Chapter 8: Introduction to High-level Language Programming

Invitation to Computer Science,
C++ Version, Third Edition

Objectives

In this chapter, you will learn about:

- High-level languages
- Introduction to C++
- Virtual data storage
- Statement types
- Putting the pieces together

Objectives

- Managing complexity
- Object-oriented programming
- Graphical programming
- The big picture: software engineering

Where Do We Stand?

- Early days of computing
  - Programmers were satisfied with assembly language
    - Programs written by technically oriented people
- Later decades
  - Programmers demanded a more comfortable programming environment
    - Programs could be written by “nontechie” people

High-level Languages

- High-level programming languages
  - Called third-generation languages
  - Overcame deficiencies of assembly language
  - Programmer didn’t need to manage details of data storage or movement

High-level Languages (continued)

- Expectations of a high-level language program (continued)
  - Programmer can take a macroscopic view of tasks; "primitive operations" can be larger
  - Programs will be portable
  - Code will be closer to standard English and use standard mathematical notation

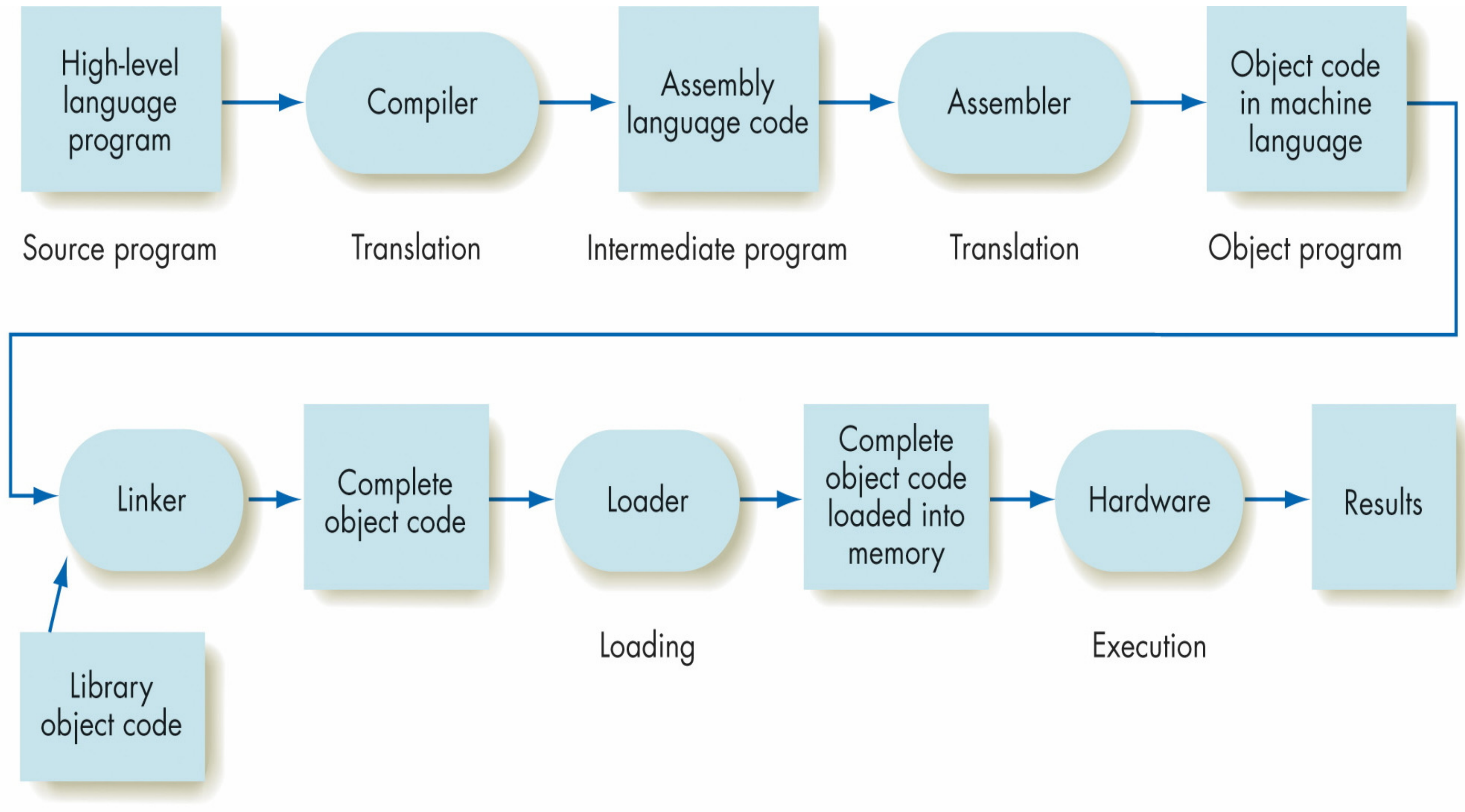


Figure 8.1

Transitions of a High-level Language Program

```
//program Numerology
//this program gets the user's favorite number
//and prints a greeting

#include <iostream>
using namespace std;

void main()
{
     int your_number; //stores the number entered by user
     cout << "Please enter your favorite number: ";
     cin >> your_number;
     cout << endl;
     cout << "Your favorite number is " << your_number "."
                << endl;
     cout << "That is a nice number." << endl;
}
```

Figure 8.2

A Simple C++ Program

```
prologue comment      [optional]
include directives    [optional]
using directive       [optional]
functions             [optional]
main function
{
      declarations    [optional]
      main function body
}
```

Figure 8.3

The Overall Form of a Typical C++ Program

Introduction to C++

- Some components of program in Figure 8.2
  - Comments
    - Give information to human readers of code
  - Include directive
    - The linker includes object code from a library
  - Using directive
    - Tells compiler to look in a namespace for definitions not mentioned in the program

Virtual Data Storage

- Identifiers: names in a programming language
- Keywords: have special meanings in C++
- C++: case-sensitive, free-format language
- Data items can be constants or variables

