CSE 331
Software Design & Implementation

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Module Design and General Style Guidelines
(Based on slides by Mike Ernst, David Notkin, Hal Perkins)
“Use the active voice.”
“Omit needless words.”

“Don't patch bad code - rewrite it.”
“Make sure your code 'does nothing' gracefully.”
A **module** is a relatively general term for a class or a type or any kind of design unit in software.

A **modular design** focuses on what modules are defined, what their specifications are, how they relate to each other:
- Not the implementations of the modules
- Each module respects other modules’ abstraction barriers!
Ideals of modular software

Decomposable – can be broken down into modules to reduce complexity and allow teamwork

Composable – “Having divided to conquer, we must reunite to rule [M. Jackson].”

Understandable – one module can be examined, reasoned about, developed, etc. in isolation

Continuity – a small change in the requirements should affect a small number of modules

Isolation – an error in one module should be as contained as possible
Two general design issues

*Cohesion* – how well components fit together to form something that is self-contained, independent, and with a single, well-defined purpose

*Coupling* – how much dependency there is between components

Guideline: *decrease* coupling, *increase* cohesion

Applies to modules and smaller units
  – Each method should do one thing well
  – Each module should provide a single abstraction
Cohesion

The common design objective of *separation of concerns* suggests a module should represent a single concept

- A common “concept” is an ADT

If a module implements more than one abstraction, consider breaking it into separate modules for each one
Coupling

How are modules dependent on one another?
  – Statically (in the code)\? Dynamically (at run-time)\? More?
  – Ideally, split design into parts that don't interact much

An application

A poor decomposition (parts strongly coupled)

A better decomposition (parts weakly coupled)

Roughly, the more coupled modules are, the more they need to be reasoned about as though they are a single, larger module
Coupling is the path to the dark side

- Coupling leads to complexity
- Complexity leads to confusion
- Confusion leads to suffering
- Once you start down the dark path, forever will it dominate your destiny, consume you it will
God classes

*god class*: a class that hoards much of the data or functionality of a system

– Poor cohesion – little thought about why all the elements are placed together
– Reduces coupling but only by collapsing multiple modules into one (which replaces dependences between modules with dependences within a module)

A god class is an example of an *anti-pattern*: a known bad way of doing things
Cohesion again…

Methods should do one thing well:
- Compute a value but let client decide what to do with it
- Observe or mutate, don’t do both
- Don’t print as a side effect of some other operation

Don’t limit future possible uses of the method by having it do multiple, not-necessarily-related things

“Flag” variables are often a symptom of poor method cohesion
Effective Java (EJ) Tip #40: Design method signatures carefully
- Avoid long parameter lists
- Perlis: “If you have a procedure with ten parameters, you probably missed some.”
- Especially error-prone if parameters are all the same type
- Avoid methods that take lots of Boolean “flag” parameters

EJ Tip #41: Use overloading judiciously
Can be useful, but avoid overloading with same number of parameters, and think about whether methods really are related
Field design

A variable should be made into a field if and only if:
- It is part of the inherent internal state of the object
- It has a value that retains meaning throughout the object's life
- Its state must persist past the end of any one public method

All other variables can and should be local to the methods in which they are used
- Fields should not be used to avoid parameter passing
- Not every constructor parameter needs to be a field

Exception to the rule: Certain cases where overriding is needed
- Example: \texttt{Thread.run}
Constructor design

Constructors should take all arguments necessary to initialize the object's state – no more, no less

Object should be completely initialized after constructor is done (i.e., the rep invariant should hold)

Shouldn't need to call other methods to “finish” initialization
Good names

EJ Tip #56: Adhere to generally accepted naming conventions

- Class names: generally nouns
  - Beware "verb + er" names, e.g. Manager, Scheduler, ShapeDisplayer
- Interface names often -able/-ible adjectives: Iterable, Comparable, ...
- Method names: noun or verb phrases
  - Nouns for observers: size, totalSales
  - Verbs+noun for observers: getX, isX, hasX
  - Verbs for mutators: move, append
  - Verbs+noun for mutators: setX
  - Choose affirmative, positive names over negative ones
    isSafe not isUnsafe
    isEmpty not hasNoElements
Bad names

count, flag, status, compute, check, value, pointer, names starting with my...
  – Convey no useful information

Describe what is being counted, what the “flag” indicates, etc.

numberOfStudents, isCourseFull, calculatePayroll, validateWebForm, ...

