Design Patterns (I)

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Contents

Introduction

What? A recurring design.

Why? Reuse solutions

▶ Introduction ▶ Definitions

Alexander et al. "A Pattern Language", 1977

> "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"

James W. Cooper "The Design Patterns Java Companion"

> " · · · design patterns describe how objects communicate without become entangled in each other's data models and methods."
>
> "· · · design patterns are not just about the design of objects, but about the communication between objects."

▶ Introduction ▶ Types of Pattern

- Creational Patterns
  - Create objects
  - E.g., *Factory* method patterns
  - More power over how objects are created
- Structural Patterns
  - Compose objects in complex ways
  - E.g., *Composite*, *Decorator* patterns
- Behavioral Patterns
  - Control communication and flow of program
  - E.g., *Iterator*, *Visitor* patterns

▶ Introduction ▶ Pattern elements

1. A name
   - E.g., iterator, composite, visitor
2. The problem
   - Where to apply the pattern
3. The solution

- General implementation of the pattern

4. Consequences
   - Tradeoffs. What benefits/penalties for a particular pattern

▸ Introduction ▸ Reuse: Inheritance

- Inheritance gives us reuse
  - Reuse code inherited from parent class
- Disadvantages:
  - Inheritance decided at compile time
  - Change in parent implementation can force change in subclasses
    - A kind of coupling?

▸ Introduction ▸ Reuse: Composition

- Composition gives us reuse
  - Compose pre-existing structures (objects) into a more complex whole
- Disadvantages:
  - Need careful design of interfaces so that objects may interact
  - Coupling

Gamma, Helm, Johnson, Vlissides:
"Favour object composition over class inheritance"

▸ Introduction ▸ Designing for Change

- Maximizing reuse
  - Design code that is robust to changes
  - Unanticipated change → redesign expensive!
- We won't look at all patterns, but only
  - Iterator

  - Composite
  - Factory
  - Decorator
  - Visitor
- Far more patterns. This is an introduction only!

Coming next: Iterator

Iterator

- Problem
- Solution
- Example
- Consequences

- Iterator pattern is implemented directly in Java

```
public class Zoo {
  private Collection zooInventory = new LinkedList();

  public void feedAnimals() {
    Iterator itr = zooInventory.iterator();
    while (itr.hasNext()){
     // Feed each animal in turn
    }
  }
}
```

Iterator ▸ Problem

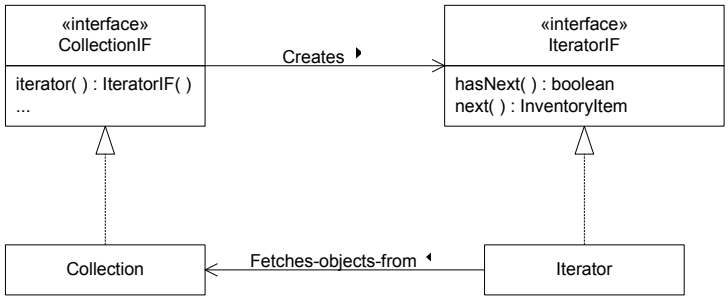
- Problem
  - Want to traverse an aggregate (e.g., a list) without knowing internal details

Iterator ▸ Solution

- Solution
  - Provide an interface for accessing/traversing elements In Java collections interface:

```
public Iterator iterator();
```

- I.e., can ask any collection to return an Iterator



▶ Iterator ▶ Example

- The Java Iterator hides details
  - Gives us traversal interface no matter what type of collection
- Compare two different implementations of zooInventory:
  - as a LinkedList

```
private Collection zooInventory = new LinkedList();

public void feedAnimals() {
  Iterator itr = zooInventory.iterator();
  while (itr.hasNext()){
   // Feed each animal in turn
  }
}
```

  - as an ArrayList

```
private Collection zooInventory = new ArrayList();

public void feedAnimals() {
  Iterator itr = zooInventory.iterator();
  while (itr.hasNext()){
   // Feed each animal in turn
  }
}
```

▶ Iterator ▶ Consequences

- Hides traversal details
  - E.g., traversal of trees in pre-order, post-order, etc.
  - Can change traversal algorithm later

