# CMSC433, Spring 2002
# OMT and Design Patterns

Alan Sussman
March 21, 2002

## Administrivia

- Project 4 due date extended to Friday, April 5
- Design pattern readings will be posted
  - be selective in what you read



## Last time

- RMI example
  - RMIregistry
  - passing arguments, return values
  - marshalling/unmarshalling
  - Serializable vs. Remote



## OMT – Object Modeling Technique

- To denote relationships and interactions between classes and objects
  - **class diagram** depicts classes, their structure, and static relationships between them
  - **interaction diagram** shows flow of requests between objects (dynamic behavior of classes)
- Used to describe behavior of a design pattern



## Class diagram

Abstract and concrete classes

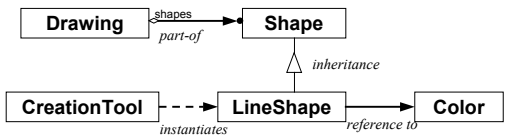
| ***AbstractClassName*** |
| --- |
| *AbstractOperation1()*<br>*Type AbstractOperation2()* |

| **ConcreteClassName** |
| --- |
| Operation1()<br>Type Operation2() |
| instanceVariable1<br>Type instanceVariable2 |

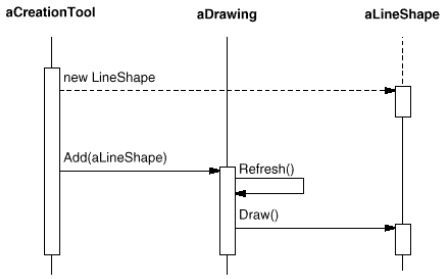


## Class diagram, cont.

Class relationships



## Interaction diagram






## Design Patterns

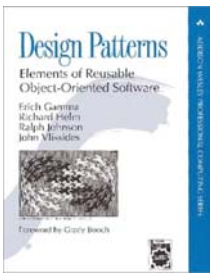
## What is a pattern?

- Patterns = problem/solution pairs in context
- Patterns facilitate reuse of successful software architectures and design
- Not code reuse
  - Instead, solution/strategy reuse
  - Sometimes, interface reuse



## Gang of Four

- The book that started it all
- Community refers to authors as the "Gang of Four"
- Figures and some text in these slides come from book






## Some design patterns you already know

- Iterator
  - Provide a way to access the elements of an aggregate object sequentially without exposing its underlying representation.
- Observer
  - Define a one-to-many dependency between objects so that when one object changes state, all its dependents are notified and updated automatically.
- Proxy
  - Provide a surrogate or placeholder for another object to control access to it.



## CMSC433, Spring 2002 Design Patterns

Alan Sussman
April 2, 2002

## Administrivia

- Project 4 due Friday
- Design pattern readings posted
  - be selective in what you read



## Last time

- OMT
  - class diagrams – abstract/concrete classes and class relationships (inheritance, instantiates, reference to, …)
  - interaction diagrams – shows calls between objects, when objects active
- Design patterns
  - problem/solution pairs, in context
  - examples include Iterator, Observer, Proxy



## Class diagram

Abstract and concrete classes

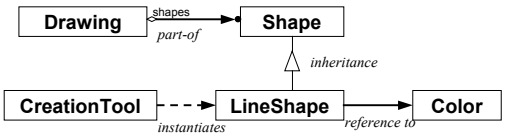
| ***AbstractClassName*** |
| --- |
| *AbstractOperation1()*<br>*Type AbstractOperation2()* |

| **ConcreteClassName** |
| --- |
| Operation1()<br>Type Operation2() |
| instanceVariable1<br>Type instanceVariable2 |



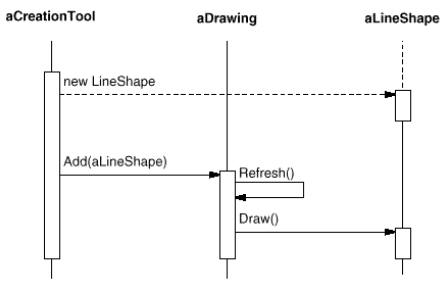
## Class diagram, cont.

