Jin L.C. Guo

M2 (a) - Types and Polymorphism

Image Source: https://upload.wikimedia.org/wikipedia/commons/2/2b/Cepaea_nemoralis_active_pair_on_tree_trunk.jpg

Recap of last module

- Programming mechanisms:
  - Scope and Visibility
- Concepts and Principles:
  - Information Hiding, Encapsulation, Escaping Reference, Immutability
- Design Techniques:
  - Object Diagrams
- Patterns and Antipatterns:
  - Primitive Obsession 👎

Objective of this lecture

- Concepts and Principles:

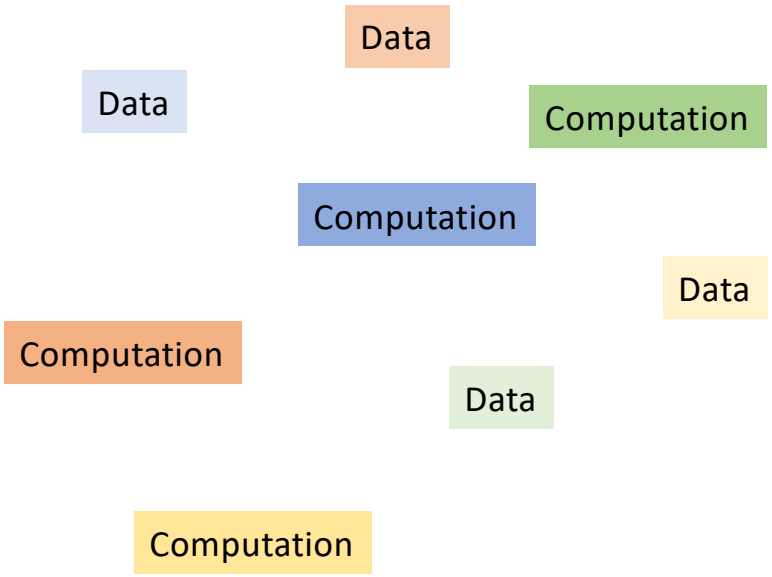
Class's interface, Separation of concerns

- Programming mechanism:

Java Interface type, Subtype polymorphism

- Design techniques:

Interface-based behavior specification, UML Class Diagrams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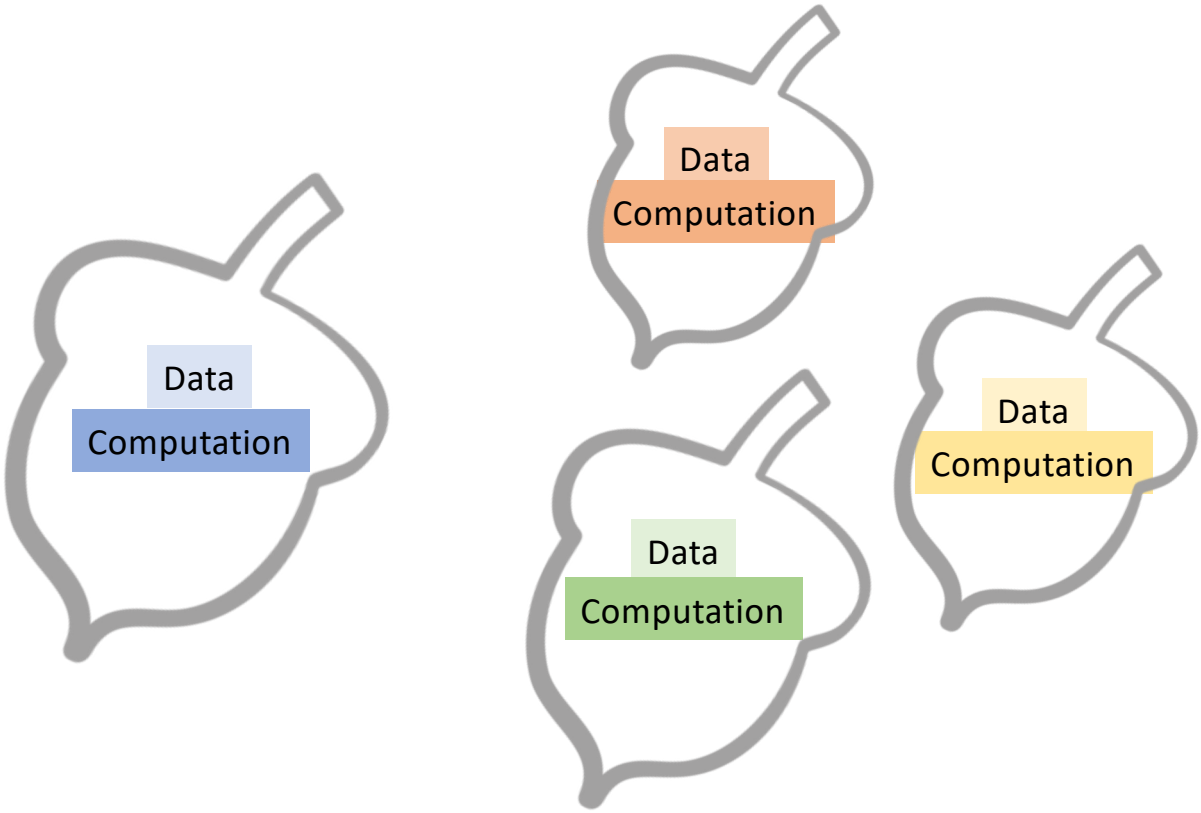
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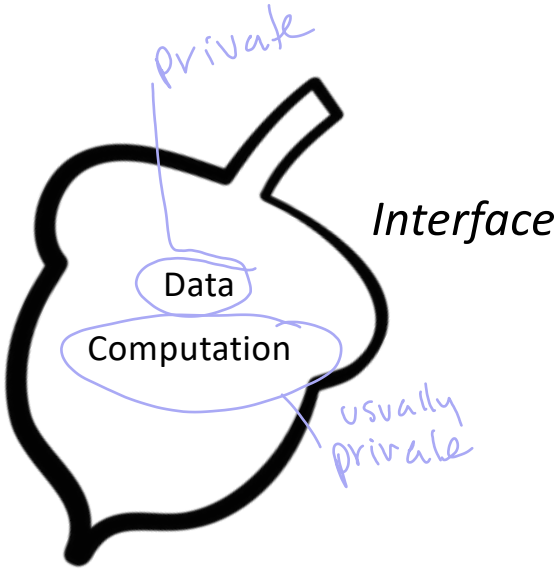
Object Interaction



