CSE 331
Software Design & Implementation

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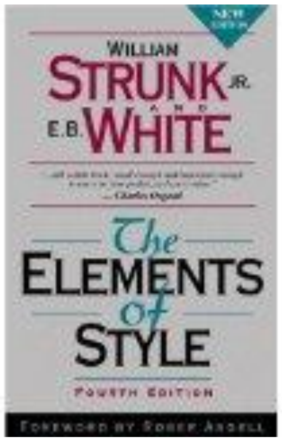
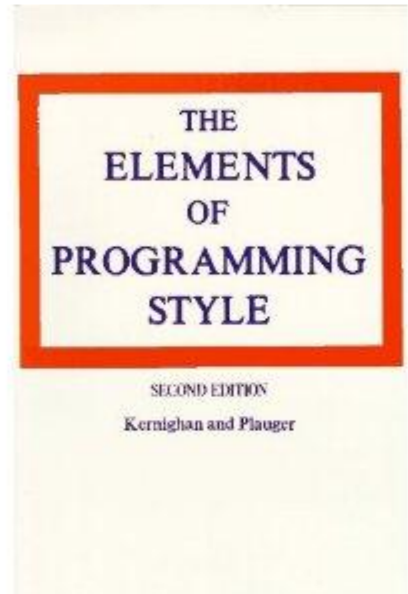
Module Design and General Style Guidelines

(Based on slides by David Notkin and Mike Ernst)

Style: It isn’t just about fashion…



“Use the active voice.”
“Omit needless words.”



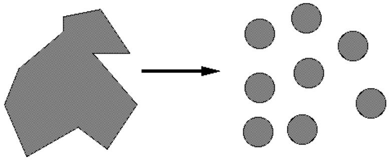
“Don't patch bad code - rewrite it.”
“Make sure your code 'does nothing' gracefully.”

Modules

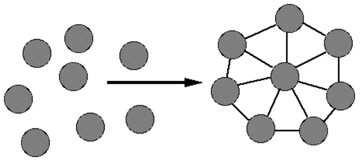
- A *module* is a relatively general term for a class or a type or any kind of design unit in software
- A *modular design* focuses on what modules are defined, what their specifications are, how they relate to each other, but not usually on the implementation of the modules themselves

Ideals of modular software

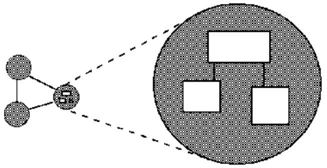
- Decomposable – can be broken down into modules to reduce complexity and allow teamwork



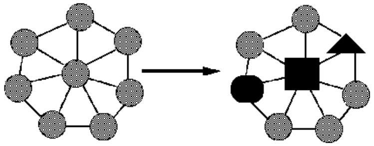
- Composable – “Having divided to conquer, we must reunite to rule [M. Jackson].”



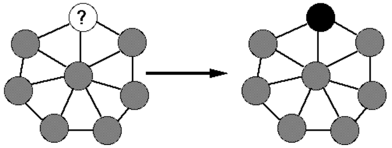
- Understandable – one module can be examined, reasoned about, developed, etc. in isolation



- 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: reduce coupling, increase cohesion

- Applies to modules and to individual routines

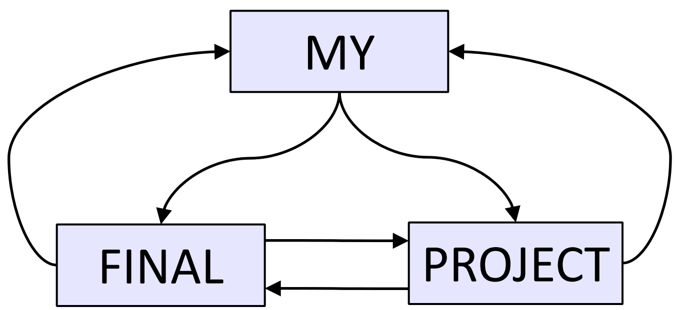
Cohesion

- The most common reason to put elements – data and behavior – together is to form an ADT
  - There are, at least historically, other reasons to place elements together – for example, for performance reasons it was sometimes good to place together all code to be run upon initialization of a program
- The common design objective of separation of concerns suggests a module should address a single set of concerns

