Object Oriented Analysis & Design

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An Introduction to Design Patterns

What is Design Pattern

- Design pattern is a general **reusable** solution to a commonly occurring problem in software design.
- A design pattern is not a finished design that can be transformed directly into code. It is a description or template for how to solve a problem that can be used in many different situations.

Why Design Patterns

- •To **design a new** software system quickly and efficiently.
- •To **understand a existing** software system.

Introduction

- Promote reuse.
- Use the experiences of software developers.
- A shared library/lingo used by developers.
- “Design patterns help a designer get a design right faster”.

Introduction

- **Based on** the principles of object-oriented programming: abstraction, inheritance, polymorphism and association.
- Are **solutions to recurring problems** to software design.
- Are **independent of the application domain**.
- Example – Variability of interfaces – the modeller view controller (MVC) pattern.
  - Code ignitor, Laravel, Yii, etc.

The Downside

- Although design patterns are useful in promoting flexibility, this maybe at the expense of a more **complicated design**.
- There does not exist
  - A **standardization** for indexing patterns
  - **General practices/processes** for using design patterns during the design process have not as yet been established.

Object-Oriented Principles

- Involves identifying:
  - **Classes** and **objects**
  - What to **encapsulate**
  - **Association** hierarchies
  - **Inheritance** hierarchies
- Object-oriented designs are evaluated in terms of how **reusable**, **extensible** and **maintainable** they are.

Types of Pattern – Catalog 1

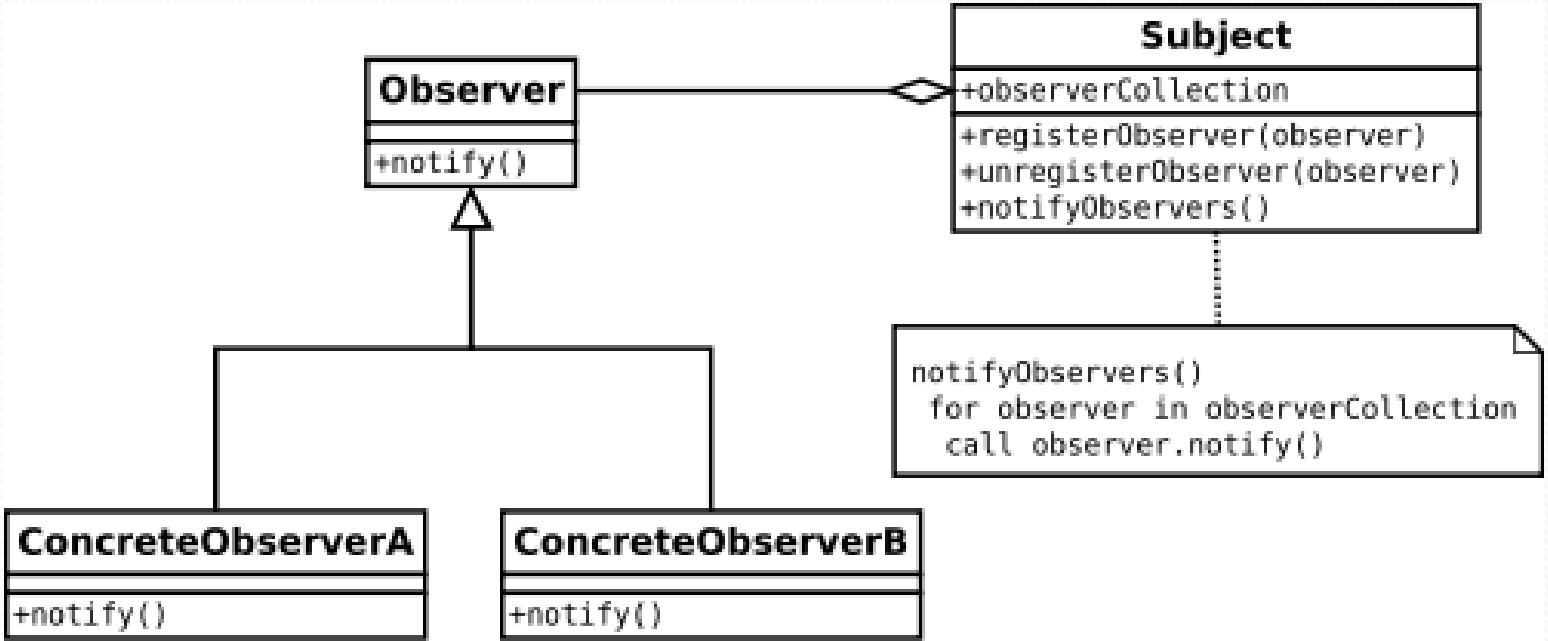
- Creational patterns
  - Focus on Object creation.
  - Focus on the best way to create instances of objects to promote flexibility, e.g. factory pattern.
- Structural patterns
  - Focus on Relationship between entities.
  - Focus on the composition of classes and objects into larger structures, e.g. the adapter pattern.
- Behavioural patterns
  - Focus on Communication between objects
  - Focus on the interaction between classes or objects, e.g. the observer pattern.