Class relationships



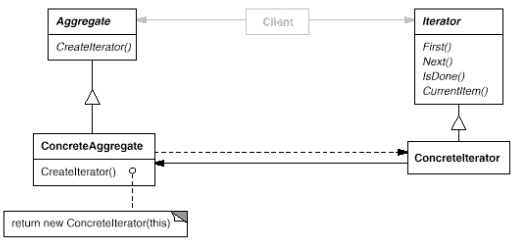



## Interaction diagram

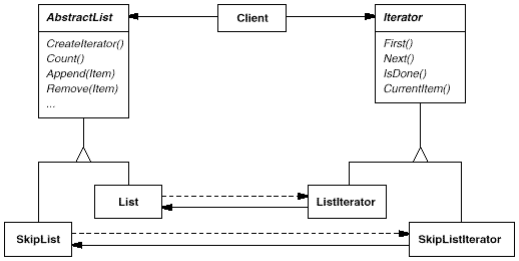





## Iterator pattern



# Uses of Iterator Pattern



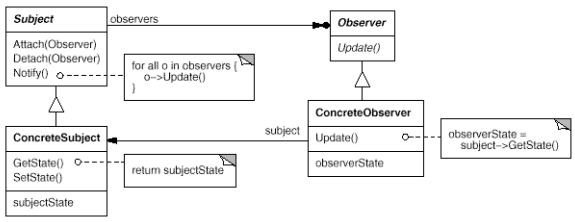



# You've already seen this in Java

- Iterators for Collections
  - Also, Enumerators for Hashtables and Vectors

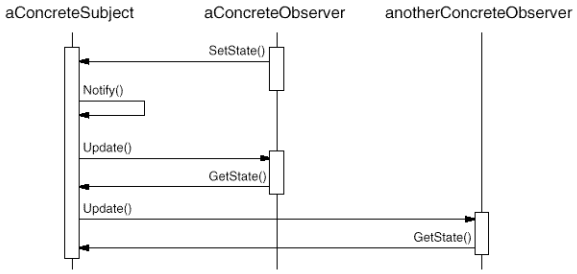


# Observer pattern






# Use of an Observer pattern






# Implementation details

- Observing more than one subject.
  - It might make sense in some situations for an observer to depend on more than one subject. The subject can simply pass itself as a parameter in the Update operation, thereby letting the observer know which subject to examine.
  - *Making sure Subject state is self-consistent before notification.*



# More Implementation Issues

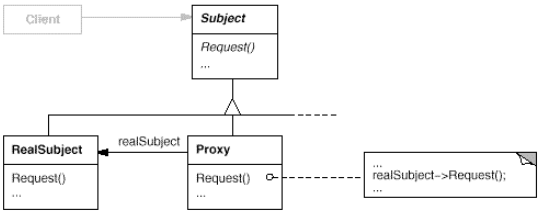
- Implementations of the Observer pattern often have the subject broadcast additional information about the change.
  - At one extreme, the subject sends observers detailed information about the change, whether they want it or not. At the other extreme the subject sends nothing but the most minimal notification, and observers ask for details explicitly thereafter
- You can extend the subject's registration interface to allow registering observers only for specific events of interest.

## You will see this later in detail

- MessageListener in project 4 is an example of the Observer pattern
- The standard Java and JavaBean event model is an example of an observer pattern