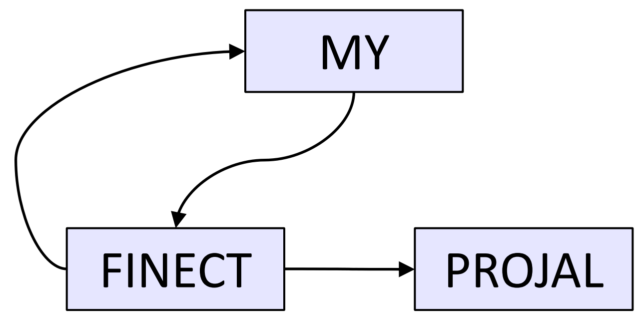
Coupling

- 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 thought of as 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

Law of Demeter
Karl Lieberherr and colleagues

- Law of Demeter: An object should know as little as possible about the internal structure of other objects with which it interacts – a question of coupling
- Or… "only talk to your immediate friends"
- Closely related to representation exposure and (im)mutability
- Bad example – too-tight chain of coupling between classes

```
general.getColonel().getMajor(m).getCaptain(cap)
  .getSergeant(ser).getPrivate(name).digFoxHole();
```

- Better example

```
general.superviseFoxHole(m, cap, ser, name);
```

An object should only send messages to … (More Demeter)

- itself (**`this`**)
- its instance variables
- its methods' parameters
- any object it creates
- any object returned by a call to one of **`this`**'s methods
- any objects in a collection of the above

- notably absent: objects returned by messages sent to other objects

Guidelines: not strict rules! But thinking about them will generally help you produce better designs

God classes

- *god class*: a class that hoards too much of the data or functionality of a system
  - Poor cohesion – little thought about why all of the elements are placed together
  - Only reduces coupling by collapsing multiple modules into one (and thus reducing the dependences between the modules to dependences within a module)
- A god class is an example of an *anti-pattern* – it is a known bad way of doing things

Method design

- A method should do only one thing, and do it well – for example, observe but not mutate, …
- 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 the 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 don't overload with the same number of parameters and think about whether the methods really are related.

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 something 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

- If you’ve got a method that is doing too much, split it up
  - Maybe separate, unrelated methods; maybe one method that does a task and another that calls it

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

Constructor design

- Constructors should take all arguments necessary to initialize the object's state – no more, no less
  - Don't make the client pass in things they shouldn't have to
- Object should be completely initialized after constructor is done
  - Shouldn't need to call other methods to “finish” initialization
- Minimize the work done in a constructor
  - A constructor should not do any heavy work, such as calling **`println`** to print state, or performing expensive computations
  - If an object's creation is heavyweight, use a **`static`** method instead

Naming

- Choose good names for classes and interfaces
  - Class names should be nouns
    - Watch out for "verb + er" names, e.g. **`Manager`**, **`Scheduler`**, **`ShapeDisplayer`**
    - Interface names often end in -able or -ible, e.g. **`Iterable`**, **`Comparable`**
  - Method names should be verb phrases
    - Observer methods can be nouns such as **`size`** or **`totalQuantity`**
    - Many observers should be named with "get" or "is" or "has"
    - Most mutators should be named with "set" or similar
    - Choose affirmative, positive names over negative ones
      - **`isSafe`** not **`isUnsafe`**
      - **`isEmpty`** not **`hasNoElements`**

- EJ Tip #56: Adhere to generally accepted naming conventions

Terrible names…

- **`count, flag, status, compute, check, value, pointer`**, any name starting with **`my`**…
  - These convey no useful information
  - **`myWidget`** is a cliché – sounds like picked by a 3-year-old
  - What others can you think of?

