Lecture 13: Design Patterns

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Object-Oriented Analysis and Design

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Pattern Resources

- Pattern Languages of Programming
  - Technical conference on Patterns
- The Portland Pattern Repository
  - http://c2.com/ppr/
- Patterns Homepage
  - http://hillside.net/
  - Go to page then click on “Patterns tab”

Design Patterns

- Addison-Wesley book published in 1995
  - Erich Gamma
  - Richard Helm
  - Ralph Johnson
  - John Vlissides
  - ISBN 0-201-63361-2
- Known as “The Gang of Four”
- Presents 23 Design Patterns
- Material in this lecture and lecture 26 is drawn from this book, and is thus copyright © 1995 by Addison-Wesley Publishing Company

What are Patterns?

- Christopher Alexander talking about buildings and towns
  - “Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice”
  - Alexander, et al., A Pattern Language. Oxford University Press, 1977

Patterns, continued

- Patterns can have different levels of abstraction
- In Design Patterns (the book),
  - Patterns are not classes
  - Patterns are not frameworks
  - Instead, Patterns are descriptions of communicating objects and classes that are customized to solve a general design problem in a particular context

Patterns, continued

- So, patterns are formalized solutions to design problems
  - They describe techniques for maximizing flexibility, extensibility, abstraction, etc.
- These solutions can typically be translated to code in a straightforward manner

Elements of a Pattern

- Pattern Name
  - More than just a handle for referring to the pattern
  - Each name adds to a designer's vocabulary
    - Enables the discussion of design at a higher abstraction
- The Problem
  - Gives a detailed description of the problem addressed by the pattern
  - Describes when to apply a pattern
    - Often with a list of preconditions

Elements of a Pattern, continued

- The Solution
  - Describes the elements that make up the design, their relationships, responsibilities, and collaborations
  - Does not describe a concrete solution
    - Instead a template to be applied in many situations

Elements of a Pattern, continued

- The consequences
  - Describes the results and tradeoffs of applying the pattern
    - Critical for evaluating design alternatives
  - Typically include
    - Impact on flexibility, extensibility, or portability
    - Space and Time tradeoffs
    - Language and Implementation issues

Design Pattern Template

- Pattern Name and Classification
  - Creational
  - Structural
  - Behavioral
- Intent
- Also Known As
- Motivation and Applicability
- Structure and Participants
- Collaborations
- Consequences
- Implementation
- Sample Code
- Known Uses
- Related Patterns

Examples

- Singleton
- Factory Method
- Adapter

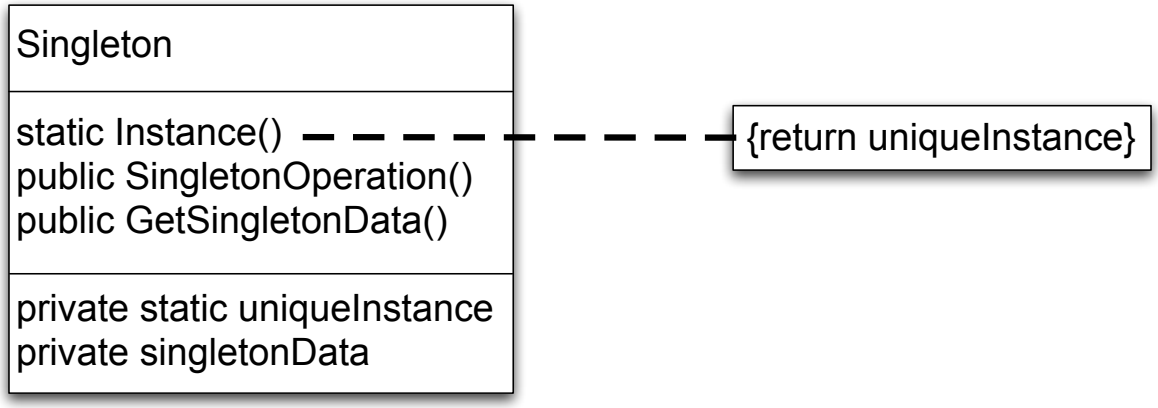
Singleton

- Intent
  - Ensure a class has only one instance, and provide a global point of access to it
- Motivation
  - Some classes represent objects where multiple instances do not make sense or can lead to a security risk (e.g. Java security managers)

Singleton, continued

- Applicability
  - Use the Singleton pattern when
    - there must be exactly one instance of a class, and it must be accessible to clients from a well-known access point
    - when the sole instance should be extensible by subclassing, and clients should be able to use an extended instance without modifying their code

Singleton Structure



Singleton, continued

- Participants
  - Just the Singleton class
- Collaborations
  - Clients access a Singleton instance solely through Singleton's Instance operation
- Consequences
  - Controlled access to sole instance
  - Reduced name space (versus global variables)
  - Permits a variable number of instances (if desired)

