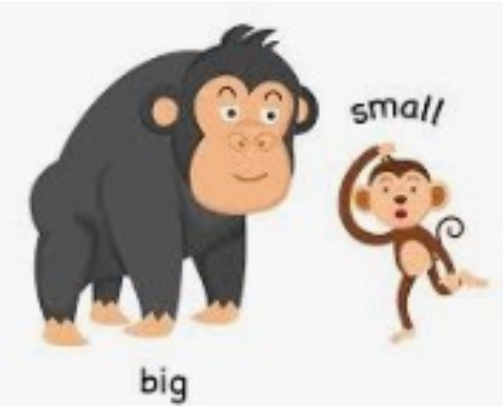
Identify areas likely to change

- Separate items likely to change from more-stable items
- Isolate the change

- Typical areas of change
  - Business rules
  - Hardware dependencies
  - Input and output
  - Non-standard language features
  - Tricky design or algorithm areas
  - Status variables

Anticipate different degrees of change

- Design so that something perceived as a small change should have a small scope of impact
  - Don’t let a small change become the 100 pound gorilla on your back



Keep coupling loose

- …said several times before in the class.
  - Nothing new to add.

Look for common design patterns

- Transformations or actions that you do repeatedly should be collected together
  - Would likely lead to refactoring later if you didn't
  - Seek common "well known" solutions
    - Boilerplate solution
    - Company standard on how to address the problem
    - Industry best practice "design pattern" solution
    - Solution already encapsulated in a library

Design Considerations

- Aim for high cohesion
- Build hierarchies
- Formalize class contracts
- Assign responsibilities
- Design for testing
- Choose the binding time consciously
- Make central points of control
- Keep your design modular

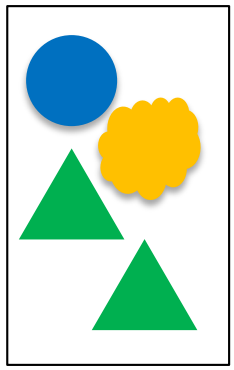
Design practices

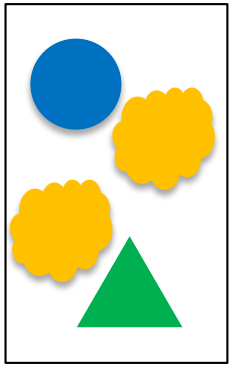
- Iterate, iterate, iterate
- Divide and conquer
- Top-down and bottom-up design
- Experimental prototyping
- Collaborative design

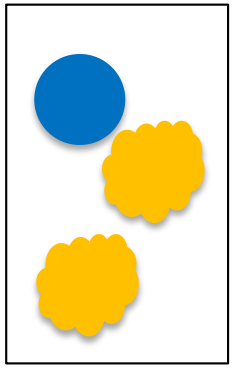
Common Design Criteria -- Cohesion

- Cohesion is a measure of relatedness to a single idea or responsibility within a method, class, or package
  - A measure of how well everything stick together
  - Aim for high cohesion
- Low cohesion means that either
  - You need to look to many methods, classes, or packages to get a task done because the pieces are fragmented or
  - One method, class, or package is trying to do a lot of different things, which makes the code difficult to understand

