C++ Data Types

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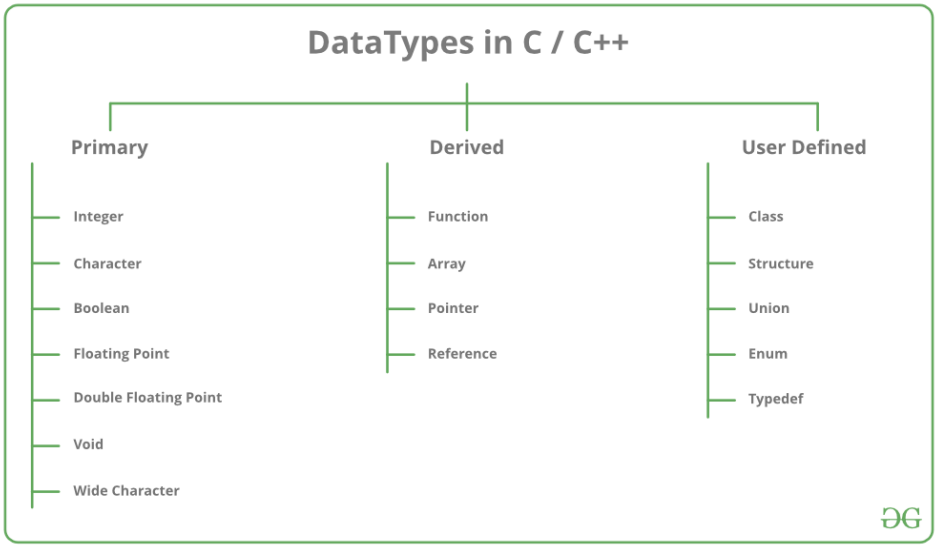
All variables use data type during declaration to restrict the type of data to be stored. Therefore, we can say that data types are used to tell the variables the type of data they can store. Whenever a variable is defined in C++, the compiler allocates some memory for that variable based on the data type with which it is declared. Every data type requires a different amount of memory.

C++ supports a wide variety of data types and the programmer can select the data type appropriate to the needs of the application. Data types specify the size and types of values to be stored. However, storage representation and machine instructions to manipulate each data type differ from machine to machine, although C++ instructions are identical on all machines.

C++ supports the following data types:

1. **Primary** or **Built-in** or **Fundamental data type**
2. **Derived data types**
3. **User-defined data types**



Data Types in C++ are Mainly Divided into 3 Types:

1. Primitive Data Types: These data types are built-in or predefined data types and can be used directly by the user to declare variables. example: int, char, float, bool, etc. Primitive data types available in C++ are:

- Integer
- Character
- Boolean
- Floating Point
- Double Floating Point
- Valueless or Void
- Wide Character

2. Derived Data Types: Derived data types that are derived from the primitive or built-in datatypes are referred to as Derived Data Types. These can be of four types namely:

- Function
- Array
- Pointer
- Reference

3. Abstract or User-Defined Data Types: Abstract or User-Defined data types are defined by the user itself. Like, defining a class in C++ or a structure. C++ provides the following user-defined datatypes:

- Class
- Structure
- Union
- Enumeration
- Typedef defined Datatype

Primitive Data Types

- **Integer**: The keyword used for integer data types is **int**. Integers typically require 4 bytes of memory space and range from -2147483648 to 2147483647.
- **Character**: Character data type is used for storing characters. The keyword used for the character data type is **char**. Characters typically require 1 byte of memory space and range from -128 to 127 or 0 to 255.
- **Boolean**: Boolean data type is used for storing Boolean or logical values. A Boolean variable can store either *true* or *false*. The keyword used for the Boolean data type is **bool**.
- **Floating Point**: Floating Point data type is used for storing single-precision floating-point values or decimal values. The keyword used for the floating-point data type is **float**. Float variables typically require 4 bytes of memory space.
- **Double Floating Point**: Double Floating Point data type is used for storing double-precision floating-point values or decimal values. The keyword used for the double floating-point data type is **double**. Double variables typically require 8 bytes of memory space.
- **void**: Void means without any value. void data type represents a valueless entity. A void data type is used for those function which does not return a value.
- **Wide Character**: Wide character data type is also a character data type but this data type has a size greater than the normal 8-bit data type. Represented by **wchar_t**. It is generally 2 or 4 bytes long.
- **sizeof() operator:** sizeof() operator is used to find the number of bytes occupied by a variable/data type in computer memory.

Example:

```
int m , x[50];
cout<<sizeof(m); //returns 4 which is the number of bytes occupied by the integer variable "m".
```

cout<<sizeof(x); //returns 200 which is the number of bytes occupied by the integer array variable "x".

The size of variables might be different from those shown in the above table, depending on the compiler and the computer you are using.