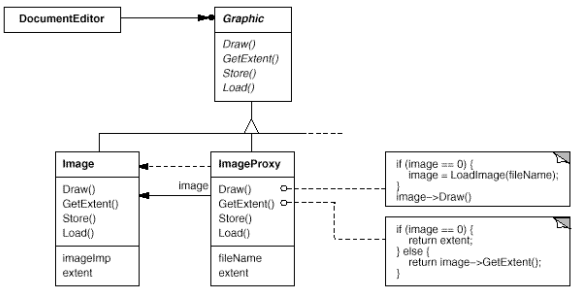


## Proxy pattern






## Example of Proxy Pattern






## Known uses (from DP book)

- McCullough [McC87] discusses using proxies in Smalltalk to access remote objects. Pascoe [Pas86] describes how to provide side-effects on method calls and access control with "Encapsulators."
- NEXTSTEP [Add94] uses proxies (instances of class NXProxy) as local representatives for objects that may be distributed.
  - On receiving a message, the proxy encodes it along with its arguments and then forwards the encoded message to the remote subject. Similarly, the subject encodes any return results and sends them back to the NXProxy object.



## Creation patterns

- Singleton
  - Ensure a class only has one instance, and provide a global point of access to it.
- Abstract Factory
  - Provide an interface for creating families of related or dependent objects without specifying their concrete classes.



## Structural patterns

- Adapter
  - Convert the interface of a class into another interface clients expect. Adapter lets classes work together that couldn't otherwise because of incompatible interfaces.

## Behavioral patterns

- State
  - Allow an object to alter its behavior when its internal state changes. The object will appear to change its class.
- Visitor
  - Represent an operation to be performed on the elements of an object structure. Visitor lets you define a new operation without changing the classes of the elements on which it operates.



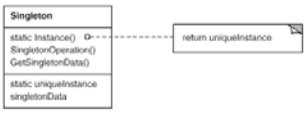
## Singleton pattern

- It's important for some classes to have exactly one instance
  - Many printers, but only one print spooler
  - One file system
  - One window manager
- Such designs can be limiting



## The Singleton solution

- Make the class itself responsible for keeping track of its sole instance.
- Make constructor private
- Provide static method/field to allow access to the only instance of the class






## Implementing the Singleton method

- In Java, just define a final static field

```
Class Singleton {
    private Singleton() {…}
    final static Singleton instance
            = new Singleton();
    …
  }
```

- Java semantics guarantee object is created immediately before first use



## Implementing the Singleton Method in C++

- C++ static initialization is very limited and ill-defined
- Use instance() method
- Note: not thread safe
  - Java method is thread safe



## Implementing the Singleton Method in C++

```
Class Singleton {
  private:
    Singleton() {…}
    static Singleton _instance = 0;
  public:
    static Singleton instance() {
      if (_instance == 0)
        _instance = new Singleton();
      return _instance;
      }
  …
  }
```

# CMSC433, Spring 2002
# Design Patterns

Alan Sussman
April 4, 2002

## Administrivia

- Project 4 due Friday
- Project 5 posted soon
  - talk about it on Tuesday
- Project 3 commentary due Wed., April 10



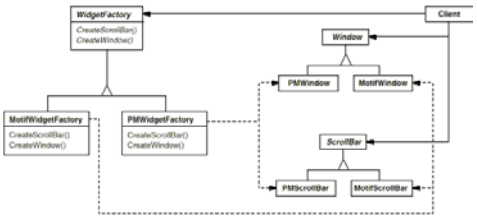
## Last time

- Design patterns
  - **Iterator** – as in Java collection classes
  - **Observer** – as in event listeners for GUIs
  - **Proxy** – like web proxies
  - **Singleton** – like myCounter



## Abstract Factory

- Different look-and-feels define different appearances and behaviors for user interface "widgets" like scroll bars, windows, and buttons.



