer\t:\t%d bytes\n",
           sizeof(ptr_char));
    printf("Size of Structure Pointer\t:\t%d bytes\n",
           sizeof(ptr_str));
    printf("Size of Function Pointer\t:\t%d bytes\n",
           sizeof(ptr_func));
    printf("Size of NULL Void Pointer\t:\t%d bytes",
           sizeof(ptr_vn));

    return 0;
}
```

Output

```
Size of Integer Pointer      :    8 bytes
Size of Character Pointer    :    8 bytes
Size of Structure Pointer    :    8 bytes
Size of Function Pointer    :    8 bytes
Size of NULL Void Pointer    :    8 bytes
```

As we can see, no matter what the type of pointer it is, the size of each and every pointer is the same.

Now, one may wonder that if the size of all the pointers is the same, then why do we need to declare the pointer type in the declaration? The type declaration is needed in the pointer for dereferencing and pointer arithmetic purposes.

Pointer Arithmetic

Only a limited set of operations can be performed on pointers. The Pointer Arithmetic refers to the legal or valid operations that can be performed on a pointer. It is slightly different from the ones that we generally use for mathematical calculations. The operations are:

- Increment in a Pointer
- Decrement in a Pointer
- Addition of integer to a pointer
- Subtraction of integer to a pointer
- Subtracting two pointers of the same type
- Comparison of pointers of the same type.
- Assignment of pointers of the same type.

C

```c
// C program to illustrate Pointer Arithmetic

#include <stdio.h>

int main()
{

    // Declare an array
    int v[3] = { 10, 100, 200 };

    // Declare pointer variable
    int* ptr;

    // Assign the address of v[0] to ptr
    ptr = v;
    for (int i = 0; i < 3; i++) {

        // print value at address which is stored in ptr
        printf("Value of *ptr = %d\n", *ptr);

        // print value of ptr
        printf("Value of ptr = %p\n\n", ptr);

        // Increment pointer ptr by 1
        ptr++;
    }
    return 0;
}
```

Output

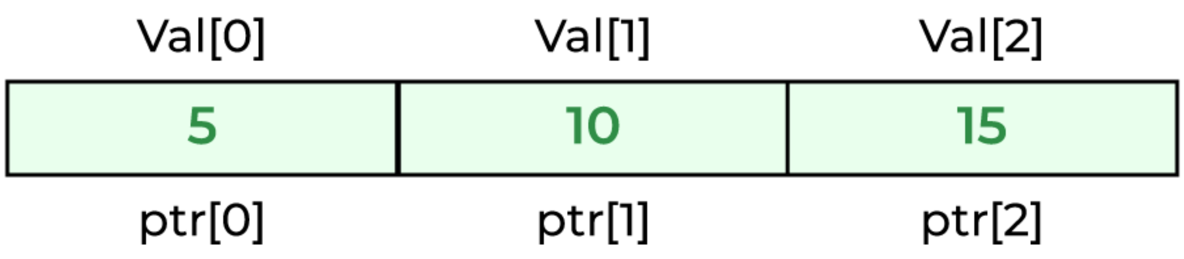
```
Value of *ptr = 10
Value of ptr = 0x7ffe8ba7ec50

Value of *ptr = 100
Value of ptr = 0x7ffe8ba7ec54

Value of *ptr = 200
Value of ptr = 0x7ffe8ba7ec58
```

C Pointers and Arrays Relation

In C programming language, pointers and arrays are closely related. An array name acts like a pointer constant. The value of this pointer constant is the address of the first element. For example, if we have an array named val then **val** and **&val[0]** can be used interchangeably.

If we assign this value to a non-constant pointer to the array, then we can access the elements of the array using this pointer.

Example 1: Accessing Array Elements using Pointer with Array Subscript



C

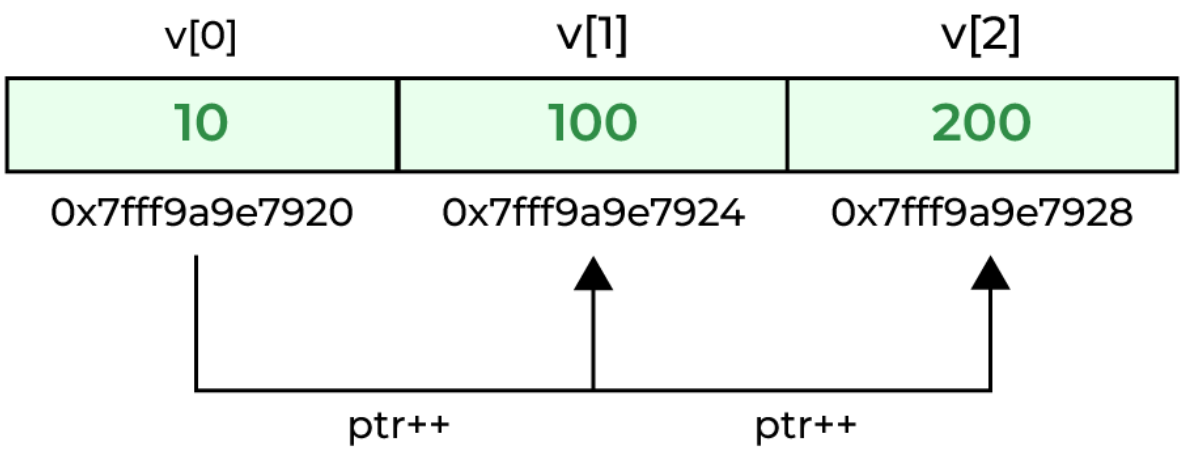
```
// C Program to access array elements using pointer
#include <stdio.h>

