CS/ENGRD 2110
Object-Oriented Programming and Data Structures

Spring 2012

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Lecture 13: Designing, Coding, and Documenting

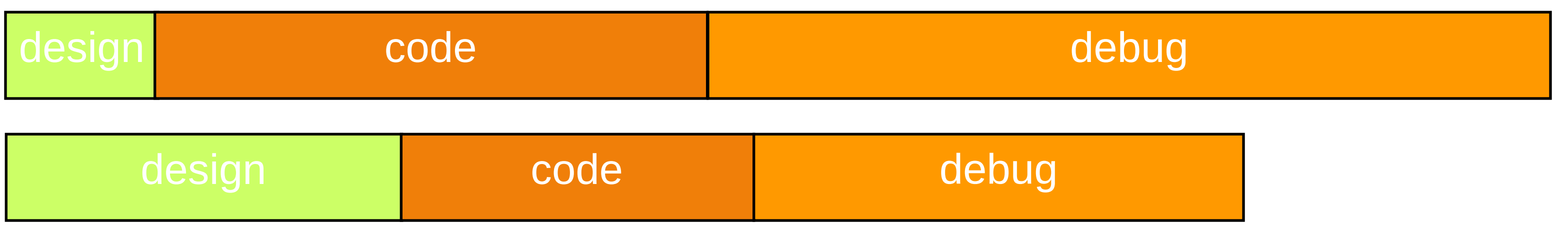
Designing and Writing a Program

- Don't sit down at the terminal immediately and start hacking
- Design stage – *THINK* first
  - about the data you are working with
  - about the operations you will perform on it
  - about data structures you will use to represent it
  - about how to structure all the parts of your program so as to achieve abstraction and encapsulation
- Coding stage – code in small bits
  - test as you go
  - understand preconditions and postconditions
  - insert sanity checks (assert statements in Java are good)
  - worry about corner cases
- Use Java API to advantage

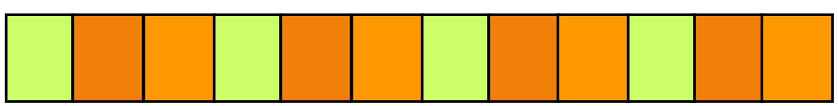
The Design-Code-Debug Cycle

- Design is faster than debugging (and more fun)
  - extra time spent designing reduces coding and debugging

- Which is better?



- Actually, should be more like this:



Divide and Conquer!

- Break program into manageable parts that can be implemented, tested in isolation
- Define interfaces for parts to talk to each other – develop contracts (preconditions, postconditions)
- Make sure contracts are obeyed
  - Clients use interfaces correctly
  - Implementers implement interfaces correctly (test!)
- Key: good interface documentation

Pair Programming

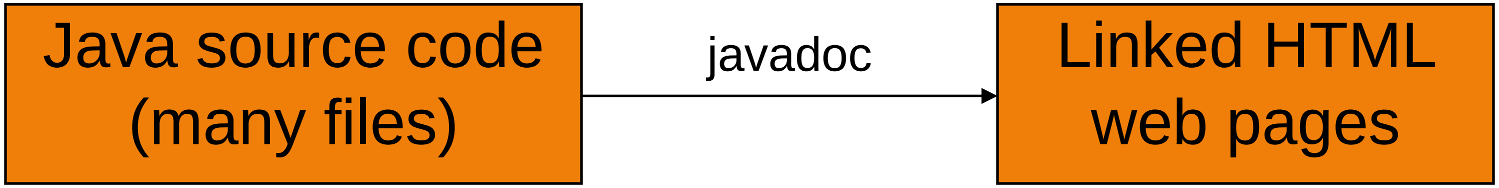
- Work in pairs
- Pilot/copilot
  - pilot codes, copilot watches and makes suggestions
  - pilot must convince copilot that code works
  - take turns
- Or: work independently on different parts after deciding on an interface
  - frequent design review
  - each programmer must convince the other
  - reduces debugging time
- Test everything