Types of Pattern – Catalog 2

- Architectural patterns
  - Focus on the form of the **overall system**.
- Design patterns
  - Focus on the form of the **subsystems** making up the overall system and essentially **provides schemes** for refining them.

Observer Design Pattern

- •Observer Design Pattern is a software design pattern in which an object, called the subject, maintains a list of its dependents, called observers, and notifies them automatically of any state changes, usually by calling one of their methods.
- •Type : Behavioral pattern.

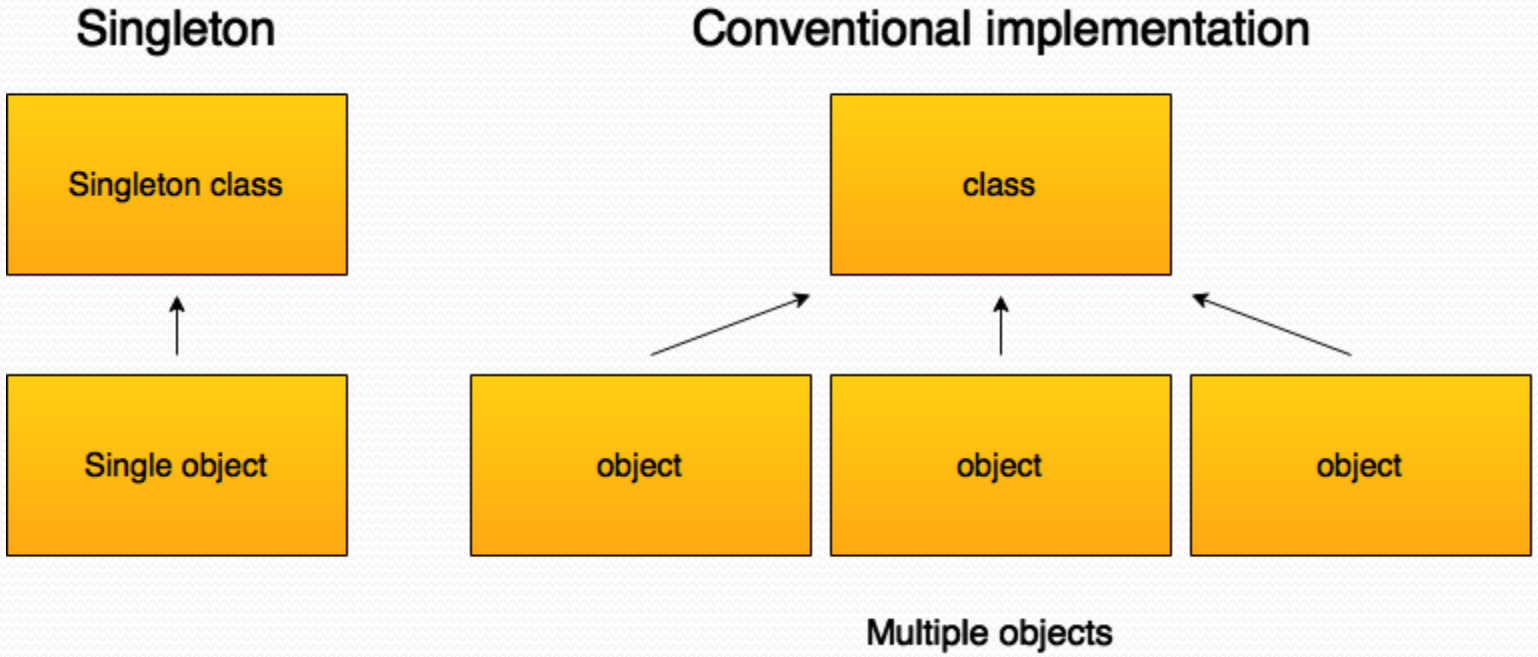


Factory Design Pattern

- Define an interface for creating an object, but let the subclasses decide which class to instantiate. The Factory method lets a class defer instantiation to subclasses.
- Type : Creational pattern.

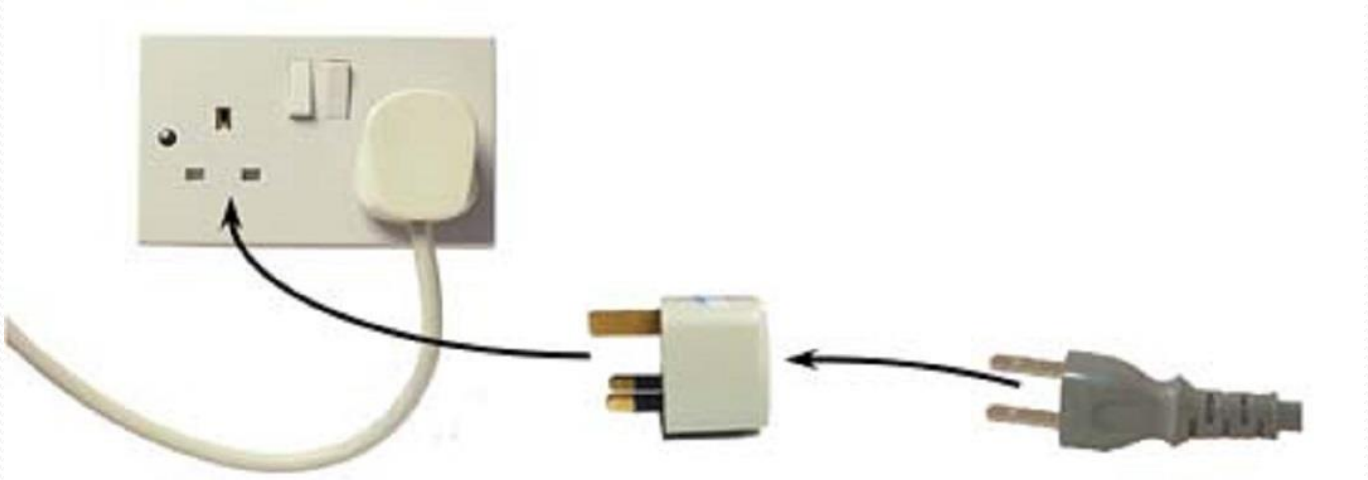
Singleton Design Pattern

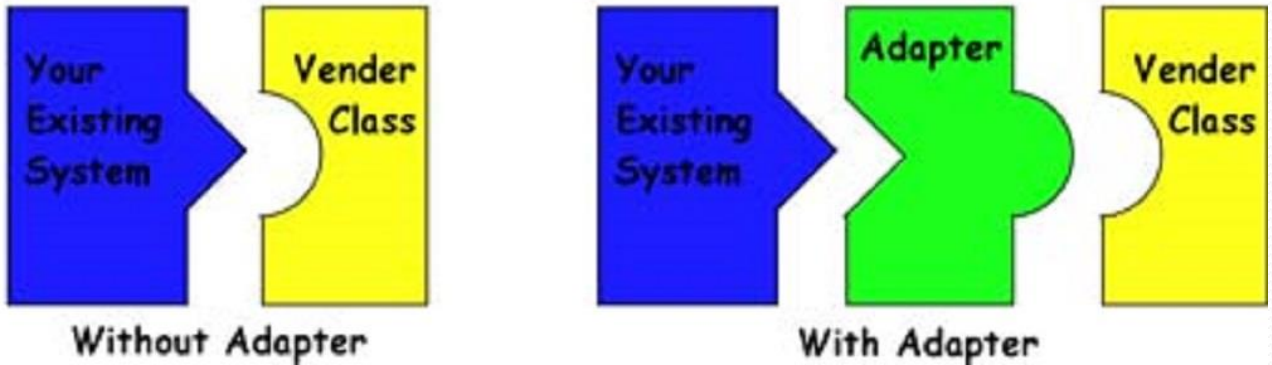
- Ensure a class has only one instance, and provide a global point of access to it.
- Encapsulated “just-in-time initialization” or “initialization on first use”.
- Type : Creational pattern.



