Introduction To Design Patterns

What Is A Pattern?

- Current use comes from the work of the architect Christopher Alexander
- Alexander studied ways to improve the process of designing buildings and urban areas
- “Each pattern is a three-part rule, which expresses a relation between a certain context, a problem and a solution.”
- Hence, the common definition of a pattern: “A solution to a problem in a context.”
- Patterns can be applied to many different areas of human endeavor, including software development

Why Patterns?

- "Designing object-oriented software is hard and designing reusable object-oriented software is even harder." - Erich Gamma
- Experienced designers reuse solutions that have worked in the past
- Well-structured object-oriented systems have recurring patterns of classes and objects
- Knowledge of the patterns that have worked in the past allows a designer to be more productive and the resulting designs to be more flexible and reusable

Software Patterns History

- 1987 - Cunningham and Beck used Alexander's ideas to develop a small pattern language for Smalltalk
- 1990 - The Gang of Four (Gamma, Helm, Johnson and Vlissides) begin work compiling a catalog of design patterns
- 1991 - Bruce Anderson gives first Patterns Workshop at OOPSLA
- 1993 - Kent Beck and Grady Booch sponsor the first meeting of what is now known as the Hillside Group
- 1994 - First Pattern Languages of Programs (PLoP) conference
- 1995 - The Gang of Four (GoF) publish the *Design Patterns* book

Types Of Software Patterns

- Analysis
- Design
- Organizational
- Process
- Project Planning
- Configuration Management

Types Of Software Patterns

- Riehle and Zullighoven in "*Understanding and Using Patterns in Software Development*" mention three types of software patterns
- Conceptual Pattern
  - ⇨ Pattern whose form is described by means of terms and concepts from the application domain
- Design Pattern
  - ⇨ Pattern whose form is described by means of software design constructs, such as objects, classes, inheritance and aggregation
- Programming Pattern (Programming Idiom)
  - ⇨ Pattern whose form is described by means of programming language constructs

Design Pattern Levels Of Abstraction

- Complex design for an entire application or subsystem

More Abstract

- Solution to a general design problem in a particular context

More Concrete

- Simple reusable design class such as a linked list, hash table, etc.

GoF Design Patterns

- The GoF design patterns are in the middle of these levels of abstraction
- “A design pattern names, abstracts, and identifies key aspects of a common design structure that makes it useful for creating a reusable object-oriented design.”
- The GoF design patterns are “descriptions of communicating objects and classes that are customized to solve a general design problem in a particular context.”

GoF Classification Of Design Patterns

- Purpose - what a pattern does
  - Creational Patterns
    - Concern the process of object creation
  - Structural Patterns
    - Deal with the composition of classes and objects
  - Behavioral Patterns
    - Deal with the interaction of classes and objects
- Scope - what the pattern applies to
  - Class Patterns
    - Focus on the relationships between classes and their subclasses
    - Involve inheritance reuse
  - Object Patterns
    - Focus on the relationships between objects
    - Involve composition reuse

GoF Essential Elements Of Design Patterns

- Pattern Name
  - ➩ Having a concise, meaningful name for a pattern improves communication among developers
- Problem
  - ➩ What is the problem and context where we would use this pattern?
  - ➩ What are the conditions that must be met before this pattern should be used?
- Solution
  - ➩ A description of the elements that make up the design pattern
  - ➩ Emphasizes their relationships, responsibilities and collaborations
  - ➩ Not a concrete design or implementation; rather an abstract description
- Consequences
  - ➩ The pros and cons of using the pattern
  - ➩ Includes impacts on reusability, portability, extensibility

GoF Pattern Template

- Pattern Name and Classification
  - ➩ A good , concise name for the pattern and the pattern's type
- Intent
  - ➩ Short statement about what the pattern does
- Also Known As
  - ➩ Other names for the pattern
- Motivation
  - ➩ A scenario that illustrates where the pattern would be useful
- Applicability
  - ➩ Situations where the pattern can be used

GoF Pattern Template (Continued)

