A COMPARISON OF C PROGRAMMING LANGUAGE & JAVA

First, let's start with a brief introduction of these two programming languages: C programming language and Java. C programming language is a general-purpose computer programming language. It was created in the 1970s by Dennis Ritchie and remains very widely used and influential. By design, C programming language's features cleanly reflect the capabilities of the targeted CPUs. It has found lasting use in operating systems, device drivers, protocol stacks, though decreasingly for application software. C programming language is commonly used on computer architectures that range from the largest supercomputers to the smallest microcontrollers and embedded systems. Java is a high level, class based, object oriented programming language that is designed to have as few implementation dependencies as possible. It is a general purpose programming language intended to let programmers write once, run anywhere meaning that compiled Java code can run on all platforms that support Java without the need to recompile. Java was originally developed by James Gosling at Sun Microsystems. It was released in May 1995 as a core component of Sun Microsystems' Java platform.

By considering the four main criteria and characteristics, different programming languages can be examined and compared. These four main criteria are: readability, writability, reliability and cost. Making comparisons for each characteristic then generalizing the comparison results to main four criteria according to the table make things easier to understand.

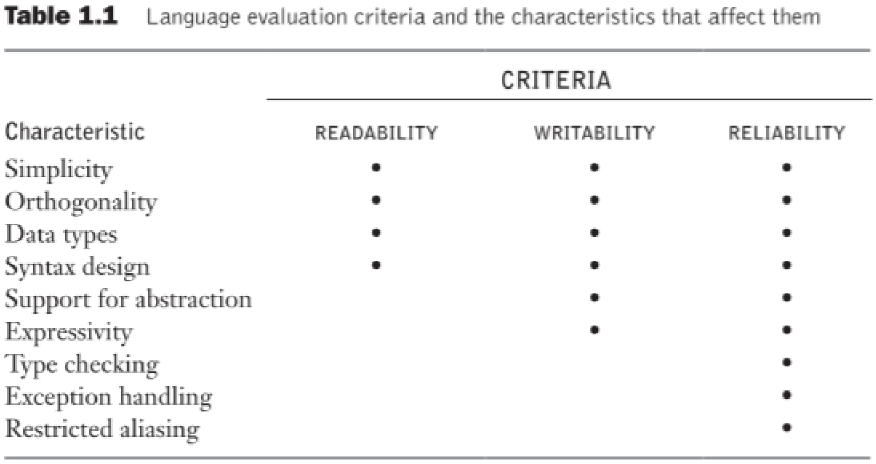

Table 1.1 Language evaluation criteria and the characteristics that affect them

	CRITERIA		
Characteristic	READABILITY	WRITABILITY	RELIABILITY
Simplicity	•	•	•
Orthogonality	•	•	•
Data types	•	•	•
Syntax design	•	•	•
Support for abstraction		•	•
Expressivity		•	•
Type checking			•
Exception handling			•
Restricted aliasing			•

Simplicity:

According to the Oracle documentation, Java is simplified successor of C programming language and C++ programming language, also looks like C++ programming language. Java is concentrated or removed some of principal features which inherited by C and C++ to make programming language simpler. Also, this similarity make things easier to learn Java for programmers who familiar with C programming language, Objective C, C++ programming language, Eiffel, Ada, and related languages. Java and C eliminating operator overloading leads to great simplification of code.

No functions exist in Java. Functional and procedural methods are superseded by object oriented programming. Combining the two just causes confusion and compromises the object oriented language's integrity. By designing a class and writing methods for it, you can accomplish anything a function can do.

In contrast to C, Java has no pre processor, no #define and similar features, no typedef, and with all those features, header files are no longer necessary. In Java, the effects of #define obtained by using constants. Also by defining new classes, the effects of typedef can be obtained. Java becomes astonishingly context free by removing all of this baggage. Programmers can read and understand code more quickly and easily, as well as edit and reuse code.