Adaptor Design pattern

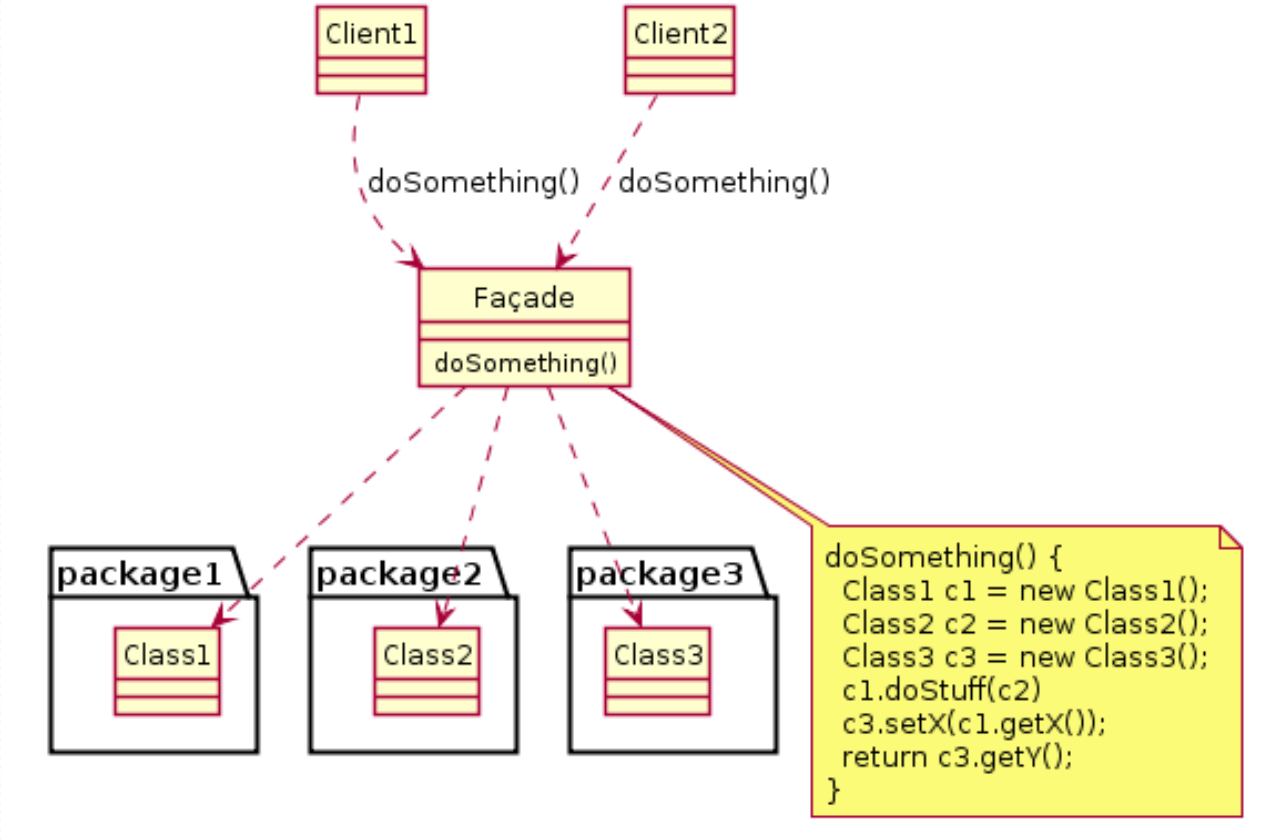
- The adapter pattern (often referred to as the wrapper pattern or simply a wrapper) is a design pattern that ***translates*** one interface for a class into a compatible interface.



