

# Comparative Study of C, C++, C# and Java Programming Languages

Mrs. Partibha<sup>1</sup>, Mrs. Ashu Khokhar<sup>2</sup>

<sup>1,2</sup>Lecturer, PG Department of Computer Science, Jat College, Rohtak, Haryana

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**ABSTRACT:** By the comparative study of four chosen programming languages C, C++, C# and Java from theoretical aspect to practical aspect, this review paper highlights the technical features and actual performance of these programming languages. The main purpose of this study is to guide people to make a strategic decision to use the most suitable programming language to develop the new software system.

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## Brief history of programming languages, C, C++, C#, and Java

### Brief history of C language:

"C is a programming language which born at 'AT & T's Bell Laboratories' of USA in 1972. It was written by Dennis Ritchie. This language was created for a specific purpose: to design the UNIX operating system (which is used on many computers). From the beginning, C was intended to be useful--to allow busy programmers to get things done." [6] After that, C began to be used by more and more people outside the Bell Laboratories because it is more efficient than other programming languages at that time. In the late 70's, C took the dominant position of programming languages. "The committee formed by the American National Standards Institute (ANSI) approved a version of C in 1989 which is known as ANSI C. With few exceptions, every modern C compiler has the ability to adhere to this standard. ANSI C was then approved by the International Standards Organization (ISO) in 1990." [6] There is something interesting about the name of C. It was named C because its predecessor was called B which was also developed by Ken Thompson of Bell Labs.

### Brief history of C++ language:

"C++ was written by Bjarne Stroustrup at Bell Labs during 1983-1985. C++ is an extension of C. Prior to 1983, Bjarne Stroustrup added features to C and formed what he called 'C with Classes'. He had combined the Simula's use of classes and object-oriented features with the power and efficiency of C. The term C++ was first used in 1983." [7] "C++ was designed for the UNIX system environment, it represents an enhancement of the C programming language and enables programmers to improve the quality of code produced, thus making reusable code easier to write." [8]

### Brief history of C# language:

"The primary architects of C# were Peter Golde, Eric Gunnerson, Anders Hejlsberg, Peter Sollichy and Scott Wiltamuth. Of course, the principal designer of the C# language was Anders Hejlsberg, a lead architect at Microsoft." [9] C# was designed to be a pure object-oriented programming language. "C# debuted in the year 2000 at the Professional Developers Conference (PDC) where Microsoft founder Bill Gates was the keynote speaker. At the same time, Visual Studio .NET was announced." [9]

### Brief history of Java language:

Java started to be developed in 1991 by James Gosling from Sun Microsystems and his team. The original version of Java is designed for programming home appliances. In 1994, James Gosling started to make a connection between Java and internet. "In 1995, Netscape Incorporated released its latest version of the Netscape browser which was capable of running Java programs." [10] The original name of Java is Oak. But it had to change its original name because Oak had been used by another programming language. The new name Java was inspired by a coffee bean. "While Java is viewed as a programming language to design applications for the Internet, it is in reality a general all-purpose language which can be used independent of the Internet." [10]

### **Comparison of C, C++, C#, and Java from theoretical**

#### **Aspects:**

#### **Data Types and Sizes:**

“Some common types of data types are used in the programming languages called as the primitive types like characters, integers floating point numbers etc.” In C, C++, C# and Java, all variables must be declared before they are used, usually at the beginning of the function before any executable statements.

#### **C**

In C Language, There are four basic Datatype.

Basic data type in C language.

1. int- “an integer, typically reflecting the natural size of integers on the host machine”
2. float - “single-precision floating point”
3. double- “double-precision floating point”
4. char- “a single byte, capable of holding one character in the local character set”

There are five Type Specifiers in C programming

- a) long
- b) long long
- c) short
- d) unsigned
- e) signed

There are 32 reserved keywords in C language. “These keywords cannot be abbreviated, used as variable names, or used as any other type of identifiers.” In C, every data type such as a character, integer, or floating-point number has a range of values associated with it. The range is decided by the amount of storage that is allocated to store a particular type of data in the memory of the computer. It depends on the computer you’re running. This feature for C language is called “machine-dependent”. For example, an integer might take up 32 bits on your computer, or perhaps it might be stored in 64 bits on another computer. Don’t write any program that assumes the size of the data types in C.

#### **Reserved keywords for C**

auto	Else	long	Switch
break	enum	register	typedef
char	Extern	for	union
const	Return	short	unsigned
case	Float	signed	void
continue	If	sizeof	volatile
default	goto	static	void
do	Int	struct	double

#### **C++**

In C++, the basic data type is almost the same as C. In C++, there is one more type Booleans. A Boolean, bool, can have one of the two values true or false. A Boolean is used to express the results of logical operations.