Documentation is Code

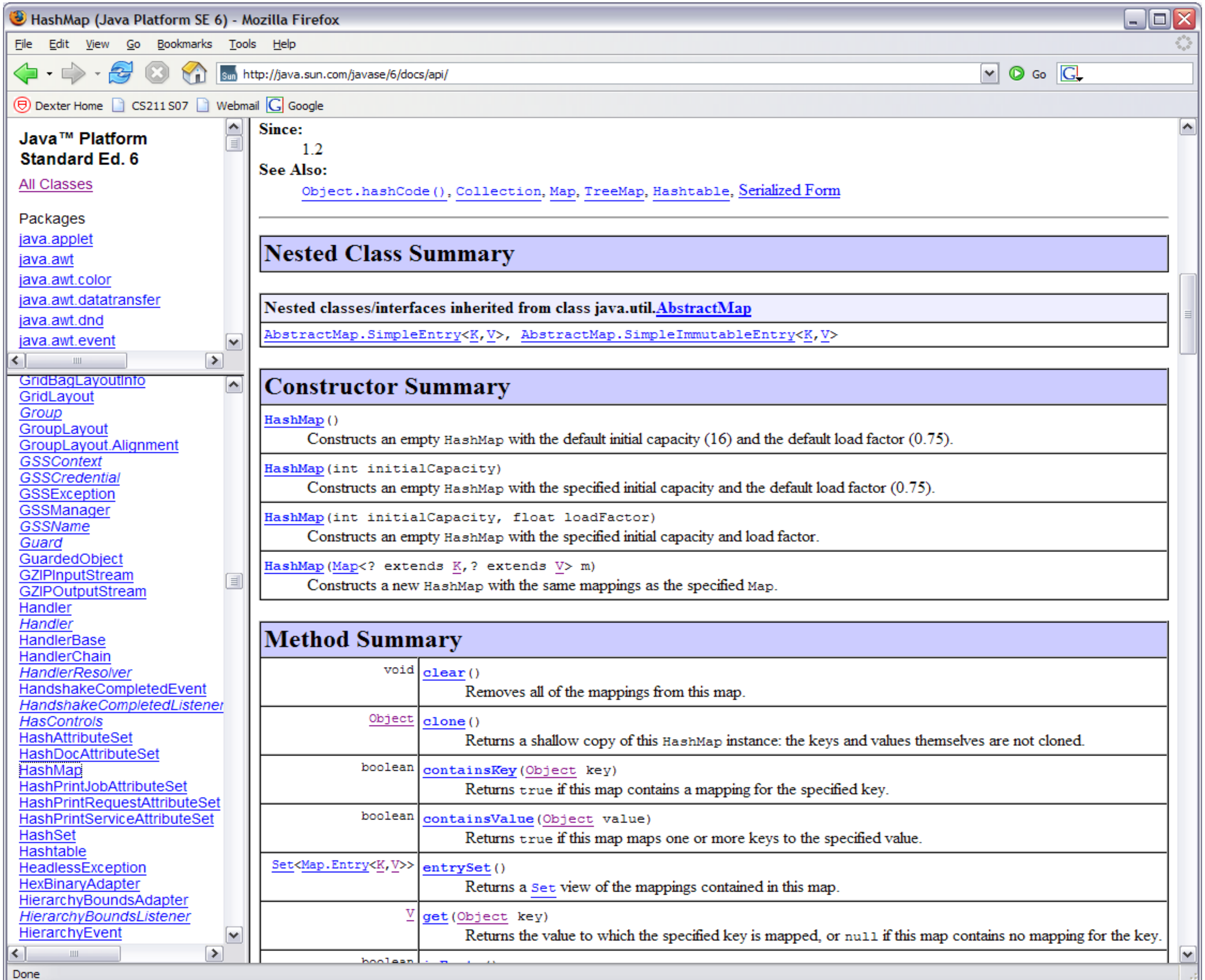
- Comments (esp. specifications) are as important as the code itself
  - determine successful use of code
  - determine whether code can be maintained
  - creation/maintenance = 1/10
- Documentation belongs in code or as close as possible
  - Code evolves, documentation drifts away
  - Put specs in comments next to code when possible
  - Separate documentation? Code should link to it.
- Avoid useless comments
  - **`x = x + 1; //add one to x`** -- Yuck!
  - Need to document algorithm? Write a paragraph at the top.
  - Or break method into smaller, clearer pieces.

