Bjarne Stroustrup

THE C++ PROGRAMMING LANGUAGE

SECOND EDITION

The C++ Programming Language

Second Edition

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Preface

The road goes ever on and on.
– Bilbo Baggins

As promised in the first edition of this book, C++ has been evolving to meet the needs of its users. This evolution has been guided by the experience of users of widely varying backgrounds working in a great range of application areas. The C++ user-community has grown a hundredfold during the six years since the first edition of this book; many lessons have been learned, and many techniques have been discovered and/or validated by experience. Some of these experiences are reflected here.

The primary aim of the language extensions made in the last six years has been to enhance C++ as a language for data abstraction and object-oriented programming in general and to enhance it as a tool for writing high-quality libraries of user-defined types in particular. A "high-quality library," is a library that provides a concept to a user in the form of one or more classes that are convenient, safe, and efficient to use. In this context, *safe* means that a class provides a specific type-safe interface between the users of the library and its providers; *efficient* means that use of the class does not impose significant overheads in run-time or space on the user compared with hand-written C code.

This book presents the complete C++ language. Chapters 1 through 10 give a tutorial introduction; Chapters 11 through 13 provide a discussion of design and software development issues; and, finally, the complete C++ reference manual is included. Naturally, the features added and resolutions made since the original edition are integral parts of the presentation. They include refined overloading resolution, memory management facilities, and access control mechanisms, type-safe linkage, `const` and `static` member functions, abstract classes, multiple inheritance, templates, and exception handling.

C++ is a general-purpose programming language; its core application domain is

systems programming in the broadest sense. In addition, C++ is successfully used in many application areas that are not covered by this label. Implementations of C++ exist from some of the most modest microcomputers to the largest supercomputers and for almost all operating systems. Consequently, this book describes the C++ language itself without trying to explain a particular implementation, programming environment, or library.

This book presents many examples of classes that, though useful, should be classified as "toys." This style of exposition allows general principles and useful techniques to stand out more clearly than they would in a fully elaborated program, where they would be buried in details. Most of the useful classes presented here, such as linked lists, arrays, character strings, matrices, graphics classes, associative arrays, etc., are available in "bulletproof" and/or "goldplated" versions from a wide variety of commercial and non-commercial sources. Many of these "industrial strength" classes and libraries are actually direct and indirect descendants of the toy versions found here.

This edition provides a greater emphasis on tutorial aspects than did the first edition of this book. However, the presentation is still aimed squarely at experienced programmers and endeavors not to insult their intelligence or experience. The discussion of design issues has been greatly expanded to reflect the demand for information beyond the description of language features and their immediate use. Technical detail and precision have also been increased. The reference manual, in particular, represents many years of work in this direction. The intent has been to provide a book with a depth sufficient to make more than one reading rewarding to most programmers. In other words, this book presents the C++ language, its fundamental principles, and the key techniques needed to apply it. Enjoy!

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Preface to the first Edition

Language shapes the way we think,
and determines what we can think about.
– B.L.Whorf

C++ is a general purpose programming language designed to make programming more enjoyable for the serious programmer. Except for minor details, C++ is a superset of the C programming language. In addition to the facilities provided by C, C++ provides flexible and efficient facilities for defining new types. A programmer can partition an application into manageable pieces by defining new types that closely match the concepts of the application. This technique for program construction is often called *data abstraction*. Objects of some user-defined types contain type information. Such objects can be used conveniently and safely in contexts in which their type cannot be determined at compile time. Programs using objects of such types are often called *object based*. When used well, these techniques result in shorter, easier to understand, and easier to maintain programs.

The key concept in C++ is *class*. A class is a user-defined type. Classes provide data hiding, guaranteed initialization of data, implicit type conversion for user-defined types, dynamic typing, user-controlled memory management, and mechanisms for overloading operators. C++ provides much better facilities for type checking and for expressing modularity than C does. It also contains improvements that are not directly related to classes, including symbolic constants, inline substitution of functions, default function arguments, overloaded function names, free store management operators, and a reference type. C++ retains C's ability to deal efficiently with the fundamental objects of the hardware (bits, bytes, words, addresses, etc.). This allows the user-defined types to be implemented with a pleasing degree of efficiency.

C++ and its standard libraries are designed for portability. The current implementation will run on most systems that support C. C libraries can be used from a C++

program, and most tools that support programming in C can be used with C++.

This book is primarily intended to help serious programmers learn the language and use it for nontrivial projects. It provides a complete description of C++, many complete examples, and many more program fragments.

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In addition, hundreds of people contributed to the development of C++ and its compiler by sending me suggestions for improvements, descriptions of problems they had encountered, and compiler errors. I can mention only a few: Gary Bishop, Andrew Hume, Tom Karzes, Victor Milenkovic, Rob Murray, Leonie Rose, Brian Schmult, and Gary Walker.

Many people have also helped with the production of this book, in particular, Jon Bentley, Laura Eaves, Brian Kernighan, Ted Kowalski, Steve Mahaney, Jon Shopiro, and the participants in the C++ course held at Bell Labs, Columbus, Ohio, June 26-27, 1985.

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