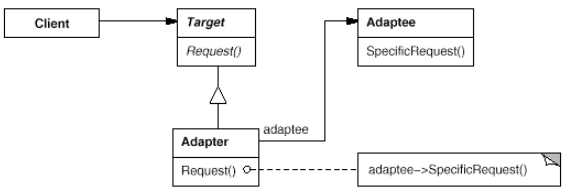

## Using an abstract factory

- Get a reference to a type WidgetFactory
  - To an object of the appropriate subtype of WidgetFactory
  - Ask the WidgetFactory for a scroll bar, or for a window



## Adapter pattern

- Clients needs a target that implements one interface



## JDK 1.3 Proxy class

- Can be used for both Proxy and Adapter pattern
- Use java.lang.reflect.Proxy
- Create object that implements a set of interfaces
  - Specified dynamically
  - Invocation handler handles calls



## State pattern

- Suppose an object is always in one of several known states
- The state an object is in determines the behavior of several methods
- Could use if/case statements in each method
- Better solution: **state pattern**

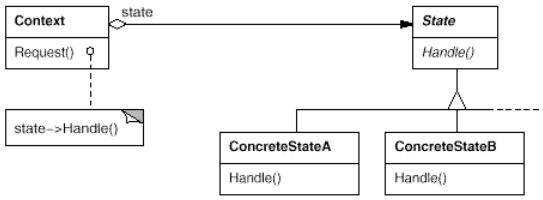


## State pattern

- Have a reference to a state object
  - Normally, state object doesn't contain any fields
  - Change state: change state object
  - Methods delegate to state object

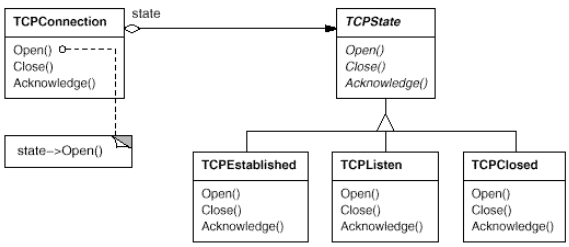


## Structure of State pattern






## Instance of State Pattern






## State pattern notes

- Can use singletons for instances of each state class
  - State objects don't encapsulate state, so can be shared
- Easy to add new states
  - New states can extend other states
    - Override only selected functions

## Example – Finite State Machine

```
class FSM {
   State state;
   public FSM(State s) { state = s;  }
   public void move(char c) {  state = state.move(c); }
   public boolean accept() {  return state.accept();}
}

public interface State {
    State move(char c);
    boolean accept();
}
```



## FSM Example – cont.

```
class State1 implements State {
  static State1 instance = new State1();
  private State1() {}
  public State move (char c) {
      switch (c) {
        case 'a': return State2.instance;
        case 'b': return State1.instance;
        default: throw new
IllegalArgumentException();  }
  }
  public boolean accept() { return false; }
}
```

```
class State2 implements State {
  static State2 instance = new State2();
  private State2() {}
  public State move (char c) {
      switch (c) {
        case 'a': return State1.instance;
        case 'b': return State1.instance;
        default: throw new
IllegalArgumentException();  }
  }
  public boolean accept() {return true;}
}
```

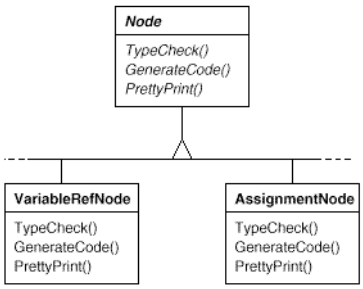


## Visitor pattern

- A visitor encapsulates the operations to be performed on an entire structure
  - E.g., all elements of a parse tree
- Allows the operations to be specified separately from the structure
  - But doesn't require putting all of the structure traversal code into each visitor/operation

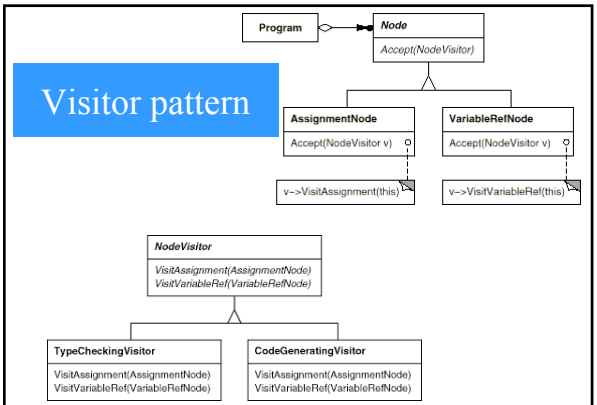


## Not a visitor






## Visitor pattern






## Double-dispatch

- Accept code is always trivial
  - Just dynamic dispatch on argument, with runtime type of structure node taken into account in method name
- A way of doing double-dispatch
  - Dynamic dispatching on the run-time types of two arguments
  - Visitor code invoked depends on run-time type of both visitor and node