Javadoc

- An important Java documentation tool



- Extracts documentation from classes, interfaces
  - Requires properly formatted comments
- Produces browsable, hyperlinked HTML web pages


HashMap (Java Platform SE 6) - Mozilla Firefox
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http://java.sun.com/javase/6/docs/api/
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All Classes
Packages
java.applet
java.awt
java.awt.color
java.awt.datatransfer
java.awt.dnd
java.awt.event
GridBagLayoutInfo
GridLayout
Group
GroupLayout
GroupLayout.Alignment
GSSContext
GSSCredential
GSSException
GSSManager
GSSName
Guard
GuardedObject
GZIPInputStream
GZIPOutputStream
Handler
Handler
HandlerBase
HandlerChain
HandlerResolver
HandshakeCompletedEvent
HandshakeCompletedListener
HasControls
HashAttributeSet
HashDocAttributeSet
HashMap
HashPrintJobAttributeSet
HashPrintRequestAttributeSet
HashPrintServiceAttributeSet
HashSet
Hashtable
HeadlessException
HexBinaryAdapter
HierarchyBoundsAdapter
HierarchyBoundsListener
HierarchyEvent
Since:
1.2
See Also:
Object.hashCode(), Collection, Map, TreeMap, Hashtable, Serialized Form
Nested Class Summary
Nested classes/interfaces inherited from class java.util.AbstractMap
AbstractMap.SimpleEntry<K,V>, AbstractMap.SimpleImmutableEntry<K,V>
Constructor Summary
HashMap()
Constructs an empty HashMap with the default initial capacity (16) and the default load factor (0.75).
HashMap(int initialCapacity)
Constructs an empty HashMap with the specified initial capacity and the default load factor (0.75).
HashMap(int initialCapacity, float loadFactor)
Constructs an empty HashMap with the specified initial capacity and load factor.
HashMap(Map<? extends K,? extends V> m)
Constructs a new HashMap with the same mappings as the specified Map.
Method Summary
void clear()
Removes all of the mappings from this map.
Object clone()
Returns a shallow copy of this HashMap instance: the keys and values themselves are not cloned.
boolean containsKey(Object key)
Returns true if this map contains a mapping for the specified key.
boolean containsValue(Object value)
Returns true if this map maps one or more keys to the specified value.
Set<Map.Entry<K,V>> entrySet()
Returns a Set view of the mappings contained in this map.
V get(Object key)
Returns the value to which the specified key is mapped, or null if this map contains no mapping for the key.
Done

How Javadoc is Produced

indicates Javadoc comment

Javadoc keywords

can include HTML

```
/**
 * Constructs an empty <tt>HashMap</tt> with the specified initial
 * capacity and the default load factor (0.75).
 *
 * @param  initialCapacity the initial capacity.
 * @throws IllegalArgumentException if the initial capacity is negative.
 */
 public HashMap(int initialCapacity) {
     this(initialCapacity, DEFAULT_LOAD_FACTOR);
 }

/**
 * Constructs an empty <tt>HashMap</tt> with the default initial capacity
 * (16) and the default load factor (0.75).
 */
 public HashMap() {
     this.loadFactor = DEFAULT_LOAD_FACTOR;
     threshold = (int)(DEFAULT_INITIAL_CAPACITY * DEFAULT_LOAD_FACTOR);
     table = new Entry[DEFAULT_INITIAL_CAPACITY];
     init();
 }
```

Some Useful Javadoc Tags

- **`@return`** *description*
  - Use to describe the return value of the method, if any
  - E.g., **`@return the sum of the two intervals`**
- **`@param`** *parameter-name description*
  - Describes the parameters of the method
  - E.g., **`@param i the other interval`**
- **`@author`** *name*
- **`@deprecated`** *reason*
- **`@see package.class#member`**
- **`{@code`** *expression* **`}`**
  - Puts expression in code font

Developing and Documenting an ADT

- Write an overview – purpose of the ADT
- Decide on a set of supported operations
- Write a specification for each operation

1. Writing an ADT Overview

- Example abstraction: a closed interval [a,b] on the real number line
  - $[a,b] = \{ x \mid a \leq x \leq y \}$

- Example overview:

```
/**
* An Interval represents a closed interval [a,b]
* on the real number line.
*/
```