Virtual Data Storage (continued)

- A declaration of a data item tells
  - Whether the item is a constant or a variable
  - The identifier used to name the item
  - The data type of the item

int	A positive or negative integer quantity
double	A real number
char	A character (a single keyboard character, such as 'a')

Figure 8.5

Some of the C++ Standard Data Types

Virtual Data Storage (continued)

- An array
  - Groups together a collection of memory locations, all storing data of the same type

Figure 8.6

A 12-Element Array Hits

Statement Types

- Input/output statement
  - Input statement
    - Collects a specific value from the user for a variable within the program
  - Output statement
    - Writes a message or the value of a program variable to the user's screen or to a file

Statement Types (continued)

- Assignment statement
  - Assigns a value to a program variable
- Control statement
  - Directs the flow of control
    - Can cause it to deviate from usual sequential flow

Input/Output Statements

- Example
  - Pseudocode

    Get value for Radius
  - C++

    ```
    cin >> Radius;
    ```
- cin: input stream
- Code for extraction operator (>>) and the definition of the cin stream come from the iostream library and std namespace

Input/Output Statements (continued)

- Example
  - Pseudocode

    Print the value of Circumference
  - C++

    ```
    cout << Circumference;
    ```
- cout: output stream
- Code for the insertion operator (<<) and the definition of the cout stream come from the iostream library and std namespace

The Assignment Statement

- General form
  - Pseudocode

    Set the value of “variable” to “arithmetic expression”
  - C++

    variable = expression;

1. Expression on the right is evaluated
2. The result is written into the memory location named on the left

Control Statements

- Types of control mechanisms
  - Sequential
    - Instructions are executed in order
  - Conditional
    - Choice of which instructions to execute next depends on some condition
  - Looping
    - Group of instructions may be executed many times

Control Statements (continued)

- Default mode of execution: sequential
- Conditional flow of control
  - Evaluation of a Boolean condition (also called a Boolean expression)
  - Which programming statement to execute next is decided based on the value of the Boolean condition (true or false)

Control Statements (continued)

- Conditional flow of control (continued)
  - if-else statement

```
if (Boolean condition)
        S1;
else
        S2;
```