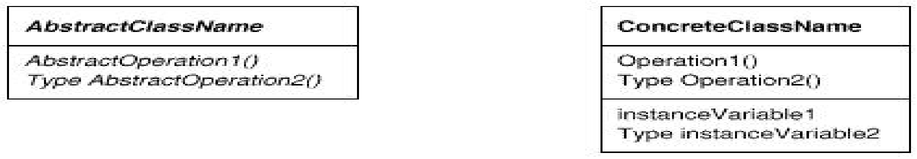
- Structure
  - ⇨ A graphical representation of the pattern
- Participants
  - ⇨ The classes and objects participating in the pattern
- Collaborations
  - ⇨ How to do the participants interact to carry out their responsibilities?
- Consequences
  - ⇨ What are the pros and cons of using the pattern?
- Implementation
  - ⇨ Hints and techniques for implementing the pattern

GoF Pattern Template (Continued)

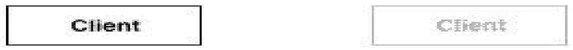
- Sample Code
  - ⇨ Code fragments for a sample implementation
- Known Uses
  - ⇨ Examples of the pattern in real systems
- Related Patterns
  - ⇨ Other patterns that are closely related to the pattern

GoF Notation

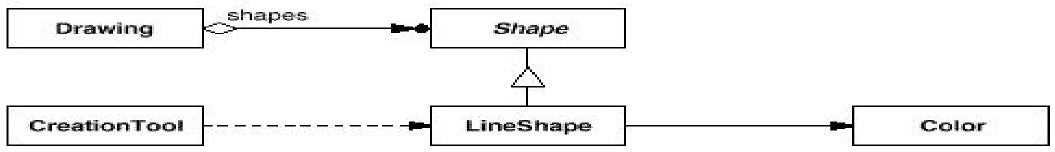
- The GoF book uses the Object Modeling Technique (OMT) notation for class and object diagrams:



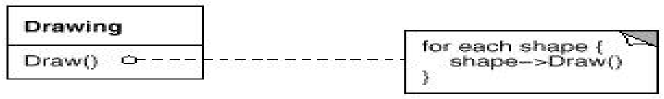
(a) Abstract and concrete classes



(b) Participant Client class (left) and implicit Client class (right)



