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Object Oriented Programming with C++

Fourth Edition

C++面向对象程序设计

（第4版）

E Balagurusamy 著

清华大学出版社

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出 版 说 明

进入21世纪，世界各国的经济、科技以及综合国力的竞争将更加激烈。竞争的中心无疑是对人才的竞争。谁拥有大量高素质的人才，谁就能在竞争中取得优势。高等教育，作为培养高素质人才的事业，必然受到高度重视。目前我国高等教育的教材更新较慢，为了加快教材的更新频率，教育部正在大力促进我国高校采用国外原版教材。

清华大学出版社从1996年开始，与国外著名出版公司合作，影印出版了“大学计算机教育丛书（影印版）”等一系列引进图书，受到国内读者的欢迎和支持。跨入21世纪，我们本着为我国高等教育教材建设服务的初衷，在已有的基础上，进一步扩大选题内容，改变图书开本尺寸，一如既往地请有关专家挑选适用于我国高校本科及研究生计算机教育的国外经典教材或著名教材，组成本套“大学计算机教育国外著名教材系列（影印版）”，以飨读者。深切期盼读者及时将使用本系列教材的效果和意见反馈给我们。更希望国内专家、教授积极向我们推荐国外计算机教育的优秀教材，以利我们把“大学计算机教育国外著名教材系列（影印版）”做得更好，更适合高校师生的需要。

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Preface

Object-Oriented Programming (OOP) has become the preferred programming approach by the software industries, as it offers a powerful way to cope with the complexity of real-world problems. Among the OOP languages available today, C++ is by far the most widely used language.

Since its creation by Bjarne Stroustrup in early 1980s, C++ has undergone many changes and improvements. The language was standardized in 1998 by the American National Standards Institute (ANSI) and the International Standards Organization (ISO) by incorporating not only the new features but also the changes suggested by the user groups. This book has been thoroughly revised and this edition confirms to the specifications of ANSI/ISO standards. Besides confirming to the standards, many smaller changes and additions to strengthen the existing topics as well as corrections to typographical errors and certain inaccuracies in the text have been incorporated. The highlight of this edition is the inclusion of two new programming projects in Appendix A - (1) Menu Based Calculation System and (2) Banking System that demonstrate how to integrate the various features of C++ in real life applications.

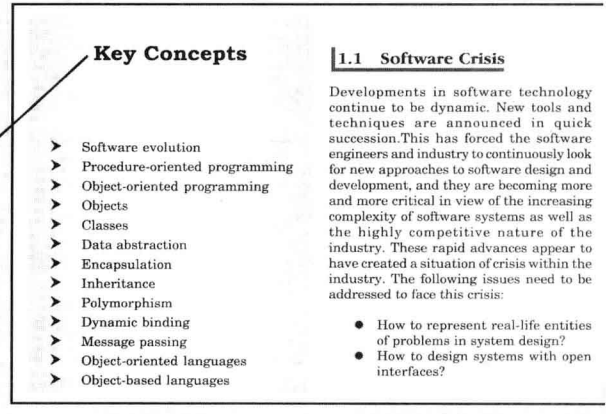
This book is for the programmers who wish to know all about C++ language and object-oriented programming. It explains in a simple and easy-to-understand style the what, why and how of object-oriented programming with C++. The book assumes that the reader is already familiar with C language, although he or she need not be an expert programmer.

The book provides numerous examples, illustrations and complete programs. The sample programs are meant to be both simple and educational. Wherever necessary, pictorial descriptions of concepts are included to improve clarity and facilitate better understanding. The book also presents the concept of object-oriented approach and discusses briefly the important elements of object-oriented analysis and design of systems.

Key Pedagogical Features

Key Concepts

Key concepts provide a quick look into the concepts that will be discussed in the chapter. These are followed by an Introduction that introduces the topics to be covered in that chapter and also relates them to those already learned.



completed before the next begins. The activities include problem definition, requirement analysis, design, coding, testing, and maintenance. Further refinements to this model include iteration back to the previous stages in order to incorporate any changes or missing links.

Problem Definition. This activity requires a precise definition of the problem in user terms. A clear statement of the problem is crucial to the success of the software. It helps not only the developer but also the user to understand the problem better.