  - Information hiding!
- Iterator looks after own traversal state
  - Can use multiple iterators on same structure
  - Could not do this if structure itself held state

Coming next: Composite

▸ Composite

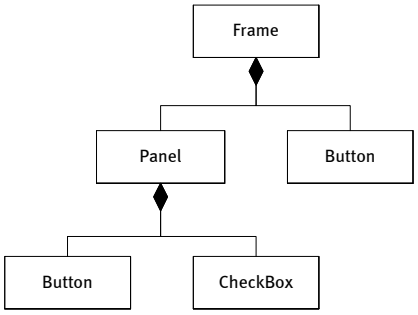
- Problem
- Solution
- Example
- Consequences

▸ Composite ▸ Problem

- Problem
  - Part and whole; may have to use different interfaces
  - Want to use the same interface
- For example,
  - AWT$_{(Abstract\ Window\ Toolkit)}$ Frames are Containers (e.g., contain Panel, Buttons)
  - repaint() Button
  - repaint() Panel (recursively paint Button)
  - repaint() Frame (recursively paint Panel, Button)

▸ Composite ▸ Solution

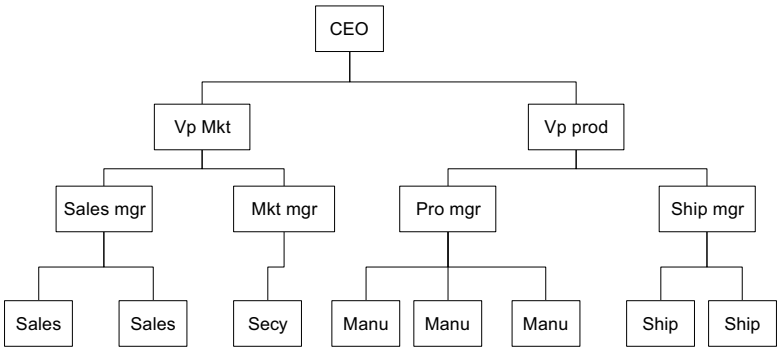
- Many times store a tree structure of objects



- Want one interface
  - For leaf or node
- Solution:
  - Recursion

▶ Composite ▶ Example

- From *The Design Patterns Java Companion*, Employees have subordinates:



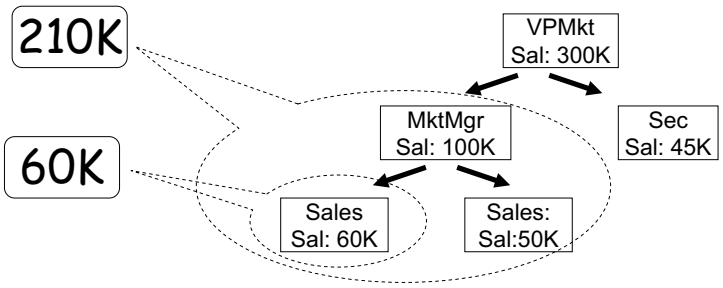
▶ Composite ▶ Example

- Employees have
  - A salary
  - A list (vector) of subordinates

```
public class Employee {
  ...
  float salary;
  Vector subordinates;
  ...
  float getSalary() {
    return salary;
  }
  void add(Employee e) {
    subordinates.addElement(e);
  }
}
```

▶ Composite ▶ Example

- Want salary function:
  - calculates salary of employee + employee's subordinates



▶ Composite ▶ Example

- Recursively descend to the subordinates
  - Sub-trees calculate getSalaries( )
  - Pass value back up tree

```
public float getSalaries() {

  float sum = salary; //this one's salary

  //add in subordinates salaries
  Iterator i = subordinates.iterator();
  while(i.hasNext())
    sum += ((Employee)i.next()).getSalaries();

  return sum;
}
```

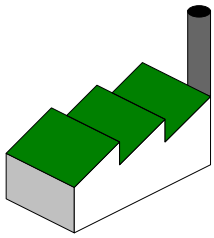
▸ Composite ▸ Consequences

- Same interface for primitive (i.e. single) object or composite object
  - Simpler access by client code
- Easier to add new components
  - New subclasses work automatically with client code

