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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:

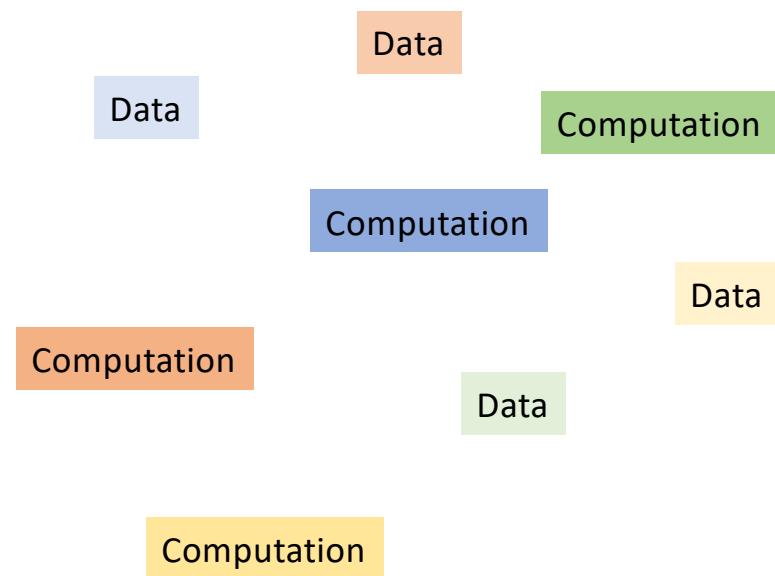
Class's interface, Separation of concerns

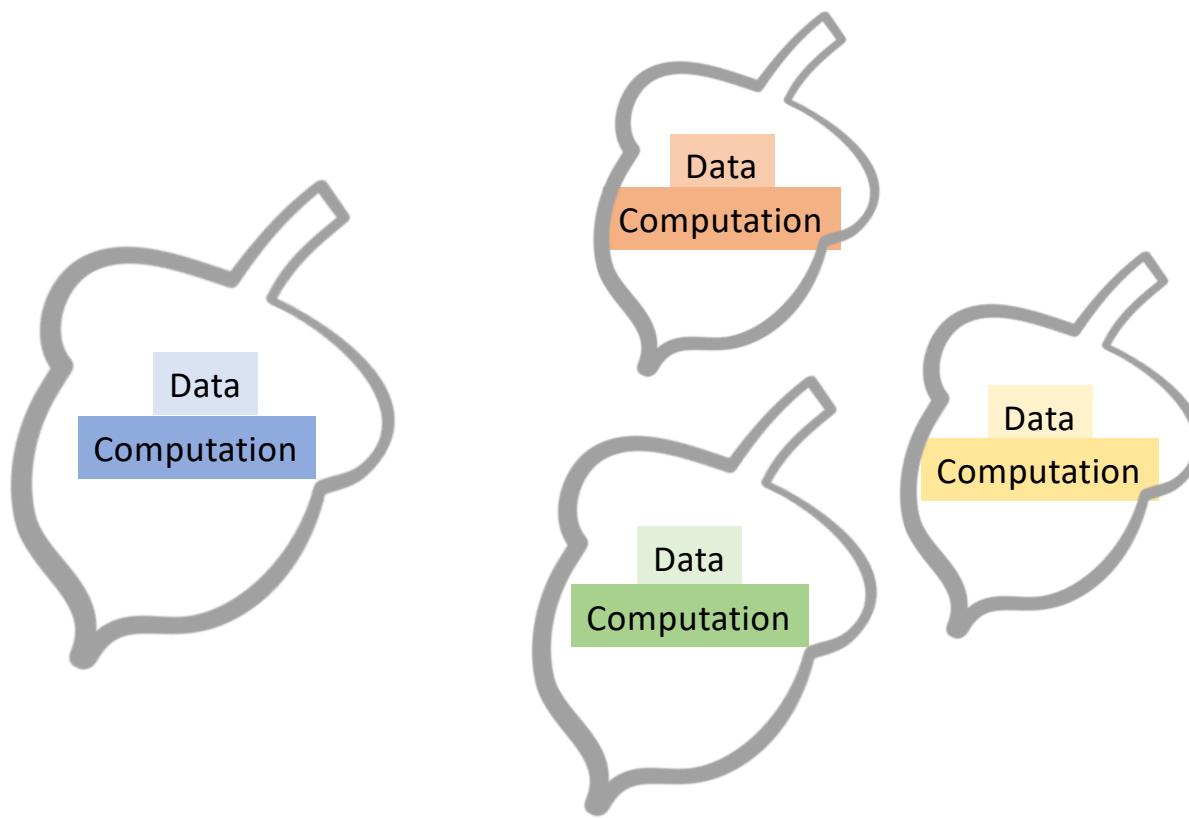
- Programming mechanism:

Java Interface type, Subtype polymorphism

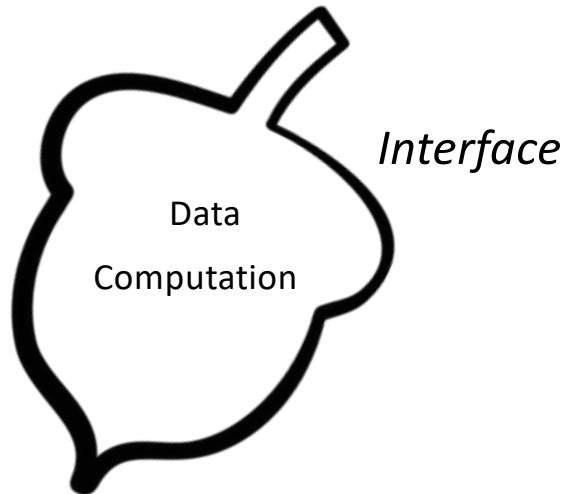
- Design techniques:

Interface-based behavior specification, UML Class Diagrams





Object Interaction



Supply the service through interface

Activity 1: **Which ones should be public?**

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

Add the grade

Iterate through grades for existing course

Update the grade

View the existing grade for certain course

Validate the grade

Print out the grade to a file

Calculate the average the grade

Open a file

Write to a file

Specification of public interface

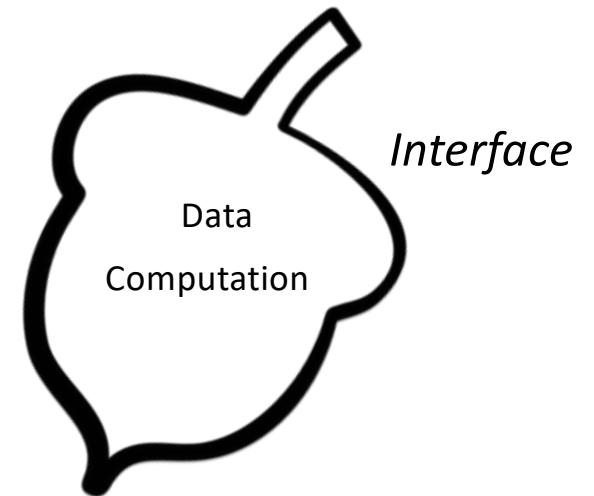
- Requires What needs be true in order call this the method?
- Modifies When this method is called,
 is the state of any object going to be changed?
- Effects What will happen if this method is called?

Add the grade

Java Interface Type

- 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();  
}
```



Subtype Relationship

```
public class Undergrad implements Student
```

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)

```
Student s1 = new Undergrad();  
String id = s1.getID();
```

Why do we need this?