Implementation

```
import java.util.Date;

public class Singleton {
    private static Singleton theOnlyOne;
    private Date d = new Date();

    private Singleton() {
    }
    public synchronized static Singleton instance() {
        if (theOnlyOne == null) {
            theOnlyOne = new Singleton();
        }
        return theOnlyOne;
    }
    public Date getDate() {
        return d;
    }
}
```

Using our Singleton Class

```
public class useSingleton {
    public static void main(String[] args) {
        Singleton a = Singleton.instance();
        Singleton b = Singleton.instance();
        System.out.println("" + a.getDate());
        System.out.println("" + b.getDate());
        System.out.println("" + a);
        System.out.println("" + b);
    }
}

Output:
Sun Apr 07 13:03:34 MDT 2002
Sun Apr 07 13:03:34 MDT 2002
Singleton@136646
Singleton@136646
```


Names of Classes in Patterns

- Are the class names specified in a pattern required?
  - No!
    - Consider an environment where a system has access to only one printer
    - Would you want to name the class that provides access to the printer "Singleton"??!!
      - No, you would want to name it something like "Printer"!
  - On the other hand
    - Incorporating the names of a pattern's roles can help to communicate their use to designers
      - "Oh, I see you have a "PrinterObserver" class, are you using the Observable design pattern?

Names, continued

- So, if names are unimportant, what is?
  - Structure!
- We can name our Singleton class anything so long as it
  - has a private or protected constructor
    - need a protected constructor to allow subclasses
  - has a static “instance” operation to retrieve the single instance

Factory Method

- Intent
  - Define an interface for creating an object, but let subclasses decide which class to instantiate
- Also Known As
  - Virtual Constructor
- Motivation
  - Frameworks define abstract classes, but any particular domain needs to use specific subclasses; how can the framework create these subclasses?
    - See example on page 107 of the design patterns book

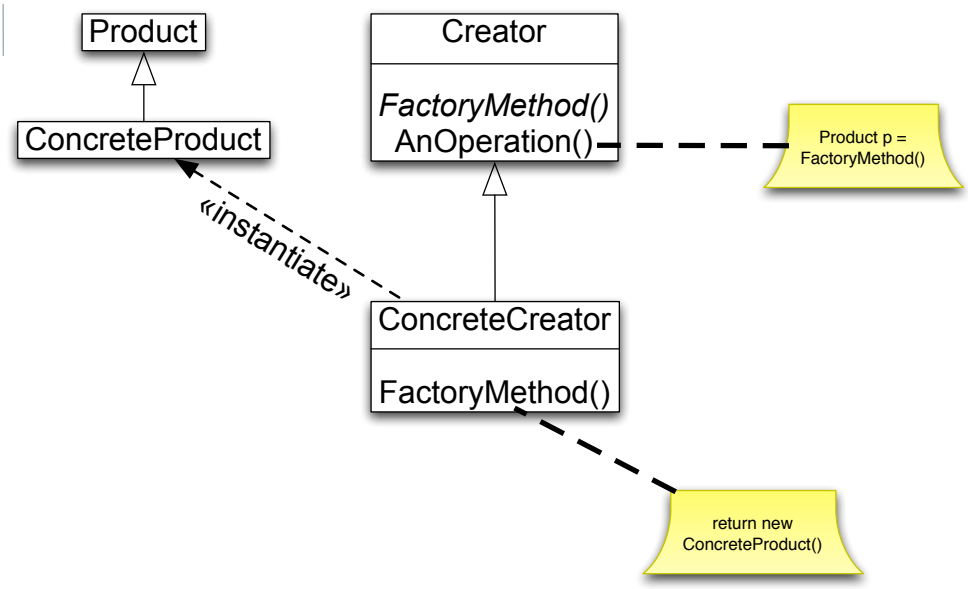
Factory Method, continued

- Applicability
  - Use the Factory Method pattern when
    - a class can't anticipate the class of objects it must create
    - a class wants its subclasses to specify the objects it creates
    - classes delegate responsibility to one of several helper subclasses, and you want to localize the knowledge of which helper subclass is the delegate
- In a nutshell
  - A "factory" object creates "products" for a client; the type of products created depends on the subclass of the factory object used; the client knows only about the factory, not its subclasses

Factory Method, continued

- Participants
  - Product
    - Defines the interface of objects the factory method creates
  - Concrete Product
    - Implements the Product Interface
  - Creator
    - declares the Factory method which returns an object of type Product
  - Concrete Creator
    - overrides the factory method to return an instance of a Concrete Product

Factory Method Structure



Factory Method Consequences

- Factory methods eliminate the need to bind application-specific classes into your code
- Potential disadvantage is that clients must use subclassing in order to create a particular ConcreteProduct
  - In single-inherited systems, this constrains your partitioning choices
- Provides hooks for subclasses
- Connects parallel class hierarchies
  - See page 110 of the design patterns book