usually private

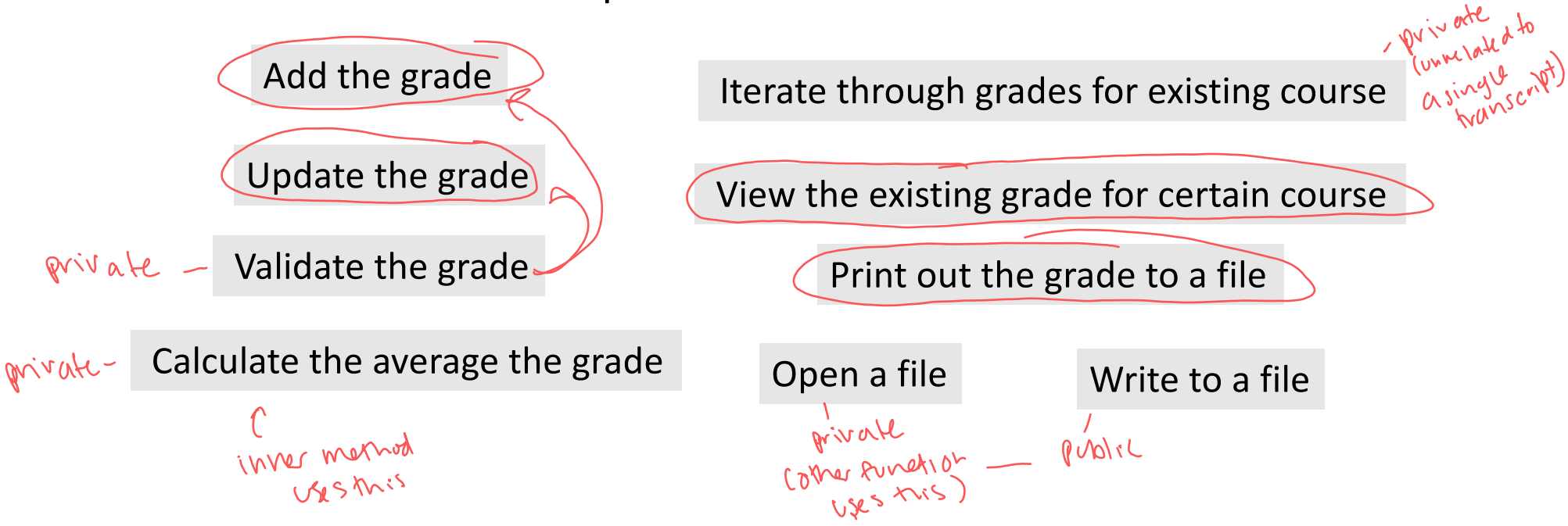
Supply the service through interface

interact through interface

Activity 1:

Which ones should be public?

- Thank about the design of a Class **StudentTranscipt**, which provides the basic functions related to the students' grade. What kind of methods should this class provide?



only make essential things public

Specification of public interface

- Requires — What needs be true in order call this the method?
- Modifies — When this method is called, is the state of any object going to be changed? (is internal state changing?)
- Effects — What will happen if this method is called?

Add the grade

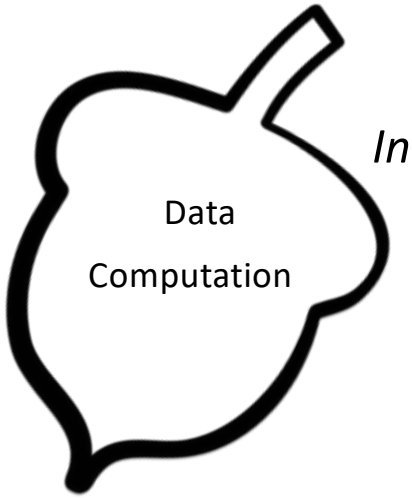
- required - grade, course, student
  valid grade
- modifies — transcript object
- effect - transcript reflects added grade

Java Interface Type

helps you specify a class interface before implementing

- Specification of related methods
- Reference to invoke those methods
- No implementation yet (except default and static methods)

```
public interface Student {
    /*
    * @return The unique id associated with student
    */
    String getID();
    /*
    * @return The first name of the student.
    */
    String getFirstName();
    /*
    * @return The Last name of the student.
    */
    String getLastName();

}
```



Interface

separate interface

Subtype Relationship

```
public class Undergrad implements Student
```

```
Student s1 = new Undergrad();

String id = s1.getID();
```

1. Undergrad need to provide implementation of methods in Student
2. Objects of Undergrad can be referred using variables of type Student.

Undergrad is-a **Student** (subtype relation)

all undergrads are students

not all students are undergrads

Why do we need this?

Student is interface type

```
public class Undergrad implements Student

public class Graduate implements Student

public class NonDegreeStudent implements Student

public class VisitingStudent implements Student
```

Program through interface

Polymorphic **Student**

Extensibility

Loosely coupling

Program to the interface

```
public boolean attendSeminar(Student pStudent)
{
     if(registeredStudents.size()<=cap) {
          registeredStudents.add(pStudent.getID());
          return true;

     }
     return false;
}
```

Polymorphism

- Many + Forms
- In programming languages, it's the ability to present the same interface for different underlying types.