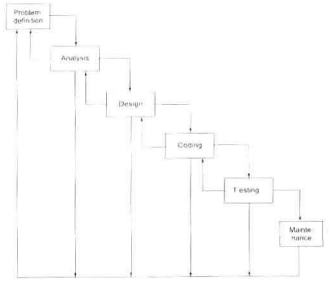


Fig. 17.2 Classic software development life cycle (Embedded 'water-fall' mode)

Figures

Figures are used exhaustively in the text to illustrate the concepts and methods described.

PROGRAM 5.1

```
#include <iostream>

using namespace std;

class time
{
        int  hours;
        int  minutes;
  public:
        void gettime(int h, int m)
        {  hours = h; minutes = m; }
        void puttime(void)
        {
              cout << hours << " hours and ";
              cout << minutes << " minutes " << "\n";
        }
        void sum(time, time);  // declaration with objects as arguments
};
void time :: sum(time t1, time t2)          // t1, t2 are objects
{
        minutes = t1.minutes + t2.minutes;
        hours = minutes/60;
        minutes = minutes%60;
        hours = hours + t1.hours + t2.hours;
}
int main()
{
        time T1, T2, T3;

        T1.gettime(2,45);     // get T1
        T2.gettime(3,30);     // get T2

        T3.sum(T1,T2);// T3=T1+T2

        cout << "T1 = "; T1.puttime();       // display T1
        cout << "T2 = "; T2.puttime();       // display T2
        cout << "T3 = "; T3.puttime();       // display T3

        return 0;
}
```

PROGRAM 5.7

Program Codes

Codes with comments are given throughout the book to elaborate how the various lines of code work.

The output of Program 2.3 is:

```
Enter Name: Ravinder
Enter Age:  30

Name: Ravinder
Age:  30
```

note

cin can read only one word and therefore we cannot use names with blank spaces.

The program defines **person** as a new data of type class. The class person includes two basic data type items and two functions to operate on that data. These functions are called **member functions**. The main program uses **person** to declare variables of its type. As pointed out earlier, class variables are known as *objects*. Here, p is an object of type **person**. Class objects are used to invoke the functions defined in that class. More about classes and objects is discussed in Chapter 5.

Notes

Language tips and other special considerations are highlighted as notes wherever essential.

SUMMARY

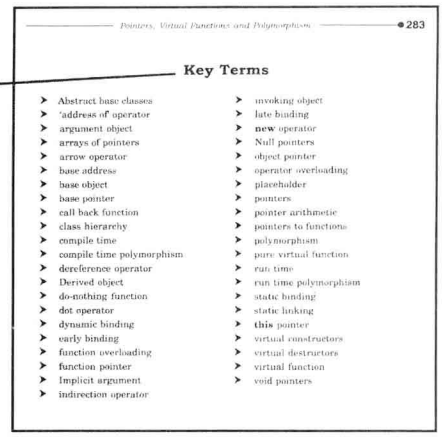
- C++ is a superset of C language.
- C++ adds a number of object-oriented features such as objects, inheritance, function overloading and operator overloading to C. These features enable building of programs with clarity, extensibility and ease of maintenance.
- C++ can be used to build a variety of systems such as editors, compilers, databases, communication systems, and many more complex real-life application systems.
- C++ supports interactive input and output features and introduces a new comment symbol // that can be used for single line comments. It also supports C-style comments.
- Like C programs, execution of all C++ programs begins at **main( )** function and ends at **return( )** statement. The header file **iostream** should be included at the beginning of all programs that use input/output operations.

Summary

Summary gives the essence of each chapter in the form of bulleted points which will be helpful for a quick review during the examinations.

Key Terms

Key terms listed in each chapter give the list of important terms discussed in the chapter.