**Extra 30 Reserved keywords for C ++that are not in C**

<b>Asm</b>	Dynamic_cast	Name_space	true
Bool	Explicit	New	Reintrupt_cast
Catch	False	Operator	Static_cast
Class	Friend	Private	template
Const_cast	Inline	protected	this
Delete	Mutable	typenane	throw

Virtual	Typeid	public	Using
Try	Whar_t		

## C#

The Boolean type in C# has a little difference between that in C++. In C#, the Boolean type can only have two values: true or false. But in C++, the Boolean type can also have 0 as the value which means false and anything else means true. Integral Types in c# is also different from C and C++. In C and C++, the integral type is only one type. But “in C#, an integral is a category of types. They are whole numbers, either signed or unsigned, and the char type. The char type is a Unicode character, as defined by the Unicode Standard”. There are much more key words in C# than those in C and C++. There are total 87 reserved keywords in C#.

## Java

The Boolean type in Java is as the same as that in C#. There are only two values available for Boolean type, true and false. Integral Types in Java is different from C and C++ and it is similar to C#. In C#, an integral is a category consists of 9 data types. In Java, there are five data types that can have the integral value. There is no sbyte, uint, ulong data type in Java any more.

## String type:

In C language, there is no string type. The char type of array is used instead of String type. In C++ language, there are two types of strings, C-style strings, and C++-style strings. “A C-style strings, which consists of an array of characters terminated by the null character '\0', and which have properties over and above those of an ordinary array of characters, as well as a whole library of functions for dealing with strings represented in this form. Its header file is 'cstring'. A C++ style string is a 'class' data type. The objects of C++ style string are instances of the C++ 'string' class. There is a library of C++ string functions as well, available by including the 'string' header file.” [10]

“In C# and Java, the data type String is treated as reference type. Instance of Strings are treated as (immutable) objects in both languages, but support for string literals provides a specialized means of constructing them. C# also allows verbatim strings for quotation without escape sequences, which also allow newlines.”[10]

## Structure:

The structure in C language has two differences from structure in C++ language.

1. C Structure can only contain data items while C++ structure can contain both data and functions.
2. In C language, using 'struct' keyword is necessary to create a variable. But in C++ Only Structure name is needed to identify a variable.

The difference between structure in C++ and C# is significant. “In C++, a struct is exactly like a class, except that the default inheri ance and default access are public rather than private.” On the contrary, in C#, structs have significant difference from classes. “Structs in C# are designed to encapsulatelight weight objects. They are value types (not reference types), so they're passed by value. In addition, they have limitations that do not apply to classes. On the other hand, struct is very suitable for using a class with very small instance if you don't care that “the struct is sealed” and you don't care

“value semantics”. “Structs are more efficient than classes so they're perfect for the creation of lightweight objects.” [16] In C#, a struct can also be a value type as an part of object or store in an array. Java does not have struct value type.

### **Inheritance**

Inheritance means creating a new class derives from the existing class. The derived class inherits all the variables and methods from base class. Overriding methods and properties can extend the functionality of base class. C language does not support inheritance because it is not object-oriented language. Neither C# nor Java allows multiple inheritance which means each class can only inherit from only one class. However, both C# and Java supports multiple implementations of interfaces. C++ supports multiple inheritance of class. In C++, classes and structs are almost identical. “Furthermore, C# structs do not support inheritance, and do not support explicit default constructors (one is provided by default)”. [13] On the contrary, C++ structs support multiple inheritances.

### **Array**

“In C and C++, each sub-array of a multidimensional array must have the same dimensions. In Java and C# arrays do not have to be uniform because jagged arrays can be created as one-dimensional arrays of arrays. In a jagged array the contents of the array are arrays which may hold instances of a type or references to other arrays.” In C#, multidimensional and jagged arrays have the significant difference. “A multidimensional array is akin to a multidimensional array in C or C++ that is a contiguous block containing members of the same type. A jagged array is akin to an array in Java which is an array of arrays, meaning that it contains references to other arrays which may contain members of the same type or other arrays depending on how many levels the array has.”

### **Reference and Value Types**

“Primitive types are the basic types of data, such as byte, short, int, long, float, double, boolean, char. Reference types are any instantiable class as well as arrays, such as String, Scanner, Random, Die, int[], String[], etc.” [13] Both in C# and Java, the idea of reference type is supported. In C#, value types and reference types which have significant difference. The situation of primitive types and reference types is exactly the same as that in C#. Simple types (int, long, double, and so on) and structs are value types in C#. Neither C nor C++ has value types and reference types. In C++, basic data type, classes or user-defined value types have the same access to memory.

### **Pointer**

“A pointer is a variable containing the address of another variable.” In C and C++, pointer can be used as arrays, Strings, writeable function parameters and optimization. In C# pointer can only be declared to hold the memory address of value types and arrays. For safety reasons, Java does not support pointers or pointer-arithmetic to be used at all.

### **Partial classes**

“C# allows a class definition to be split across several source files using a feature called partial classes. Each part must be marked with the keyword partial.” [23] This function is not available in C, C++, and Java. In C++ and Java, an error about redefining already-defined classes was given. However, in C++ and Java, using inheritance can reach to the same goal.

