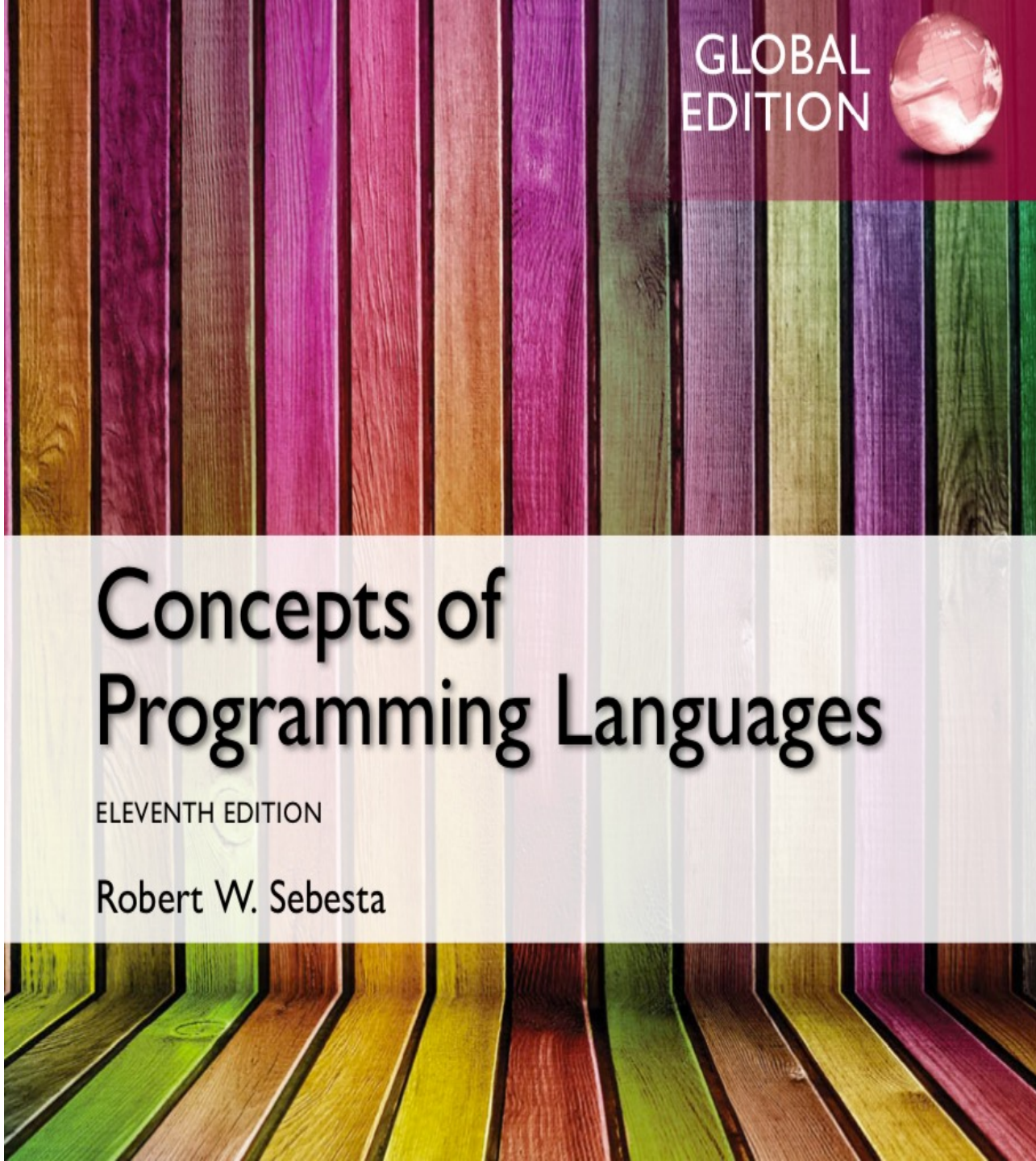
Chapter 12

Support for Object-Oriented Programming



Chapter 12 Topics

- Introduction
- Object-Oriented Programming
- Design Issues for Object-Oriented Languages
- Support for Object-Oriented Programming in Smalltalk
- Support for Object-Oriented Programming in C++
- Support for Object-Oriented Programming in Java
- Support for Object-Oriented Programming in C#
- Support for Object-Oriented Programming in Ada 95
- Support for Object-Oriented Programming in Ruby
- Implementation of Object-Oriented Constructs

Introduction

- Many object-oriented programming (OOP) languages
  - Some support procedural and data-oriented programming (e.g., Ada 95 and C++)
  - Some support functional program (e.g., CLOS)
  - Newer languages do not support other paradigms but use their imperative structures (e.g., Java and C#)
  - Some are pure OOP language (e.g., Smalltalk & Ruby)

Object-Oriented Programming

- Abstract data types
- Inheritance
  - Inheritance is the central theme in OOP and languages that support it
- Polymorphism

