From designing to coding
- 1st step: sensibly split work among team members
  - Choose splits along “thin” interfaces
    - Probably not equal parts; split biggest parts again later
    - Formalize the interfaces – think of them as contracts
    - Write least-coupled parts first … most-coupled last
      - i.e., classes that don’t depend on any other classes
  - Oh yeah, one more thing to think about: Reserve ample time for testing!

interface – a Java contract
- So write the interfaces
- Formalizes much of the contract
  - Precisely defines available services (methods)
  - But pre- and post-conditions are not insured
    - These are communicated by documentation only
- Implement class and client class independently
  - Can even compile clients (but cannot fully test)
- Note: maybe change an interface to a class later
  - e.g., client developed using interface A – okay to replace with class A later

Pre- and post-conditions
- The most important points to document
- Pre-conditions – what the client is responsible for
  - The “requires” clauses of the contract
    - Especially include any restrictions on calling arguments
    - Also any associations that should already exist
- Post-conditions – what will be accomplished by the operation if the pre-conditions are met
  - The “effects” and/or “modifies” contract clauses
    - Including all side effects (objects created/destroyed, associations formed/broken, attribute values modified)
    - Also should state any exceptions that might be thrown

javadoc comments
- “Cheap” external documentation
  - Handy way to share just a class’s interface with team
    - Should always use to document all public declarations – classes, instance variables, methods
  - Easy way to communicate pre- & post-conditions
    - Even ready to post on the web (or intranet)
  - Easily kept up-to-date – just recompile with javadoc after completing each class
  - Learn to use javadocs – then make them a habit
    - See any Java text (often in an appendix though)
    - And/or see Sun’s javadoc how-to pages

Converting designs into code
- Largely a direct translation of key artifacts
  - Class specs – variables and method definitions
  - Class and package diagrams – associations
    - Translate to instance variables and/or method arguments
    - Interaction and state-chart diagrams – method calls and sequences
  - Still involves creativity, and probably change
    - Good ideas often arise during coding – okay, go for it
      - But also plan to revise design artifacts to match later

Defining attributes and methods
- public class SalesLineItem
  - private int quantity;
  - public SalesLineItem(ProductSpecification spec, int qty) {...}
  - public Money getSubtotal() {...}

ProductSpecification
- description: Text
- unitPrice: Money
- itemID: ItemID

SalesLineItem: Described-by
- quantity: Integer
- getSubtotal(): Money

Described-by 1
- ItemID: ItemID
- ProductSpecification: ProductSpecification

quantity: Integer
- Money
- Money

getSubtotal(): Money
- Money
- Money
- ItemID
- ItemID
- ProductSpecification

Translating associations

```java
public class SalesLineItem {
    private int quantity;
    private ProductSpecification productSpec;
    public SalesLineItem(ProductSpecification spec, int qty) {... }
    public Money getSubtotal() { ... }
}
```

Implementing interactions – e.g., `enterItem(id, qty)`

```java
ProductSpecification spec = catalog.getSpecification(id);
sale.makeLineItem(spec, qty);
```

Least- to most-coupled order

Use your resources

- i.e., “don’t reinvent the wheel” if possible
  - JDC Tech Tips, Java user groups, &c – see web
  - See books like *Effective Java* (by Joshua Bloch) for lots of useful advice
- On a real project: consider 3rd party solutions, existing code, other quick fixes
  - Of course, we hope you do yourself in CS 50
- And don’t wrestle with revision control problems – use a revision control system

Revision control problem

Lock-Modify-Unlok Solution
Testing – goal is to find faults
- Faults (a.k.a. bugs) cause systems to fail
  - e.g., a system crashes – the most obvious type of fault
  - e.g., a security system that allows unauthorized entry
  - e.g., a shot-down plane that continues on its flight path
- Can verify the presence of bugs, not their absence
- Testing and debugging are separate processes
  - Testing identifies faults
  - Debugging corrects/removes faults
    - But it can also introduce new ones, so retesting is required

When are faults introduced?
- During requirements analysis
  - Incorrect, missing, or unclear requirements
- During domain analysis and system design
  - Incorrect or unclear translation of problem
  - Incorrect or unclear design specification
- During system implementation
  - Misinterpretation of system design
  - Incorrect syntax or semantics
- Even during testing
  - New faults introduced when old ones corrected

Testing steps
- Unit testing – insure each part is correct
  - Each method of each class of each package should be tested independently
- Integration testing – insure parts work together
- System testing
  - Functional tests – a.k.a. use case testing
  - Performance tests – test system attribute requirements
  - Acceptance tests – client hands-on testing
  - Installation tests – final platform testing (on-site)

Unit and integration testing
- Test parts of the system before the whole
  - Units – test basic parts (methods, classes, packages)
  - Integration – test basic connections between parts
- Requires special purpose test programs
  - i.e., “driver” programs and “stubs”
  - Or can use a framework
    - e.g., JUnit – by Erich Gamma and Kent Beck
- Java note – any class can have a main method
  - Can use just for testing all parts of that class

Note how naïve to consider this the only source of bugs
System testing phases

- Use case testing
  - Test pre- and post-conditions of system functions
  - Best if independent of the user interface
    - i.e., also requires special purpose testing code
- Performance, acceptance, installation tests
  - All involve the complete working system, GUI and all
- If any changes to code – rerun all tests

Tragic truth: testing takes time

- But it can save time and money in the long run
  - Get in the habit: “code a little, test a little, …”
- Inadequate testing costs lots of real world $$$ and maybe lives
- Fact: costs of testing/debugging increase as development progresses
  - Cheapest during requirements analysis (especially if an impossible requirement is uncovered)
  - Cheaper during unit than integration testing, …

Remaining “lecture” plan and student responsibility summary

<table>
<thead>
<tr>
<th>Week</th>
<th>Monday</th>
<th>Wednesday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>2/15 - Holiday</td>
<td>2/17 - Exam</td>
<td>2/19 – No lecture; 1st implementation due</td>
</tr>
<tr>
<td>8</td>
<td>2/22 – 3 Presentations</td>
<td>2/24 – 3 Presentations</td>
<td>2/26 – 3 Presentations</td>
</tr>
<tr>
<td>9</td>
<td>3/1 – 3 Presentations</td>
<td>3/3 – 3 Presentations</td>
<td>3/5 – 3 Presentations</td>
</tr>
<tr>
<td>10</td>
<td>3/8 – No lecture; work on project</td>
<td>3/10 – Evals; Demonstrations</td>
<td>3/12 – No lecture; final project due</td>
</tr>
</tbody>
</table>