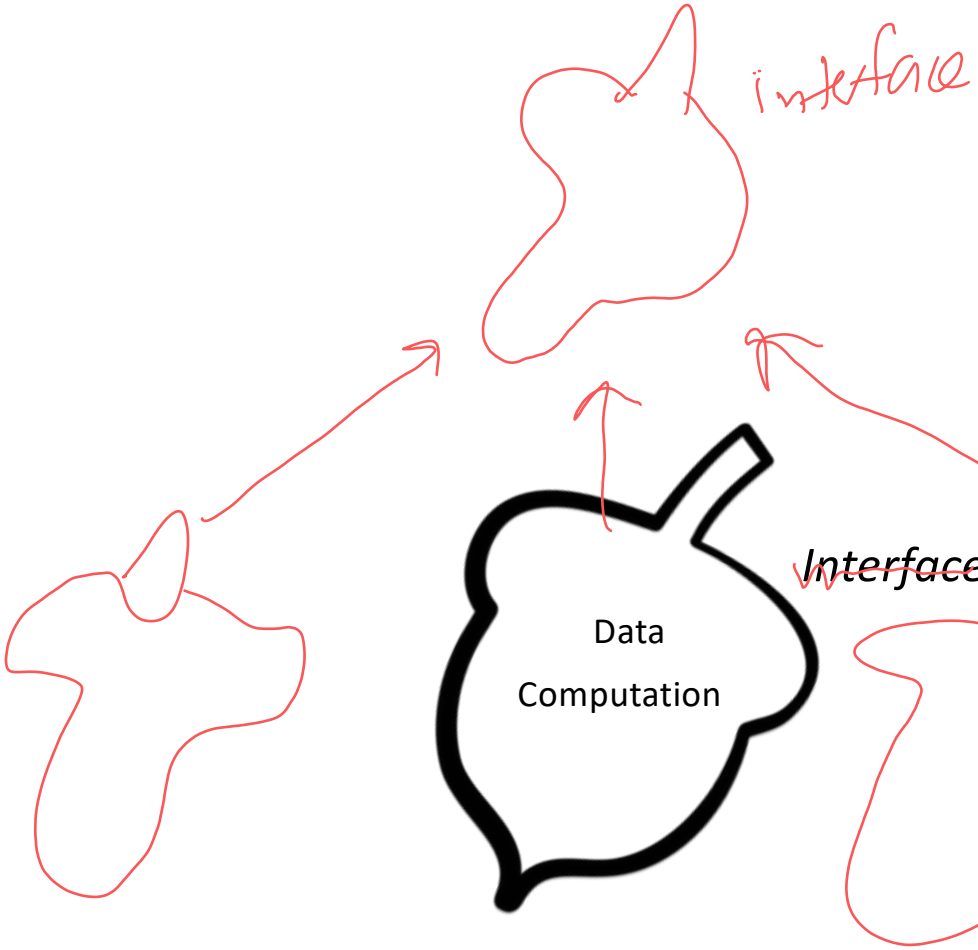
Image source: Griffith Ecology Lab (https://griffithecology.com/)

Comparison between Subtype and Subclass

- Subtype is about substitution:
  - B is a subtype of A means that if whenever the context requires an element of type A it can accept an element of type B.

- Subclass (one type of subtype) is about inheritance:
  - B is a subclass of A means that B can reuse unchanged fields and methods from A.
  - Extra dependencies between A and B
  - More in Later Modules (about inheritance)

```
public class SpecialDeck extends Deck {

        … …
}
```



What computation should be specified in the interface?