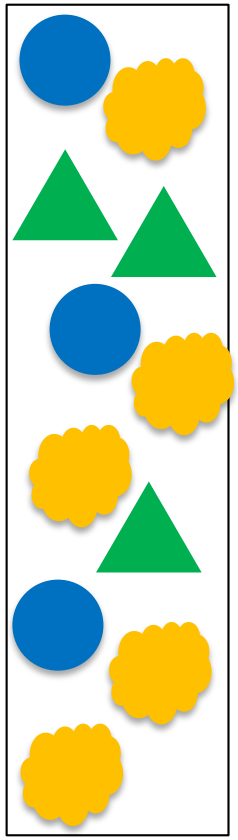
Cohesion



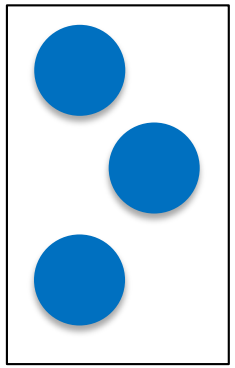


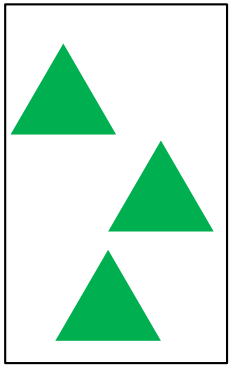


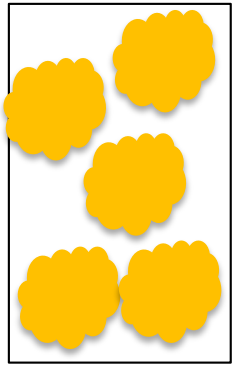
Bad cohesion
Too fragmented



Bad cohesion
Overloaded







Good cohesion

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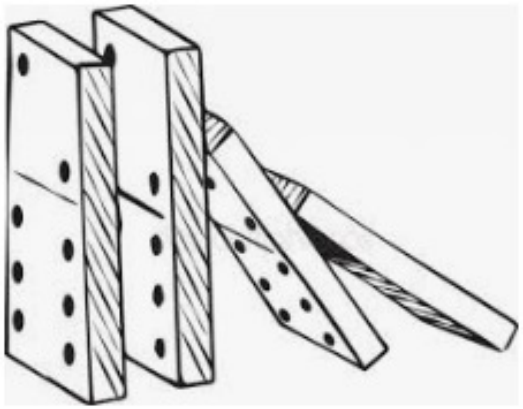
Common Design Criteria – Coupling

- Coupling is a measure of dependence between classes or between packages
- Aim for low or loose coupling

- High coupling makes your code difficult to change because of the ripple effect of changes that must be carried through to all the tightly coupled modules



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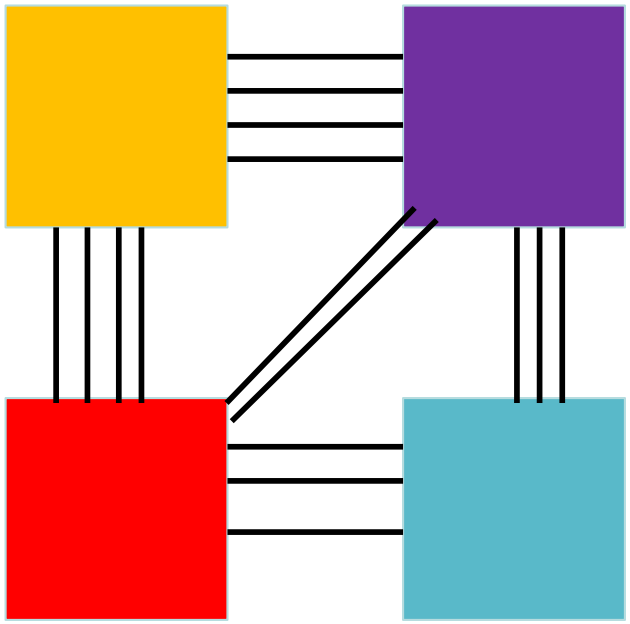
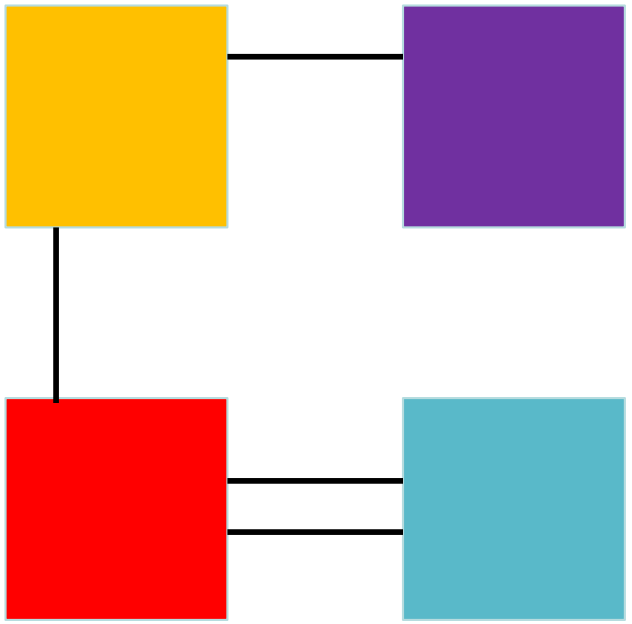
Coupling