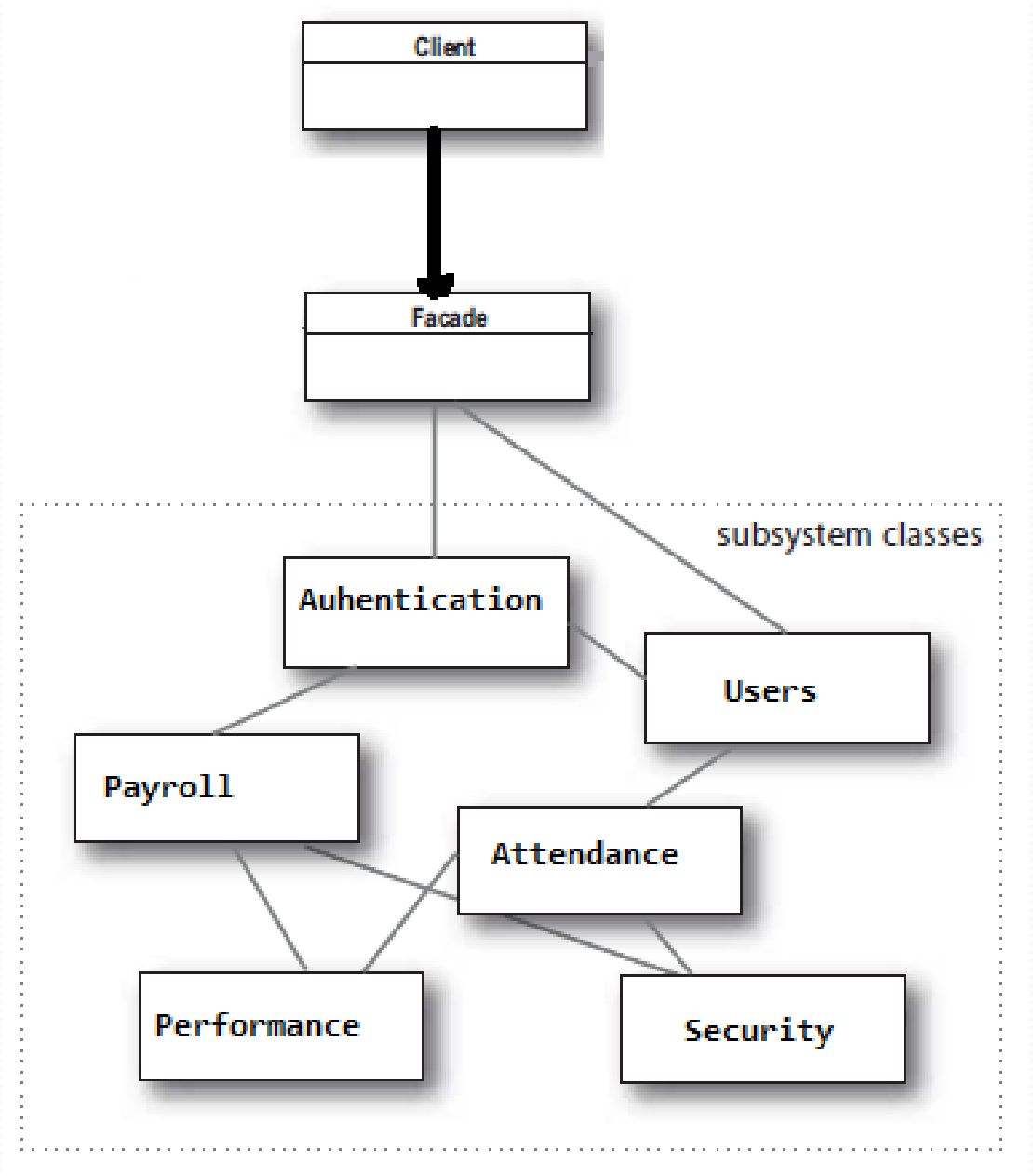


Façade pattern

- A facade is an object that provides a **simplified interface** to a larger body of code, such as a class library.
- Type: Structural Design Pattern.



Façade pattern



Pattern Scope

- The scope of a pattern specifies whether the pattern applies to **classes** or **objects**.
- **Class patterns** describe relationships between classes and their subclasses. These relationships are static.
- **Object patterns** describe the relationships between objects. Theses relationships can be changed at runtime.