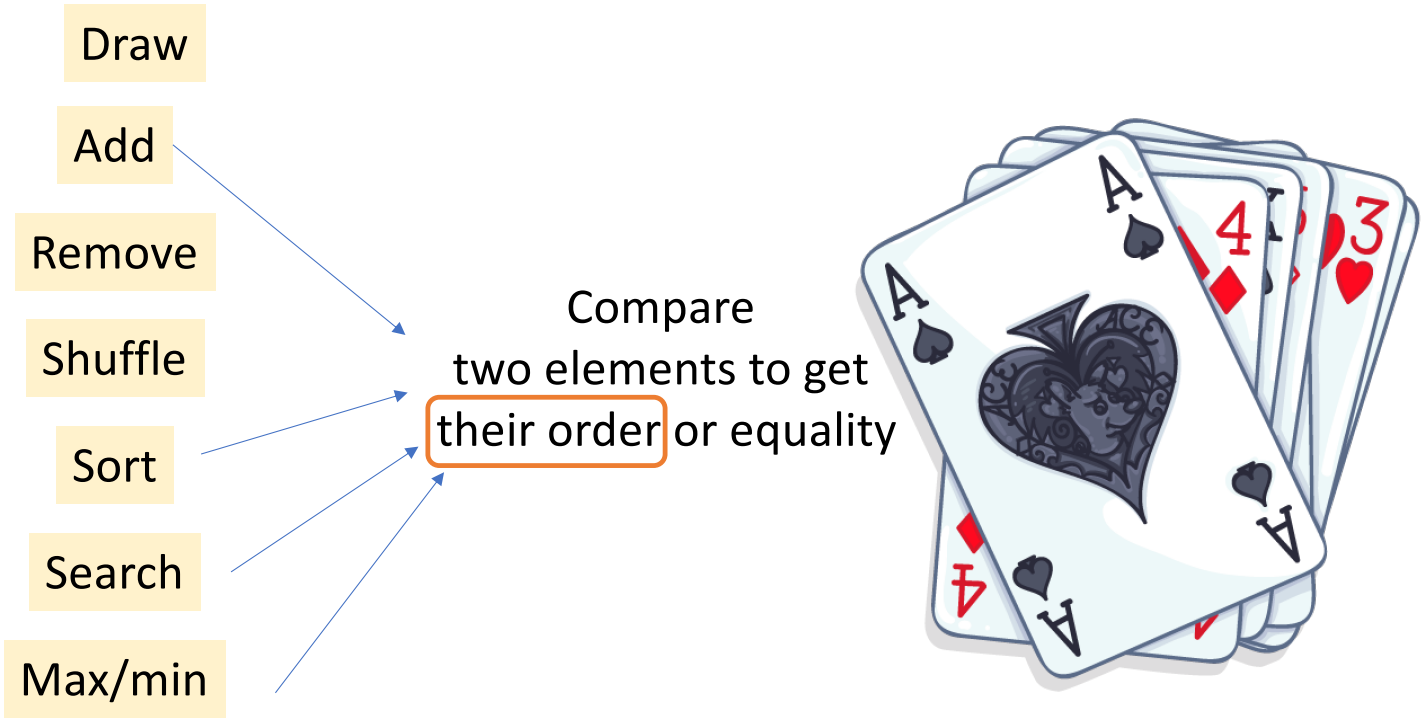
- public methods

Look for **Orthogonality**

↳ relevant things should change, irrelevant things should not

if all subtypes use a method, it should be in the interface

Operation on a Deck



Information leaking

a design knowledge is reflected in many modules

Java `Comparable<T>` Interface

- This interface imposes a total ordering on the objects of each class that implements it.

```
public interface Comparable<T>
{
        int compareTo(T o);
}
```

Generics: mechanism that takes type as parameter

needs body

Specification of `Comparable<T>`

- Compares this object with the specified object for order.

- Returns a negative integer, zero, or a positive integer as this object is less than, equal to, or greater than the specified object.

- Also properties of implementor needs to ensure, for example:

  (x.compareTo(y)>0 && y.compareTo(z)>0) implies x.compareTo(z)>0

Client

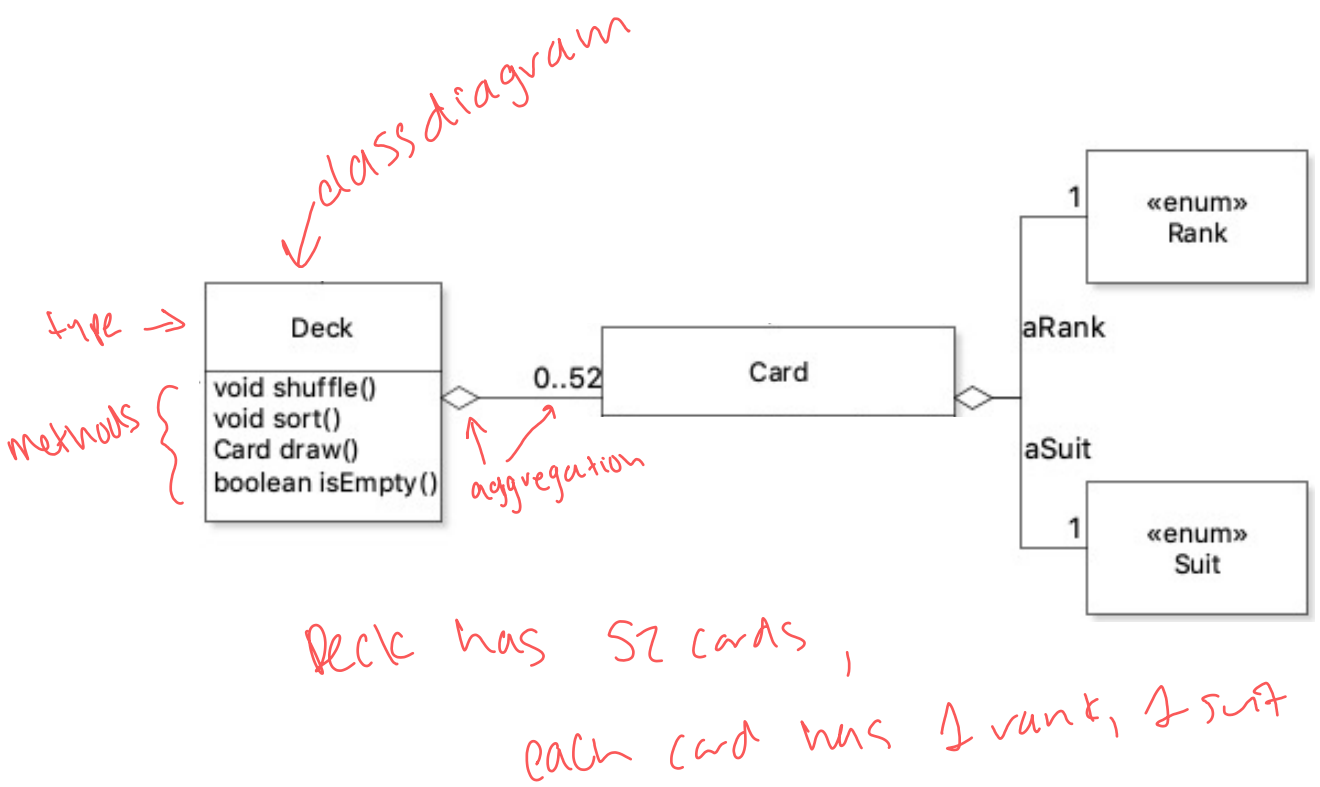
```
if(object1.compareTo(object2) >0) /*...*/
```