High Coupling /
Tight Coupling



Low Coupling /
Loose Coupling

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Cohesion vs. Coupling

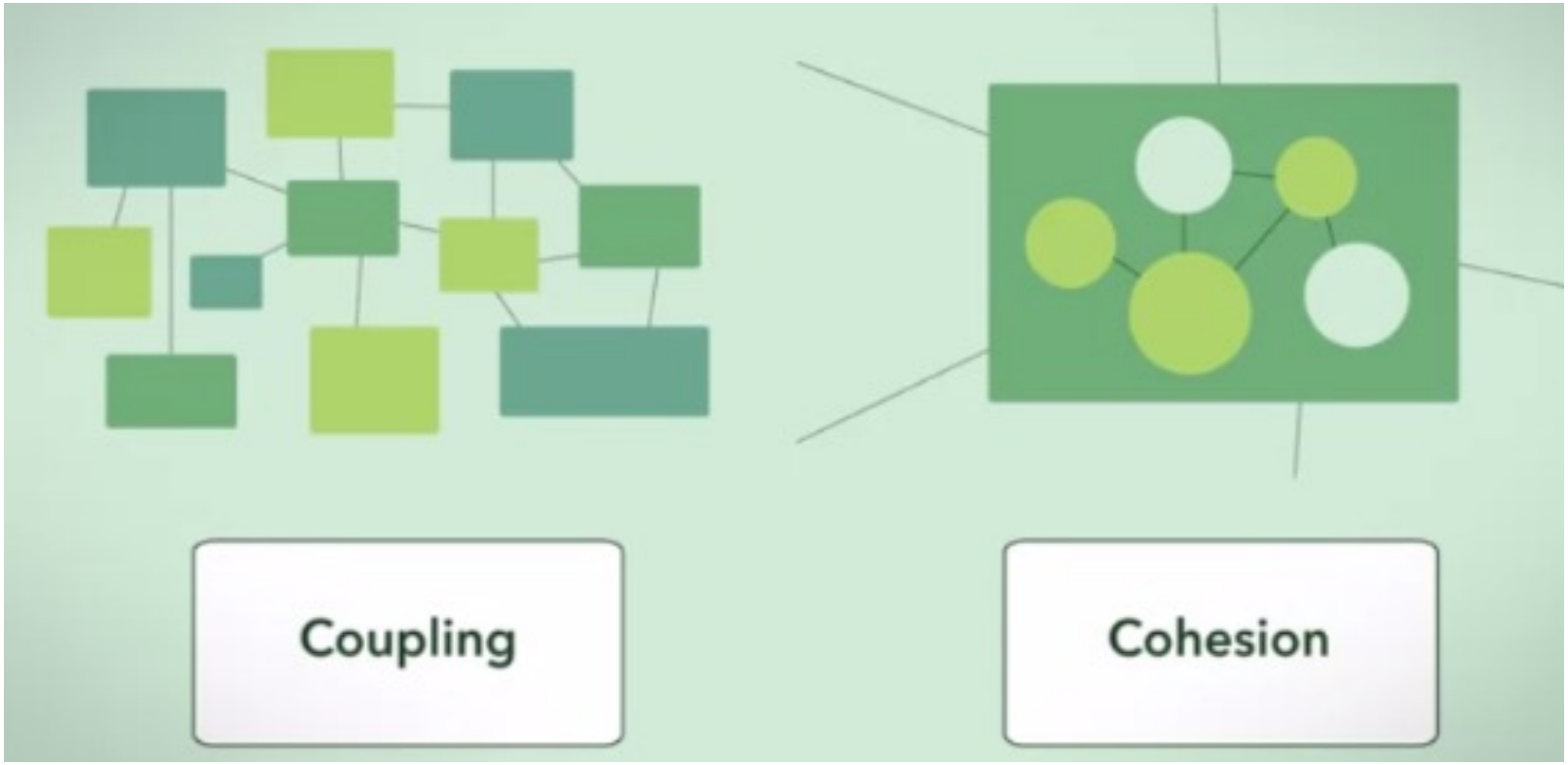


Image from StackOverflow, attributing it to
https://www.coursera.org/lecture/object-oriented-design/1-3-1-coupling-and-cohesion-q8wGt