  - if variation of the if-else statement

```
if (Boolean condition)
        S1;
```

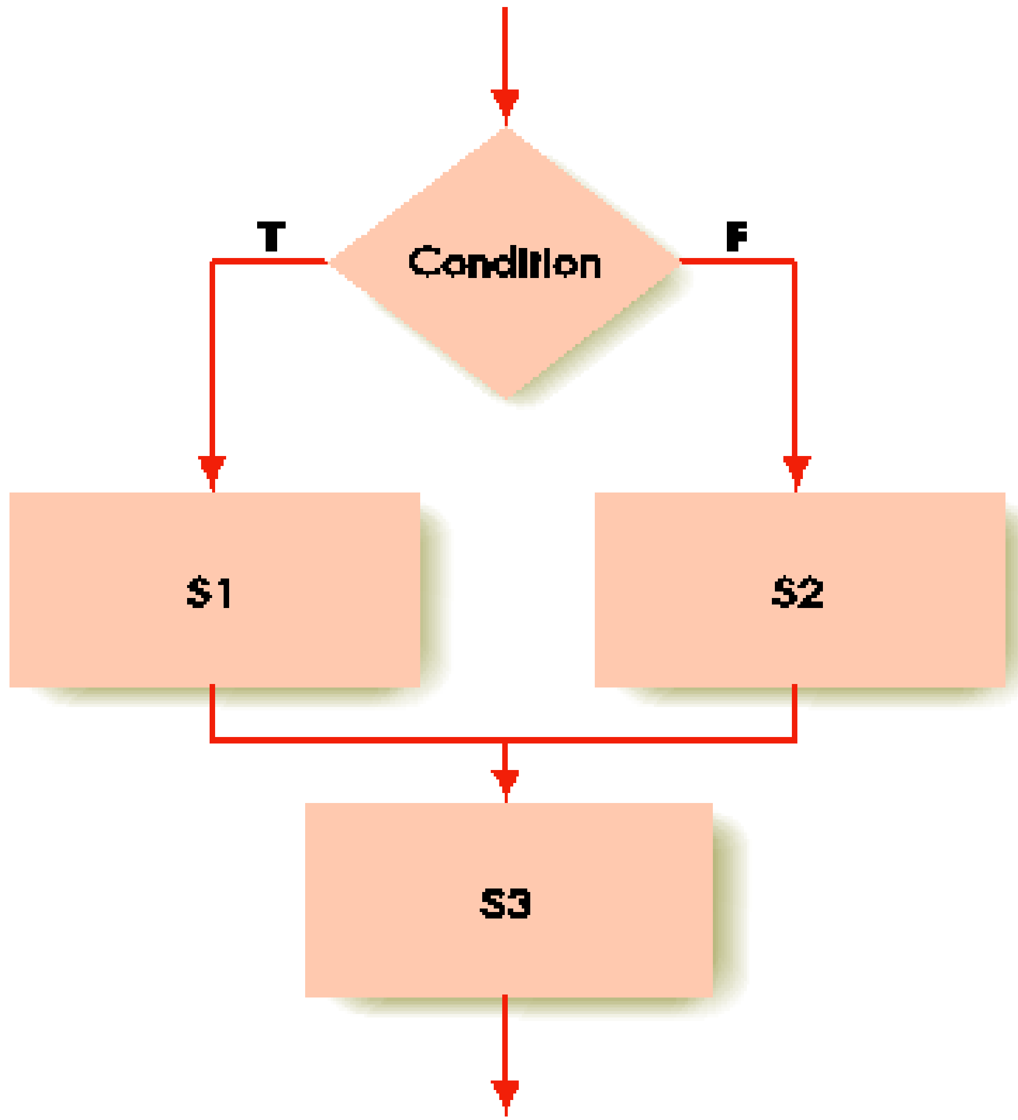


