M7 (a) - Inheritance

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Objective

- Programming mechanism:

Inheritance, subtyping, downcasting, object initialization, super calls, overriding, overloading, abstract classes, abstract methods, final classes, final methods;

- Design Techniques:

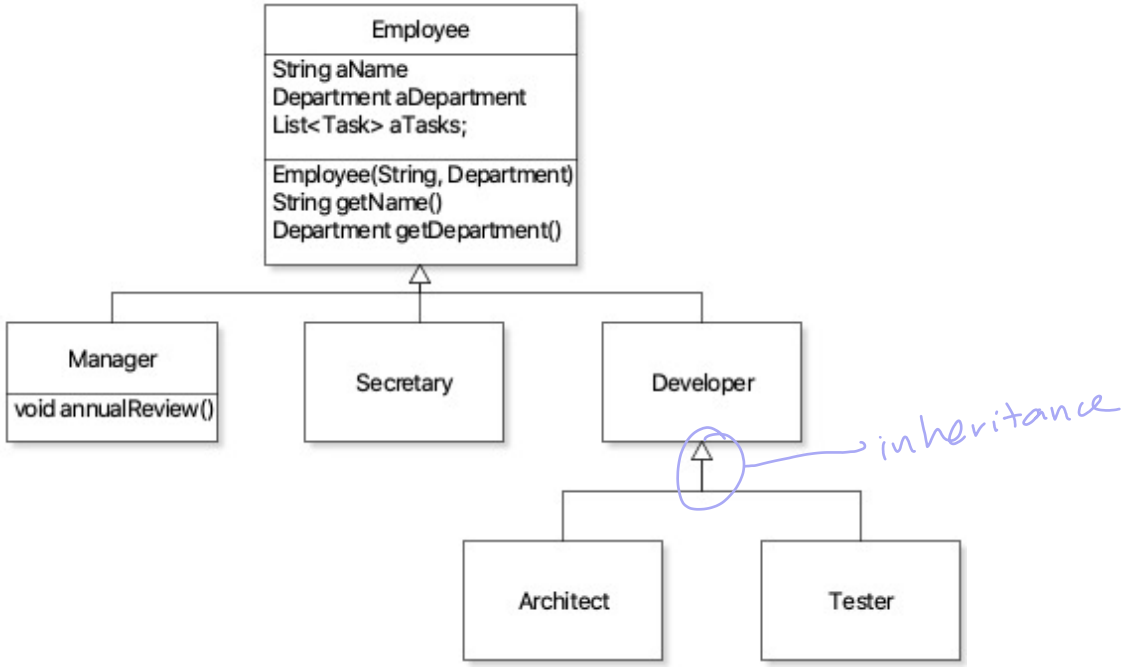
Inheritance-based reuse

- Patterns and Anti-patterns:

Template Pattern

Inheritance

"is-a"



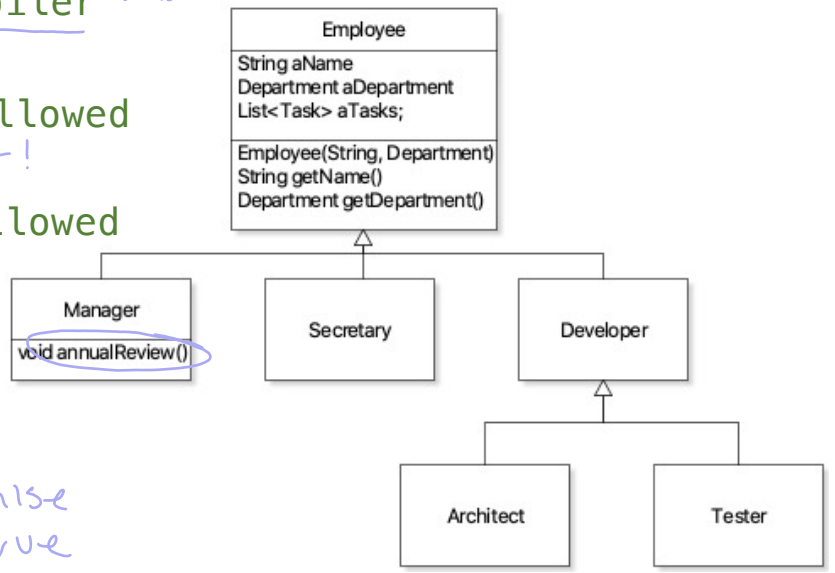
concrete class

```
Employee e1, e2;
e1 = new Developer("July", new Department("Security"));
e2 = new Manager("Diana", new Department("Security"));
```

Run-time vs Compile-time Type

```
Employee e1, e2;
e1 = new Developer("July", new Department("Security"));
e2 = new Manager("Diana", new Department("Security"));

e2.annualReview();// not allowed by the compiler

((Manager) e2).annualReview(); // compiler allowed

((Manager) e1).annualReview(); // compiler allowed
          // but run-time exception!
```

