CS 635 Advanced Object-Oriented Design & Programming
Spring Semester, 2015
Doc 11 Template Method, Singleton
March 10, 2015

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References

When is a Singleton not a Singleton, Joshua Fox, January 2001, http://java.sun.com/developer/technicalArticles/Programming/singletons/

http://en.wikipedia.org/wiki/Singleton_pattern


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Template Method
Polymorphism

class Account {
    public:
        void virtual Transaction(float amount)
        {
            balance += amount;
        }
        Account(char* customerName, float InitialDeposit = 0);
    protected:
        char* name;
        float balance;
};

class JuniorAccount : public Account {
    public: void Transaction(float amount) {//code here}
};

class SavingsAccount : public Account {
    public: void Transaction(float amount) {//code here}
};

Account* createNewAccount(){
    // code to query customer and determine what type of
    // account to create
};

main() {
    Account* customer;
    customer = createNewAccount();
    customer->Transaction(amount);
}
Deferred Methods

class Account {
    public:
    void virtual Transaction() = 0;
}

class JuniorAccount : public Account {
    public
    void Transaction() { put code here}
}

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class Account {
    public:
        void Transaction(float amount);
    protected:
        void virtual TransactionSubpartA();
        void virtual TransactionSubpartB();
        void virtual TransactionSubpartC();
    }

void Account::Transaction(float amount) {
    TransactionSubpartA();
    TransactionSubpartB();
    TransactionSubpartC(); // EvenMoreCode;
}

class JuniorAccount : public Account {
    protected: void virtual TransactionSubpartA();
}

class SavingsAccount : public Account {
    protected: void virtual TransactionSubpartC();
}

Account* customer;
customer = createNewAccount();
customer->Transaction(amount);
Intent

Define the skeleton of an algorithm in an operation, deferring some steps to subclasses

Template Method lets subclasses redefine certain steps of an algorithm without changing the algorithm’s structure
import java.awt.*;
class HelloApplication extends Frame {
    public void paint( Graphics display ) {
        int startX = 30;
        int startY = 40;
        display.drawString( "Hello World", startX, startY );
    }
}

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Ruby LinkedList Example

class LinkedList
  include Enumerable

  def [[]](index)
    Code not shown
  end

  def size
    Code not shown
  end

  def each
    Code not shown
  end

  def push(object)
    Code not shown
  end

end

def testSelect
  list = LinkedList.new
  list.push(3)
  list.push(2)
  list.push(1)

  a = list.select { |x| x.even? }
  assert(a == [2])
end

Where does list.select come from?
Methods defined in Enumerable

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>all?</td>
<td>any?</td>
<td>collect</td>
<td>detect</td>
</tr>
<tr>
<td>each_cons</td>
<td>each_slice</td>
<td>each_with_index</td>
<td>entries</td>
</tr>
<tr>
<td>enum_cons</td>
<td>enum_slice</td>
<td>enum_with_index</td>
<td>find</td>
</tr>
<tr>
<td>find_all</td>
<td>grep</td>
<td>include?</td>
<td>inject</td>
</tr>
<tr>
<td>map</td>
<td>max</td>
<td>member?</td>
<td>min</td>
</tr>
<tr>
<td>partition</td>
<td>reject</td>
<td>select</td>
<td>sort</td>
</tr>
<tr>
<td>sort_by</td>
<td>to_a</td>
<td>to_set</td>
<td>zip</td>
</tr>
</tbody>
</table>

All use "each"

Implement "each" and the above will work
java.util.AbstractCollection

Subclass AbstractCollection

Implement
    iterator
    size
    add

Get
    addAll
    clear
    contains
    containsAll
    isEmpty
    remove
    removeAll
    retainAll
    size
    toArray
    toString
Consequences

This is the most commonly used of the 23 GoF patterns

Important in class libraries

Inverted control structure

Parent class calls subclass methods
Consequences

Inverted control structure

Java's paint method is a primitive operation called by a parent method

Beginning Java programs don't understand how the following works:

```java
import java.awt.*;
class HelloApplication extends Frame {
    public void paint( Graphics display ) {
        int startX = 30;
        int startY = 40;
        display.drawString( "Hello World", startX, startY );
    }
}
```
Consequences

Template methods tend to call:
- Concrete operations
- Primitive (abstract) operations
- Factory methods
- Hook operations

Provide default behavior that subclasses can extend

It is important to denote which methods
- Must overridden
- Can be overridden
- Can not be overridden
Refactoring to Template Method

Simple implementation
   Implement all of the code in one method
   The large method you get will become the template method

Break into steps
   Use comments to break the method into logical steps
   One comment per step

Make step methods
   Implement separate methods for each of the steps

Call the step methods
   Rewrite the template method to call the step methods

Repeat above steps
   Repeat the above steps on each of the step methods
   Continue until:
      All steps in each method are at the same level of generality
      All constants are factored into their own methods

Design Patterns Smalltalk Companion pp. 363-364.
class Account {
    public:
        void Transaction(float amount);
    protected:
        void virtual TransactionSubpartA();
        void virtual TransactionSubpartB();
        void virtual TransactionSubpartC();
};

void Account::Transaction(float amount) {
    TransactionSubpartA();
    TransactionSubpartB();
    TransactionSubpartC();  // EvenMoreCode;
}

class JuniorAccount : public Account {
    protected:  
        void virtual TransactionSubpartA();
};

class SavingsAccount : public Account {
    protected:  
        void virtual TransactionSubpartC();
};

Account* customer;
customer = createNewAccount();
customer->Transaction(amount);
Template Method & Functional Programming