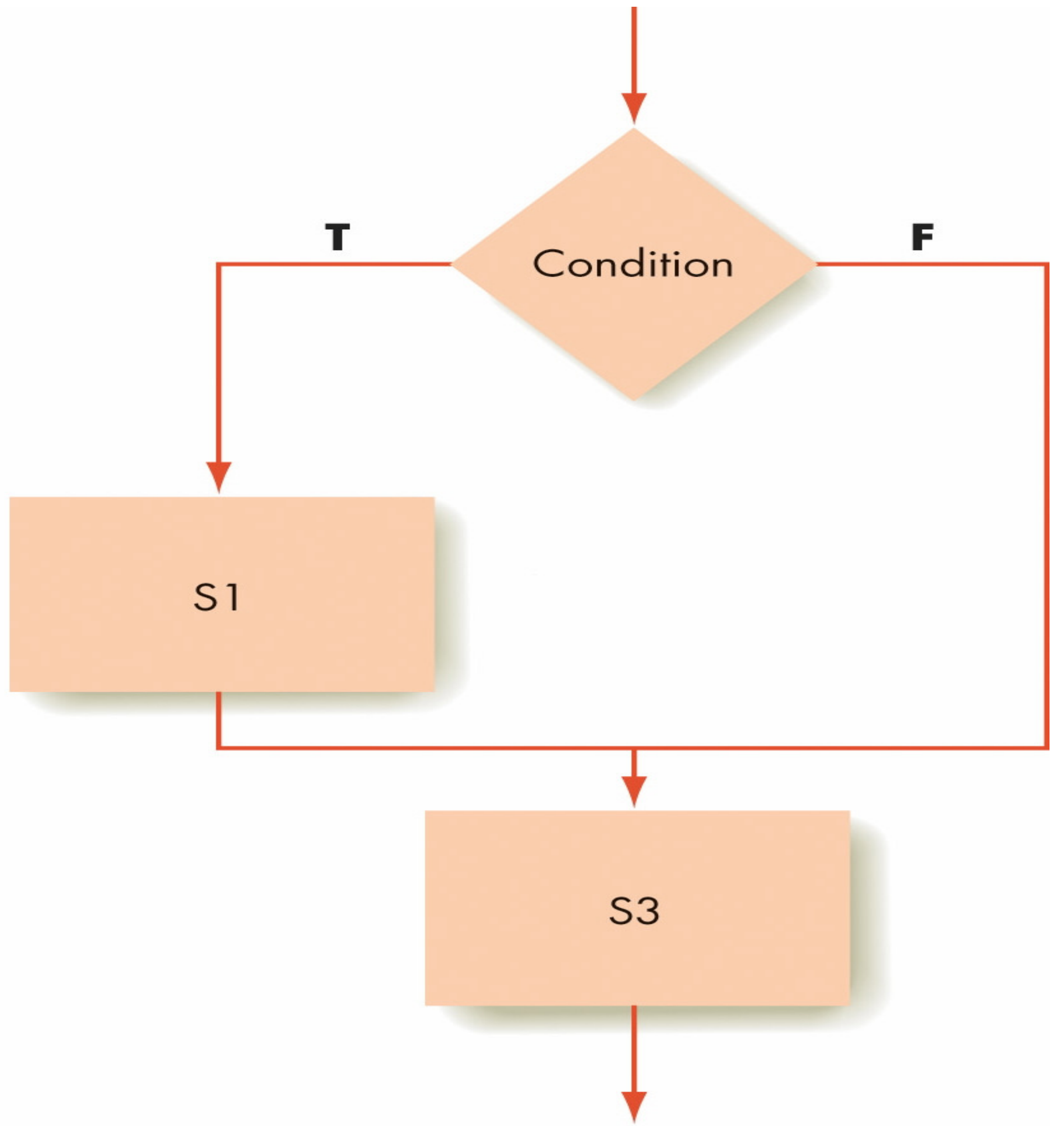
Figure 8.12

Conditional Flow of Con

(If-Else)