- because e2 is a general employee
↳ down cast!
↳ not actually true
might be true / is possible

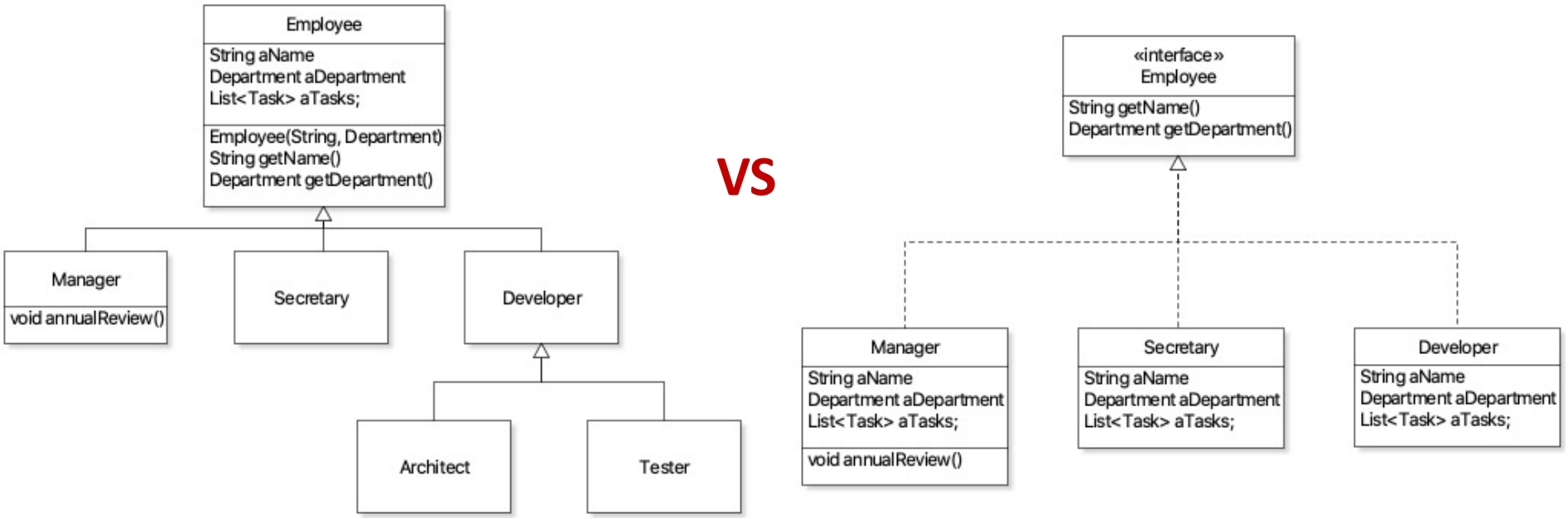



```
System.out.println(e1 instanceof Manager);
System.out.println(e2 instanceof Manager);
```

False
true

e1.getClass() == Manager.class

Comparing Inheritance and Interface

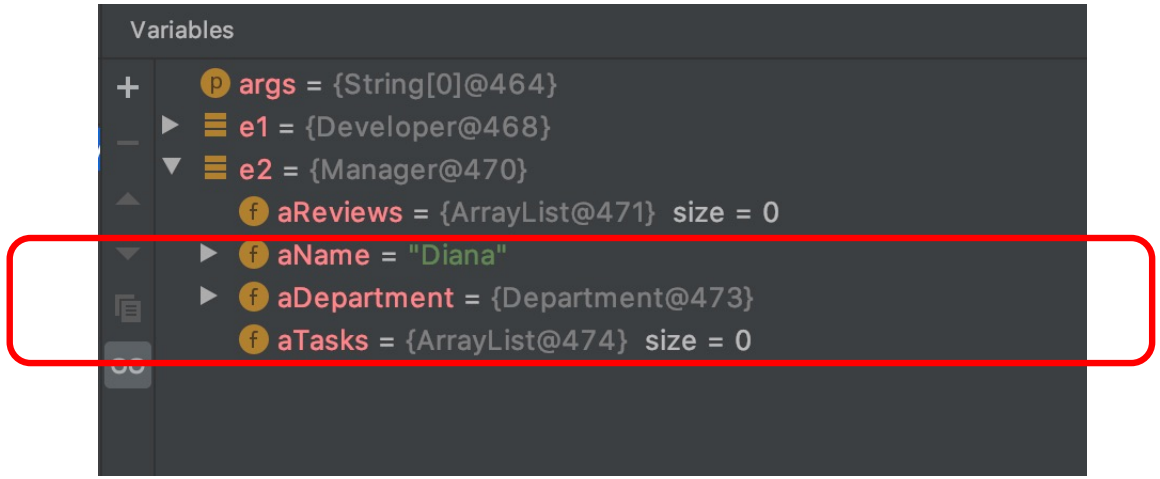


```java
public class Employee {
    private String aName;
    private Department aDepartment;
    private List<Task> aTasks = new ArrayList<>();

    Employee(String pName, Department pDepartment) {
        aName = pName;
        aDepartment= pDepartment;
    }

    ……
}
```

```java
public class Manager extends Employee
{
    private final List<Review> aReviews = new ArrayList<>();
}
```