```
public class Undergrad implements Student
```

```
public class Graduate implements Student
```

```
public class NonDegreeStudent implements Student
```

```
public class VisitingStudent implements Student
```

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.



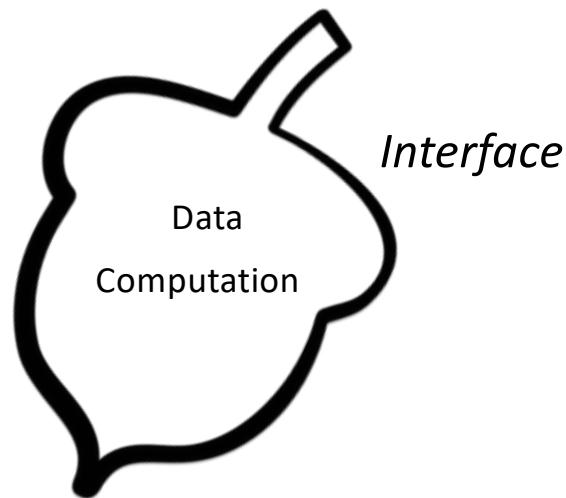
Image source: Griffith Ecology Lab (<https://griffithecology.com/>)

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)

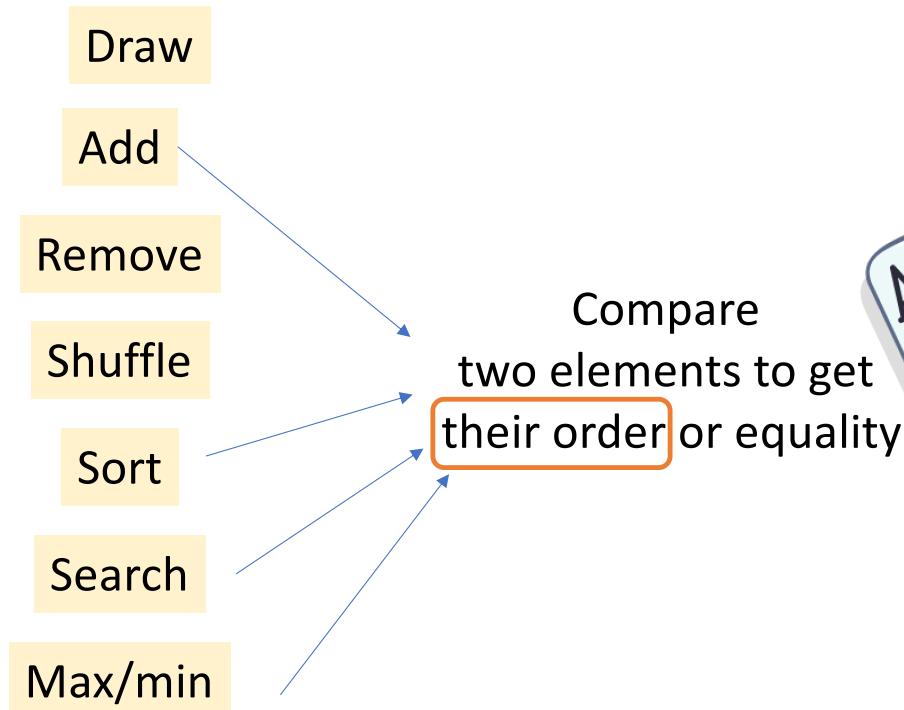