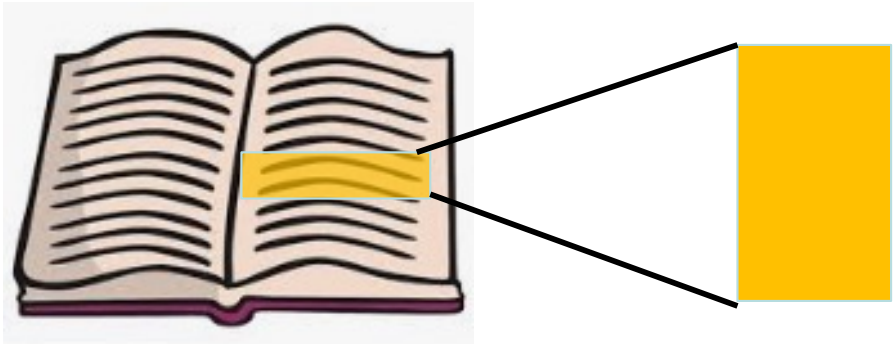
Design Principles – SOLID

- Single responsibility principle
- Open / closed principle
- Liskov substitution principle
- Interface segregation principle
- Dependency inversion principle

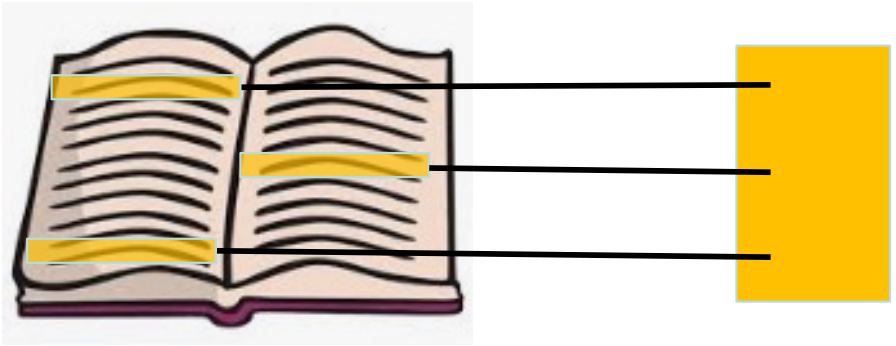
Single Responsibility Principle

- "A class should only have a single responsibility, that is, only changes to one part of the software's specification should be able to affect the specification of the class." (https://en.wikipedia.org/wiki/SOLID)

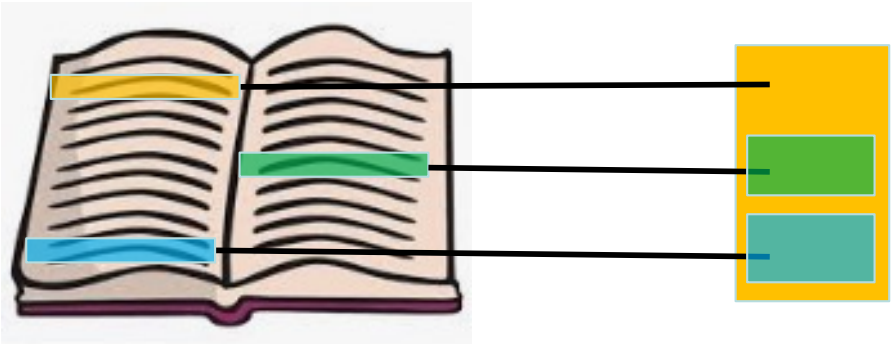
Single Responsibility Principle



Principle kept



Principle not kept



Principle really not kept

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Single Responsibility Principle – bad example

- Public class student {
  public String getName();
  public int getAge();
  public int getFeesOwing();
  public int[ ] getRegisteredCourses();
  public boolean hasCheckedOutLibraryBook();
  }

Single Responsibility Principle – correct use

```
Public class studentInfo {
        public String getName();
        public int getAge();
}
pubic class studentFinances {
        public int getFeesOwing();
}
public class studentRegistration {
        public int[ ] getRegisteredCourses();
}
public class studentLibrary {
        public boolean hasCheckedOutLibraryBook();
}
```

Single Responsibility Principle – correct use

- Public class student {

```
        private studentInfo info;
        private studentFinances finances;
        private studentRegistration registrations;
        private studentLibrary libraryUse;
}
```