### **Compiler Technology**

There are two ways to implement programming languages: Interpretation and compilation. “Compilation is a program that reads your program and translates it into machine code. Then the computer obeys the machine code. Interpretation is a program that looks at each line of your program in turn, works out what it means, obeys it, and then goes onto the next line.” In other word, Compilation and interpretation like two ways of reading. Compilation is like translating an English article into Chinese totally and then reading the Chinese article. Interpretation is like translate the every word in the article from English to Chinese one by one by using Chinese dictionary. Java is a dynamically compiled language, while C and C++ are statically compiled languages.

The difference between dynamically compiled languages and statically compiled languages is significant. “A static compiler converts source code directly to machine code that can be directly executed on the target platform, and different hardware platforms require different compilers. The Java compiler converts Java source code into portable JVM (Java Virtual



Machine) byte codes, which are ‘virtual machine instructions’ for the JVM.” There are two generations of JVM (Java Virtual Machine). The Compilation Process of Java is quite different between that of C/C++. We can call Java the "semi-interpreted" language because “Java programs execute in the Java Virtual Machine (or JVM), which makes it an interpreted language.” “On the other hand Java unlike pure interpreted languages passes through an intermediate compilation step.” Java code compile to the “intermediate byte code” that run in the virtual machine rather than “native code that the operating system executes on the CPU”.

### **Application Paradigm**

C is a minimalistic programming language because it could be compiled in a straight forward manner by a relatively simple compiler. C offers low-level access to memory via pointers and the ability to access specific hardware addresses. C generates only a few instructions of machine languages for each of its core language elements and does not require extensive run-time support. It can be concluded that C language is suitable for many systems-programming applications that had traditionally been implemented in assembly languages. However, as C is structured oriented programming language and focuses on the procedural programming paradigm, it is relatively hard to control the large-scale program. As C language has high level and machine level mixed programming capacity, it is used in most hardware related applications. It is very suitable for writing programs in embedded device, chip designing, industrial automation products and so forth and so on. Meanwhile, Software such as “Unix”, “windows”, and other antivirus can also be created by C language. Last but not at least, algorithm can also be implemented in C language easily.

C++ was originally designed to be an enhancement to C language. Basically it inherits all the advantages of C language. In addition, it has more features than C, such as encapsulation, multiple inheritance, and Polymorphism. It can be concluded that it is relatively easy to use C++ to develop a large or huge system compared with C language as C++ supports the object-oriented (OO) features. However, C++ has some disadvantages. C++ code is easily prone to errors related to data types because C++ does not offer very strong type-checking. C++ does not support platform independent. It can't run on the all kinds of platforms. The main disadvantage is that C++ is not a pure object oriented programming language as it doesn't have the feature of garbage collection. C++ adopts the pointers which lead to no security for the data. C++ can be widely used in the software industry. As C++ can be a very fast programming language after compiled, the software such as application software, device drivers and high-performance server can be designed by C++. C# is designed for programming the Microsoft .NET Framework. C# is a combination of all the other programming languages in an almost perfect balance. C# is a pure object-oriented language. The concise syntax of C is also added to it. C# syntax is more similar to Java rather than to C++. Pointer memory management in C# is not a problem anymore because the garbage collector takes care of this, much like Java. The relational database management system (RDBMS) such as Mysql, Oracle, and Microsoft SQL Server can work with C# by the simple connection procedures. On the other hand, C# has the disadvantages. C# is not flexible. C# depends greatly on .NET framework. Without the component in the .NET framework, C# is difficult to implement.

C# can be applied to the application development because C# is a rapid application development (RAD) language. It can reduce the period of the application development significantly. Furthermore C# is also very suitable for the development of web application because C# consists of a large framework of pre-developed components which can simplify the code of web applications.

Java is a pure object-oriented programming language. It makes modular programs available in order to reuse the code. Java is open source. People can use it for free. It is also platform-independent, which is one of the most significant advantages of Java. Programs written in Java can easily move from one computer system to another. Java also has some disadvantages. Java is a memory-consuming programming language. Java is slow because it has an extra layer between the systems and the programs. The extra layer is Java Virtual Machine (JVM). Anything done by the Java programs has to be executed by the Java Virtual Machine. Then it makes the system to do the actual instructions. Java has three different forms, Java 2 Standard Edition (J2SE), Java2 Micro Edition (J2ME), and Java2 Enterprise Edition (J2EE) which is quite similar to what we have in Windows operating systems such as Windows Vista Home Basic Edition, Windows Vista Business Edition and Windows Vista Ultimate Edition. Each form of Java has its suitable application field. J2SE, which is also called CORE Java, is suitable for the desktop applications. J2ME is mainly used in embedded systems development, such as mobile phones, wireless application and PDA programming. J2EE, designed for enterprise applications, is mainly used for the development of distributed network program, such as e-commerce website and ERP systems.

### **Conclusion**

It can be concluded that all four programming languages C, C++, C#, and Java have the advantages and disadvantages. It is really hard to say which one is better than the others and which one is faster than the others. But all four programming languages have their most suitable fields to apply. People can get fast and stable performance from the software written in a suitable programming language.

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