Implements `Comparable<T>`

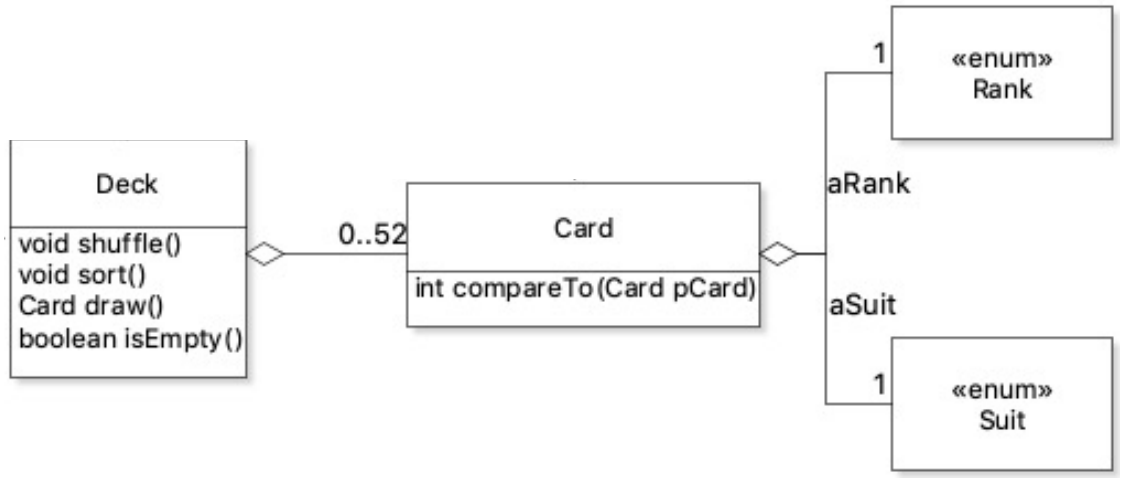
```
Collections.sort(aCards);// aCards is a List<Card> instance
```

```
public class Card implements Comparable<Card>
{

 … …


   @Override
   public int compareTo(Card pCard)
   {
   … …   return aRank.compareTo(pCard.aRank);
   }
}
```

Current Design of Deck



Current Design of Deck



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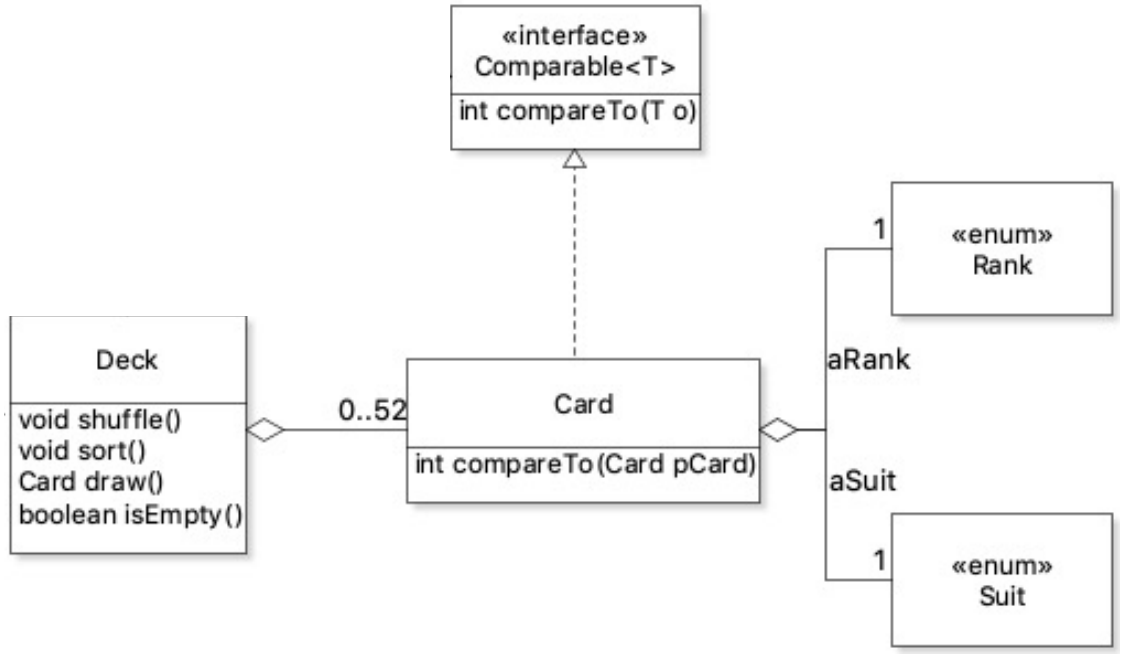

