CS 520

Theory and Practice of Software Engineering
Fall 2018

Object Oriented Design Patterns

September 25, 2018

Today

- Recap: Object oriented design principles
- Design problems & potential solutions
- Design patterns:
  - What is a design pattern?
  - Categories of design patterns
  - Structural design patterns

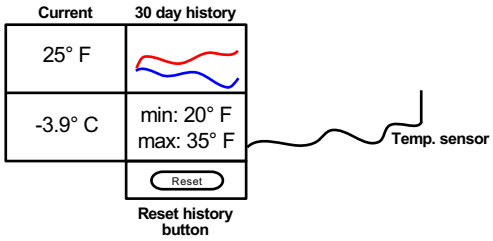
Recap

Object oriented design principles

- Information hiding (and encapsulation)
- Open/closed principle
- Liskov substitution principle
- Composition/aggregation over inheritance

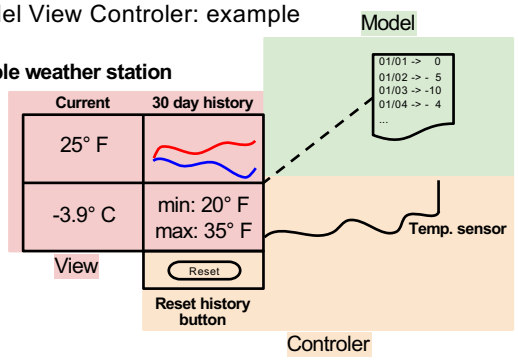
A first design problem

Weather station revisited

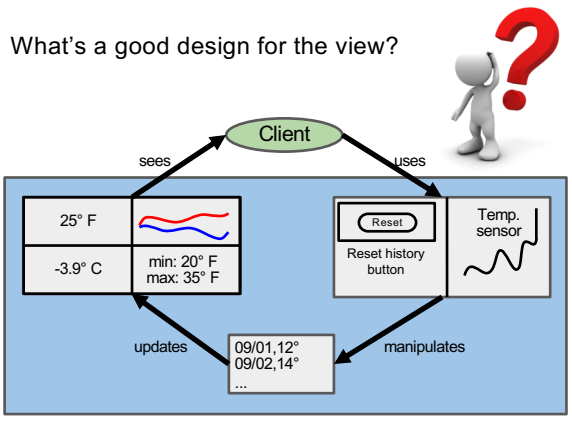


Model View Controler: example

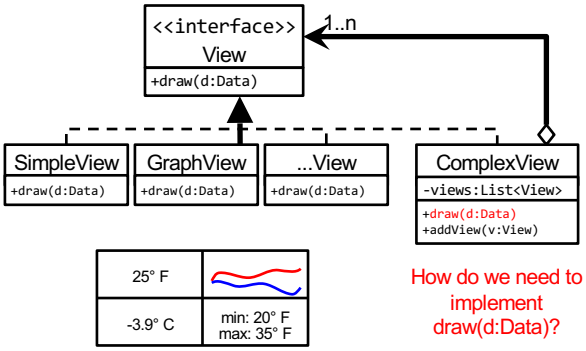
Simple weather station



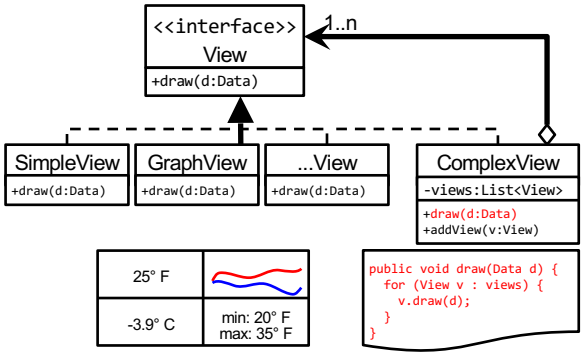
What's a good design for the view?



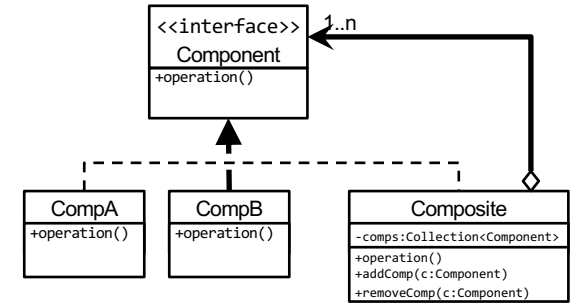
Weather station: view



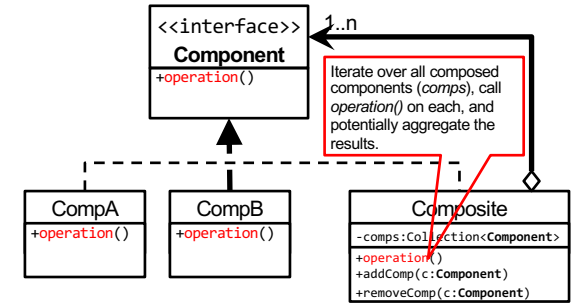
Weather station: view



Design pattern: Composite



Design pattern: Composite



What is a design pattern?