Figure 8.13

If-Else with Empty Else

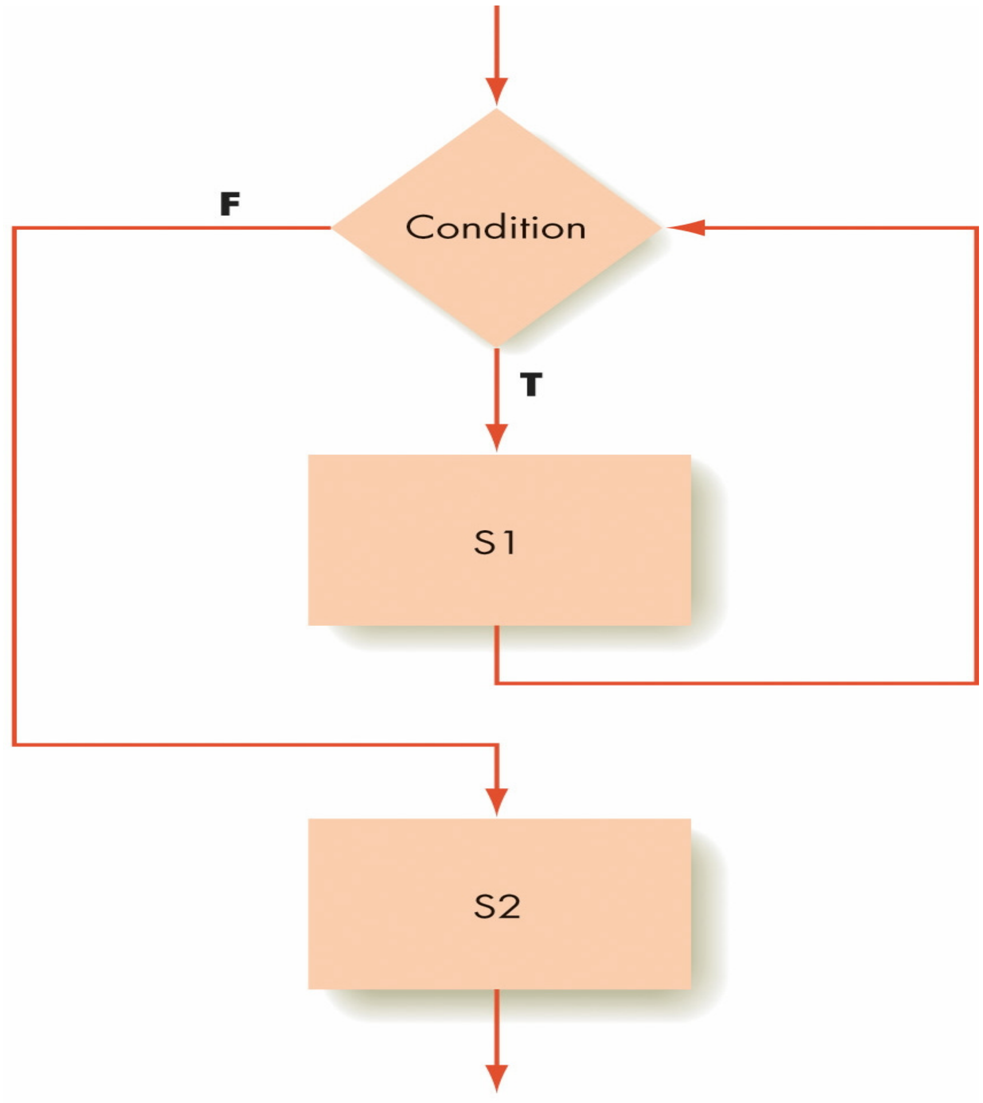


Control Statements (continued)

- Looping (iteration)
  - The loop body may be executed repeatedly based on the value of the Boolean condition
  - while statement

```
while (Boolean condition)
        S1;
```

Figure 8.14
While Loop



Putting the Pieces Together

- At this point, we can:
  - Perform input and output
  - Assign values to variables
  - Direct the flow of control using conditional statements or looping
- For a complete program, we need to:
  - Assemble the statements in the correct order
  - Fill in the missing pieces

Meeting Expectations

- C++ meets the four expectations for a high-level programming language
- Expectations
  - Programmer need not manage details of the movement of data items within memory, nor pay any attention to where they are stored

Meeting Expectations (continued)