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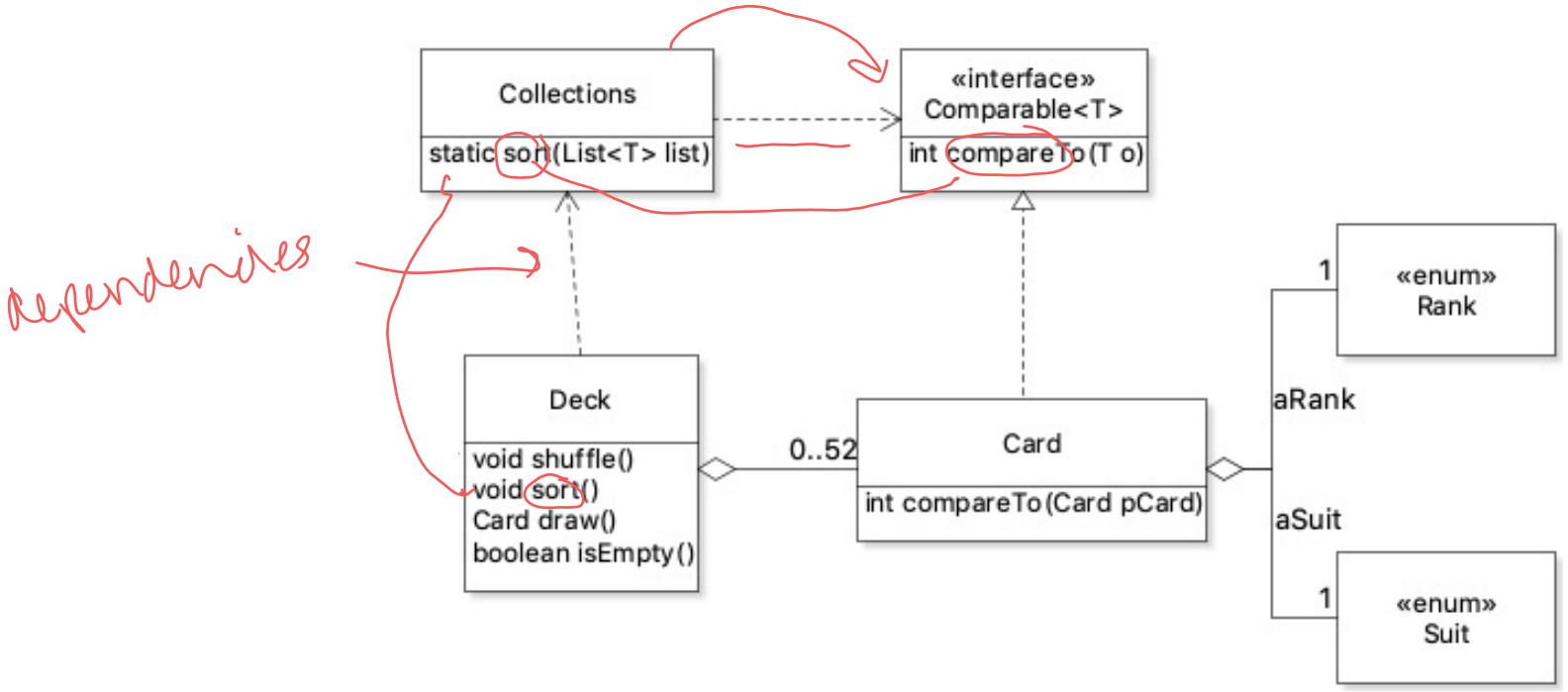

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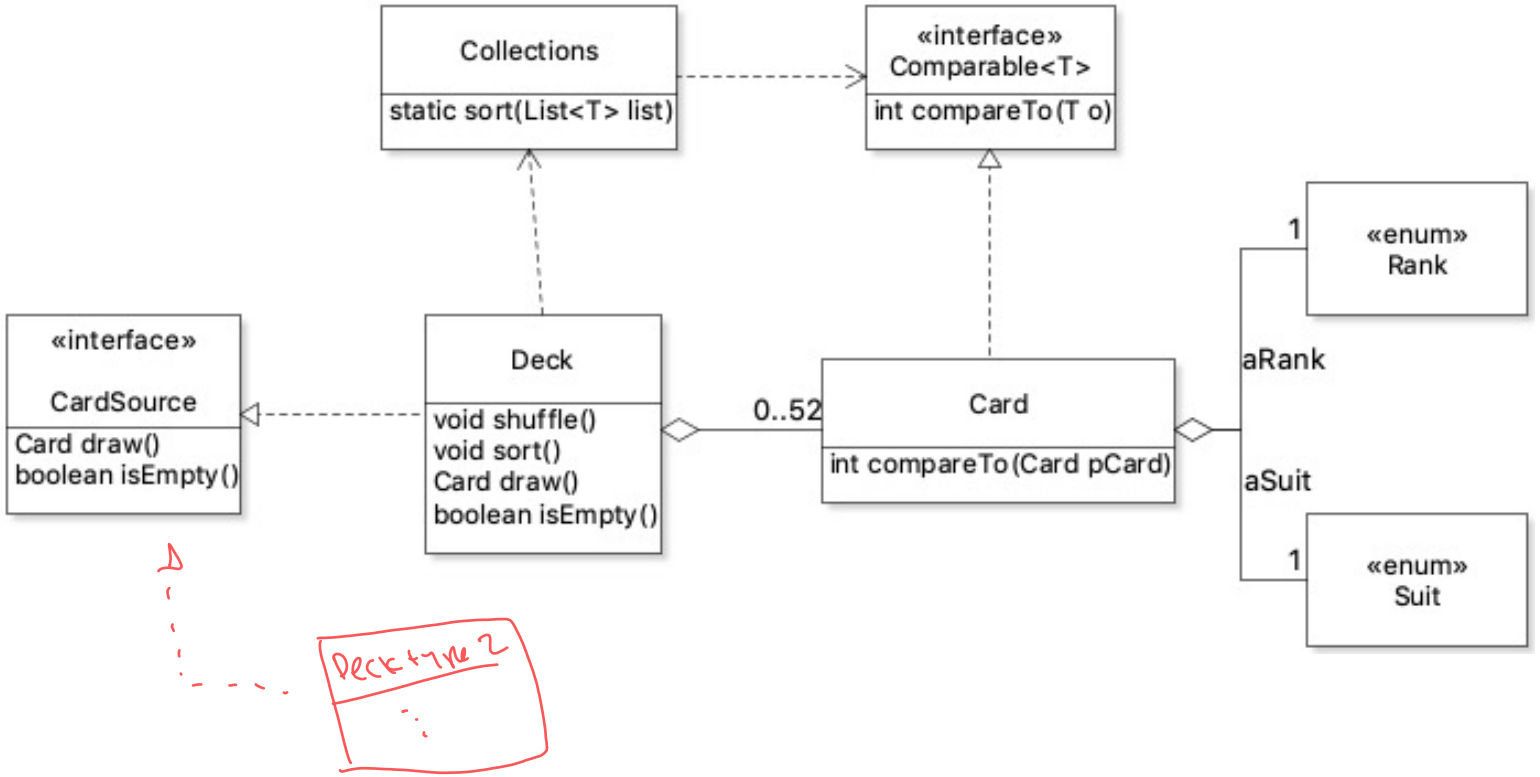
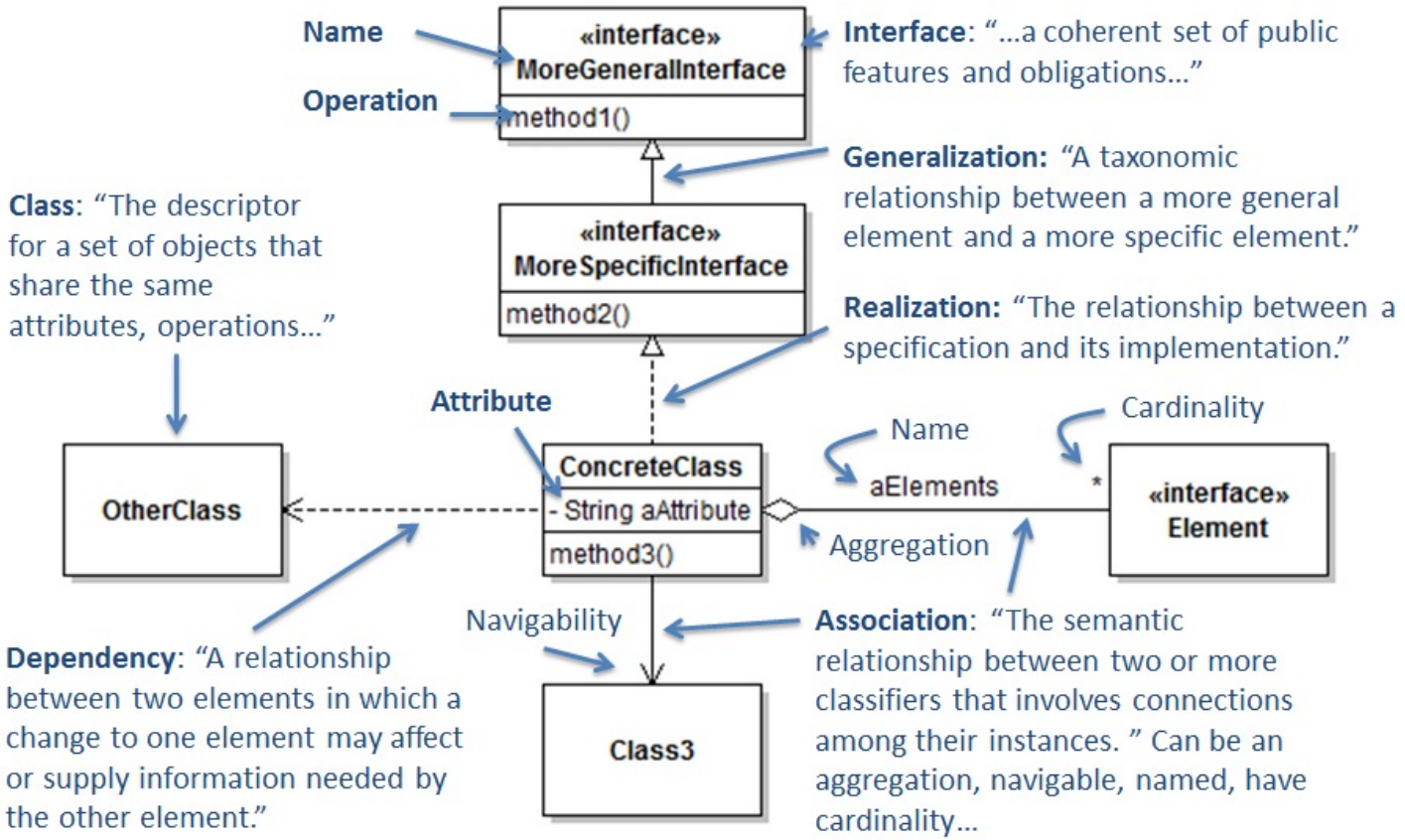