Javadoc comment

Abstract description of the ADT’s values

2. Identify the Operations

- Enough operations for needed tasks
- Avoid unnecessary operations – keep it simple!
  - Don’t include operations that client (without access to internals of class) can implement

3. Writing Method Specifications

- Include
  - Signature: types of method arguments, return type
  - Description of what the method does (abstractly)
- Good description (definitional)

```
– /** Add two intervals. The sum of two intervals is
–   * a set of values containing all possible sums of
–   * two values, one from each of the two intervals.
–   */
– public Interval plus(Interval i);
```

- Bad description (operational)

```
– /** Return a new Interval with lower bound a+i.a,
–   * upper bound b+i.b.
–   */
–   public Interval plus(Interval i);
```

Not abstract, might as well read the code…

3. Writing Specifications (cont'd)

Attach before methods of class or interface

Method overview

```
/** Add two intervals. The sum of two intervals is
 * a set of values containing all possible sums of
 * two values, one from each of the two intervals.
 *
 * @param i the other interval
 * @return the sum of the two intervals
 */
```

Method description

Additional tagged clauses

Know Your Audience

- Code and specs have a target audience
  - the programmers who will maintain and use it
- Code and specs should be written
  - with enough documented detail so they can understand it
  - while avoiding spelling out the obvious
- Try it out on the audience when possible
  - design reviews before coding
  - code reviews

Consistency

- Pick a consistent coding style, stick with it
  - Don’t make understanding your code harder than necessary
- Teams should set common style
- Match style when editing someone else’s code
  - Not just syntax, also design style

Simplicity

- *The present letter is a very long one, simply because I had no time to make it shorter. – Blaise Pascal*
- *Be brief. – Strunk & White*

- Applies to programming… simple code is
  - Easier and quicker to understand (at least it often is)
  - More likely to be correct
- Good code is simple, short, and clear
  - Save complex algorithms, data structures for where they are needed
  - Always reread code (and writing) to see if it can be made shorter, simpler, clearer

Choosing Names

- Don’t try to document with variable names
  - Longer is not necessarily better

  - ```
    int searchForElement(
      int[] array_of_elements_to_search,
      int element_to_look_for);
    ```

  - ```
    int search(int[] a, int x);
    ```

- Names should be short but suggestive
- Local variable names should be short

Avoid Copy-and-Paste

- Biggest single source of program errors
  - Bug fixes never reach all the copies
  - Think twice before using your editor's copy-and-paste function

- Abstract instead of copying!
  - Write many calls to a single function rather than copying the same block of code around

Design vs Programming by Example

- Programming by example:
  - copy code that does something like what you want
  - hack it until it works
- Problems:
  - inherit bugs in code
  - don't understand code fully
  - usually inherit unwanted functionality
  - code is a bolted-together hodge-podge
- Alternative: design
  - understand exactly why your code works
  - reuse abstractions, not code templates

Avoid Premature Optimization

- Temptations to avoid
  - Copying code to avoid overhead of abstraction mechanisms
  - Using more complex algorithms & data structures unnecessarily
  - Violating abstraction barriers
- Result:
  - Less simple and clear
  - Performance gains often negligible
- Avoid trying to accelerate performance until
  - You have the program designed and working
  - You know that simplicity needs to be sacrificed
  - You know where simplicity needs to be sacrificed

Avoid Duplication

- Duplication in source code creates an implicit constraint to maintain, a quick path to failure
  - Duplicating code fragments (by copying)
  - Duplicating specs in classes and in interfaces
  - Duplicating specifications in code and in external documents
  - Duplicating same information on many web pages
- Solutions:
  - Named abstractions (e.g., declaring functions)
  - Indirection (linking pointers)
  - Generate duplicate information from source (e.g., Javadoc!)
- If you must duplicate:
  - Make duplicates link to each other so can find all clones