Defining Patterns

- Are defined in terms of classes and objects and relationships between them.
- Using existing well-tested patterns saves time instead of deriving them from scratch each time.
- Patterns may consist of smaller patterns/sub-patterns.
- Class diagrams are used to express design patterns.

Core Components of a Pattern

- The problem which the pattern was used to solve and the situation giving rise to the problem. A **list of the conditions that must be met** in order to apply the pattern may also be included.
- The **core solution** to the problem in terms of a description of the design rather than implementation details.
- **Uses** of the solution

A More Detailed Definition

- Name
- Intent of the pattern
- Aliases
- The problem
- Solution
- Example/s
- Applicability
- Structure
- Participants
- Collaborations
- Implementation
- Sample code
- Known uses
- Related patterns
- Consequences

Design pattern space

		Purpose		
		Creational	**Structural**	**Behavioral**
Scope	**Class**	Factory Method	Adapter (class)	Interpreter Template Method
	Object	Abstract Factory Builder Prototype Singleton	Adapter (object) Bridge Composite Decorator Facade Flyweight Proxy	Chain of Responsibility Command Iterator Mediator Memento Observer State Strategy Visitor

Problems Solved by Design Patterns

- Finding appropriate objects.
- Determining the granularity of objects.
- Specifying object interfaces – definition of interfaces and relationships between them.
- Specifying object implementations.
- Using reuse mechanisms – delegation and parameterised types.
- Relating runtime and compile-time structures

Designing for Change

- A design must facilitate reuse and change.
- We need to design so as to avoid redesign.
- Certain design patterns can be used to prevent particular causes of redesign.

Avoiding Redesign

- Explicitly declaring class instances instead of using an interface -abstract factory, factory method and prototype patterns.
- Dependence of specific operations, i.e. using hard-coded requests - chain of responsibility and the command patterns.
- Limit software and hardware platform dependencies - abstract factory and bridge patterns.
- Dependence on object representations and implementations - Object representations and/or implementations may need to be changed - abstract factory, bridge, memento and proxy.

Avoiding Redesign

- Algorithmic dependencies - Algorithms that are likely to change should be isolated from the definition of the objects using them -builder, iterator, strategy, template and visitor patterns.
- Tight coupling - Tight coupling does not facilitate reuse- abstract factory, bridge, chain of responsibility, command, facade, mediator and observer patterns.
- Subclassing to extend functionality - Rather than using inheritance or association it maybe more efficient to combine both by creating one subclass that is associated with existing class - bridge, chain of responsibility, composite, decorator, observer and strategy classes.
- Difficulty in altering classes - In some cases adapting a class maybe difficult, e.g. the source code may not be available adapter, creator and visitor patterns.

Applying a Pattern

- In designing a system different patterns are used to design the different aspects of the system.
- Design patterns allow parts of the system to vary independently of other parts of the system.
- Patterns are often combined. Using one pattern my introduce further patterns into the design.
- Methods for applying design patterns and deciding which one to use.

Breaking Down the Problem

- Describe the problem and its subproblems.
- Select the category of patterns that is suitable for the design task.
- Compare the problem description with each pattern in the category.
- Identify the benefits and disadvantages of using each of the patterns in the category.
- Choose the pattern that best suits the problem.

Choosing a Design Pattern

- Consider the problems solved by design problems and what solution is needed for the problem at hand.
- Consider the intent of each pattern and which is most similar to the problem at hand.
- Analyse the relationships between patterns to determine which is the correct group of patterns to use.
- Determine whether creational, structural or behavioural patterns are needed and which of the patterns in the most suitable category is/are relevant to the problem at hand.
- Look at what could cause redesign for the problem at hand and patterns that can be used to avoid this.
- Identify which aspect/s of the system need to varied independently and which patterns will cater for this.

Using a Design Pattern

- Obtain an overview of the pattern.
- Obtain an understanding of the classes and objects and relationships between them.
- Choose application-specific names for the components of the patterns.
- Define the classes.
- Choose application-specific names for the operations defined in the pattern.
- Implement the necessary operations and relationships.