- Addresses a recurring, common design problem.
- Provides a generalizable solution.
- Provides a common terminology.

What is a design pattern?

- Addresses a recurring, common design problem.
- Provides a generalizable solution.
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Pros

- Improves communication and documentation.
- "Toolbox" for novice developers.

Cons

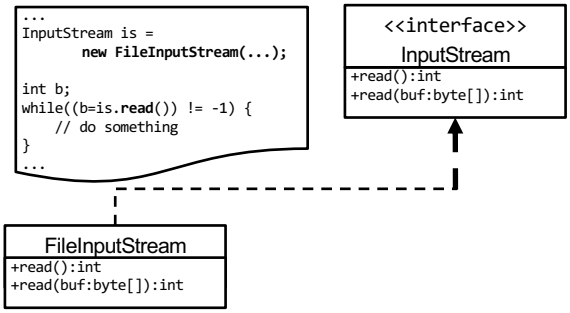
- Risk of over-engineering.
- Potential impact on system performance.

More than just a name for common sense and best practices.

Design patterns: categories

1. Structural
   - Composite
   - Decorator
   - ...
2. Behavioral
   - Template method
   - Visitor
   - ...
3. Creational
   - Singleton
   - Factory (method)
   - ...

Another design problem: I/O streams



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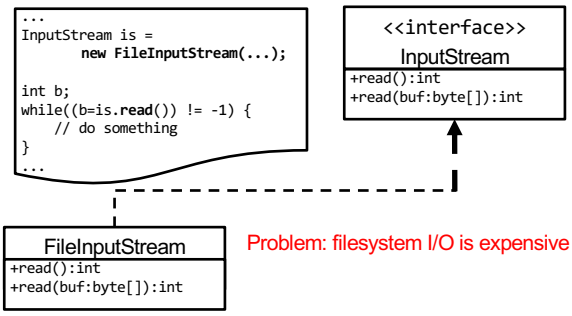
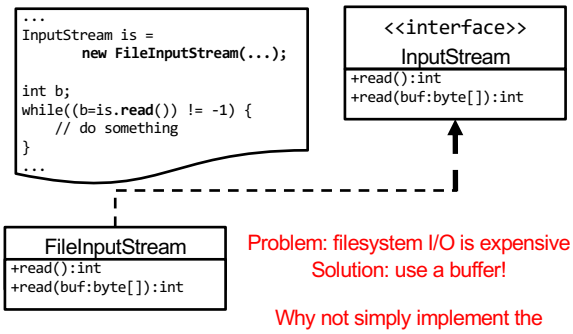


Problem: filesystem I/O is expensive

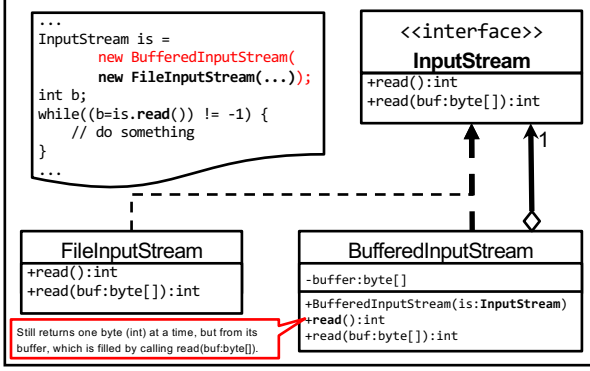
Another design problem: I/O streams



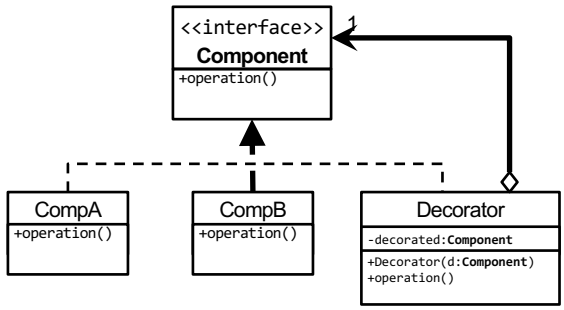
Problem: filesystem I/O is expensive
Solution: use a buffer!