- Expectations (continued)
  - Programmer can take a macroscopic view of tasks, thinking at a higher level of problem-solving
  - Programs written in high-level languages will be portable rather than machine-specific
  - Programming statements in a high-level language
    - Will be closer to standard English
    - Will use standard mathematical notation

Managing Complexity: Divide and Conquer

- Divide and conquer
  - To solve a problem, divide it into smaller pieces
- In a computer program
  - Divide the code into modules (subprograms), each doing a part of the overall task
  - Empower these modules to work together to solve the original problem

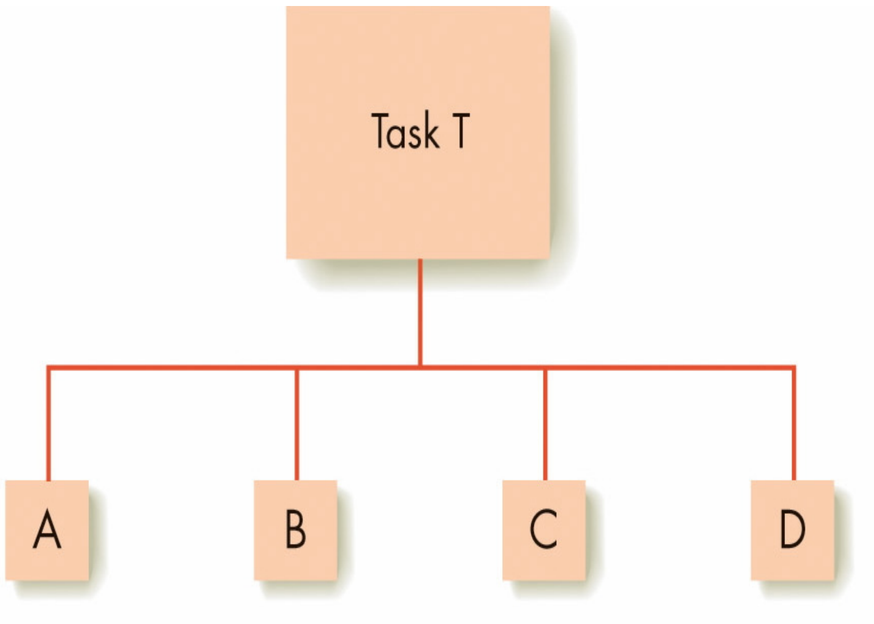


Figure 8.19

A Structure Chart

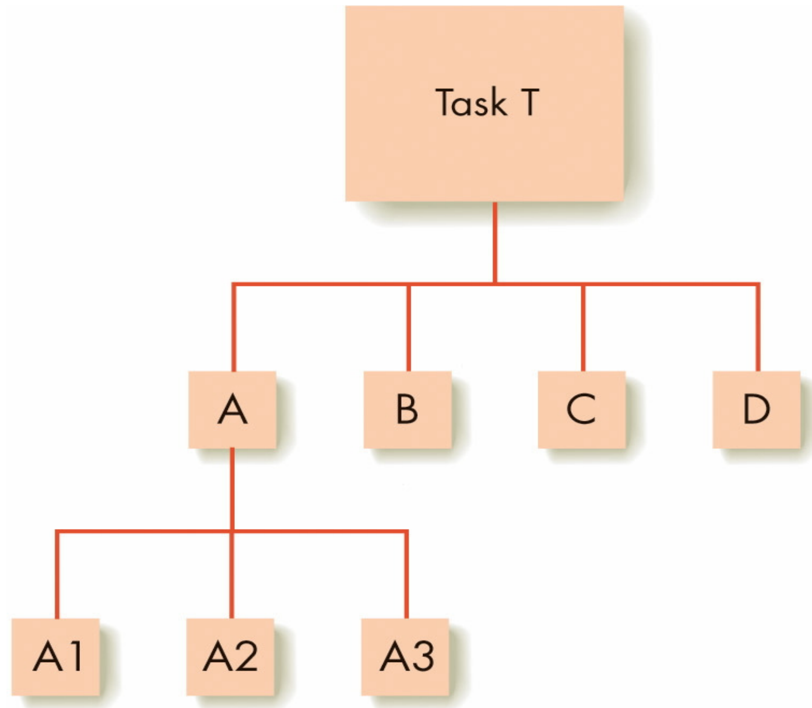


Figure 8.20

A More Detailed Structure Chart

Using Functions

- Function
  - A module of code in C++
  - Named using ordinary C++ identifiers
- Subtask functions: optional
- The main function: mandatory