```
public class SpecialDeck extends Deck {  
    ...  
}
```

What computation should
be specified in the interface?



Look for **Orthogonality**

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

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

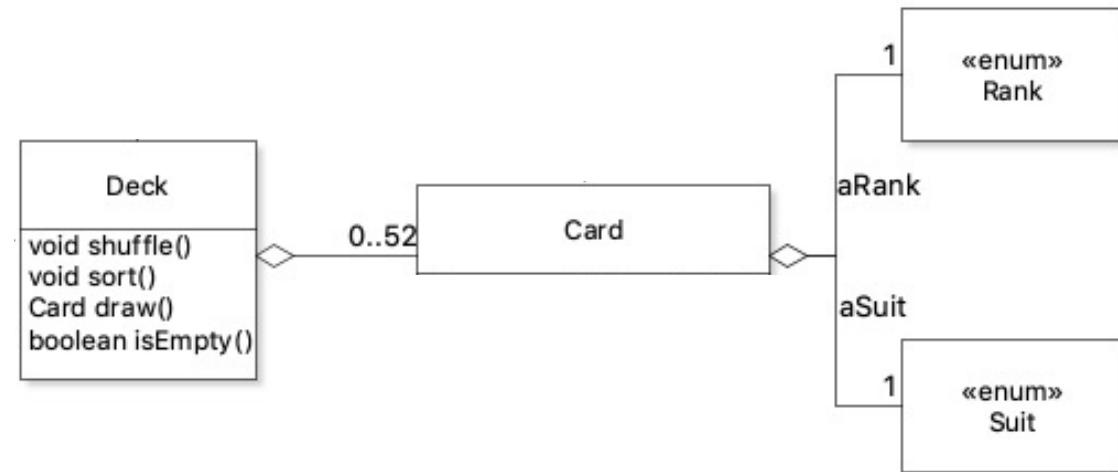
```
if(object1.compareTo(object2) > 0) /*...*/
```

Implements Comparable<T>

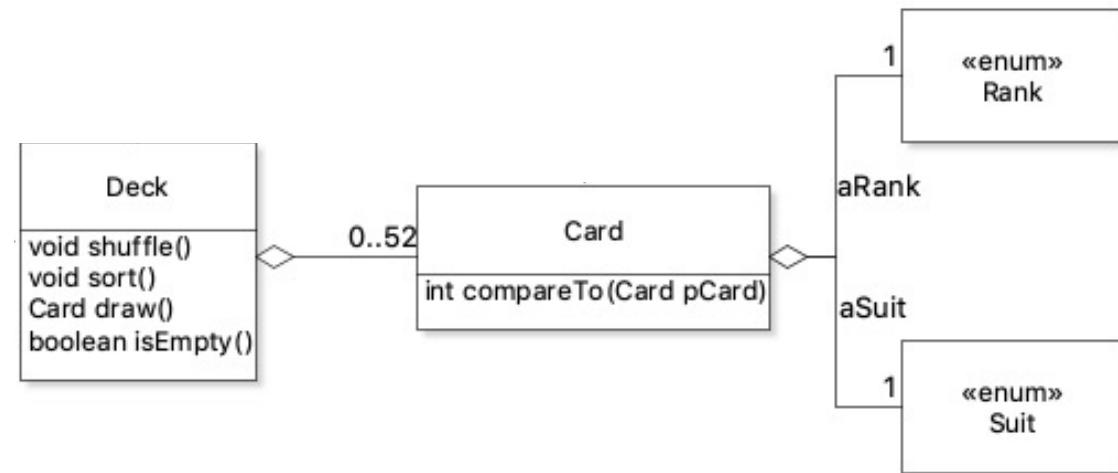
```
Collections.sort(aCards); // aCards is a List<Card> instance