## Using overloading in a visitor

- You can name all of the visitXXX(XXX x) methods just visit(XXX x)
  - Calls to Visit (AssignmentNode n) and Visit(VariableRefNode n) distinguished by compile-time overload resolution



## Easy to provide default behavoir

- Default visit(BinaryPlusOperatorNode) can just forward call to visit(BinaryOperatorNode)
- Visitor can just provide implementation of visit(BinaryOperatorNode) if it doesn't care what type of binary operator node it is at



## State in a visitor pattern

- A visitor can contain state
  - E.g., the results of parsing the program so far
- Or use stateless visitors and pass around a separate state object



## CMSC433, Spring 2002 Design Patterns

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April 9, 2002

## Administrivia

- Project 3 commentary due tomorrow
- Project 5 posted
  - redo Project 3, in parts
- One more design pattern today, then back to concurrent programming, from Lea book
  - read Ch. 1 if you haven't already



## Last time

- Design patterns
  - Abstract factory
  - Adaptor
  - State
  - Visitor

## Traversals

- In the standard visitor pattern, the visitor at a node is responsible for visiting the components (i.e., children) of that node
  - if that is what is desired
    - Visitors can be applied to flat object structures
- Several other solutions
  - acceptAndTraverse methods
  - Visit/process methods
  - traversal visitors applying an operational visitor



## Reactor Pattern

## Intent

- The Reactor architectural pattern allows event-driven applications to
  - demultiplex and dispatch service requests
  - delivered to an application from one or more clients
- Also known as
  - Dispatcher, Notifier



## Forces

- A good solution must resolve the following forces:
  - To enhance scalability and minimize latency, an application must not block indefinitely waiting on any single source
  - To maximize throughput, unnecessary utilization of the CPU(s) should be avoided
  - Minimal modifications and maintenance effort should be required to integrate new or enhanced services



## Solution

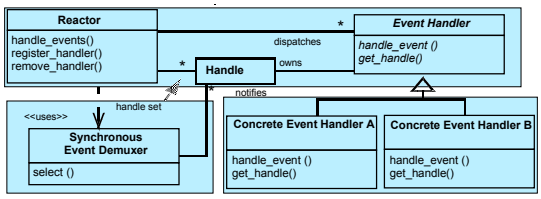
- Synchronously await indication events on one or more event sources
- Integrate the mechanisms that demultiplex events and dispatch them to processing elements
- Decouple these from application-specific processing elements



## Applicability

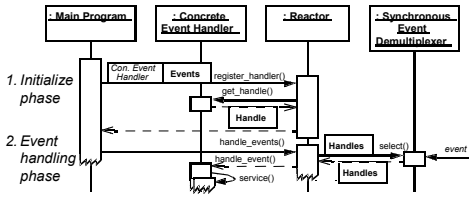
- Use Reactor Pattern when a process is event-driven and:
  - Threading leads to poor performance
  - Threading requires complex concurrency control
  - OS does not support multiple threading within a process