Why not simply implement the buffering in the client or subclass?

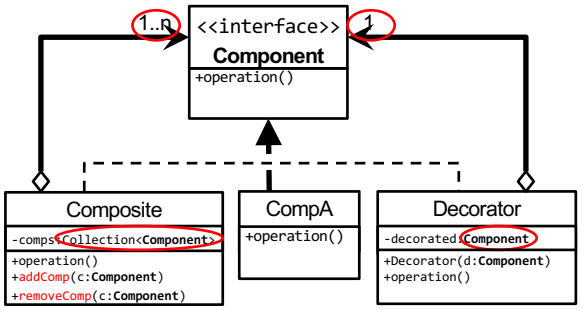
Another design problem: I/O streams



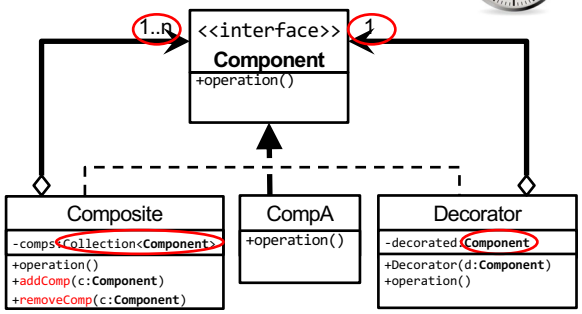
Design pattern: Decorator



Composite vs. Decorator



Recap: Composite vs. Decorator



Find the median in an array of doubles

Examples:

- median([1, 2, 3, 4, 5]) = ???
- median([1, 2, 3, 4]) = ???

Find the median in an array of doubles

Examples:

- median([1, 2, 3, 4, 5]) = 3
- median([1, 2, 3, 4]) = 2.5

Algorithm
Input: *array* of length *n* **Output**: median

Find the median in an array of doubles

Examples:

- median([1, 2, 3, 4, 5]) = 3
- median([1, 2, 3, 4]) = 2.5

Algorithm
Input: *array* of length *n* **Output**: median

1. Sort *array*
2. if *n* is *odd* return $((n+1)/2)$th element
   otherwise return arithmetic mean of
   $(n/2)$th element and $((n/2)+1)$th element

Median computation: naive solution

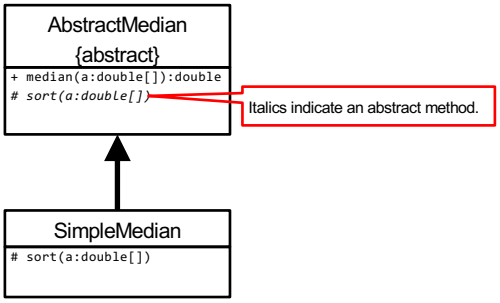
```
public static void main(String ... args) {
        System.out.println(median(1,2,3,4,5));
}

public static double median(double ... numbers) {
     int n = numbers.length;
          boolean swapped = true;
     while(swapped) {
          swapped = false;
          for (int i = 1; i<n; ++i) {
                    if (numbers[i-1] > numbers[i]) {
                                        ...
                              swapped = true;
                              }
          }
     }
     if (n%2 == 0) {
          return (numbers[(n/2) - 1] + numbers[n/2]) / 2;
     } else {
          return numbers[n/2];
     }
}
```

What's wrong with this design?
How can we improve it?

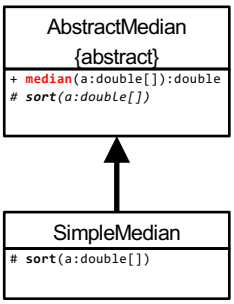
Ways to improve

- 1: Monolithic version, static context.
- 2: Extracted sorting method, non-static context.
- 3: Proper package structure and visibility, extracted main method.
- 4: Proper testing infrastructure and build system.

One possible solution: template method pattern

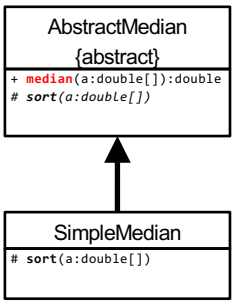


One possible solution: template method pattern



- The template method (**median**) implements the algorithm but leaves the **sorting** of the array undefined.
- The concrete subclass only needs to implement the actual **sorting**.