- Describe what is being counted, what the "flag" indicates, etc.
  - numberOfStudents, courseFull, flightStatus (still not great), 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++) theItems[theLoopCounter]=0;

Class design ideals

- Cohesion and coupling, already discussed

- *Completeness*: Every class should present a complete interface
- *Clarity*: Interface should make sense without confusion
- *Convenience*: Provide simple ways for clients to do common tasks
- *Consistency*: In names, param/returns, ordering, and behavior

Completeness

- Leaving out important methods makes a class cumbersome to use
  - counterexample: A collection with **`add`** but no **`remove`**
  - counterexample: A tool object with a **`setHighlighted`** method to select it, but no **`setUnhighlighted`** method to deselect it
  - counterexample: **`Date`** class has no date-arithmetic features
- Related
  - Objects that have a natural ordering should implement **`Comparable`**
  - Objects that might have duplicates should implement **`equals`**
  - Almost all objects should implement **`toString`**

Consistency

- A class or interface should be consistent with respect to names, parameters/returns, ordering, and behavior
- Use a similar naming scheme; accept parameters in the same order – not like
  - **`setFirst(int index, String value)`**
    `setLast(String value, int index)`
- Some counterexamples
  - **`Date/GregorianCalendar`** use 0-based months
  - **`String`** **`equalsIgnoreCase, compareToIgnoreCase;`** but **`regionMatches(boolean ignoreCase)`**
  - **`String.length(), array.length, collection.size()`**

Clarity and Convenience

- Clarity: An interface should make sense without creating confusion
  - Even without fully reading the spec/docs, a client should largely be able to follow his/her natural intuitions about how to use your class – although reading and precision are crucial
  - Counterexample: **`Iterator`**'s **`remove`** method

- Convenience: Provide simple ways for clients to do common tasks
  - If you have a **`size`** / **`indexOf`**, include **`isEmpty`** / **`contains`**, too
  - Counterexample: **`System.in`** sucks; finally fixed with **`Scanner`**

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 change by modifying existing ones – existing code works and changing it can introduce bugs and errors.
- Related: Code to interfaces, not to classes
  - Ex: accept a **`List`** parameter, not **`ArrayList`** or **`LinkedList`**
  - EJ Tip #52: Refer to objects by their interfaces

Cohesion again ("expert pattern")

- The class that contains most of the data needed to perform a task should perform the task
  - counterexample: A class with lots of getters but not a lot of methods that actually do work – this relies on other classes to "get" the data and process it externally
- Reduce duplication
  - Only one class should be responsible for maintaining a set of data, even (especially) if it is used by many other classes

Invariants

- Class invariant: An assertion that is true about every object of a class throughout each object’s lifetime
  - Ex: A **`BankAccount`**'s balance will never be negative
- State them in your documentation, and enforce them in your code

Documenting a class

- Keep internal and external documentation separate
- external: `/** ... */` Javadoc for classes, interfaces, and 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/postconditons and class invariants
- 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 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

Static vs. non-static design

- What members should be **`static`**?
  - members that are related to an entire class
  - not related to the data inside a particular object of that class's type
  - Should I have to construct an object just to call this method?
- Examples
  - **`Time.fromString`**
  - **`Math.pow`**
  - **`Calendar.getInstance`**
  - **`NumberFormatter.getCurrencyInstance`**
  - **`Arrays.toString`**? **`Collections.sort`**?

Public vs. private design

- Strive to minimize the public interface of the classes you write
  - Clients like classes that are simple to use and understand
  - Reasoning is easier with narrower interfaces and specifications
- Achieve a minimal public interface by
  - Removing unnecessary methods – consider each one
  - Making everything private unless absolutely necessary
  - Pulling out unrelated behavior into a separate class
- **`public static`** constants are okay if declared **`final`**
  - But still better to have a **`public static`** method to get the value; why?
  - Or use enums if that's what you're trying to do

Choosing types

- Numbers: Favor **`int`** and **`long`** for most numeric computations
  - EJ Tip #48: Avoid **`float`** and **`double`** if exact answers are required
  - Classic example: Representing money (round-off is bad here)
- Favor the use of collections (e.g. lists) over arrays
- Strings are often overused since much data comes in as text
- Consider use of **`enums`**, even with only two values – which of the following is better?
  - ```
    oven.setTemp(97, true);
    oven.setTemp(97, Temperature.CELSIUS);
    ```
- Wrapper types should be used minimally (usually with collections)
  - EJ Tip #49: Prefer primitive types to boxed primitives (that is, **`Integer`**, **`Float`**, etc.)
    - Bad: **`public Counter(Character ch)`**
    ```

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 **`println`** 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()
```