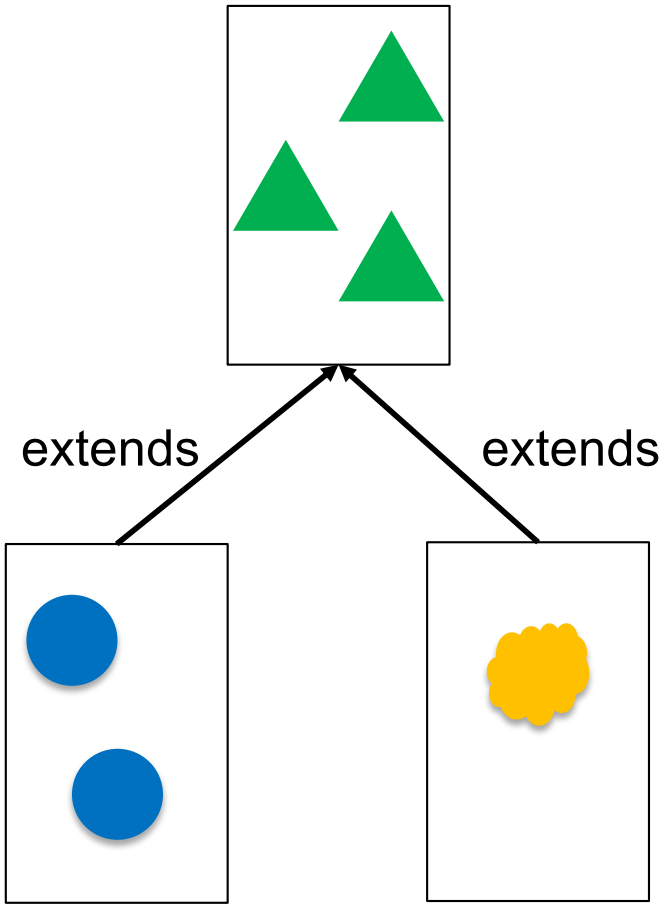
- Each smaller class has a more direct responsibility
- One aggregating class, if needed, to gather all the information
  - Don't replicate the methods of the attributes to the "student" class
  - Allow others to get references to the specific objects instead

Open / Closed Principle

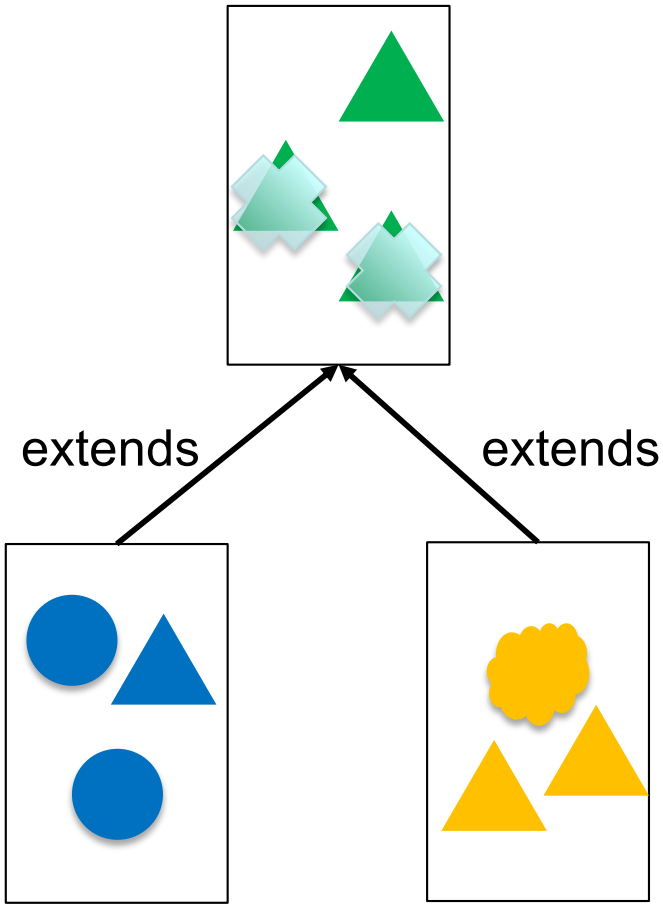
- "' Software entities ... should be open for extension, but closed for modification.'" (https://en.wikipedia.org/wiki/SOLID)

- **Relates strongly to subclasses and inheritance:**
  - **Write classes expecting / hoping that others will extend it**
    - **Better alternative than many others modifying your class**
    - **Once the class is written, we hope to not change it much**
  - **Subclasses should add functionality rather than rewrite methods from the superclass**
    - **If you need to rewrite many methods then maybe you shouldn't be extending the class**

