CS 535 Object-Oriented Programming & Design
Fall Semester, 2013
Doc 12 Abstract Classes & Abstractions
Oct 8 2013

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References

Object-Oriented Design Heuristics, Riel

Inheritance

What should I use as a super class?

A has a B
   Indicates that an instance variable of A is an instance of B

A is a B
A is a type of B
   Indicates that A is a subclass of B

A car has an engine, so car object contains an engine object

A BinarySearchTree has nodes, so it has instance variables left and right

A WordStream is a type of ReadStream so it is a subclass of ReadStream
Common Mistakes

Using has-a relation for inheritance

“I need access to engine methods in the car class and now I have it.”
Roles Verses Classes

2.11 Be sure the abstractions you model are classes and not simply the roles objects play

```plaintext
mother := Mother new.
father := Father new
```

```
father := Person new.
mother := Person new.
```

Diagram:

```
Person
  /   \
|     |
Father  Mother  Child
```
Abstract Classes

Abstract class
A class that can not be instantiated

Concrete class
A class that can be instantiated

Why Abstract Classes

Define an abstraction
Define a type
Define interface for subclasses
Define methods for subclasses

Hide the existence of concrete subclasses
Abstract Class

Is not the same as an abstraction
Abstract Class

Is not the same as an abstraction

But abstract class should represent an abstraction
Smalltalk Collections

- **Object**
- **Collection**
  - **Bag**
  - **SequenceableCollection**
  - **Set**
  - **ArrayCollection**
  - **Interval**
  - **OrderedCollection**
  - **Dictionary**
    - **Array**
    - **CharacterArray**
    - **SortedCollection**
      - **String**
      - **Text**
        - **Symbol**

*Italic* - Abstract Class

*Bold* - Concrete class
Collection Class

No instance variables

60 methods

Three abstract methods
add:
remove:ifAbsent:
do:

Use three abstract methods to implement other 57 methods

detect: aBlock ifNone: exceptionBlock
  "Evaluate aBlock with each of the receiver's elements as the argument. Answer the first element for which aBlock evaluates to true."
  
  self do: [:each | (aBlock value: each) ifTrue: [^each]].
  ^exceptionBlock value

Tuesday, October 8, 13
Defining Abstract Classes

Some languages have special syntax

```java
public abstract class NoObjects {
    public void aFunction() {
        System.out.println( "Hi Mom" );
    }
    public abstract void subClassMustImplement( int foo );
}
```
Defining Abstract Classes - Smalltalk

Mark methods as abstract with “self subclassResponsibility”

Collection>>do: aBlock
    self subclassResponsibility

Indicate class is abstract in class comment

Include list of abstract methods

Browser will create methods stubs in subclass
What does self subclassResponsibility do?

Informs reader
   Method is abstract
   Concrete subclasses need to implement the method

Raises an exception when executed to indicate
   Subclass did not implement an abstract method
   Created an instance of an abstract class

Informs browser which methods subclasses need to implement
How to Prohibit Instances of Abstract Class

Documentation is normally enough

Implement new so it throws an exception

Stream class>>new

"Provide an error notification that Streams are not created using this message."

self error: ('Streams are created with on: and with:')
How do subclass objects get created?

Stream class>>new
   self error: ('Streams are created with on: and with:')

PositionableStream class>>on: aCollection
   ^super new on: aCollection

What happens when this is done?

PositionableStream on: String new
How do subclass objects get created?

Use basicNew

PositionableStream class>>on: aCollection
  ^self basicNew on: aCollection

basicNew
  Does the same thing as new
  Is used to get around super class’s new method
  Only used in class instance creation methods
  Never implement basicNew
Abstract Classes and Data

Abstract classes commonly do not have instance variables

How can they implement methods?