Orthogonality:

The accessibility specifiers in Java, like public and private, are totally orthogonal to the specifier static. Variable types, however, determine how they are stored. So, there are consequences to specifying a variable's type. A programming language is considered nonorthogonal if the majority of its constructs cannot be combined in a variety of ways without producing unwanted side effects. Non orthogonality simply means that there are exceptions to the standard syntax and grammatical rules. C programming language is another illustration. For instance, it comes with arrays and structs as two built in data structures. In C, we are able to return a struct from a function, but not an array. In a similar vein, arrays cannot be of type void, and structs cannot have members of any type other than void or a structure of the same type. According to these orthogonality characteristics, it is seen that Java is more orthogonal than C programming language when compared.

Data Types:

Unlike C programming language, Java has no structs, enums and unions. Already using classes makes them dysfunctional and unnecessary. Java including some primitive data types different than C programming language. For example, as a primitive type, Java adds a Boolean data type. A Boolean in Java programming language is a separate data type; unlike in C programming language, a Boolean in Java programming language cannot be transformed to any numeric type. There is no unsigned type specifier for integer data types in Java. The 8-bit byte data type in Java has replaced the old C programming language char data type.

Java programming language arrays are first-class language objects, in contrast to C programming language and C++ programming language. An array is a real object having a run-time representation in the Java programming language. Any type of array may be declared and allocated, and arrays of arrays can be allocated to create multi-dimensional arrays. The idea of a pointer in C programming language to an array of memory components has been eliminated, along with the uncontrolled pointer arithmetic that causes C programming language programs to be unstable. The ability to walk off the edge of an array has been removed since doing so might potentially corrupt memory and cause the infamous "delayed-crash" scenario, in which a memory-access violation today presents itself hours or days later. Java's array validation will provide more robust and reliable code, so programmers can be sure.

Strings are immutable Java programming language objects, not pseudo-arrays of characters as in C programming language. Java also uses the ‘+’ operator for string concatenation unlike C programming language.

By defining objects and arrays of objects, every activity that would normally require arrays, structures, and pointers in C programming language may be accomplished more quickly and accurately in Java. Since there are no pointers in Java, no need to dangling pointers and trashing memory because of misusing pointers.

Syntax Design:

Java’s syntax design is strongly like C programming language but there are huge differences between them. C programming language is a low-level programming language this means the code which is written by C programming language is closer to machine language than human language. Java is a high-level programming language, so it is closer to human language than machine language. This means that Java is typically easy to learn and use by contrast with C programming language. Java is an interpreted language, while C programming language is a compiled language.

Support for Abstraction:

Abstraction is used to obscure background information or other extraneous data implementation so that consumers only see the relevant data. One of the most significant and fundamental aspects of object-oriented programming is this. Java support abstraction, unlike C programming language.

Expressivity:

Expressivity for a programming language means that it is easy to write and read code both for a programmer or any human reader and for the compiler. For example, in C programming language it is much easier to understand count++ than count = count + 1; So, if a programming language has more complicated ways of specifying computations, it decreases expressivity. Because C programming language allows one to constrain variables to hold values of specified types, it is more expressive in this case. In contrast to C programming language, Java allows you to test whether a value is inside the length of an array, making it more expressive in this case.

Type Checking:

The reliability of language is significantly influenced by type checking. Compile time type checking is preferred because run time type checking is more expensive. Furthermore, it is cheaper to make the necessary repairs the earlier errors in programs are found. The type of nearly all variables and expressions must be verified at compile time due to Java's and C programming language’s design. This virtually eliminates type errors in Java and C programming language programs at run time.

Exception Handling:

Exception handling is the capacity of a program to detect run-time problems, rectify them, and then proceed is a clear benefit to reliability. This language feature is known as exception handling. Although Java has substantial exception handling capabilities, similar facilities are almost non-existent in some commonly used languages, such as C programming language. Java has a mechanism which called as Java Exception Handling to handle runtime errors such as ClassNotFoundException, IOException etc. Java defines several types of exceptions in a hierarchical order that relate to its various class libraries. In Java’s exception hierarchy all exceptions and error types are child of Throwable class, which is the base class of the hierarchy. This base class has two sub-class which are named as Exceptions and Errors. Java also allows users to define their own exceptions.