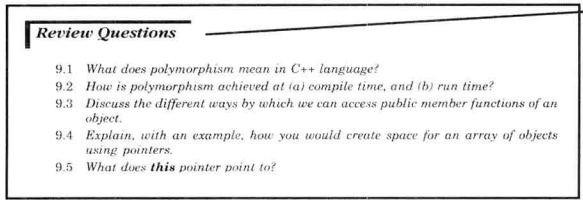
Pointers, Virtual Functions and Polymorphism 283

Key Terms

- Abstract base classes
- 'address of' operator
- argument object
- arrays of pointers
- arrow operator
- base address
- base object
- base pointer
- call back function
- class hierarchy
- compile time
- compile time polymorphism
- dereference operator
- Derived object
- do-nothing function
- dot operator
- dynamic binding
- early binding
- function overloading
- function pointer
- Implicit argument
- indirection operator
- invoking object
- late binding
- **new** operator
- Null pointers
- object pointer
- operator overloading
- placeholder
- pointers
- pointer arithmetic
- pointers to functions
- polymorphism
- pure virtual function
- run time
- run time polymorphism
- static binding
- static linking
- **this** pointer
- virtual constructors
- virtual destructors
- virtual function
- void pointers

Chapter-end Exercises

More than 350 chapter-end exercise problems are given for the students to work out and practice. These include review questions, debugging exercises and programming problems.

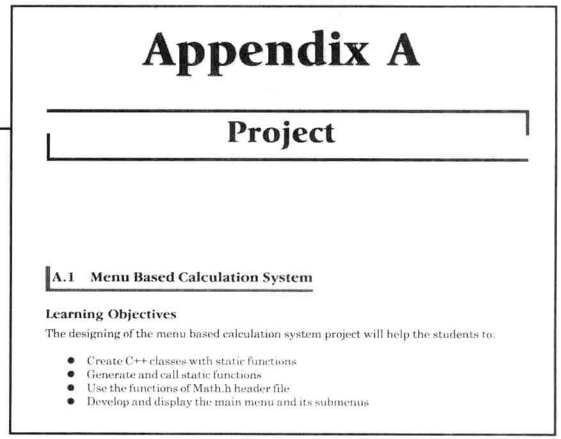


Review Questions

9.1 *What does polymorphism mean in C++ language?*
9.2 *How is polymorphism achieved at (a) compile time, and (b) run time?*
9.3 *Discuss the different ways by which we can access public member functions of an object.*
9.4 *Explain, with an example, how you would create space for an array of objects using pointers.*
9.5 *What does* ***this*** *pointer point to?*

Programming Projects

The two programming projects in Appendix A will give an insight on how to integrate the various features of C++ in real-life problems.



Appendix A

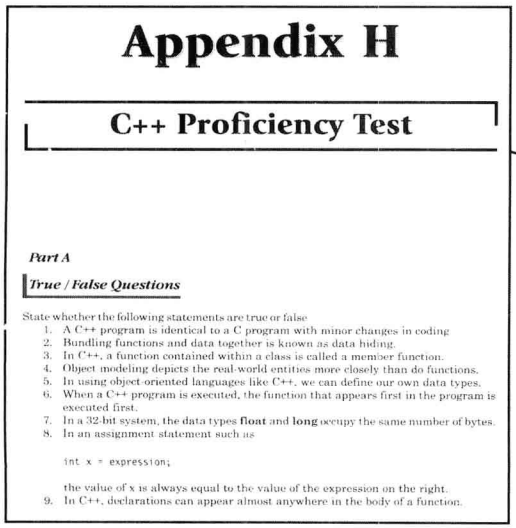
Project

A.1 Menu Based Calculation System

Learning Objectives

The designing of the menu based calculation system project will help the students to:

- Create C++ classes with static functions
- Generate and call static functions
- Use the functions of Math.h header file
- Develop and display the main menu and its submenus



Appendix H

C++ Proficiency Test

Part A

True / False Questions

State whether the following statements are true or false

1. A C++ program is identical to a C program with minor changes in coding
2. Bundling functions and data together is known as data hiding.
3. In C++, a function contained within a class is called a member function.
4. Object modeling depicts the real-world entities more closely than do functions.
5. In using object-oriented languages like C++, we can define our own data types.
6. When a C++ program is executed, the function that appears first in the program is executed first.
7. In a 32-bit system, the data types **float** and **long** occupy the same number of bytes.
8. In an assignment statement such as

```
int x = expression;
```

the value of x is always equal to the value of the expression on the right.
9. In C++, declarations can appear almost anywhere in the body of a function.