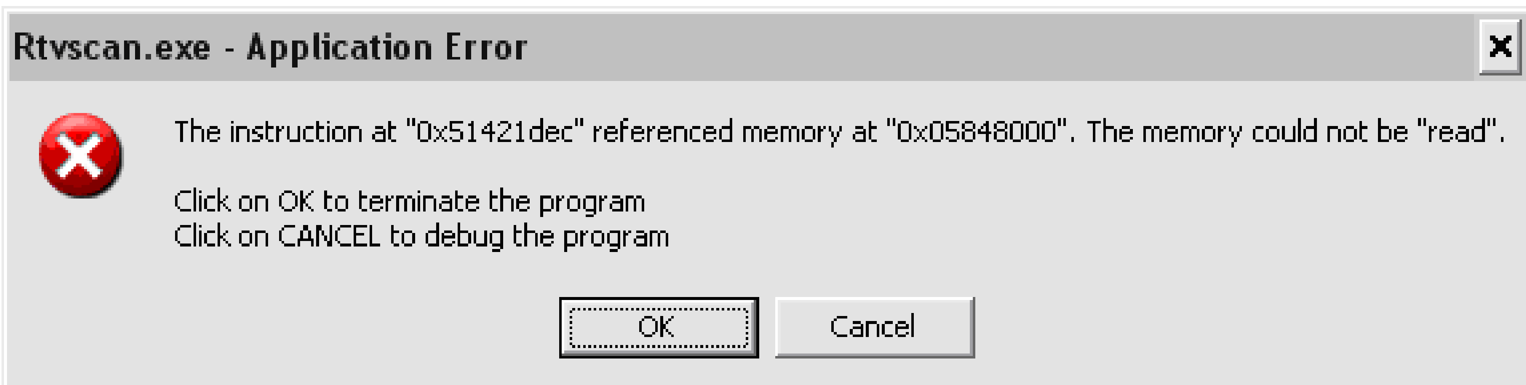
Maintain State in One Place

- Often state is duplicated for efficiency
- But difficult to maintain consistency
- Atomicity is the issue
  - if the system crashes while in the middle of an update, it may be left in an inconsistent state
  - difficult to recover

Error Handling

- It is usually an afterthought — it shouldn’t be
- User errors vs program errors — there is a difference, and they should be handled differently
- Insert lots of ‘‘sanity checks’’ — the Java assert statement is good way to do this
- Avoid meaningless messages

Avoid Meaningless Messages



Design Patterns

- Introduced in 1994 by Gamma, Helm, Johnson, Vlissides (the "Gang of Four")

- Identified 23 classic software design patterns in OO programming

- More than 1/2 million copies sold in 14 languages

Design Patterns

- Abstract Factory groups object factories that have a common theme.
- Builder constructs complex objects by separating construction and representation.
- Factory Method creates objects without specifying the exact class to create.
- Prototype creates objects by cloning an existing object.
- Singleton restricts object creation for a class to only one instance.
- Adapter allows classes with incompatible interfaces to work together by wrapping its own interface around that of an already existing class.
- Bridge decouples an abstraction from its implementation so that the two can vary independently.
- Composite composes one-or-more similar objects so that they can be manipulated as one object.
- Decorator dynamically adds/overrides behavior in an existing method of an object.
- Facade provides a simplified interface to a large body of code.
- Flyweight reduces the cost of creating and manipulating a large number of similar objects.
- Proxy provides a placeholder for another object to control access, reduce cost, and reduce complexity.