Inheritance

- Productivity increases can come from reuse
  - ADTs are difficult to reuse—always need changes
  - All ADTs are independent and at the same level
- Inheritance allows new classes defined in terms of existing ones, i.e., by allowing them to inherit common parts
- Inheritance addresses both of the above concerns--reuse ADTs after minor changes and define classes in a hierarchy

Object-Oriented Concepts

- ADTs are usually called *classes*
- Class instances are called *objects*
- A class that inherits is a *derived class* or a *subclass*
- The class from which another class inherits is a parent class or *superclass*
- Subprograms that define operations on objects are called *methods*

Object-Oriented Concepts (continued)

- Calls to methods are called *messages*
- The entire collection of methods of an object is called its *message protocol* or *message interface*
- Messages have two parts--a method name and the destination object
- In the simplest case, a class inherits all of the entities of its parent

Object-Oriented Concepts (continued)

- Inheritance can be complicated by access controls to encapsulated entities
  - A class can hide entities from its subclasses
  - A class can hide entities from its clients
  - A class can also hide entities for its clients while allowing its subclasses to see them
- Besides inheriting methods as is, a class can modify an inherited method
  - The new one *overrides* the inherited one
  - The method in the parent is *overriden*

Object-Oriented Concepts (continued)

- There are two kinds of variables in a class:
  - *Class variables* – one/class
  - *Instance variables* – one/object
- There are two kinds of methods in a class:
  - *Class methods* – accept messages to the class
  - *Instance methods* – accept messages to objects
- Single vs. Multiple Inheritance
- One disadvantage of inheritance for reuse:
  - Creates interdependencies among classes that complicate maintenance

Dynamic Binding

- A *polymorphic variable* can be defined in a class that is able to reference (or point to) objects of the class and objects of any of its descendants
- When a class hierarchy includes classes that override methods and such methods are called through a polymorphic variable, the binding to the correct method will be dynamic
- Allows software systems to be more easily extended during both development and maintenance

Dynamic Binding Concepts

- An *abstract method* is one that does not include a definition (it only defines a protocol)
- An *abstract class* is one that includes at least one virtual method
- An abstract class cannot be instantiated

Design Issues for OOP Languages

- The Exclusivity of Objects
- Are Subclasses Subtypes?
- Type Checking and Polymorphism
- Single and Multiple Inheritance
- Object Allocation and Deallocation
- Dynamic and Static Binding
- Nested Classes
- Initialization of Objects

The Exclusivity of Objects

- Everything is an object
  - Advantage – elegance and purity
  - Disadvantage – slow operations on simple objects
- Add objects to a complete typing system
  - Advantage – fast operations on simple objects
  - Disadvantage – results in a confusing type system (two kinds of entities)
- Include an imperative-style typing system for primitives but make everything else objects
  - Advantage – fast operations on simple objects and a relatively small typing system
  - Disadvantage – still some confusion because of the two type systems

Are Subclasses Subtypes?

- Does an "is-a" relationship hold between a parent class object and an object of the subclass?
  - If a derived class is-a parent class, then objects of the derived class must behave the same as the parent class object
- A derived class is a subtype if it has an is-a relationship with its parent class
  - Subclass can only add variables and methods and override inherited methods in "compatible" ways

Type Checking and Polymorphism

- Polymorphism may require dynamic type checking of parameters and the return value
  - Dynamic type checking is costly and delays error detection
- If overriding methods are restricted to having the same parameter types and return type, the checking can be static

Single and Multiple Inheritance

- Multiple inheritance allows a new class to inherit from two or more classes
- Disadvantages of multiple inheritance:
  - Language and implementation complexity (in part due to name collisions)
  - Potential inefficiency – dynamic binding costs more with multiple inheritance (but not much)
- Advantage:
  - Sometimes it is quite convenient and valuable

Allocation and DeAllocation of Objects

- From where are objects allocated?
  - If they behave line the ADTs, they can be allocated from anywhere
    - Allocated from the run-time stack
    - Explicitly create on the heap (via `new`)
  - If they are all heap-dynamic, references can be uniform thru a pointer or reference variable
    - Simplifies assignment – dereferencing can be implicit
  - If objects are stack dynamic, there is a problem with regard to subtypes
- Is deallocation explicit or implicit?

Dynamic and Static Binding

- Should all binding of messages to methods be dynamic?
  - If none are, you lose the advantages of dynamic binding
  - If all are, it is inefficient
- Allow the user to specify

Nested Classes

- If a new class is needed by only one class, there is no reason to define so it can be seen by other classes
  - Can the new class be nested inside the class that uses it?
  - In some cases, the new class is nested inside a subprogram rather than directly in another class
- Other issues:
  - Which facilities of the nesting class should be visible to the nested class and vice versa

Initialization of Objects

- Are objects initialized to values when they are created?
  - Implicit or explicit initialization
- How are parent class members initialized when a subclass object is created?