public class Card implements Comparable<Card>
{
    ...
    @Override
    public int compareTo(Card pCard)
    {
        ... return aRank.compareTo(pCard.aRank);
    }
}
```

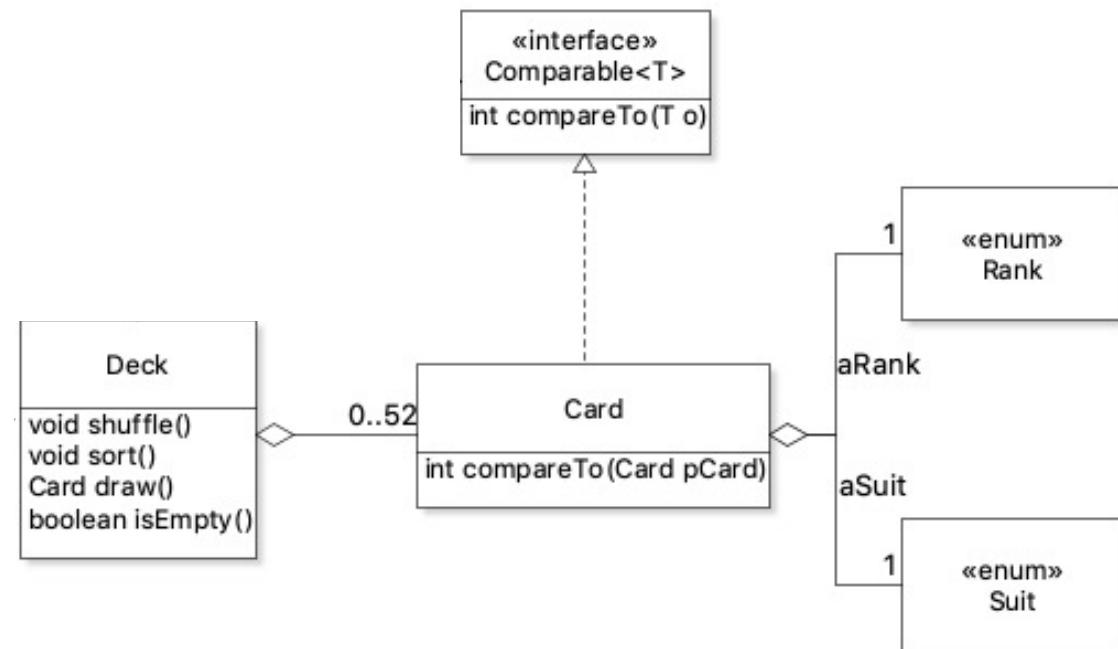
Current Design of Deck



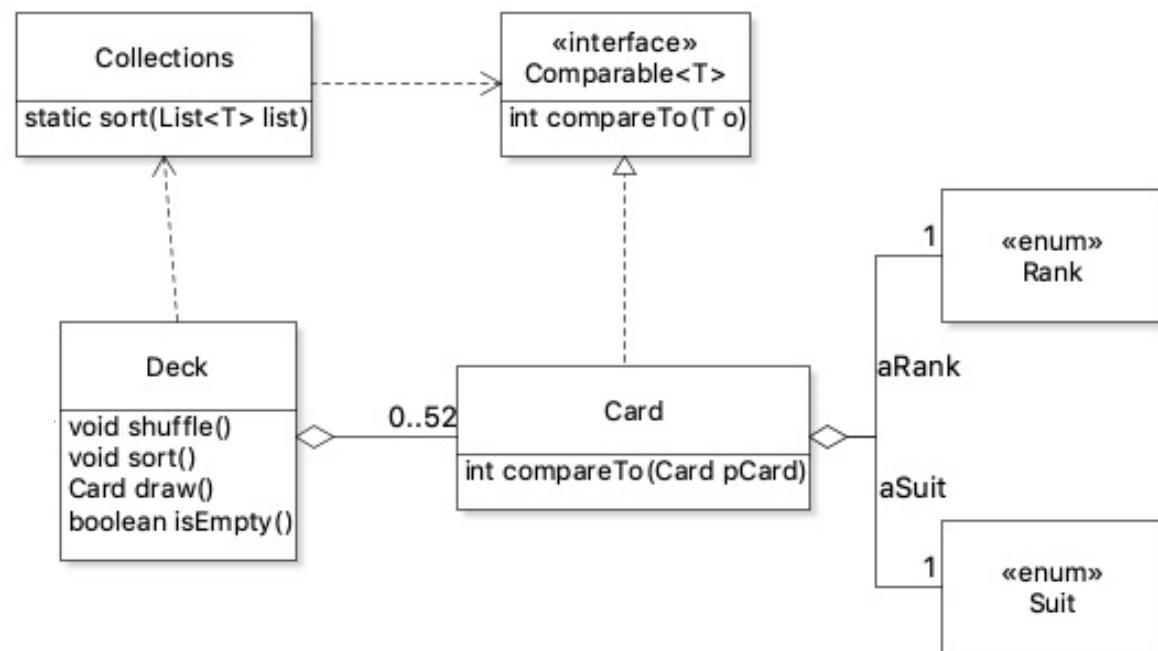
Current Design of Deck



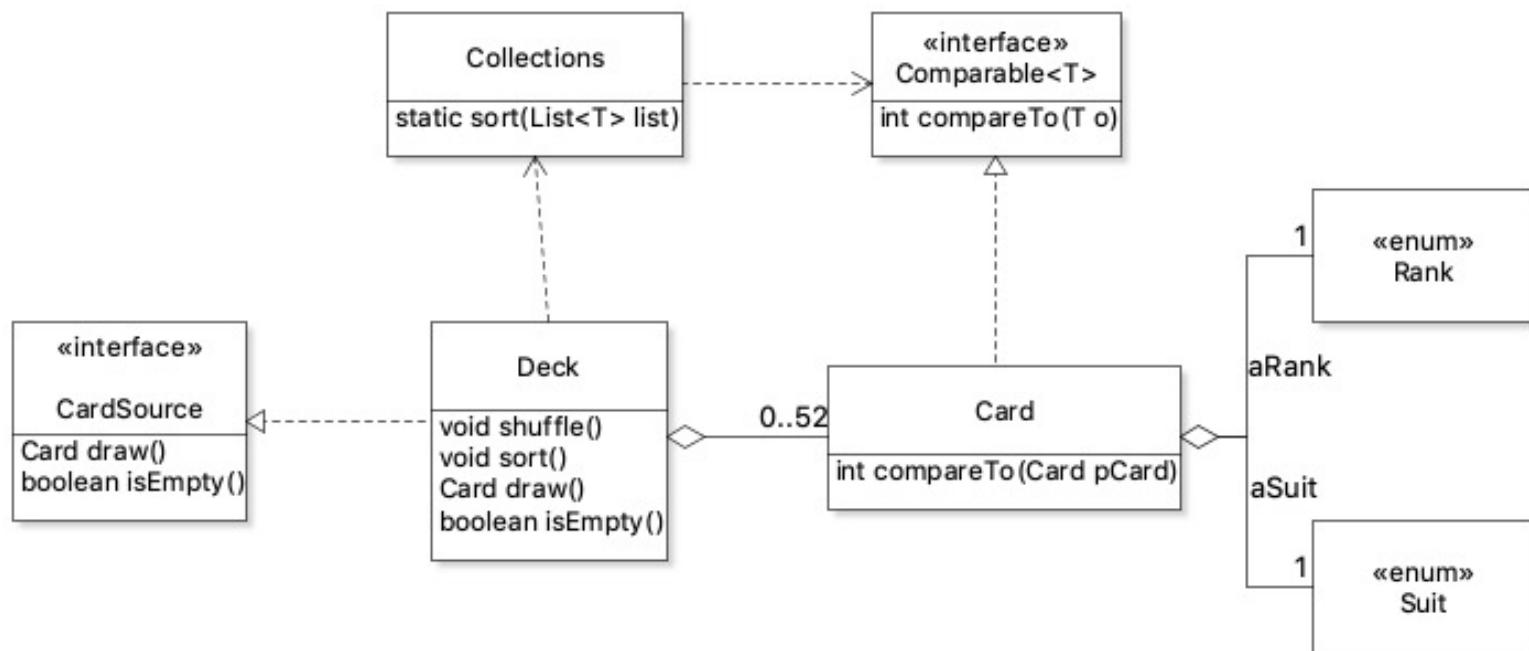
Current Design of Deck



Current Design of Deck

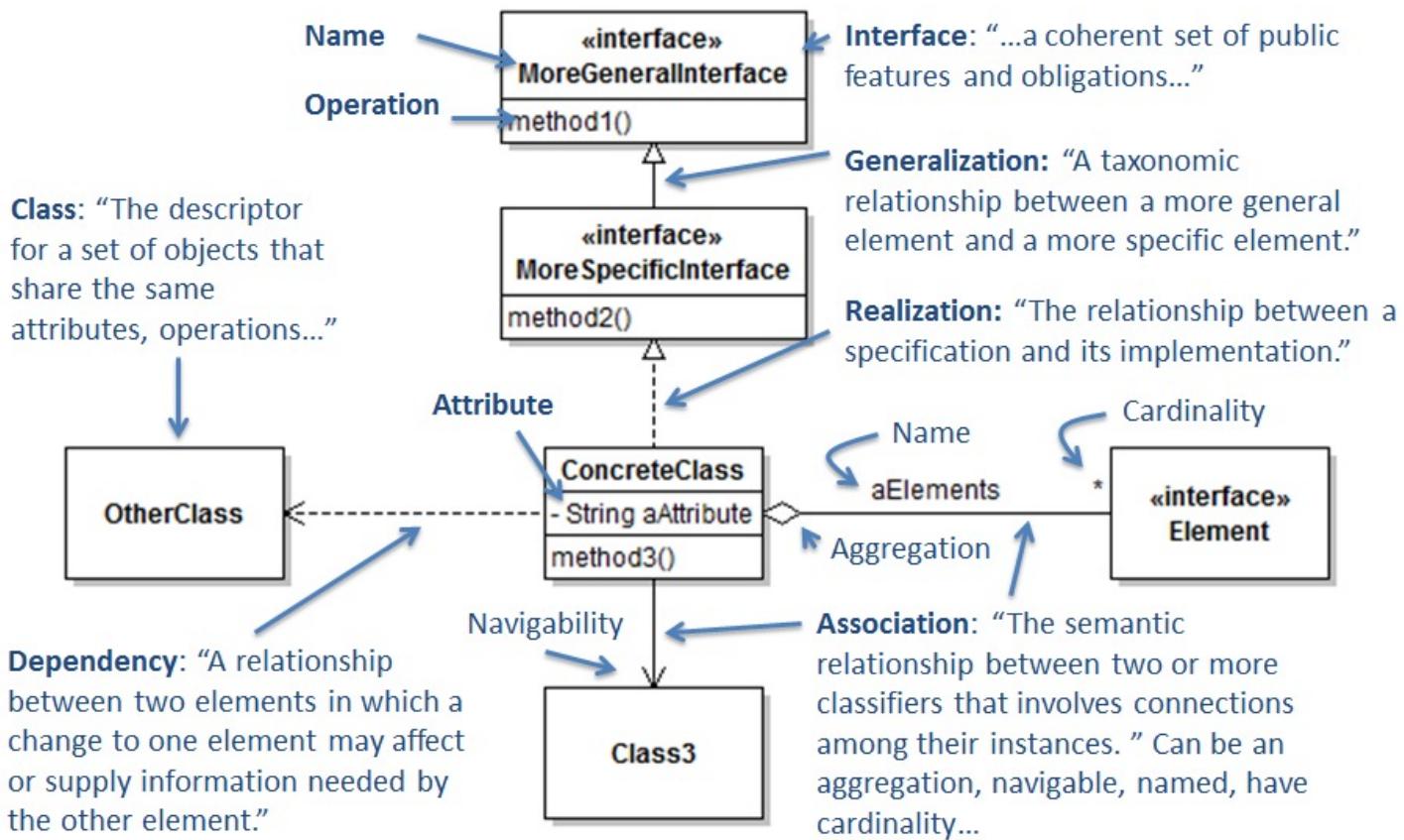


Current Design of Deck



UML Class Diagram

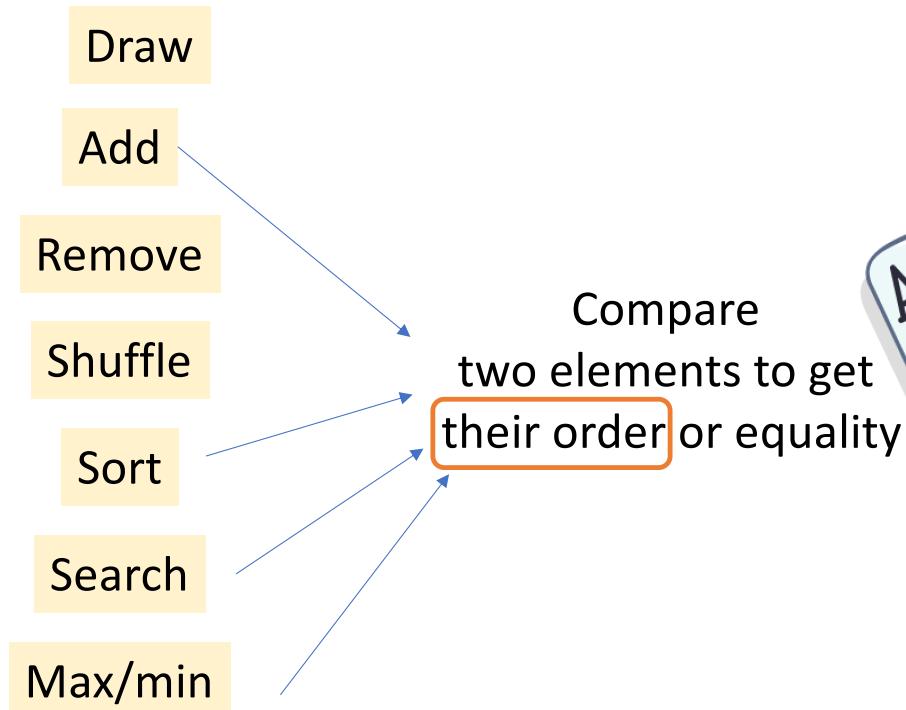
- Represent Type (mainly classes and interfaces) definitions and relations
- *Static* view (cannot show *run-time* properties)
- Tool: JetUML



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.