Identify a core set of abstract operations

Implement other methods using core methods
**Collection Class**

No instance variables

60 methods

Three abstract methods

add:
remove:ifAbsent:
do:

Use three abstract methods to implement other 57 methods

detect: aBlock ifNone: exceptionBlock

"Evaluate aBlock with each of the receiver's elements as the argument. Answer the first element for which aBlock evaluates to true."

self do: [:each | (aBlock value: each) ifTrue: [^each]].
^exceptionBlock value
Abstract Classes, Types and Hinges

Declaring a variable to be an Abstract class instance

Indicates which operations are allowed on the variable

Allows any subclass to be used in the variable

Provides flexibility particularly in languages with static type checking

SomeClass>>foo: aCollection
  ^aCollection fold: [:a :b | a max: b].

public class SomeClass {
  public int foo(Collection a) { blah}
}

public class Restricted {
  public int foo(Array a) { blah}
}
Abstract Classes and Hiding Subclasses

Smalltalk VM on startup informs Filename of the correct concrete class for the current platform.

```smalltalk
file := 'foo' asFilename.
file class　　"MacOSXFilename (on my machine)"
```
How it works

File := 'foo' asFilename.

String>>asFilename
  ^Filename named: self string

Filename Class>>named: str
  str isEmpty
    ifTrue: [OSErrorHolder invalidArgumentsSignal raiseWith: str].
  ^self concreteClass createInstanceNamed: str

Filename Class>>concreteClass
  self == Filename ifTrue: [^self defaultClass].
  ^self

Filename Class>>defaultClass: cls
  "Assign the appropriate concrete subclass for this platform.
Only done at start-up."
  DefaultClass := cls

Filename Class>>defaultClass
  ^DefaultClass

Filename Class>>named: str
  str isEmpty
    ifTrue: [OSErrorHolder invalidArgumentsSignal raiseWith: str].
  ^self concreteClass createInstanceNamed: str

Filename Class>>concreteClass
  self == Filename ifTrue: [^self defaultClass].
  ^self
Platform Independence Aside

Mac, PC and Unix have different end of line characters

When you read a file:
   Smalltalk converts the platform’s end of line character to cr

When you write a file
   Smalltalk converts cr to the platform’s end of line character

Same code
   Works on all three platforms
   Produces files with the correct end of line character
Hide the existence of concrete subclasses

String is an abstract class

String new
  Does not create a string object
  Creates an instance of a subclass
  Appears to create a String object

String subclasses
  Don’t add new methods
  Provide specific implementations
Strings Continued

| a |
a := String new.
a class. "returns ByteString"

| b |
b := (String with: (Character value: 3585)) "3585 is a Thai character".
b class "returns TwoByteString"

| c |
c := String with: $a.
c class. "returns ByteString"
c at: 1 put: (3585 asCharacter).
c class "returns TwoByteString"

To learn about character encodings read:  http://www.joelonsoftware.com/articles/Unicode.html
become: Smalltalk Magic

| c |
c := String with: $a.
c class. "returns ByteString"
c at: 1 put: (Character value: 3585).
c class "returns TwoByteString"

How did c change class?

a become: b

  Change all references to ‘a’ to reference ‘b’

  Change all references to ‘b’ to reference ‘a’

  ‘a’ basically becomes ‘b’ and ‘b’ becomes ‘a’
String Class Transformation without become?

Use composition

String has instance variable that holds real string

String forwards messages to the real string

String can replace the real string with a different object
Sample Implementation

Smalltalk.Core defineClass: '#String
   superclass: #{Core.CharacterArray}
   instanceVariableNames: 'realString'

size
   ^realString size

at: anInteger
   ^realString at: anInteger

at: anInteger put: aCharacter
   aCharacter value > 256
      ifTrue: [realString := realString asTwoByteString].
   realString at: anInteger put: aCharacter.
Abstraction
Information Hiding
Polymorphism
Information Hiding

An object should hide design decisions from its users

Hide

What is stored & what is computed

Classes used

How does Point store its data?

How does OrderedCollection hold elements?
Heuristic 2.1

All data should be hidden within its class.