Design Patterns

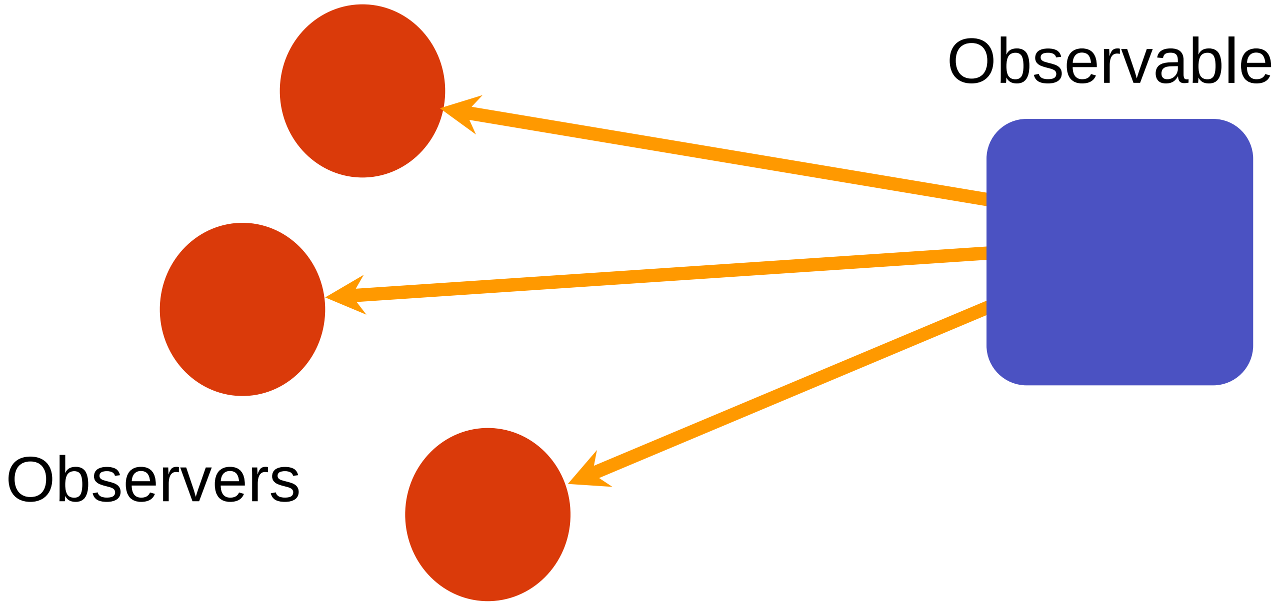
- Chain of responsibility delegates commands to a chain of processing objects.
- Command creates objects which encapsulate actions and parameters.
- Interpreter implements a specialized language.
- Iterator accesses the elements of an object sequentially without exposing its underlying representation.
- Mediator allows loose coupling between classes by being the only class that has detailed knowledge of their methods.
- Memento provides the ability to restore an object to its previous state (undo).
- Observer is a publish/subscribe pattern that allows a number of observer objects to see an event.
- State allows an object to alter its behavior when its internal state changes.
- Strategy allows one of a family of algorithms to be selected on-the-fly at runtime.
- Template method defines the skeleton of an algorithm as an abstract class, allowing its subclasses to provide concrete behavior.
- Visitor separates an algorithm from an object structure by moving the hierarchy of methods into one object.

Observer Pattern

- Observable
  - changes from time to time
  - is aware of Observers, other entities that want to be informed when it changes
  - but may not know (or care) what or how many Observers there are
- Observer
  - interested in the Observable
  - want to be informed when the Observable changes

Observer Pattern

- Issues
  - does the Observable push information, or does the Observer pull it? (e.g., email vs rss reader)
  - whose responsibility is it to check for changes?
  - publish/subscribe paradigm



Observer Pattern

```
public interface Observer<E> {
   void update(E event);
}

public class Observable<E> {
   private Set<Observer<E>> observers = new HashSet<Observer<E>>();
   boolean changed;

   void addObserver(Observer<E> obs) {
      observers.add(obs);
   }

   void removeObserver(Observer<E> obs) {
      observers.remove(obs);
   }

   void notifyObservers(E event) {
      if (!changed) return;
      changed = false;
      for (Observer<E> obs : observers) {
         obs.update(event);
      }
   }
}
```

Visitor Pattern

- A data structure provides a generic way to iterate over the structure and do something at each element
- The visitor is an implementation of interface methods that are called at each element
- The visited data structure doesn't know (or care) what the visitor is doing
- There could be many visitors, all doing different things

Visitor Pattern

```
public interface Visitor<T> {
   void visitPre(T datum);
   void visitIn(T datum);
   void visitPost(T datum);
}

public class TreeNode<T> {
   TreeNode<T> left;
   TreeNode<T> right;
   T datum;

   TreeNode(TreeNode<T> l, TreeNode<T> r, T d) {
      left = l;
      right = r;
      datum = d;
   }

   void traverse(Visitor<T> v) {
      v.visitPre(datum);
      if (left != null) left.traverse(v);
      v.visitIn(datum);
      if (right != null) right.traverse(v);
      v.visitPost(datum);
   }
}
```

No Silver Bullets

- These are all rules of thumb; but there is no panacea, and every rule has its exceptions
- You can only learn by doing – we can't do it for you
- Following software engineering rules only makes success more likely!