Implementation

- See code example (available on class website)
- A factory can return balloons of different colors
  - The factory hides several specific creators and cycles among them to create balloons
- A client retrieves multiple balloons and displays their colors

Adapter

- Intent
  - Convert the interface of a class into another interface clients expect. Adapter lets classes work together that could not otherwise because of incompatible interfaces
- Also Known As
  - Wrapper
- Motivation
  - Sometimes a toolkit class that is designed for reuse is not reusable because its interface does not match the domain-specific interface an application requires
    - Page 139-140 of Design Patterns provides an example

Adapter, continued

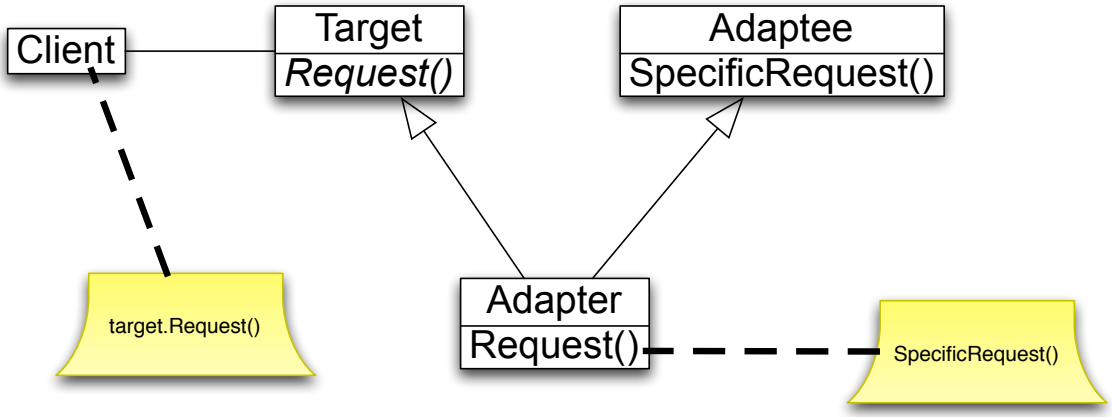
- Applicability
  - Use the Adapter pattern when
    - you want to use an existing class, and its interface does not match the one you need
    - you want to create a reusable class that cooperates with unrelated or unforeseen classes

Adapter, continued

- Participants
  - Target
    - defines the domain-specific interface that Client uses
  - Client
    - collaborates with objects conforming to the Target interface
  - Adaptee
    - defines an existing interface that needs adapting
  - Adapter
    - adapts the interface of Adaptee to the Target interface

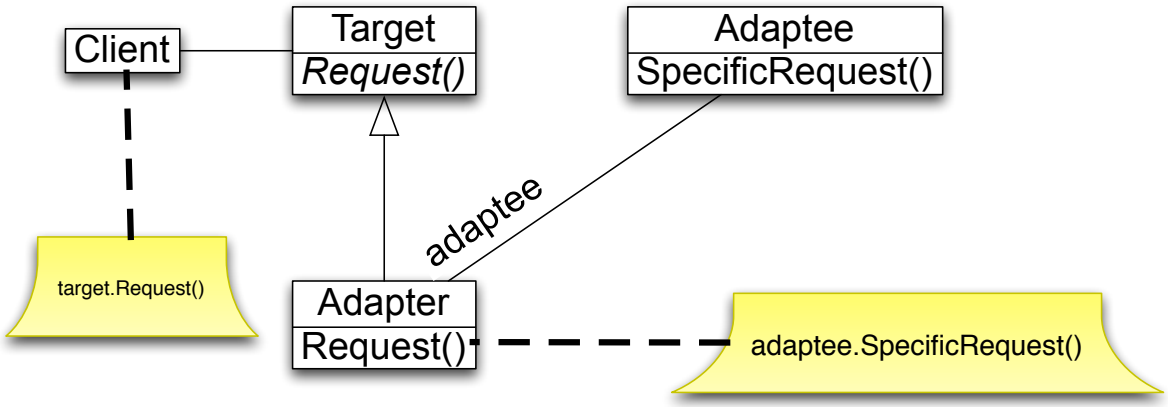
Adapter Structure

Class Adapter



Adapter Structure

Object Adapter



Adapter, continued

- Collaborations
  - Clients call operations on an Adapter instance. In turn, the adapter calls Adaptee operations that carry out the request
- Consequences
  - Class Adapters
    - adapts Adaptee to Target by committing to concrete Adapter class; Adapter can override Adaptee behavior
  - Object Adapters
    - lets a single Adapter work with many Adaptees; makes it harder to override Adaptee behavior

Implementation

- See code example (available on class website)
- Very simple implementation of the object adapter but it shows the basic idea
  - object adapter chosen simply because I don't like multiple inheritance :-)