# Class Diagram



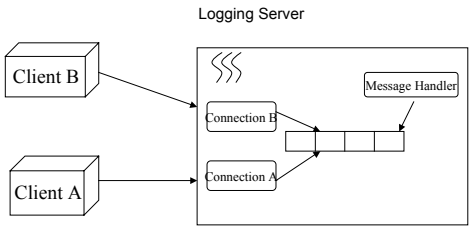



# Interaction Diagram



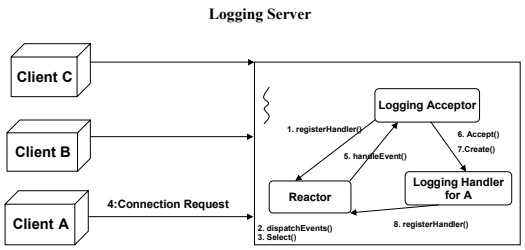



# Logging Server Example



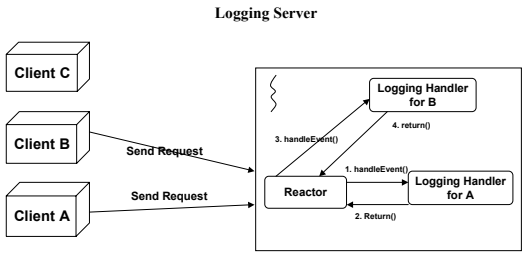



# Logging Server Example (Cont.)






# Logging Server Example (Cont.)






# Consequences

- Benefits:
  - Separation of concerns
  - Reusability
  - Modularity, reusability, and configurability
  - Portability
  - Coarse-grained concurrency control
- Liabilities:
  - Restricted applicability
  - Non-preemptive
  - Hard to debug

## Design Patterns Again

## Why patterns?

- Sometimes, patterns are just a cool idea you might not have come up with on your own
  - Learn from others
- If you work with code written by someone else
  - If they use a pattern you know, it will be easier for you to understand their code
- Some frameworks can automatically build/manipulate certain design patterns



## Pattern hype

- Patterns get a lot of hype and fanatical believers
  - *We are going to have a design pattern reading group, and this week we are going to discuss the Singleton Pattern!*
- Patterns are sometimes wrong (e.g., double-checked locking) or inappropriate for a particular language or environment
  - Patterns developed for C++ can have very different solutions in Smalltalk or Java



## More on visitor traversals

## Traversals

- In the standard visitor pattern, the visitor at a node is responsible for visiting the components (i.e., children) of that node
  - if that is what is desired
    - Visitors can be applied to flat object structures
- Several other solutions
  - acceptAndTraverse methods
  - Visit/process methods
  - traversal visitors applying an operational visitor



## acceptAndTraverse methods

- accept method could be responsible for traversing children
  - Assumes all visitors have same traversal pattern
    - E.g., visit all nodes in pre-order traversal
  - Could provide previsit and postvisit methods to allow for more complicated traversal patterns
    - Still visit every node
    - Can't do out of order traversal
    - In-order traversal requires inVisit method

## Accept and traverse

- Class BinaryPlusOperatorNode {
  void accept(Visitor v) {
  v->visit(this);
  lhs->accept(v);
  rhs->accept(v);
  }
  …}



## Visitor/process methods

- Can have two parallel sets of methods in visitors
  - Visit methods
  - Process methods
- Visit method on a node:
  - Calls process method of visitor, passing node as an argument
  - Calls accept on all children of the node (passing the visitor as an argument



## Preorder visitor

- Class PreorderVisitor {
  void visit(BinaryPlusOperatorNode n) {
  process(n);
  n->lhs->accept(this);
  n->rhs->accept(this);
  }
  …}



## Visit/process, continued

- Can define a PreorderVisitor
  - Extend it, and just redefine process method
    - Except for the few cases where something other than preorder traversal is required
- Can define other traversal visitors as well
  - E.g., PostOrderVisitor



## Traversal visitors applying an operational visitor

- Define a Preorder traversal visitor
  - Takes an operational visitor as an argument when created
- Perform preorder traversal of structure
  - At each node
    - Have node accept operational visitor
    - Have each child accept traversal visitor



## PreorderVisitor with payload

- Class PreorderVisitor {
  Visitor payload;
  void visit(BinaryPlusOperatorNode n) {
  payload->visit(n);
  n->lhs->accept(this);
  n->rhs->accept(this);
  }
  …}