Open

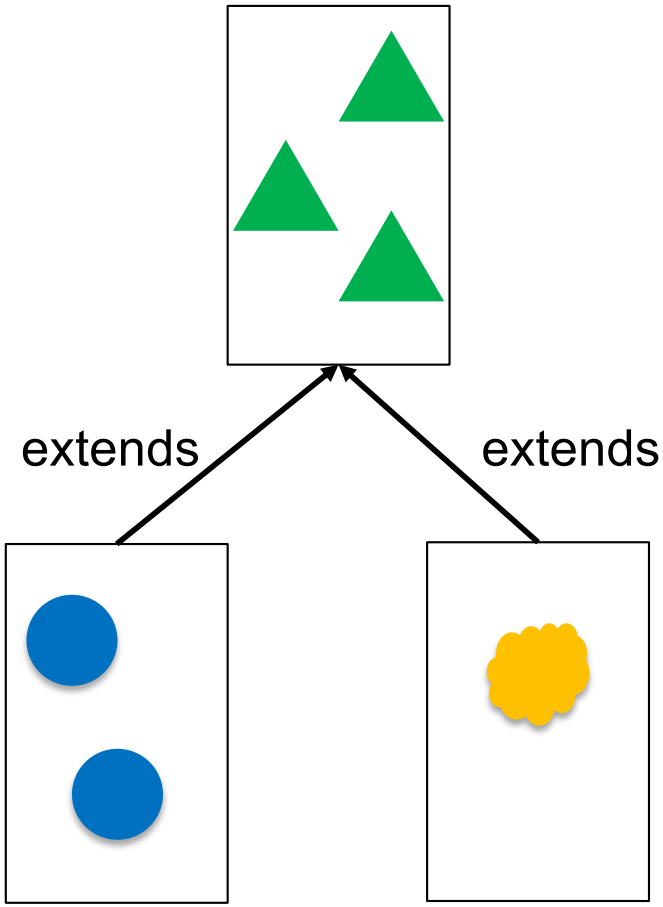


Good and expected

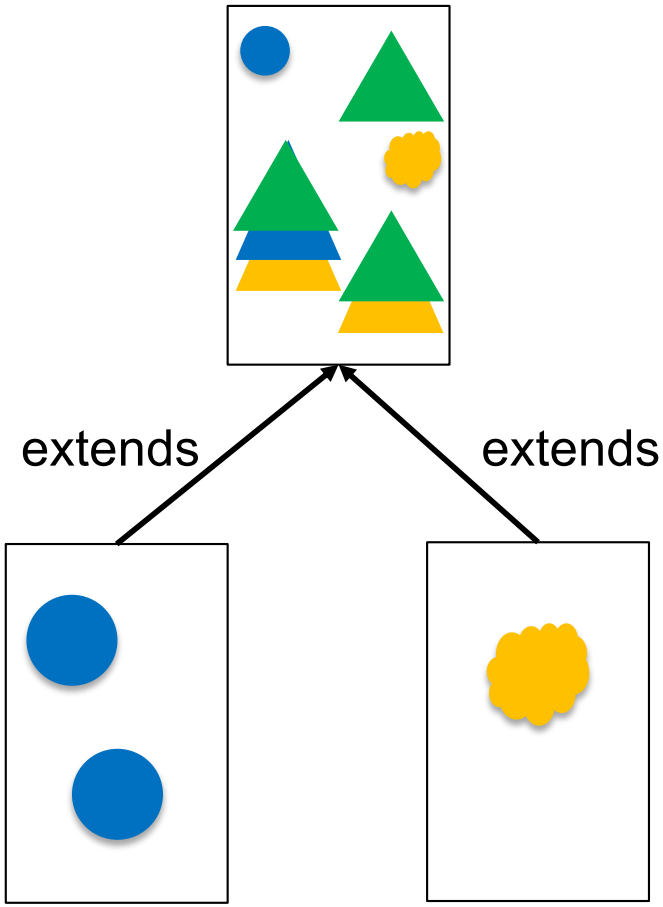


Bad since little of the parent is left

Closed

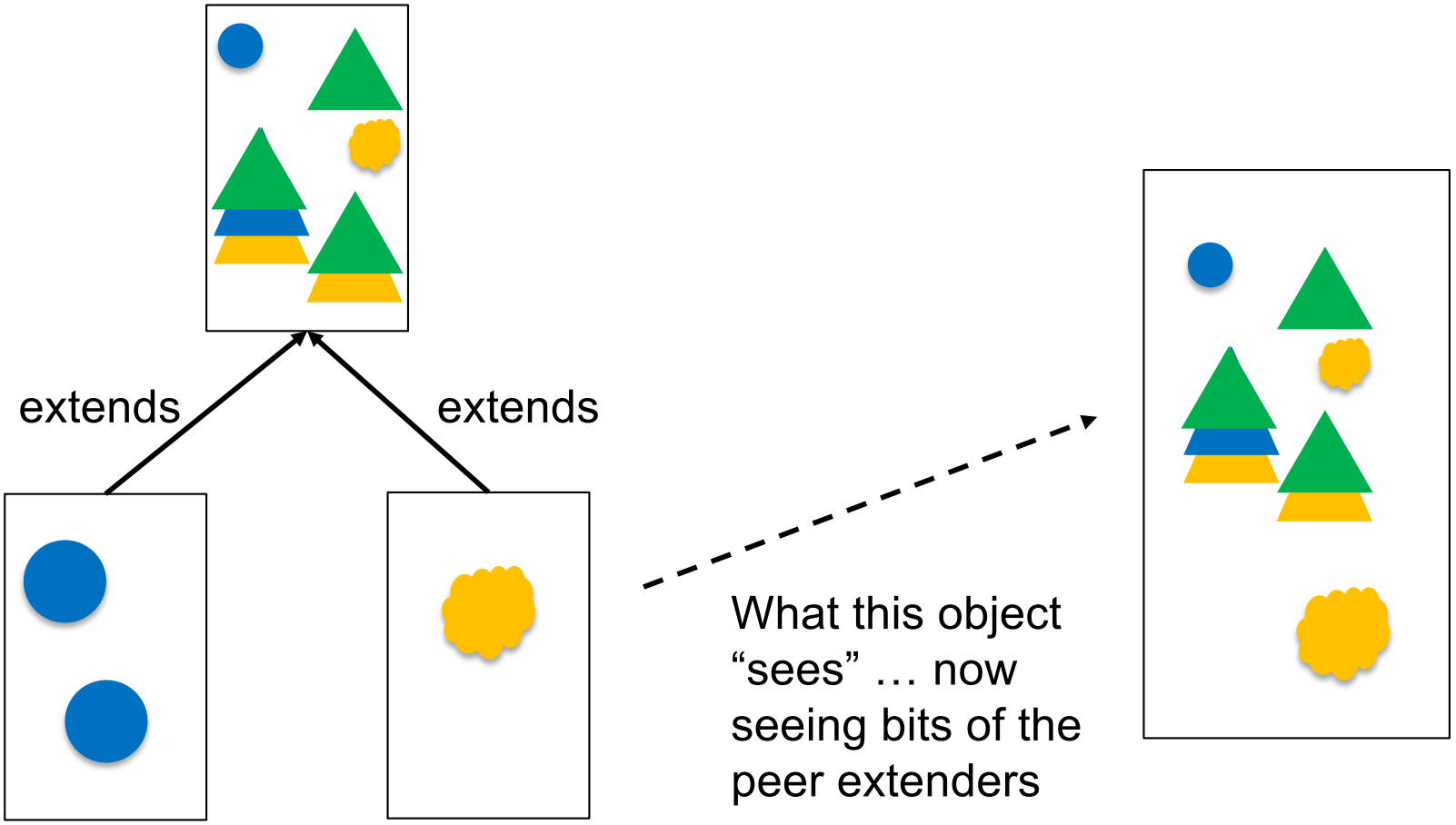


Good and expected



Bad since the parent shouldn't change

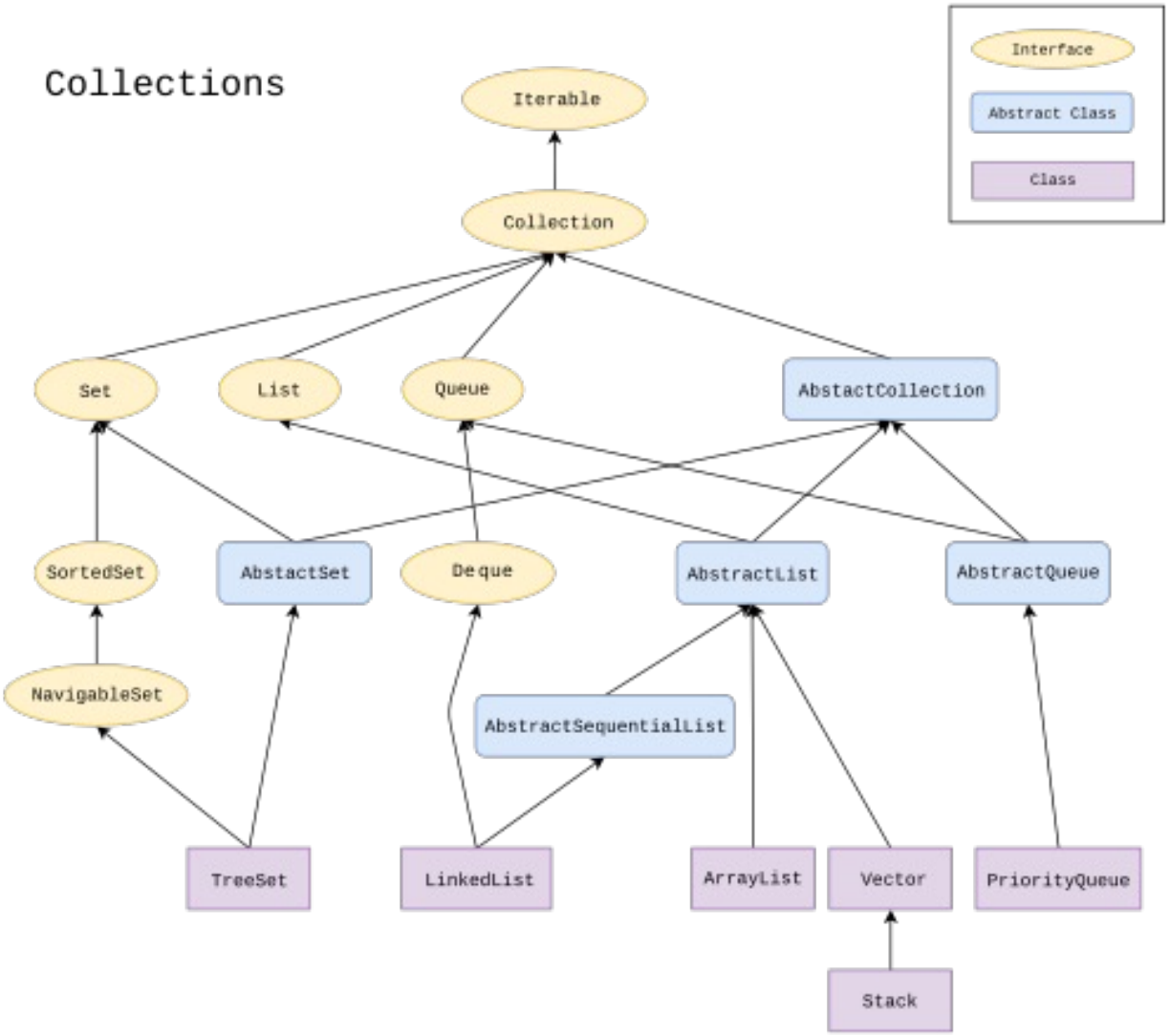
Closed – Effect of poor use



Liskov Substitution Principle

- “’ Objects in a program should be replaceable with instances of their subtypes without altering the correctness of that program’” (https://en.wikipedia.org/wiki/SOLID)

Java Collection Framework



Any code that accepts a List should work fine if passed an object of type

- AbstractList
- ArrayList
- Vector
- Stack

Image from https://en.wikipedia.org/wiki/Java_collections_framework, accessed September 18, 2018

Sample code

- **Code uses**

```
private class cell {
        ...
        protected Set<Character> possibleValues = new HashSet<>();
        ...
}
```

Allows us to change our minds on the implementation later without searching _all_ the code for the class name to change.

Rather than

```
private class cell {
        ...
        protected HashSet<Character> possibleValues = new HashSet<>();
        ...
}
```

Locks us in to one implementation.

Design by Contract

- **Preconditions cannot be strengthened by a subtype**
  - **You can't expect more from the subclass than from the superclass**
- **Postconditions cannot be weakened by a subtype**
  - **The outcome of a subclass must be at least as dependable / strong / reliable as the superclass**