Aliasing:

An alias occurs when many variables point directly or indirectly to the same storage place. Aliasing relates to optimization assumptions regarding which variables can point to or occupy the same storage region. design of a language. Aliasing is used in some languages to compensate for limitations in the language's data abstraction facilities. Other languages severely limit aliasing in order to improve reliability. Java handles aliasing in run-time on the other hand in C programming language, strict aliasing rule required.

Portability:

The ability to run a piece of code without doing any modification when running from a different architecture, platform, or operating system is referred to as portability. Modifying a written code with C programming language is necessary to run in different architecture, platform, or operating system. On the other hand, Java uses a virtual machine which called as Java Virtual Machine (JVM) to allow Java programs to run on any device or operating system. Java Virtual Machine loads code, verifies code, executes code and provides runtime environment. Java Virtual Machine also provides memory area, class file format, register set, garbage and collected heap, fatal error reporting etc. Java is platform independent, but JVM is platform dependent.

To sum up, by considering all the characteristic comparisons above, Java and C programming language can be evaluated by comparing them based on four main criteria (Readability, Writability, Reliability and Cost).

Readability affected by simplicity, orthogonality, data types and syntax design. As mentioned before Java is simplified successor of the C programming language and C++ programming language. Also, some other object oriented features like encapsulation, class usage and also denying pre-processors makes Java simpler than the C programming language. Java has accessibility specifiers such as public and private on the contrary the C programming language include too much exceptions in syntax for example, in Array and Struct data types. As a result of it Java is more orthogonal than C programming language. On the other hand, Java has some data types which is more useful than C programming language such as Array and String etc. also there is no pointer usage in Java programming language. This information can be interpreted as the readability of Java is higher than C programming language.

Characteristics which affect readability also affects writability, but it is also necessary to add some characteristics as effects such as support for abstraction and expressivity. As previously mentioned, Java is simpler and more orthogonal than the C programming language. Also, Java contains easy to use data types and easy to learn syntactic design unlike the C programming language. Because of Java is an object oriented programming language and it is also contains an object oriented principle which named as abstraction unlike the C programming language and also it is more expressive than the C programming language, writability is much clear and easier in Java.

Both writability, readability and some other characteristics affects reliability such as type checking, exception handling and restricted aliasing. As mentioned above, Java has higher writability and readability against the C programming language. Both of the two programming languages are also contains type checking for expressions in compile time so, this virtually eliminates type errors. Exception handling is one of the important characteristics for reliability. The C programming language does not contain any exception handling mechanism in itself as opposite of Java. Java does not have strict aliasing rule and it handles this problem in run time. The C programming language requires strict aliasing rule, this makes things more reliable for C. In general comparison of reliability criteria, Java is more reliable than the C programming language.

Java is really slower than C programming language. But Java is easy to learn and with usage of JVM it is platform independent. Both of two programming languages has free to use development environments and compilers. As a result, cost of this two programming languages are close to each other.

References

- **https://en.wikipedia.org/wiki/Java_(programming_language)**
- **https://en.wikipedia.org/wiki/C_(programming_language)**
- **Robert W. Sebesta, Concepts of Programming Languages, 11th ed., Addison-Wesley.**
- **https://www.baeldung.com/cs/orthogonality-cs-programming-languages-software-databases**
- **https://www.oracle.com/java/technologies/simple-familiar.html**
- **https://www.educative.io/answers/what-is-abstraction-in-programming**
- **https://www.embedded.com/expressive-vs-permissive-languages-is-that-the-question/**
- **German, Andy. "Software Static Code Analysis Lessons Learned," CrossTalk , November 2003.**
- **Barnes, John. "Safe and Secure Software," 2008, www.adacore.com/2008/04/08/gem-30/.**