UML Class Diagram

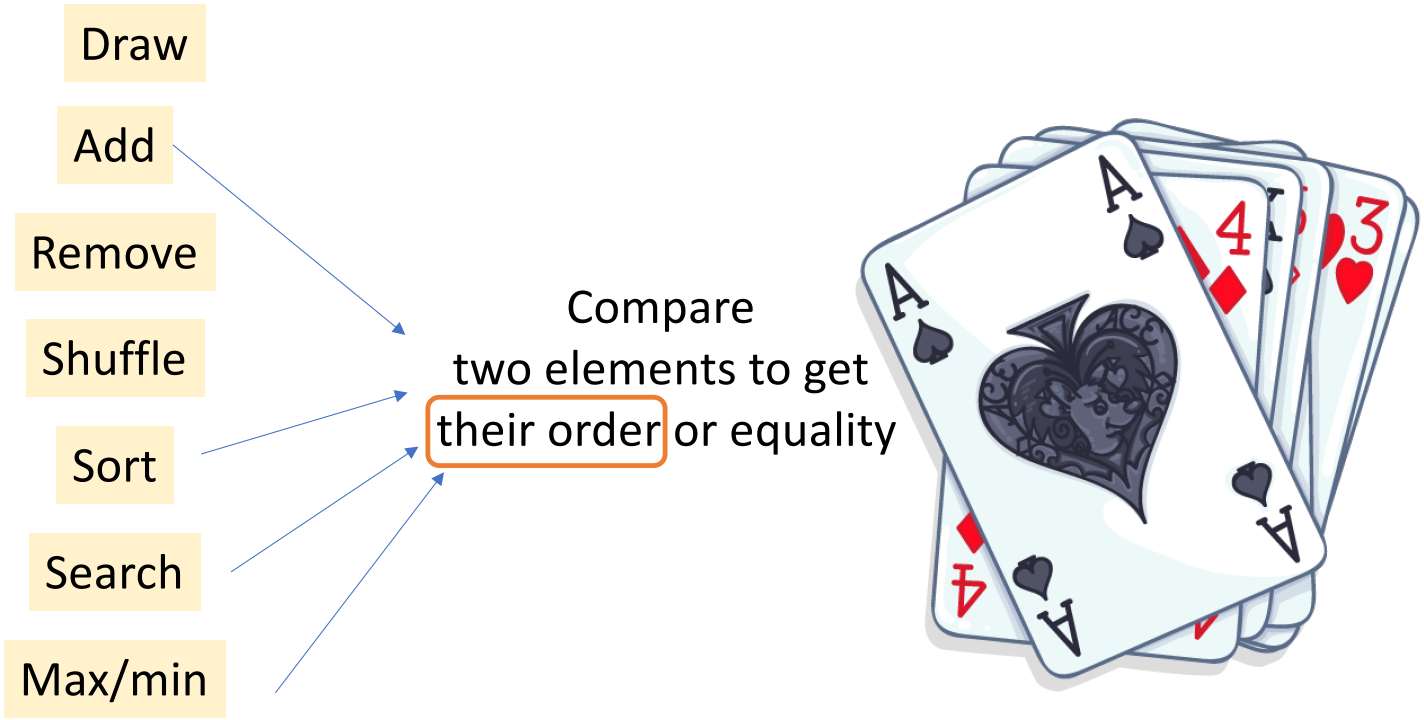
- Represent Type (mainly classes and interfaces) definitions and relations
- *Static* view (cannot show *run-time* properties)
- Tool: JetUML