Coming next: Factory

▸ Factory

- Problem
- Solution
- Example
- Consequences



▸ Factory ▸ Problem

- If don't know (at compile time) what object type we need
  - I.e., (decide at runtime)
- Can decide to create a new object, or return an existing one
  - Seamless sharing of objects
- When need more control over object creation than new( )

▶ Factory ▶ Solution

- Method for controlling the creation of new objects
- Why?
  - Single method can create a variety of different objects
  - Can manage memory better
- Solution:
  - Call
    - factoryMethod( ) not new( )
    - factoryMethod( ) chooses the object to return

▶ Factory ▶ Example

- Have an applet that allows two forms of name input:

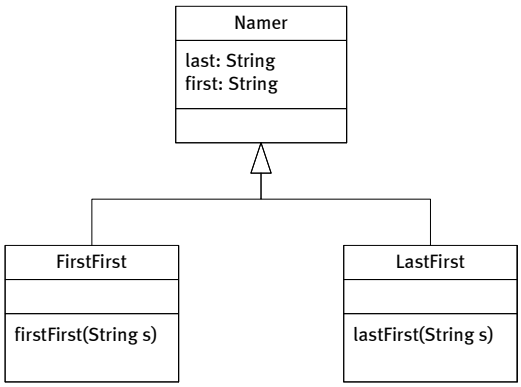
Enter your name: George Bush

Enter your name: Bush, George

- Many implementations . . . try using factory . . .

▶ Factory ▶ Example

- UML



- Decide to return different object depending on input type

▶ Factory ▶ Example

- Namer

```
class Namer {
  protected String last;
  protected String first;

  public String getFirst() {
    return first;
  }

  public String getLast() {
    return last;
  }
}
```

▶ Factory ▶ Example

- FirstFirst

Enter your name: George Bush

```
class FirstFirst extends Namer {

  public FirstFirst(String s) {
    int i = s.lastIndexOf(" ");
    if (i > 0) {
      //left is first name
      first = s.substring(0, i).trim();
      //right is last name
      last =s.substring(i+1).trim();
    }
    else {
      first = ""; // put all in last name
      last = s; // if no space
    }
  }
}
```

▶ Factory ▶ Example

- LastFirst

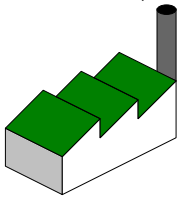
Enter your name: Bush, George

```
class LastFirst extends Namer {

  public LastFirst(String s) {
    int i = s.indexOf(","); //find comma
    if (i > 0) {
      //left is last name
      last = s.substring(0, i).trim();
      //right is first name
      first = s.substring(i + 1).trim(
    }
    else {
      last = s; // put all in last name
      first = ""; // if no comma
    }
  }
}
```

▶ Factory ▶ Example

- The factory: getNamer() returns object of either subclass



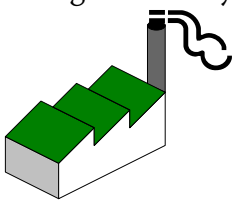
```
class NameFactory {

  public Namer getNamer(String entry) {
    int i = entry.indexOf(","); //comma determines

    //name order
    if (i>0)
      return new LastFirst(entry); //return one class
    else
      return new FirstFirst(entry); //or the other
  }
}
```

▶ Factory ▶ Example

- Using the factory



```
private void computeName() {

  Namer namer= nfactory.getNamer(entryField.getText());

  txFirstName.setText(namer.getFirst());
  txLastName.setText(namer.getLast());

}
```

- . . . without ever knowing which subclass you use

▶ Factory ▶ Consequences

- Allows dynamic (runtime) choice of subclass in creation
  - Subclass need not be a restriction, factory method can return Object
- Dynamic choice in ***how*** object is instantiated
  - Choose constructor
- Can Choose to return reference to preexisting object
  - Useful for memory management

Coming next: Summary

▶ Summary

- Iterator
  - Standard interface for traversal
  - Behavioral pattern

- Composite
  - Standard interface for processing tree-structures
  - Structural pattern
- Factory
  - Power over object creation
  - Creational pattern

References

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