CS/ENGRD 2110 Object-Oriented Programming and Data Structures

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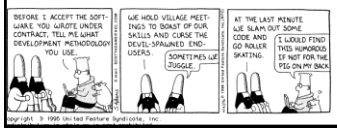
Lecture 13: Designing, Coding, and Documenting



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

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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:

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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

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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

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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.

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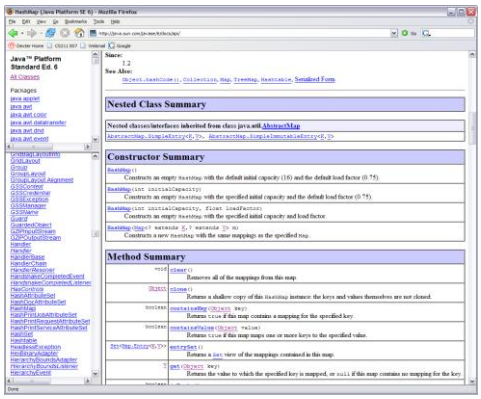
Javadoc

- An important Java documentation tool

Java source code (many files) → javadoc → Linked HTML web pages

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



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
  - $[a,b] = \{ x \mid a \le x \le y \}$
- 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

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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

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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

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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

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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

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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

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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

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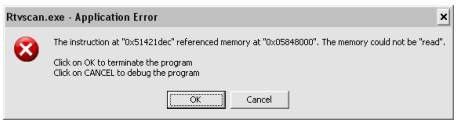
Avoid Meaningless Messages



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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

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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.

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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.

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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

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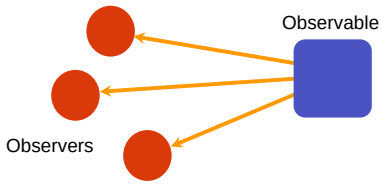
Observer Pattern

- 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



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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);
      }
   }
}
```

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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

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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);
   }
}
```

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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!

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