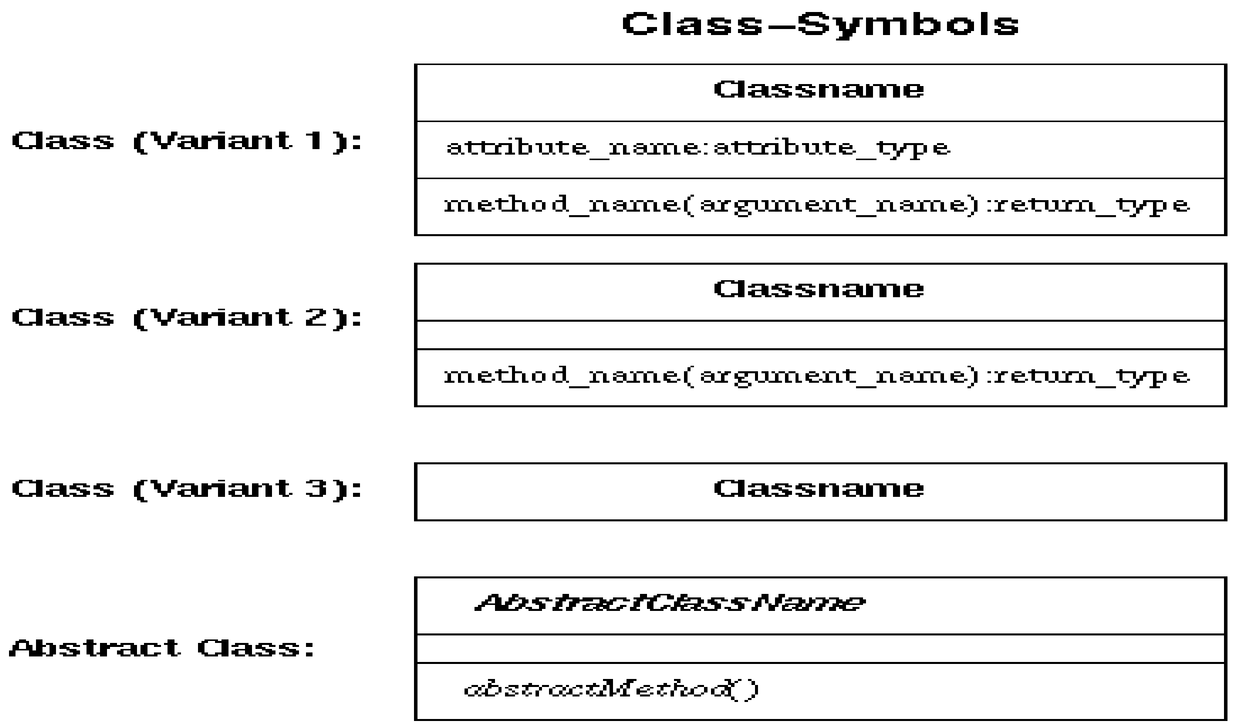
(c) Class relationships



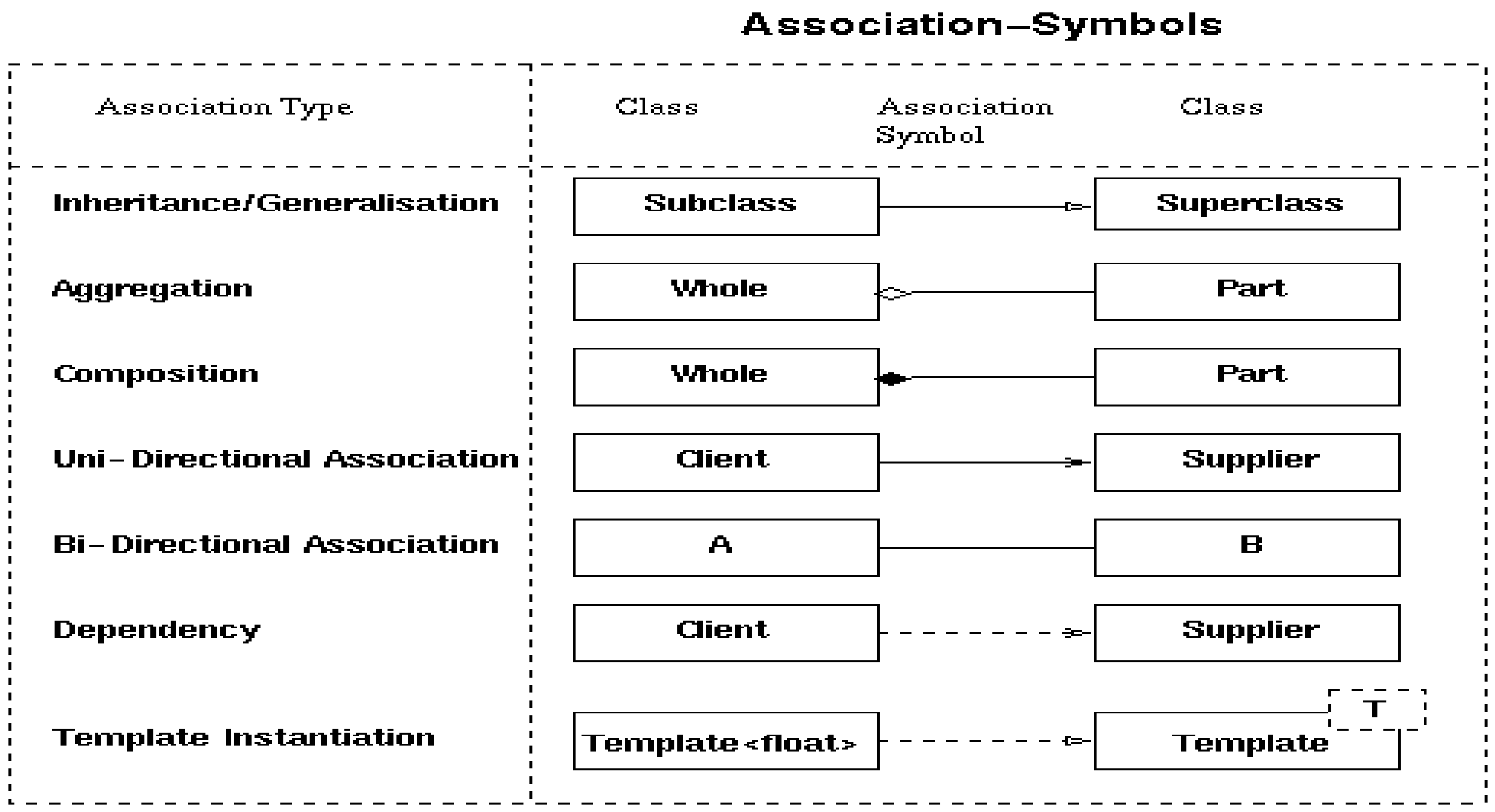
(d) Pseudocode annotation

UML Notation

- We will also use the Unified Modeling Language (UML)



UML Notation (Continued)



Benefits Of Design Patterns

- Capture expertise and make it accessible to non-experts in a standard form
- Facilitate communication among developers by providing a common language
- Make it easier to reuse successful designs and avoid alternatives that diminish reusability
- Facilitate design modifications
- Improve design documentation
- Improve design understandability

Design Patterns Books

- *Design Patterns: Elements of Reusable Object-Oriented Software*, Gamma, Helm, Johnson and Vlissides, Addison-Wesley, 1995
- *Design Patterns for Object-Oriented Software Development*, Wolfgang Pree, Addison-Wesley/ACM Press, 1995
- *Patterns of Software: Tales From The Software Community*, Richard P. Gabriel, Oxford University Press, 1996
- *Pattern Oriented Software Architecture : A System of Patterns*, Frank Buschmann (Editor), Wiley, 1996
- *Analysis Patterns: Reusable Object Models*, Martin Fowler, Addison-Wesley, 1997
- *AntiPatterns*, Brown, Malveau, McCormick and Mowbray, Wiley, 1998

Design Patterns Books

- *Pattern Hatching: Design Patterns Applied*, John Vlissides, Addison-Wesley, 1998