Using Functions (continued)

- To invoke a subtask function, the main function gives
  - Name of the function
  - Argument list for the function
- Argument list: list of identifiers for variables that concern that function
- Any function can have its own constant and variable declarations

Writing Functions

- A function header consists of:
  - Return indicator: classifies a function as a void or a nonvoid function
  - Function identifier
  - Parameter list
- By default, arguments in C++ are passed by value

```
function header
{
    local declarations    [optional]
    function body
}
```

Figure 8.24

The Outline for a C++ Function

Term	Meaning	Term	Meaning
Local variable	Declared and known only within a function	Global constant	Declared outside any function and known everywhere
Argument passed by value	Function receives a copy of the value and can make no permanent changes in the	Argument passed by reference	Function gets access to memory location where the value is stored; changes it makes value to the value persist after control returns to main function
Void function	Performs a task, function invocation is a complete C++ statement	Nonvoid function	Computes a value; must include a return statement; function invocation is used within another C++ statement

Figure 8.29

Some C++ Terminology

Object-Oriented Programming

- Object-oriented programming (OOP)
  - A program is a simulation of some part of the world that is the domain of interest
  - Each object is an example drawn from a class of similar objects
- Key elements of OOP
  - Encapsulation
    - A class consists of its subtask modules and its properties
    - Both are “encapsulated” in the class

Object-Oriented Programming (continued)

- Key elements of OOP (continued)
  - Inheritance
    - Once a class A of objects is defined, a class B of objects can be defined as a “subclass” of A
  - Polymorphism
    - One name, the name of the service to be performed, has several meanings, depending on the class of the object providing the service

What Have We Gained?

- Two major advantages of OOP
  - Software reuse
  - A more natural "world view"

Graphical Programming: Graphics Primitives

- Bitmapped display
  - The screen is made up of thousands of pixels, laid out in a two-dimensional grid
- Frame buffer
  - Memory that stores the actual screen image
- The terminal hardware displays on the screen the frame buffer value of every individual pixel