Inheriting Fields

```
Employee e1, e2;
e1 = new Developer("July", new Department("Security"));
e2 = new Manager("Diana", new Department("Security"));
```



Subclass Constructor

```
public Manager(String pName, Department pDepartment) {
    aName = pName;
    aDepartment= pDepartment;
}
```

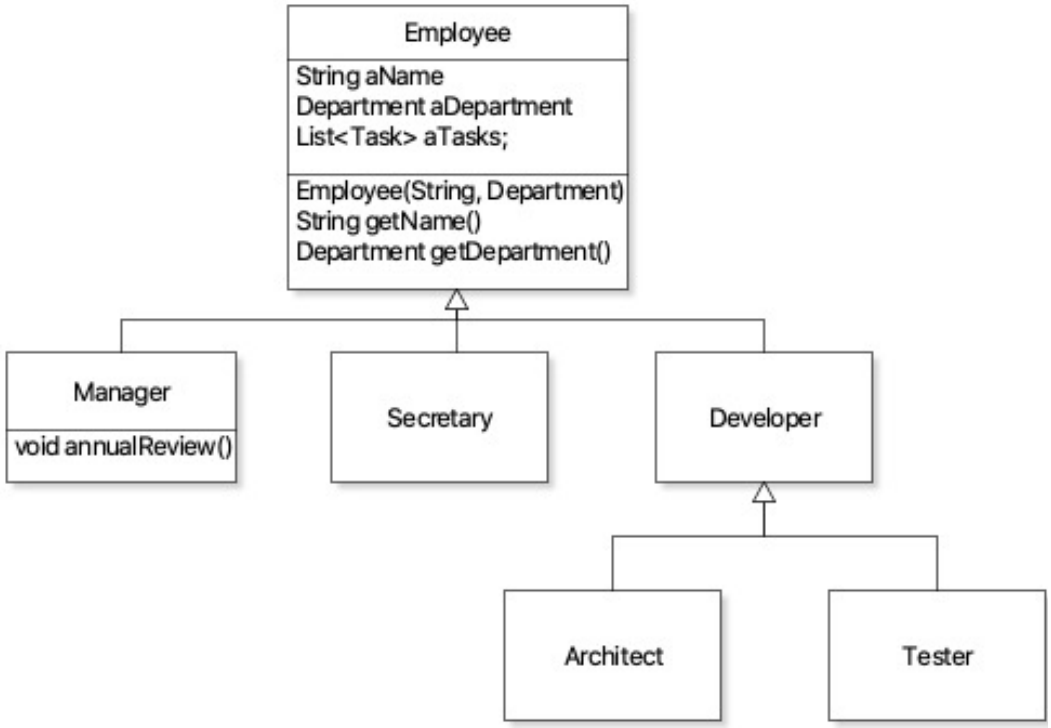
Subclass Constructor

```
public Manager(String pName, Department pDepartment) {
    super(pName, pDepartment);      new Employee(pName, pDepartment);
}
```

inherit fields and methods

Inheriting Methods

```
Employee e2 = new Manager("Diana",
     new Department("Security"));
e2.getName();
```



Override Methods

```
public class Manager extends Employee {
    private List<Review> aReviews = new ArrayList<>();


    public Manager(String pName, Department pDepartment) {
        super(pName, pDepartment);
    }


    @Override
    public String getName() {
        return "Manager " + super.getName();
    }
}
```