- *Patterns in Java Volume 1*, Mark Grand, Wiley, 2nd Ed., 2002
- *Patterns in Java Volume 2*, Mark Grand, Wiley, 1999
- *Java Enterprise Design Patterns: Patterns in Java Volume 3*, Mark Grand, Wiley, 2001
- *The Patterns Handbook*, edited by Linda Rising, Cambridge University Press, 1998
- *Java Design Patterns - A Tutorial*, James W. Cooper, Addison-Wesley, 2000

Design Patterns Books

- *Design Patterns Explained*, Alan Shalloway and James R. Trott, Addison-Wesley, 2001
- *Core J2EE Patterns: Best Practices and Design Strategies*, Alur, Crupi and Malks, 2001
- *Design Patterns Java Workbook*, Steven John Metsker, Addison-Wesley, 2002
- *Applied Java Patterns*, Stephen Stelting and Olav Maassen, Prentice Hall, 2002
- *EJB Design Patterns: Advanced Patterns, Processes, and Idioms*, Floyd Marinescu, Wiley, 2002
- *Patterns Of Enterprise Application Archictecture*, Martin Fowler, Addison-Wesley, 2002

Design Patterns Books

- *C# Design Patterns - A Tutorial*, James W. Cooper, Addison-Wesley, 2002
- *Design Patterns In C#*, Steven John Metsker, Addison-Wesley, 2004
- *Head First Design Patterns*, Freeman and Freeman, O'Reilly, 2004
- *Core Security Patterns - Best Practices and Strategies for J2EE(TM), Web Services, and Identity Management*, Christopher Steel, Ramesh Nagappan and Ray Lai, Prentice Hall, 2005
- *Refactoring To Patterns*, Joshua Kerievsky, Addison-Wesley, 2005