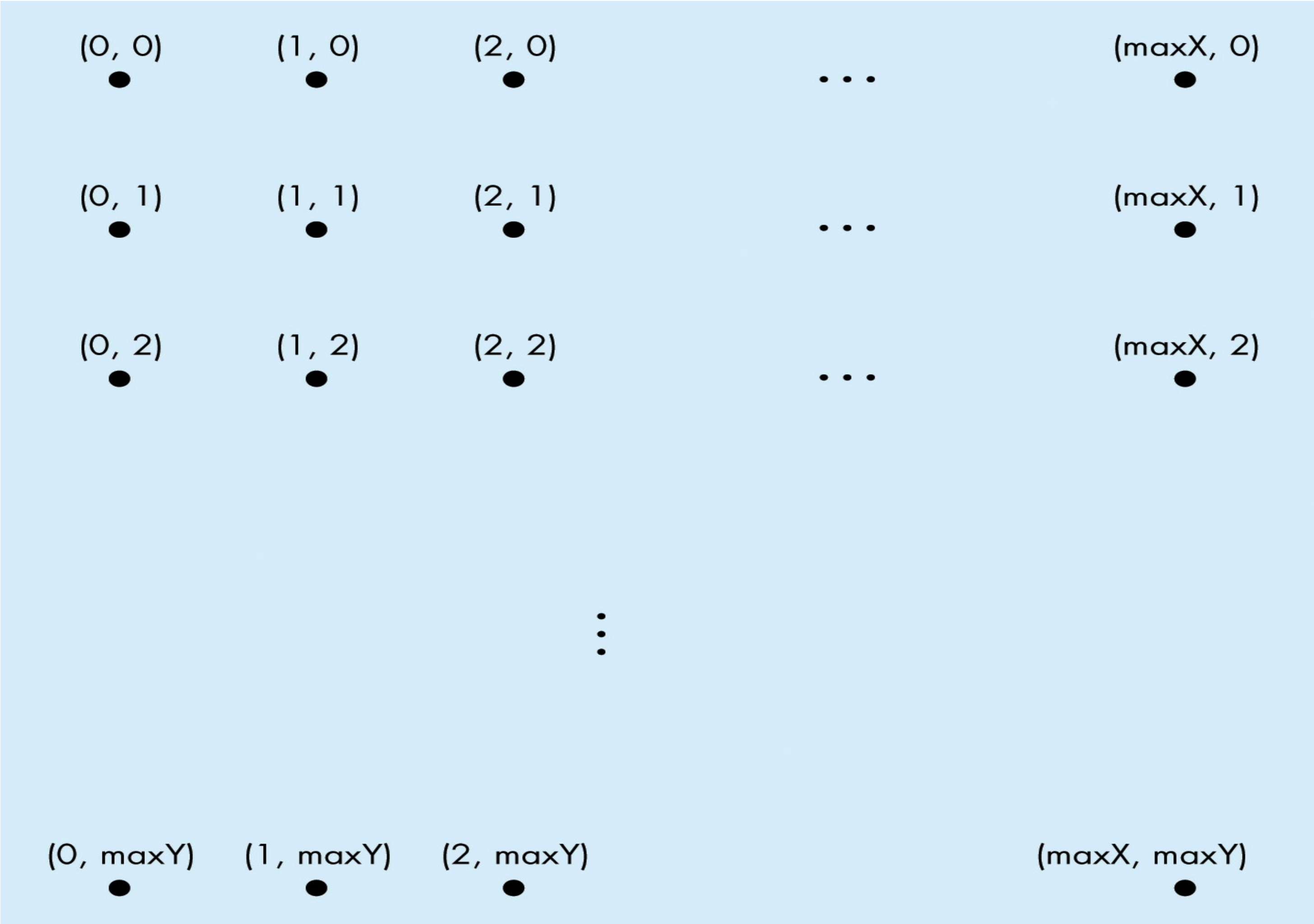


Figure 8.34

Pixel Numbering System in a Bitmapped Display

Graphics Primitives (continued)

- Graphics library
  - Software containing a collection of functions that control the setting and clearing of pixels
- Virtually all modern programming languages come with a graphics library

The Big Picture: Software Engineering

- Software life cycle
  - Overall sequence of steps needed to complete a large-scale software project
  - Implementation represents a relatively small part of the cycle

1. Before implementation
   a. Feasibility study
   b. Problem specification
   c. Program design
   d. Algorithm selection or development, and analysis
2. Implementation
   a. Coding
   b. Debugging
3. After implementation
   a. Testing, verification, and benchmarking
   b. Documentation
   c. Maintenance

Figure 8.37

Steps in the Software Development Life Cycle

Scaling Up

- Programs written by students
  - No longer than a few hundred lines
- Real-world programs
  - 2, 3, or 4 orders of magnitude larger
- Large-scale software development
  - Extensive planning and design needed
  - A team of programmers needed
  - “Software engineering”

The Software Life Cycle

- Each step in the software development life cycle
  - Has a specific purpose and activities
  - Should result in a written document
- The feasibility study
- Problem specification
- Program design

The Software Life Cycle (continued)

- Algorithm selection or development, and analysis
- Coding
- Debugging
- Testing, verification, and benchmarking
- Documentation
- Maintenance

Modern Environments

- Integrated Development Environment (IDE) speeds development by providing
  - A text editor
  - A file manager
  - A compiler
  - A linker and loader
  - Tools for debugging

Summary

- In a high-level language, the programmer:
  - Need not manage storage
  - Can think about the problem at a higher level
  - Can use more powerful and more natural-language-like program instructions
  - Can write a much more portable program

Summary

- C++ is an object-oriented, high-level programming language
- if-else statement creates a conditional flow of control
- while loop can be used for iteration
- Software life cycle: overall sequence of steps needed to complete a large-scale software project