Proficiency Test

An appendix on proficiency test will help the readers assess their level of mastery on the language.

Web Supplement

The following additional information is available on the web at http://www.mhhe.com/balagurusamy/oop4e

- Solution to the *Debugging Exercises*
- Chapter-wise *self-test quiz* with answers
- Complete code with step-by-step description and user manual for *Payroll Management Systems* (*Major Project*) and *Hospital Management Systems* (*Minor Project*).
- Differences between ANSI C, C++ and ANSI/ISO C++

Acknowledgements

Since the release of the first edition of this book a decade ago, lakhs of teachers, students and professional programmers have been using the book. Their overwhelming support encouraged me to bring out the Third Edition in 2006 and now the Fourth Edition.

My sincere thanks are due to the editorial and publishing professionals of Tata McGraw-Hill for their keen interest and support in bringing out this edition in the present form.

E BALAGURUSAMY

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Principles of Object-Oriented Programming

Key Concepts

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- Procedure-oriented programming
- Object-oriented programming
- Objects
- Classes
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- Encapsulation
- Inheritance
- Polymorphism
- Dynamic binding
- Message passing
- Object-oriented languages
- Object-based languages

1.1 Software Crisis

Developments in software technology continue to be dynamic. New tools and techniques are announced in quick succession.This has forced the software engineers and industry to continuously look for new approaches to software design and development, and they are becoming more and more critical in view of the increasing complexity of software systems as well as the highly competitive nature of the industry. These rapid advances appear to have created a situation of crisis within the industry. The following issues need to be addressed to face this crisis:

- How to represent real-life entities of problems in system design?
- How to design systems with open interfaces?

- How to ensure reusability and extensibility of modules?
- How to develop modules that are tolerant to any changes in future?
- How to improve software productivity and decrease software cost?
- How to improve the quality of software?
- How to manage time schedules?
- How to industrialize the software development process?

Many software products are either not finished, or not used, or else are delivered with major errors. Figure 1.1 shows the fate of the US defence software projects undertaken in the 1970s. Around 50% of the software products were never delivered, and one-third of those which were delivered were never used. It is interesting to note that only 2% were used as delivered, without being subjected to any changes. This illustrates that the software industry has a remarkably bad record in delivering products.

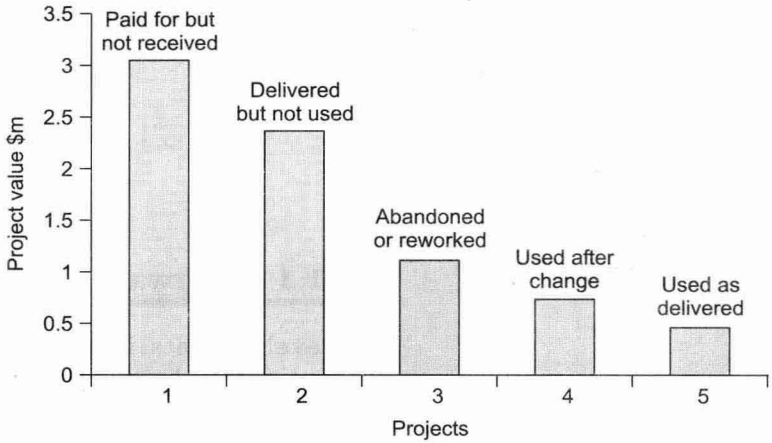

Fig. 1.1 ⇔ *The state of US defence projects (according to the US government)*

Changes in user requirements have always been a major problem. Another study (Fig. 1.2) shows that more than 50% of the systems required modifications due to changes in user requirements and data formats. It only illustrates that, in a changing world with a dynamic business environment, requests for change are unavoidable and therefore systems must be adaptable and tolerant to changes.

These studies and other reports on software implementation suggest that software products should be evaluated carefully for their quality before they are delivered and implemented. Some of the quality issues that must be considered for critical evaluation are:

1. Correctness
2. Maintainability
3. Reusability
4. Openness and interoperability