Name
«interface»
MoreGeneralInterface
Operation
method1()
Interface: "...a coherent set of public features and obligations..."
Generalization: "A taxonomic relationship between a more general element and a more specific element."
«interface»
MoreSpecificInterface
method2()
Realization: "The relationship between a specification and its implementation."
Class: "The descriptor for a set of objects that share the same attributes, operations..."
Attribute
Name
Cardinality
ConcreteClass
aElements
*
«interface»
Element
OtherClass
- String aAttribute
method3()
Aggregation
Navigability
Association: "The semantic relationship between two or more classifiers that involves connections among their instances. " Can be an aggregation, navigable, named, have cardinality...
Dependency: "A relationship between two elements in which a change to one element may affect or supply information needed by the other element."
Class3

Separation of Concern

- Concern: anything that matters in providing a solution to a problem
- Prevent information Leakage
- To achieve “orthogonality”: changes in one does not affect any of the others.

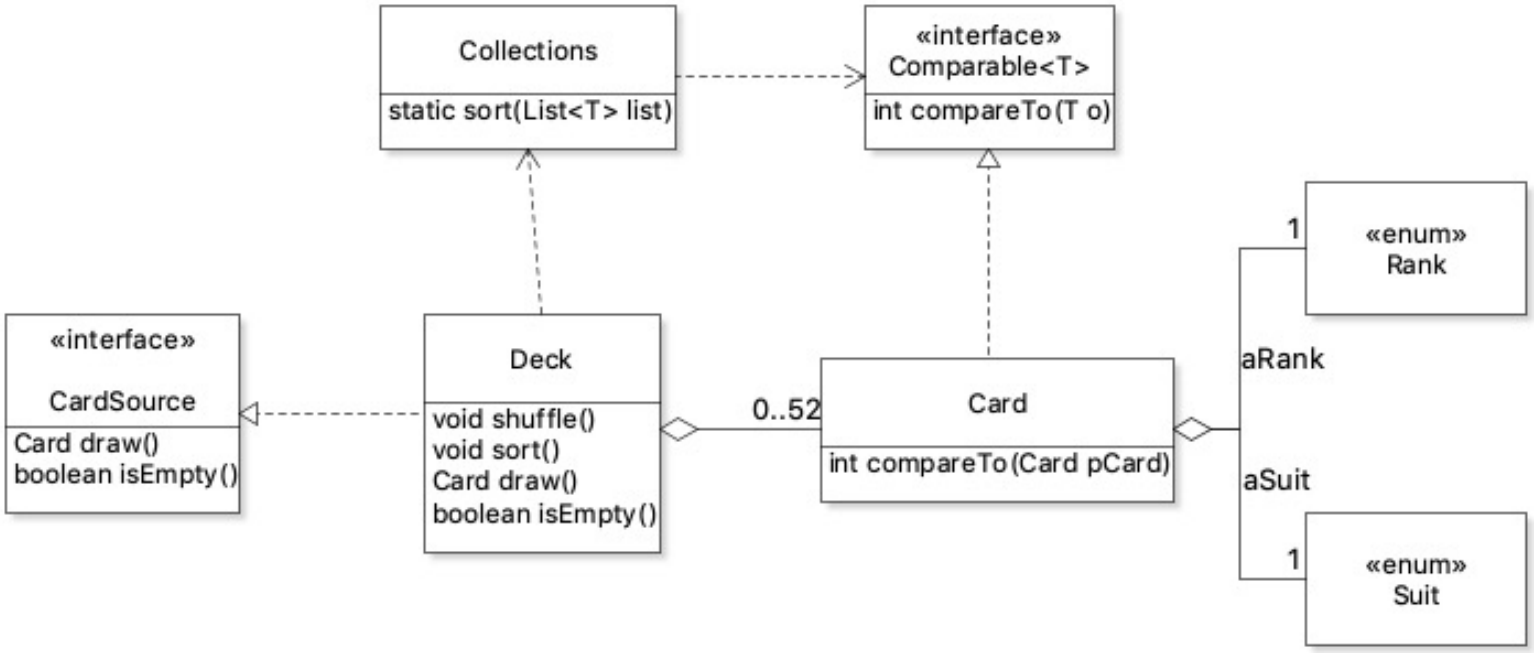
Operation on Card Collections



Information leaking

a design knowledge is reflected in many modules

How did this design apply the principle of Separation of Concern?



Summary

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