Smalltalk instance variables can be accessed in:

- Instance methods of the class where they are defined.
- Instance methods of subclasses of the class where they are defined.
Language Support for Global Data

Smalltalk has shared variables

Use sparingly

Use for constants

What is a constant?
Hiding Instance Variables

Some argue that only two methods should access an instance variable

Class BankAccount
Instance variable: balance

balance
  ^balance

balance: aNumber
  balance := anumber

deposit: aNumber
  self balance: (self balance + aNumber)
Why

This protects the class from changes in instance variables

Makes easy to enforce constraints

balance: aNumber
    aNumber < 0 ifTrue: [ NegativeBalanceError raiseSignal].
balance := aNumber
Hiding Instance Variables & Tools

Refactoring browser
  Lists all methods accessing an instance variable
  Change all accesses to be through access methods
  Removes all access through access methods

So don’t worry about hiding instance variables

If later you need to hide them it is easy to do
Abstraction

“Extracting the essential details about an item or group of items, while ignoring the unessential details.”
Edward Berard

“The process of identifying common patterns that have systematic variations; an abstraction represents the common pattern and provides a means for specifying which variation to use.”
Richard Gabriel

Pattern: Priority queue
Essential Details: length
   items in queue
   operations to add/remove/find item
Variation: link list vs. array implementation
   stack, queue
How to Find Abstractions

Look at nouns in requirements specification or system description

A refrigerator has a motor, a temperature sensor, a light and a door. The motor turns on and off primarily as prescribed by the temperature sensor. However, the motor stops when the door is opened. The motor restarts when the door is closed if the temperature is too high. The light is turned on when the door opens and is turned off when the door is closed.
Ralph Johnson’s - Finding Abstractions

Do one thing
Eliminate duplication
Keep rate of change similar
Decrease coupling, increase cohesion
Minimize interfaces
Minimize size of abstractions
Minimize number of abstractions
Do One Thing

Methods should do one thing

Method's name should tell what it does

findString:startingAt:
asNumber
asUppercase
dropFinalVowels

Class should be what its name says

String
OrderedCollection
Array
ReadStream

Break complex classes/methods into simpler ones
Eliminate Duplication

\[(\text{self asInteger} - \$a \text{ asInteger} + \text{anInteger}) \mod 26 - (\text{self asInteger} - \$a \text{ asInteger})\]

\[(\text{self alphabetValue} + \text{anInteger}) \mod 26 - \text{self alphabetValue}].\]
Keep rate of change similar

An object should not contain both
   An instance variable that changes every second
   An instance variable that changes once a month

Code that is different for each hardware platform
Code that is different for each OS

Separate tax tables from employee data from time cards
Minimize interfaces

Use the smallest interface you can

Use Number instead of Float

Avoid embedding classes in names

add: instead of addNumber:
Minimize the size of abstractions

Lots of Little Pieces

Methods should be small

Median size is 3 lines
10 lines is starting to smell

Classes should be small

7 variables is starting to smell
40 methods is starting to smell

VW 7.6

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Median</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables / class</td>
<td>2.1</td>
<td>1</td>
<td>72</td>
</tr>
<tr>
<td>Methods / class</td>
<td>16.6</td>
<td>8</td>
<td>359</td>
</tr>
<tr>
<td>LOC / method</td>
<td>3.0</td>
<td>2</td>
<td>156</td>
</tr>
</tbody>
</table>
Code used to generate Numbers

Variables Per Class

```
variablesInClass := classes collect: [:each | each instVarNames size].
```

```
average :=((variablesInClass fold: [:sum :each | sum + each] )/
variablesInClass size) asFloat.
```

```
median := variablesInClass asSortedCollection at: variablesInClass size // 2.
```

```
max := variablesInClass fold: [:partialMax :each | partialMax max: each]
```

Methods Per Class

```
methodsInClass := classes collect: [:each | each selectors size].
```

```
average :=((methodsInClass fold: [:sum :each | sum + each] )/
methodsInClass size) asFloat.
```

```
mean := methodsInClass asSortedCollection at: methodsInClass size // 2.
```

```
max := methodsInClass fold: [:partialMax :each | partialMax max: each]
```

Note how the above code could use the application of these ideas
LOC / Method

methodSizes := OrderedCollection new.

classes
do: [:class |
class selectors
do: [:method |
| periodCount |
periodCount := (class compiledMethodAt: method) decompiledSource
occurrencesOf: $..
methodSizes add: periodCount + 1]].

average :=((methodSizes fold: [:sum :each | sum + each] )/
methodSizes size) asFloat.


max := methodSizes fold: [:partialMax :each | partialMax max: each]
Minimize number of abstractions

A class hierarchy 6-7 levels deep is hard to learn

Break large system into subsystems, so people only have to learn part of the system at a time