void geeks()
{
    // Declare an array
    int val[3] = { 5, 10, 15 };

    // Declare pointer variable
    int* ptr;

    // Assign address of val[0] to ptr.
    // We can use ptr=&val[0];(both are same)
    ptr = val;

    printf("Elements of the array are: ");

    printf("%d, %d, %d", ptr[0], ptr[1], ptr[2]);

    return;
}

// Driver program
int main()
{
    geeks();
    return 0;
}
```

Output

```
Elements of the array are: 5 10 15
```

Not only that, as the array elements are stored continuously, we can pointer arithmetic operations such as increment, decrement, addition, and subtraction of integers on pointer to move between array elements.

Example 2: Accessing Array Elements using Pointer Arithmetic



C

```c
// C Program to access array elements using pointers
#include <stdio.h>

int main()
{

    // defining array
    int arr[5] = { 1, 2, 3, 4, 5 };

    // defining the pointer to array
    int* ptr_arr = &arr;

    // traversing array using pointer arithmetic
    for (int i = 0; i < 5; i++) {
        printf("%d ", *ptr_arr++);
    }
    return 0;
}
```

Output

```
1 2 3 4 5
```

This concept is not limited to the one-dimensional array, we can refer to a multidimensional array element perfectly fine using this concept.

To know more about pointers to an array, refer to this article – Pointer to an Array

Uses of Pointers

The C pointer is a very powerful tool that is widely used in C programming to perform various useful operations. It finds its use in operations such as

1. Pass Arguments by Reference
2. Accessing Array Elements
3. Return Multiple Values from Function
4. Dynamic Memory Allocation
5. Implementing Data Structures
6. In System-Level Programming where memory addresses are useful.
7. In locating the exact value at some memory location.
8. To avoid compiler confusion for the same variable name.
9. To use in Control Tables.

Advantages of Pointers

- Pointers are used for dynamic memory allocation and deallocation.
- An Array or a structure can be accessed efficiently with pointers
- Pointers are useful for accessing memory locations.
- Pointers are used to form complex data structures such as linked lists, graphs, trees, etc.
- Pointers reduce the length of the program and its execution time as well.

Disadvantages of Pointers

- Memory corruption can occur if an incorrect value is provided to pointers.
- Pointers are a little bit complex to understand.
- Pointers are majorly responsible for memory leaks in C.
- Pointers are comparatively slower than variables in C.
- Uninitialized pointers might cause a segmentation fault.

Conclusion

In conclusion, pointers in C are very capable tools and provide C language with its distinguishing features, such as low-level memory access, referencing, etc. But as powerful as they are, they should be used with responsibility as they are one of the most vulnerable parts of the language.

FAQs on Pointers in C

1. Define pointers.

Pointers are the variables that can store the memory address of another variable.

2. What is the difference between a constant pointer and a pointer to a constant?

A constant pointer points to the fixed memory location, i.e. we cannot change the memory address stored inside the constant pointer.

On the other hand, the pointer to a constant point to the memory with a constant value.

3. What is pointer to pointer?

A pointer to a pointer (also known as a double pointer) stores the address of another pointer.

4. Does pointer size depends on its type?

No, the pointer size does not depend upon its type. It only depends on the operating system and CPU architecture.

5. What are the differences between an array and a pointer?

The following table list the differences between an array and a pointer:

Pointer	Array
A pointer is a derived data type that can store the address of other variables.	An array is a homogeneous collection of items of any type such as int, char, etc.
Pointers are allocated at run time.	Arrays are allocated at runtime.
The pointer is a single variable.	An array is a collection of variables of the same type.
Dynamic in Nature	Static in Nature.

6. Why do we need to specify the type in the pointer declaration?

Type specification in pointer declaration helps the compiler in dereferencing and pointer arithmetic operations.

Quizzes: