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M2 (b) - Types and Polymorphism

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

Recall of last class

- Programming mechanism:

Java Interface type, Subtype polymorphism

- Concepts and Principles:

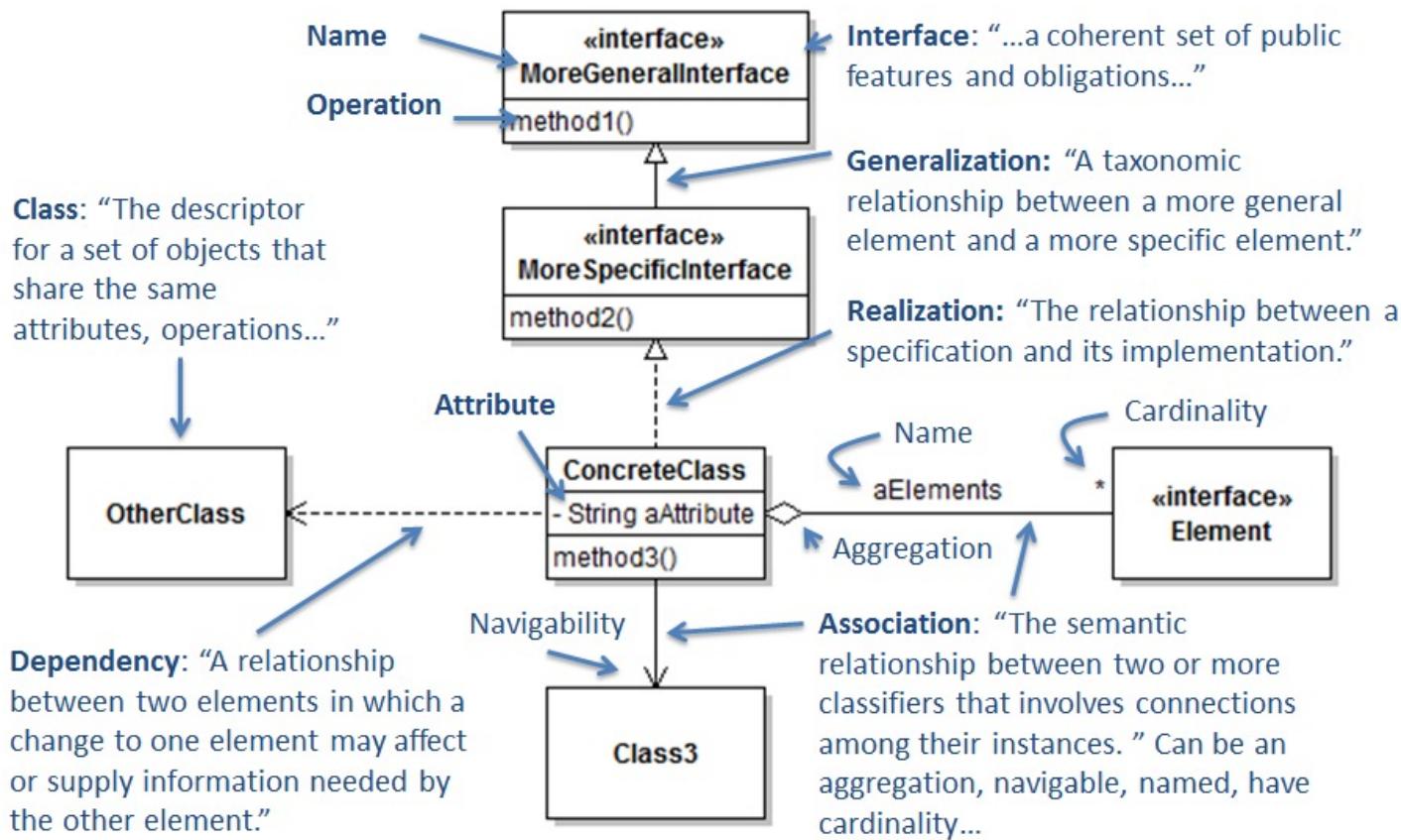
class's interface, Separation of concerns

- Design techniques:

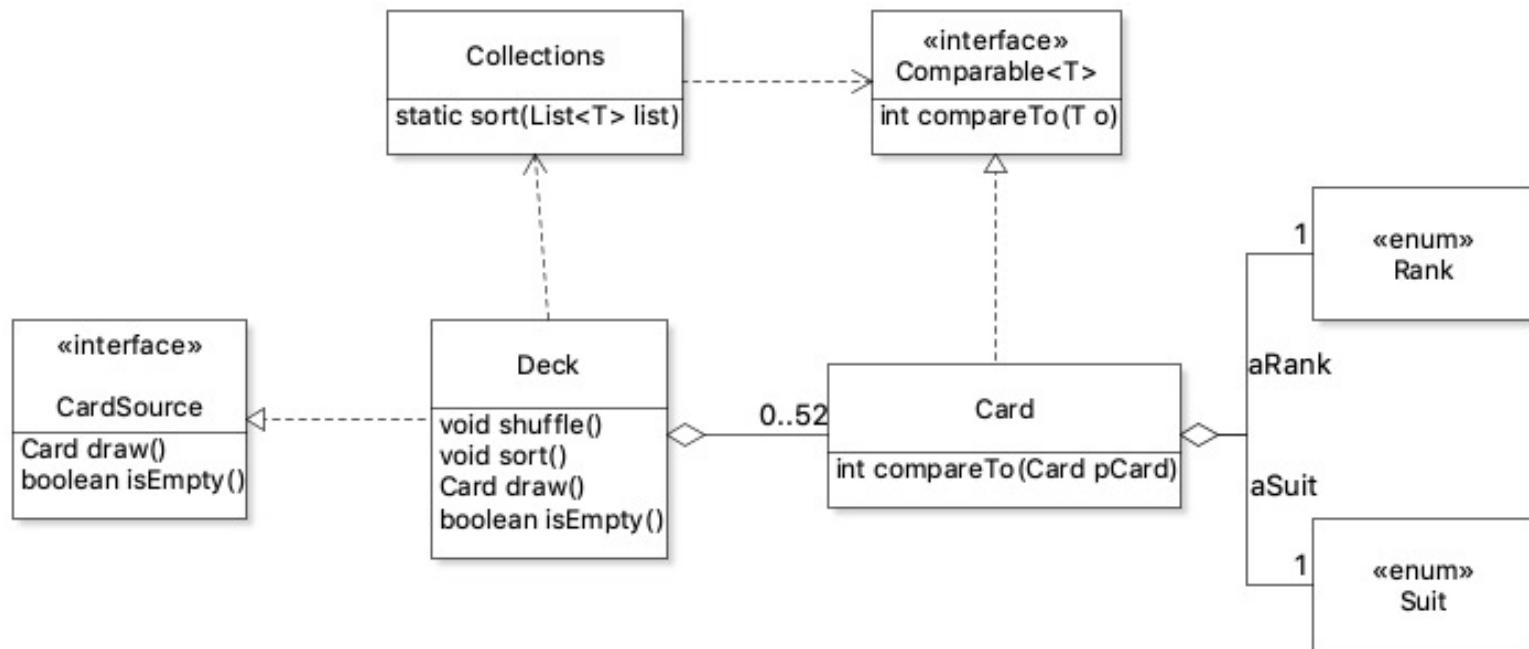
Interface-based behavior specification, UML Class Diagrams

UML Class Diagram

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



Current Design of Deck



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.

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);
    }
}
```

compareTo in Enum

compareTo

```
public final int compareTo(E o)
```

Compares this enum 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. Enum constants are only comparable to other enum constants of the same enum type. The natural order implemented by this method is the order in which the constants are declared.

Specified by:

[compareTo in interface Comparable<E extends Enum<E>>](#)

Parameters:

`o` - the object to be compared.

Returns:

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

Objective

- Programming mechanism:
Java Generics, Java Nested Classes
- Concepts and Principles:
Separation of concerns;
- Patterns and Antipatterns:
STRATEGY, SWITCH Statement 
- Design techniques:
Function objects

Java Generics

```
public interface ListOfCard {  
    boolean add(Card pElement);  
    Card get(int index);  
}
```

```
public interface ListOfNumbers {  
    boolean add(Number pElement);  
    Number get(int index);  
}
```

```
public interface ListOfIntegers {  
    boolean add(Integer pElement);  
    Integer get(int index);  
}
```

... ...

Java Generics

- Purpose: make the code reusable for many different types

```
boolean add(Number pElement);  
Number get(int index);
```

```
public interface List<E> {  
    boolean add(E pElement);  
    E get(int index);  
}
```



Java Generics

- Generic Types

- A class or interface whose declaration has one or more type parameter

Convention:

E for Element

K for Key

V for Value

T for Type

```
List<Card> cards;
```

Type Argument

Generic type invocation(Parameterized Type)

```
Raw Type ←  
public interface List<E> {  
    boolean add(E pElement);  
    E get(int index);  
}
```

Type Parameter/Variable →

Recall 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);
}

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

Activity 1: Design a generic class that represents a pair of objects with the same type.



```
public class Pair<T>
{
    final private T aFirst;
    final private T aSecond;

    public Pair(T pFirst, T pSecond)
    {
        aFirst = pFirst;
        aSecond = pSecond;
    }

    public T getFirst() { return aFirst; }
    public T getSecond() { return aSecond; }
}
```

```
Pair<Card> pair =
    new Pair<>(new Card(Rank.FIVE, Suit.CLUBS),
                 new Card(Rank.FOUR, Suit.CLUBS));
Card card1 = pair.getFirst();
```

Type Inferred by Compiler

Java Generics

- Generic Method
 - A method that takes type parameters

emptySet method in java.util.Collections:

```
public static <T> Set<T> emptySet()  
    ↗  
    Type Parameter  
Between Modifier and Return Type
```

Activity 2:

Write a static generic method that add elements of Pair in any type to a collection of the same type.

```
public class Pair<T>
{
    final private T aFirst;
    final private T aSecond;

    public Pair(T pFirst, T pSecond)
    {
        aFirst = pFirst;
        aSecond = pSecond;
    }

    public T getFirst() { return aFirst; }
    public T getSecond() { return aSecond; }
}
```

Interface Collection<E>

boolean add(E e)

Activity 2

Write a generic method that add elements of Pair in any type to a collection of the same type.

```
/*
 * Add the elements of type T stored in Pair to a Collection of Type T
 * @pre pair !=null && collection != null
 * @pre pair.getFirst()!=null && pair.getSecond()!=null
 * @post collection.contains(pair.getFirst()) && collection.contains(pair.getSecond())
 *
 * @see Pair
 */
static <T> void fromPairToCollection(Pair<T> pair, Collection<T> collection) {
    /* assertion on pre conditions*/
    collection.add(pair.getFirst());
    collection.add(pair.getSecond());
    /* assertion on post conditions*/
}
```

Adding Restriction on Type Variables

```
public class Pair<T>
{
    final private T aFirst;
    final private T aSecond;

    public Pair(T pFirst, T pSecond)
    {
        aFirst = pFirst;
        aSecond = pSecond;
    }

    public T getFirst() { return aFirst; }
    public T getSecond() { return aSecond; }
}
```

Adding Restriction on Type Variables

```
public class Pair<T extends Deck>
{
    final private T aFirst;
    final private T aSecond;

    public Pair(T pFirst, T pSecond)
    {
        aFirst = pFirst;
        aSecond = pSecond;
    }

    public T getFirst() { return aFirst; }
    public T getSecond() { return aSecond; }
}

public boolean isTopCardSame()
{
    Card topCardInFirst = aFirst.draw();
    Card topCardInSecond = aSecond.draw();
    return topCardInFirst.equals(topCardInSecond);
}
```

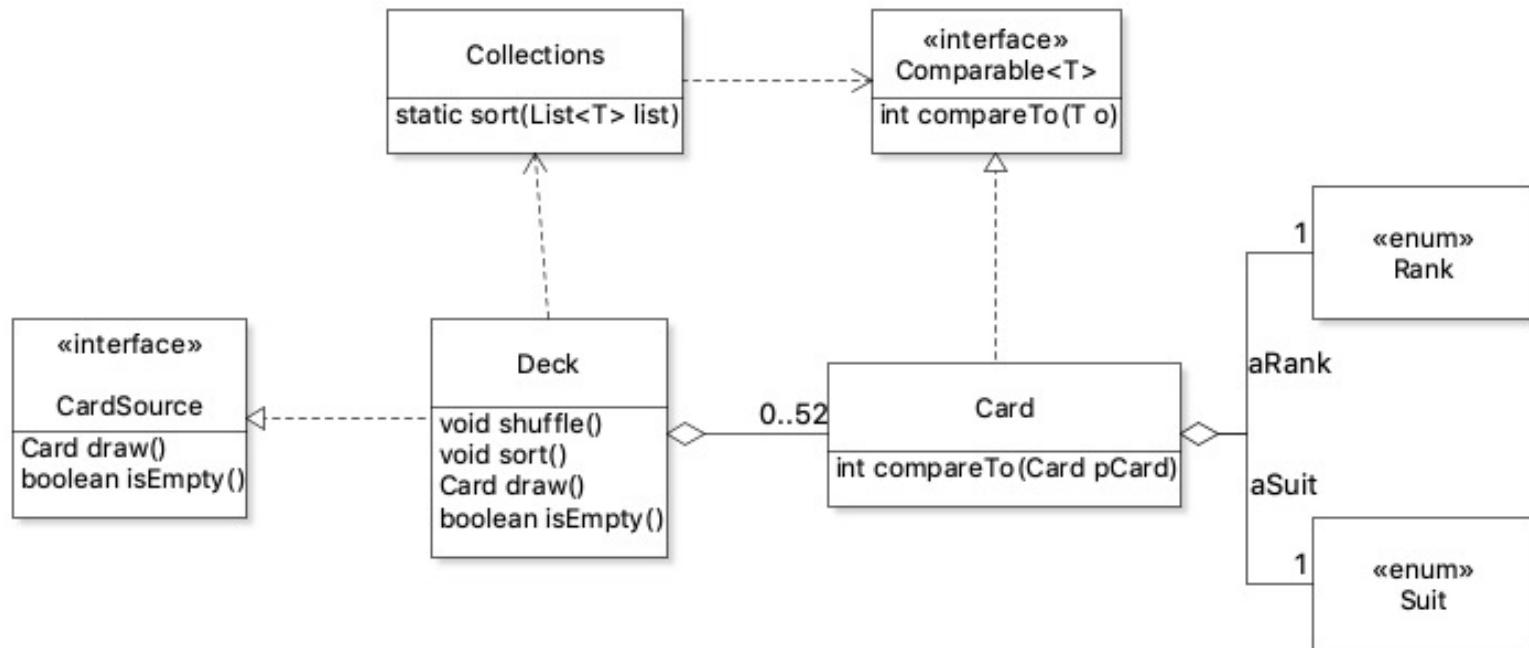
Type can only be Deck
or its subtype

call methods of Deck

Generic Method With Type Bound

```
static <T extends Deck>
void fromPairToCollection(Pair<T> pair, Collection<T> collection) {}
```

Back to the sort method for comparable types



Back to the sort method for comparable types

- In `java.util.collections`

```
public static <T extends Comparable<? super T>> void sort(List<T> list)
```

```
class Card implements Comparable<Card> {...}
```

```
class FancyCard extends Card {...}
```

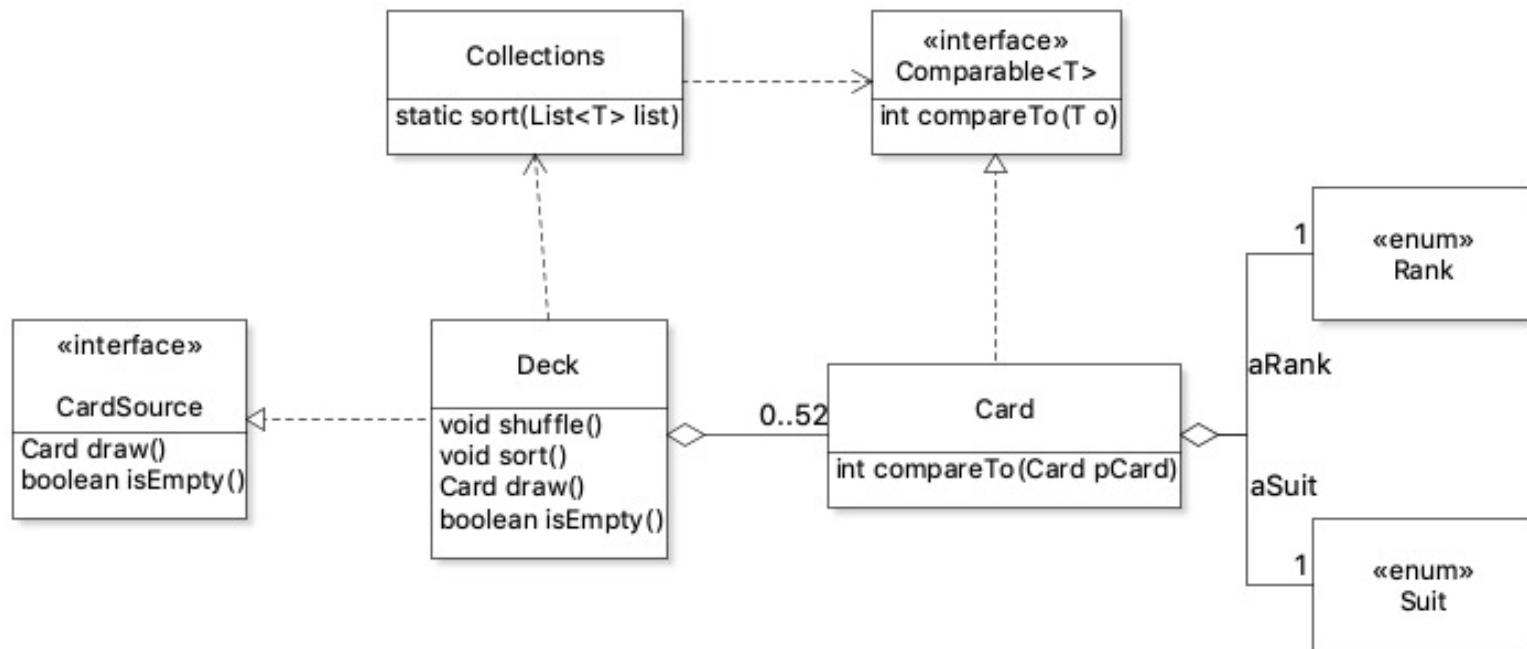
```
List<FancyCard> fancyCardList = new ArrayList<>();
```

```
Collections.sort(fancyCardList);
```

Objective

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Current Design of Deck



How to support more than one strategy to compare cards?

Activity 3

Design a UniversalComarator that can compare two cards with more than one strategies including by rank, suit, reversed rank, suit first then rank.



```
public class UniversalComparator {  
    public enum ComparisonStrategy {ByRank, BySuit, ByRankThenSuit}  
  
    ComparisonStrategy aStrategy;  
    public UniversalComparator(ComparisonStrategy pStrategy) {  
        aStrategy = pStrategy;  
    }  
    public int compare(Card c1, Card c2) {  
        switch (aStrategy) {  
            case ByRank:  
                return compareByRank(c1, c2);  
            case BySuit:  
                return compareBySuit(c1, c2);  
            case ByRankThenSuit:  
                return compareByRankThenSuit(c1, c2);  
            default:  
                throw new AssertionError(this);  
        }  
    }  
  
    private int compareBySuit(Card c1, Card c2) {  
        ...  
    }  
...}
```

Recall Polymorphism

```
public class Undergrad implements Student
```

```
public class Graduate implements Student
```

```
public class NonDegreeStudent implements Student
```

```
public class VisitingStudent implements Student
```

Polymorphic Student

Program to the interface

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

Can we do the same thing for the compare strategy?

Recall Polymorphism

```
public class ComparatorBySuit implements Comparator
```

```
public class ComparatorByRank implements Comparator
```

```
public class ComparatorBySuitThenRank implements Comparator
```

```
public class ComparatorByRankReverse implements Comparator
```

Polymorphic Comparator

Client Program to the interface

```
public void sort(Comparator pComparator)
{
    ...
    if pComparator.compare(card1, card2))
    ...
}
```

Java Comparator Interface

- **Interface Comparator<T>**

```
public int compare(T o1, T o2)
```

Compares its two arguments for order. Returns a negative integer, zero, or a positive integer as the first argument is less than, equal to, or greater than the second.

ByRank Comparator

```
public class ByRankComparator implements Comparator<Card> {

    @Override
    public int compare(Card pCard1, Card pCard2) {
        return pCard1.getRank().compareTo(pCard2.getRank());
    }
}
```

BySuit Comparator

```
public class BySuitComparator implements Comparator<Card>
{
    @Override
    public int compare(Card pCard1, Card pCard2) {
        return pCard1.getSuit().compareTo(pCard2.getSuit());
    }
}
```

Another sort method provided by Java Collections

- In `java.util.collections`

```
public static <T> void sort(List<T> list, Comparator<? super T> c)
```

```
Collections.sort(aCards new ByRankComparator());
```

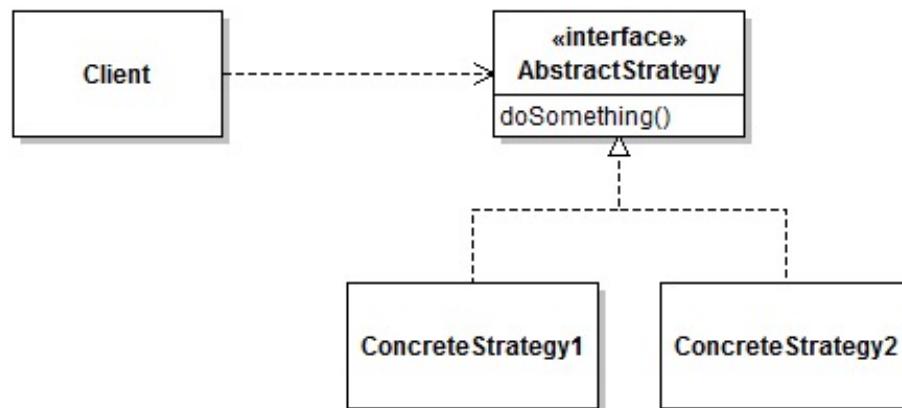
```
List<Card>
```

Objective

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Strategy Design Pattern

- Define a family of algorithms, encapsulate each one, and make them interchangeable. Strategy lets the algorithm vary independently from clients that use it.

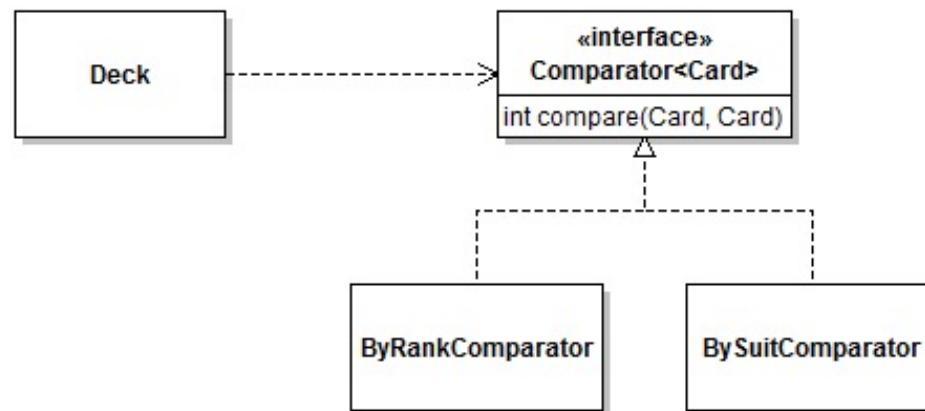


Algorithms are appropriate at different times

New Algorithms need to be introduced when necessary

Strategy Design Pattern

- Define a family of algorithms, encapsulate each one, and make them interchangeable. Strategy lets the algorithm vary independently from clients that use it.



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- ~~Design techniques:~~
Function objects

Function Object

- An interface with single abstract method
- The actual function is achieved by the object of a class which implements that interface

Function Object

```
Collections.sort(aCards, new ByRankComparator());
```

- An interface with single abstract method
- The actual function is achieved by the object of a class which implements that interface

Function Object

```
Collections.sort(aCards, new ByRankComparator());
```

- An interface with single abstract method
- The actual function is achieved by the object of a class which implements that interface

Is the function is only used once?

Should the function have state?

Does the function need to access the private field?

Anonymous Class

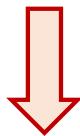
- An inner class that is declared and instantiated at the same time.

```
class OuterClass
{
    public void method()
    {
        SuperType instance = new SuperType() {
            ...
        };
    }
}
```

Anonymous Class for Function Object

```
public class ByRankComparator implements Comparator<Card> {  
    @Override  
    public int compare(Card pCard1, Card pCard2) {  
        return pCard1.getRank().compareTo(pCard2.getRank());  
    }  
}
```

```
Collections.sort(aCards, new ByRankComparator());
```



Interface to implement or class to extend

```
Collections.sort(aCards, new Comparator<Card>() {  
    public int compare(Card pCard1, Card pCard2) {  
        return pCard1.getRank().compareTo(pCard2.getRank());  
    }  
});
```

Enable access to the private field

```
public class Card
{
    public static Comparator<Card> createByRankComparator()
    {
        return new Comparator<Card>()
        {
            @Override
            public int compare(Card pCard1, Card pCard2) {
                return pCard1.aRank.compareTo(pCard2.aRank);
            }
        };
    }
}
```

Objective

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- Concepts and Principles:

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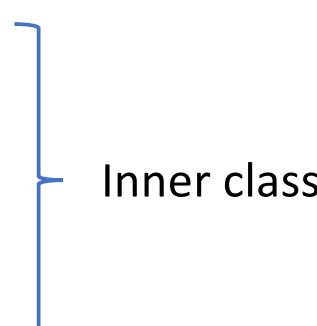
- Patterns and Antipatterns:

STRATEGY, SWITCH Statement 

- Design techniques:

Function objects

Java Nested Classes

- Classes defined within another class
 - Static member class
 - Non-static member class
 - Local class
 - Anonymous class
- 
- Inner class

Static Member Class

```
class OuterClass {  
    ...  
    static class StaticMemberClass {  
        ...  
    }  
}  
  
OuterClass.StaticMemberClass nestedObject  
= new OuterClass.StaticMemberClass();
```

Non-Static Member Class

```
class OuterClass {  
    ...  
    class InnerClass {  
        ...  
    }  
}  
  
OuterClass.InnerClass innerObject =  
    outerObject.new InnerClass();
```

Local Class

- An inner class that is defined in a block

```
class OuterClass
{
    public void method()
    {
        class LocalClass implements Supertype {
            .....
        }
        Supertype instance = new LocalClass();
    }
}
```

Anonymous Class

- An inner class that is declared and instantiated at the same time.

```
class OuterClass
{
    public void method()
    {
        SuperType instance = new SuperType() {
            ...
        };
    }
}
```

Summary

- Programming mechanism:
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