C++

```
// C++ Program to Demonstrate the correct size
// of various data types on your computer.
#include <iostream>
using namespace std;

int main()
{
    cout << "Size of char : " << sizeof(char) << endl;
    cout << "Size of int : " << sizeof(int) << endl;

    cout << "Size of long : " << sizeof(long) << endl;
    cout << "Size of float : " << sizeof(float) << endl;

    cout << "Size of double : " << sizeof(double) << endl;

    return 0;
}
```

Output

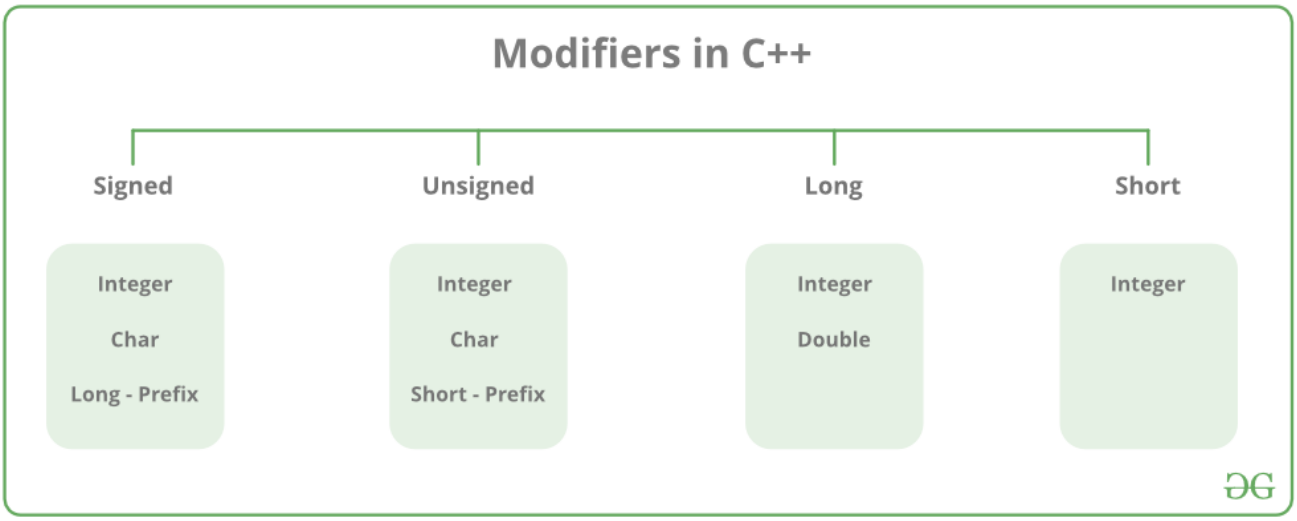
```
Size of char : 1
Size of int : 4
Size of long : 8
Size of float : 4
Size of double : 8
```

Time Complexity: O(1)

Space Complexity: O(1)

Datatype Modifiers

As the name suggests, datatype modifiers are used with built-in data types to modify the length of data that a particular data type can hold.



Data type modifiers available in C++ are:

- **Signed**
- **Unsigned**
- **Short**
- **Long**

The below table summarizes the modified size and range of built-in datatypes when combined with the type modifiers:

Data Type	Size (in bytes)	Range
short int	2	-32,768 to 32,767
unsigned short int	2	0 to 65,535
unsigned int	4	0 to 4,294,967,295
int	4	-2,147,483,648 to 2,147,483,647
long int	4	-2,147,483,648 to 2,147,483,647
unsigned long int	4	0 to 4,294,967,295
long long int	8	-(2^63) to (2^63)-1

Data Type	Size (in bytes)	Range
unsigned long long int	8	0 to 18,446,744,073,709,551,615
signed char	1	-128 to 127
unsigned char	1	0 to 255
float	4	-3.4×10^38 to 3.4×10^38
double	8	-1.7×10^308 to1.7×10^308
long double	12	-1.1×10^4932 to1.1×10^4932
wchar_t	2 or 4	1 wide character

***Note**: Above values may vary from compiler to compiler. In the above example, we have considered GCC 32 bit.*
We can display the size of all the data types by using the sizeof() operator and passing the keyword of the datatype, as an argument to this function as shown below:

Now to get the range of data types refer to the following chart

***Note: syntax<limits.h>** header file is defined to find the range of fundamental data-types. Unsigned modifiers have minimum value is zero. So, no macro constants are defined for the unsigned minimum value.*

Macro Constants

Name	Expresses
CHAR_MIN	The minimum value for an object of type char
CHAR_MAX	Maximum value for an object of type char
SCHAR_MIN	The minimum value for an object of type Signed char
SCHAR_MAX	Maximum value for an object of type Signed char
UCHAR_MAX	Maximum value for an object of type Unsigned char
CHAR_BIT	Number of bits in a char object
MB_LEN_MAX	Maximum number of bytes in a multi-byte character
SHRT_MIN	The minimum value for an object of type short int
SHRT_MAX	Maximum value for an object of type short int
USHRT_MAX	Maximum value for an object of type Unsigned short int
INT_MIN	The minimum value for an object of type int
INT_MAX	Maximum value for an object of type int
UINT_MAX	Maximum value for an object of type Unsigned int
LONG_MIN	The minimum value for an object of type long int
LONG_MAX	Maximum value for an object of type long int

Name	Expresses
ULONG_MAX	Maximum value for an object of type Unsigned long int
LLONG_MIN	The minimum value for an object of type long long int
LLONG_MAX	Maximum value for an object of type long long int
ULLONG_MAX	Maximum value for an object of type Unsigned long long int

The actual value depends on the particular system and library implementation but shall reflect the limits of these types in the target platform. LLONG_MIN, LLONG_MAX, and ULLONG_MAX are defined for libraries complying with the C standard of 1999 or later (which only includes the C++ standard since 2011: C++11).

C++ Program to Find the Range of Data Types using Macro Constants

Example:

C++

```
// C++ program to Demonstrate the sizes of data types
#include <iostream>
#include <limits.h>
using namespace std;

int main()
{
    cout << "Size of char : " << sizeof(char) << " byte"
         << endl;

    cout << "char minimum value: " << CHAR_MIN << endl;

    cout << "char maximum value: " << CHAR_MAX << endl;

    cout << "Size of int : " << sizeof(int) << " bytes"
         << endl;

    cout << "Size of short int : " << sizeof(short int)
         << " bytes" << endl;

    cout << "Size of long int : " << sizeof(long int)
         << " bytes" << endl;

    cout << "Size of signed long int : "
         << sizeof(signed long int) << " bytes" << endl;
```

```
    cout << "Size of unsigned long int : "
         << sizeof(unsigned long int) << " bytes" << endl;

    cout << "Size of float : " << sizeof(float) << " bytes"
         << endl;

    cout << "Size of double : " << sizeof(double)
         << " bytes" << endl;

    cout << "Size of wchar_t : " << sizeof(wchar_t)
         << " bytes" << endl;

    return 0;
}
```

Output

```
Size of char : 1 byte
char minimum value: -128
char maximum value: 127
Size of int : 4 bytes
Size of short int : 2 bytes
Size of long int : 8 bytes
Size of signed long int : 8 bytes
Size of unsigned long int : 8 bytes
Size of float : 4 bytes
Size of double : 8 bytes
Size of wchar_t : 4 bytes
```

Time Complexity: O(1)

Space Complexity: O(1)

C++

```
#include <iostream>
#include <string>
using namespace std;

int main() {
  // Integer data types
  int a = 10;
  short b = 20;
  long c = 30;
  long long d = 40;
  cout << "Integer data types: " << endl;
  cout << "int: " << a << endl;
  cout << "short: " << b << endl;
  cout << "long: " << c << endl;
  cout << "long long: " << d << endl;
```

```
    // Floating-point data types
    float e = 3.14f;
    double f = 3.141592;
    long double g = 3.14159265358979L;
    cout << "Floating-point data types: " << endl;
    cout << "float: " << e << endl;
    cout << "double: " << f << endl;
    cout << "long double: " << g << endl;

    // Character data types
    char h = 'a';
    wchar_t i = L'b';
    char16_t j = u'c';
    char32_t k = U'd';
    cout << "Character data types: " << endl;
    cout << "char: " << h << endl;
    wcout << "wchar_t: " << i << endl;
    cout << "char16_t: " << j << endl;
    cout << "char32_t: " << k << endl;

    // Boolean data type
    bool l = true;
    bool m = false;
    cout << "Boolean data type: " << endl;
    cout << "true: " << l << endl;
    cout << "false: " << m << endl;

    // String data type
    string n = "Hello, world!";
    cout << "String data type: " << endl;
    cout << n << endl;

    return 0;
}
```

Output

```
Integer data types:
int: 10
short: 20
long: 30
long long: 40
Floating-point data types:
float: 3.14
double: 3.14159
long double: 3.14159
Character data types:
char: a
wchar_t: b
char16_t: 99
```

```
char32_t: 100
Boolean data type:
true: 1
false: 0
String data type:
Hello, world!
```

This program declares variables of various data types, assigns values to them, and then prints out their values.

The integer data types include int, short, long, and long long. These data types represent whole numbers of varying sizes.

The floating-point data types include float, double, and long double. These data types represent real numbers with varying levels of precision.

The character data types include char, wchar_t, char16_t, and char32_t. These data types represent individual characters of varying sizes.

The boolean data type is a simple data type that can only have one of two values: true or false.

The string data type is a sequence of characters. In this program, we use the string class to declare a string variable and assign it a value.

Advantages:

Data types provide a way to categorize and organize data in a program, making it easier to understand and manage.
Each data type has a specific range of values it can hold, allowing for more precise control over the type of data being stored.
Data types help prevent errors and bugs in a program by enforcing strict rules about how data can be used and manipulated.
C++ provides a wide range of data types, allowing developers to choose the best type for a specific task.

Disadvantages:

Using the wrong data type can result in unexpected behavior and errors in a program.
Some data types, such as long doubles or char arrays, can take up a large amount of memory and impact performance if used excessively.
C++'s complex type system can make it difficult for beginners to learn and use the language effectively.
The use of data types can add additional complexity and verbosity to a program, making it harder to read and understand.

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