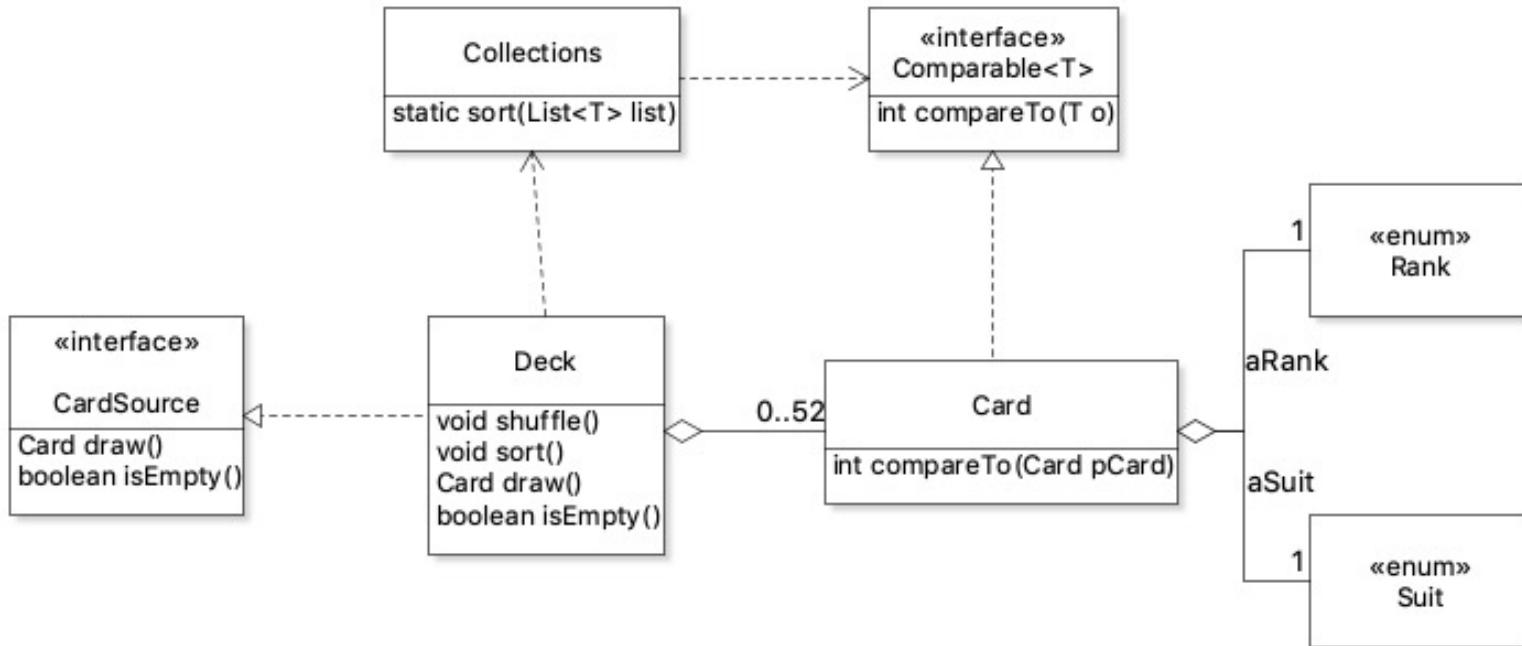
Operation on Card Collections



Information leaking

a design knowledge is reflected in many modules

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



Summary

- 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