But short names in local contexts are good:

Good: for(i = 0; i < size; i++) items[i]=0;
Bad: for(theLoopCounter = 0;
        theLoopCounter < theCollectionSize;
        theLoopCounter++)
       theCollectionItems[theLoopCounter]=0;
Class design ideals

Cohesion and coupling, already discussed

*Completeness*: Every class should present a complete interface

*Consistency*: In names, param/returns, ordering, and behavior
Completeness

Include *important* methods to make a class easy to use

Counterexamples:
- A mutable collection with `add` but no `remove`
- A tool object with a `setHighlighted` method to select it, but no `setUnHighlighted` method to deselect it
- *Date* class with no date-arithmetic operations

Also:
- Objects that have a natural ordering should implement `Comparable`
- Objects that might have duplicates should implement `equals` (and therefore `hashCode`)
- Most objects should implement `toString`
But…

Don’t include everything you can possibly think of
  – If you include it, you’re stuck with it forever (even if almost nobody ever uses it)

Tricky balancing act: include what’s useful, but don’t make things overly complicated
  – You can always add it later if you really need it

“Everything should be made as simple as possible, but not simpler.”
  - Einstein
Consistency

A class or interface should have consistent names, parameters/returns, ordering, and behavior.

Use similar naming; accept parameters in the same order.

Counterexamples:
- `setFirst(int index, String value)`
- `setLast(String value, int index)`

`Date/GregorianCalendar` use 0-based months.

`String` methods: `equalsIgnoreCase`, `compareToIgnoreCase`;
- but `regionMatches(boolean ignoreCase)`

`String.length()`, `array.length`, `collection.size()`
Open-Closed Principle

Software entities should be *open for extension*, but closed for modification

- When features are added to your system, do so by adding new classes or reusing existing ones in new ways
- If possible, don't make changes by modifying existing ones – existing code works and changing it can introduce bugs and errors.

Related: Code to interfaces, not to classes

Example: accept a `List` parameter, not `ArrayList` or `LinkedList`

EJ Tip #52: Refer to objects by their interfaces
Documenting a class

Keep internal and external documentation separate

External: /** ... */ Javadoc for classes, interfaces, methods
- Describes things that clients need to know about the class
- Should be specific enough to exclude unacceptable implementations, but general enough to allow for all correct implementations
- Includes all pre/postconditions, etc.

Internal: // comments inside method bodies
- Describes details of how the code is implemented
- Information that clients wouldn't and shouldn't need, but a fellow developer working on this class would want – invariants and internal pre/post conditions especially
The role of documentation
From Kernighan and Plauger

- If a program is incorrect, it matters little what the docs say

- If documentation does not agree with the code, it is not worth much

- Consequently, code must largely document itself. If not, rewrite the code rather than increasing the documentation of the existing complex code. Good code needs fewer comments than bad code.

- Comments should provide additional information from the code itself. They should not echo the code.

- Mnemonic variable names and labels, and a layout that emphasizes logical structure, help make a program “self-documenting”
Consider use of enums, even with only two values – which of the following is better?

```java
oven.setTemp(97, true);
oven.setTemp(97, Temperature.CELSIUS);
```
Choosing types – some hints

Numbers: Favor `int` and `long` for most numeric computations

EJ Tip #48: Avoid `float` and `double` if exact answers are required
   Classic example: Money (round-off is bad here)

Strings are often overused since much data is read as text
Independence of views

• Confine user interaction to a core set of “view” classes and isolate these from the classes that maintain the key system data

• Do not put print statements in your core classes
  – This locks your code into a text representation
  – Makes it less useful if the client wants a GUI, a web app, etc.

• Instead, have your core classes return data that can be displayed by the view classes
  – Which of the following is better?
    
    public void printMyself()
    public String toString()
Last thoughts (for now)

- Always remember your reader
  - Who are they?
    - Clients of your code
    - Other programmers working with the code
      - (including yourself in 3 weeks/months/years)
  - What do they need to know?
    - How to use it (clients)
    - How it works, but more important, *why* it was done this way (implementers)
- Read/reread style and design advice regularly
- Keep practicing – mastery takes time and experience
- You’ll always be learning. Keep looking for better ways to do things!