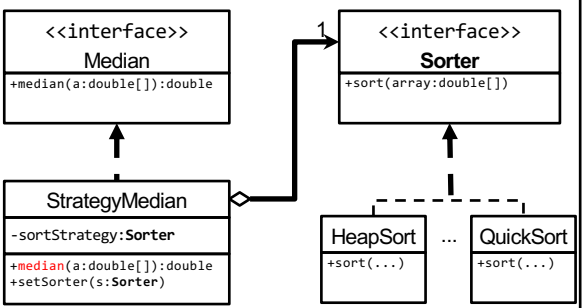
One possible solution: template method pattern



Should the median method be final?

- The template method (**median**) implements the algorithm but leaves the **sorting** of the array undefined.
- The concrete subclass only needs to implement the actual **sorting**.

Another solution: strategy pattern



"median" delegates the sorting of the array to a "sortStrategy"

Template method pattern vs. strategy pattern

Two solutions to the same problem

What are the differences, pros, and cons?

Template method pattern vs. strategy pattern

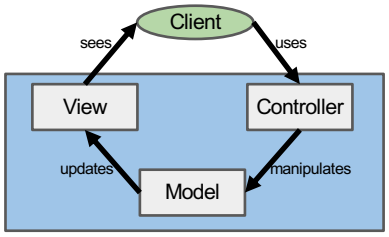
Two solutions to the same problem

Template method
- Behavior selected at compile time.
- Template method is usually final.

Strategy
- Behavior selected at runtime.
- Composition/aggregation over inheritance.

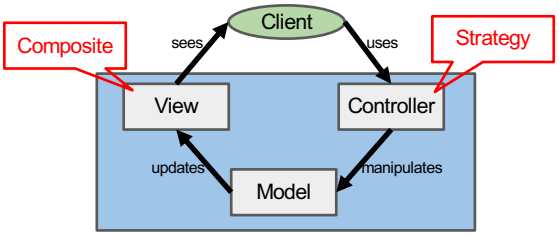
Model-View-Controller revisited

Design patterns in a MVC architecture



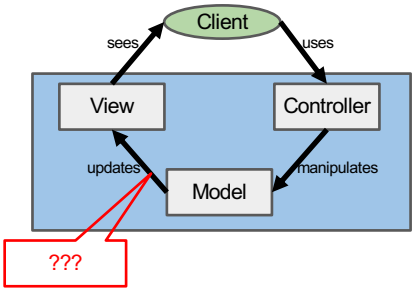
Model-View-Controller revisited

Design patterns in a MVC architecture



Model-View-Controller revisited

Design patterns in a MVC architecture



Observer pattern

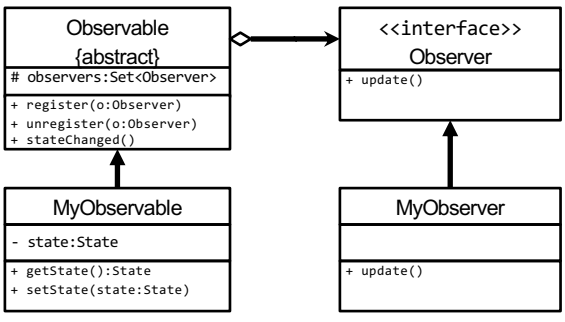
Observer pattern

From Wikipedia, the free encyclopedia

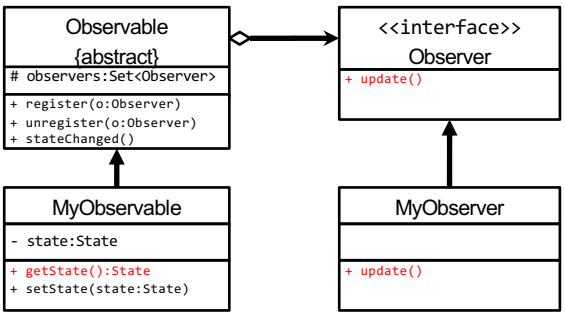
The **observer pattern** is a software design pattern in which an object, called the **subject**, maintains a list of its dependents, called **observers**, and notifies them automatically of any state changes, usually by calling one of their methods.

- Problem solved:
  - A one-to-many dependency between objects should be defined without making the objects tightly coupled.
  - When one object changes state, an open-ended number of dependent objects are updated automatically.
  - One object can notify an open-ended number of other objects.

Observer pattern



Observer pattern



Variation: pass incremental changes or the state to update method.