Pass in functions

def transaction(defaultPartA, defaultPartB, defaultPartC, amount, account) {
    defaultPartA();
    defaultPartB();
    defaultPartC();
    code code;
}

But this adds a lot of arguments

Requires knowing internal workings of transaction
Currying & Partial Evaluation

Pass in functions

    def defaultTransaction = transaction(defaultPartA, defaultPartB, defaultPartC);
    def juniorTransaction = transaction(juniorPartA, defaultPartB, defaultPartC);

    defaultTransaction(amount, account);
    juniorTransaction(amount, account);

    But this requires knowing the account type
Multi-methods

defmulti transaction(amount, account) (getAccountType)

defmethod transaction(amount, account) (:default) {
    return defaultTransaction(amount, account);
}

defmethod transaction(amount, account) (:junior) {
    return juniorTransaction(amount, account);
}

transaction(amount, account);

Now have dynamic dispatch on the type like Java
## Template Method vs Functional Solution

<table>
<thead>
<tr>
<th></th>
<th>Template Method</th>
<th>Functional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method Variation</td>
<td>In multiple classes/files</td>
<td>In one place</td>
</tr>
<tr>
<td>Add new Variation</td>
<td>Add class/file + method</td>
<td>Add function</td>
</tr>
<tr>
<td>Type Logic</td>
<td>In class &amp; parent class</td>
<td></td>
</tr>
</tbody>
</table>
Singleton
Warning

Simplest pattern
   But has subtle issues particularly in Java

Most controversial pattern
Intent

Ensure a class only has one instance

Provide global point of access to single instance
public class Counter {
    private int count = 0;
    private static Counter instance;
    private Counter() { }

    public static Counter instance() {
        if (instance == null)
            instance = new Counter();
        return instance;
    }

    public int increase() {return ++count;}
}

One instance
Global access

This version does not work correctly all the time. See later slides
Ruby Singleton

class Counter
  private_class_method :new
  @@instance = nil

  def Counter.instance
    @@instance = new unless @@instance
    @@instance
  end

  def increase
    @count = 0 unless @count
    @count = @count + 1
    @count
  end
end

require 'singleton'
class Counter
  include Singleton

  def increase
    @count = 0 unless @count
    @count = @count + 1
    @count
  end
end
Some Uses

Java Security Manager

Logging a Server

Null Object
Globals are Evil
Why Singletons Are Controversial(Evil)

Singletons provide global access point for some service

Hidden dependencies

Is there a different design that does not need singletons

Pass a reference
Why Singletons Are Controversial(Evil)

Singletons allow you to limit creation of objects of a class

Should that be the responsibility of the class?

Class should do one thing

Use factory or builder to limit the creation
Why Singletons Are Controversial (Evil)

Singletons tightly couple you to the exact type of the singleton object

   No polymorphism

   Hard to subclass
Why Singletons Are Controversial(Evil)

Singletons carry state with them that last as long as the program lasts

Persistent state makes testing hard and error prone
Why Singletons Are Controversial(Evil)

A Singleton today is a multiple tomorrow

Singleton pattern makes it hard to change to allow multiple objects
Why Singletons Are Controversial(Evil)

In Java Singletons are a lie

More on this later
Singleton Implementation
Why Not Use This?

public class Counter {
    private static int count = 0;

    public static int increase() {return ++count;}
}

Why Not Use This?

```java
public class Counter {
    private int count = 0;
    private Counter() {
    }

    public static Counter instance = new Counter();

    public int increase() {return ++count;}
}
```

Very subtle the error here
Two Useful Features

Lazy
   Only created when needed

Thread safe
public class Counter {
    private int count = 0;
    private Counter() {
    }

    private static class SingletonHolder {
        private final static Counter INSTANCE = new Counter();
    }

    public static Counter instance() {
        return SingletonHolder.INSTANCE;
    }

    public int increase() {
        return ++count;
    }
}
public class Counter {
    private int count = 0;
    protected Counter() {
    }

    private final static Counter INSTANCE = new Counter();

    public static Counter instance() {
        return INSTANCE;
    }

    public int increase() {
        return ++count;
    }
}
Lazy, Thread safe with Overhead

```java
public class Counter {
    private int count = 0;
    private static Counter instance;
    private Counter() {} 

    public static synchronized Counter instance() {
        if (instance == null)
            instance = new Counter();
        return instance();
    }

    public int increase() {return ++count;}
}
```
public class Counter {
    private int count = 0;
    private static Counter instance;
    private Counter() { }

    public static Counter instance() {
        if (instance == null)
            synchronize(this) {
                if (instance == null)
                    instance = new Counter();
            }
        return instance();
    }

    public int increase() { return ++count; }
}

Java Templates & Singleton

Does not compile

```java
public class TemplateSingleton<Type> {
    Type foo;

    public static TemplateSingleton<Type> instance = new TemplateSingleton<Type>();
}
```
When is a Singleton not a Singleton?
When Java Garbage Collects Classes

Singleton class can be garbage collected
Singleton loses any value it had

Solution

Turn off garbage collection of classes (-Xnoclassgc)

Make sure there is always a reference to the class-instance
When Multiple Java Class Loaders are Used

When loaded by two different class loaders there will be two versions of the class

Some servlet engines use different class loader for each servlet

Using custom class loaders can cause this
Purposely Reloading a Java Class

Servlet engines can force a class to be reloaded
Serialize and Deserialize Singleton Object

Serialize the singleton
Deserialize the singleton
You now have two copies

One way to serialize a Java object is using ObjectOutputStream

Ruby Marshal.dump() will not marshal a singleton