- Employee has getName() too

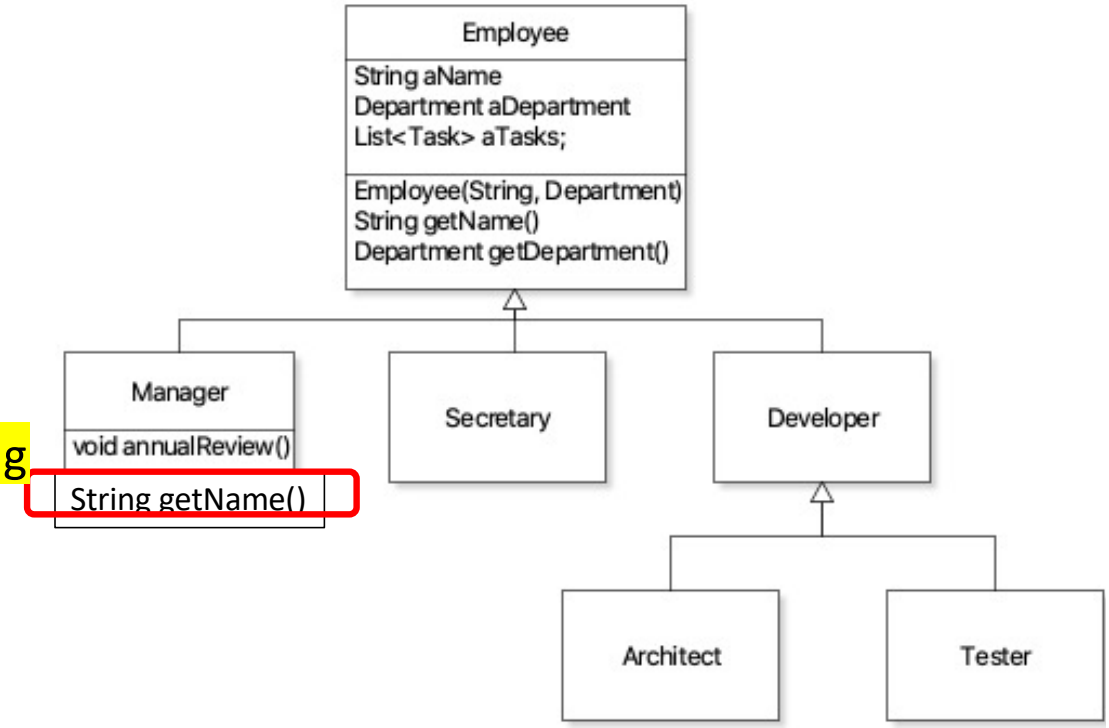
overload = same method name, different parameters

Inheriting Methods

```
Employee e2 = new Manager("Diana",
      new Department("Security"));
e2.getName();
```

uses runtime type

Dynamic Binding



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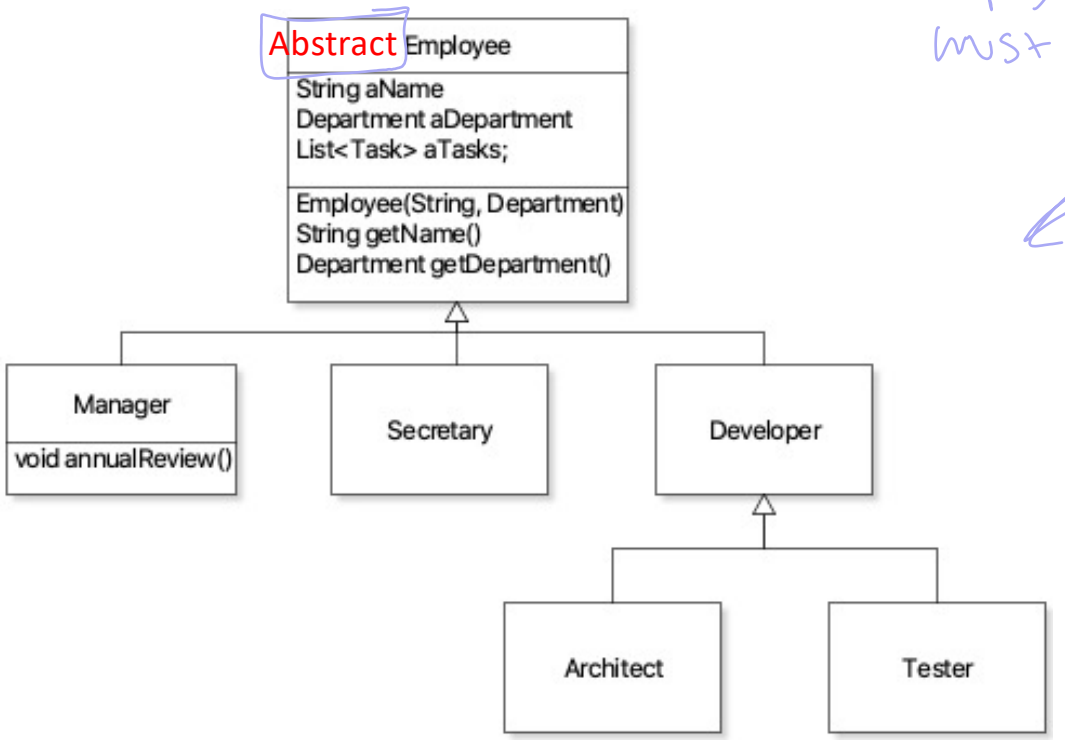
- Patterns and Anti-patterns:

Template Pattern

Abstract Class

no generic employee

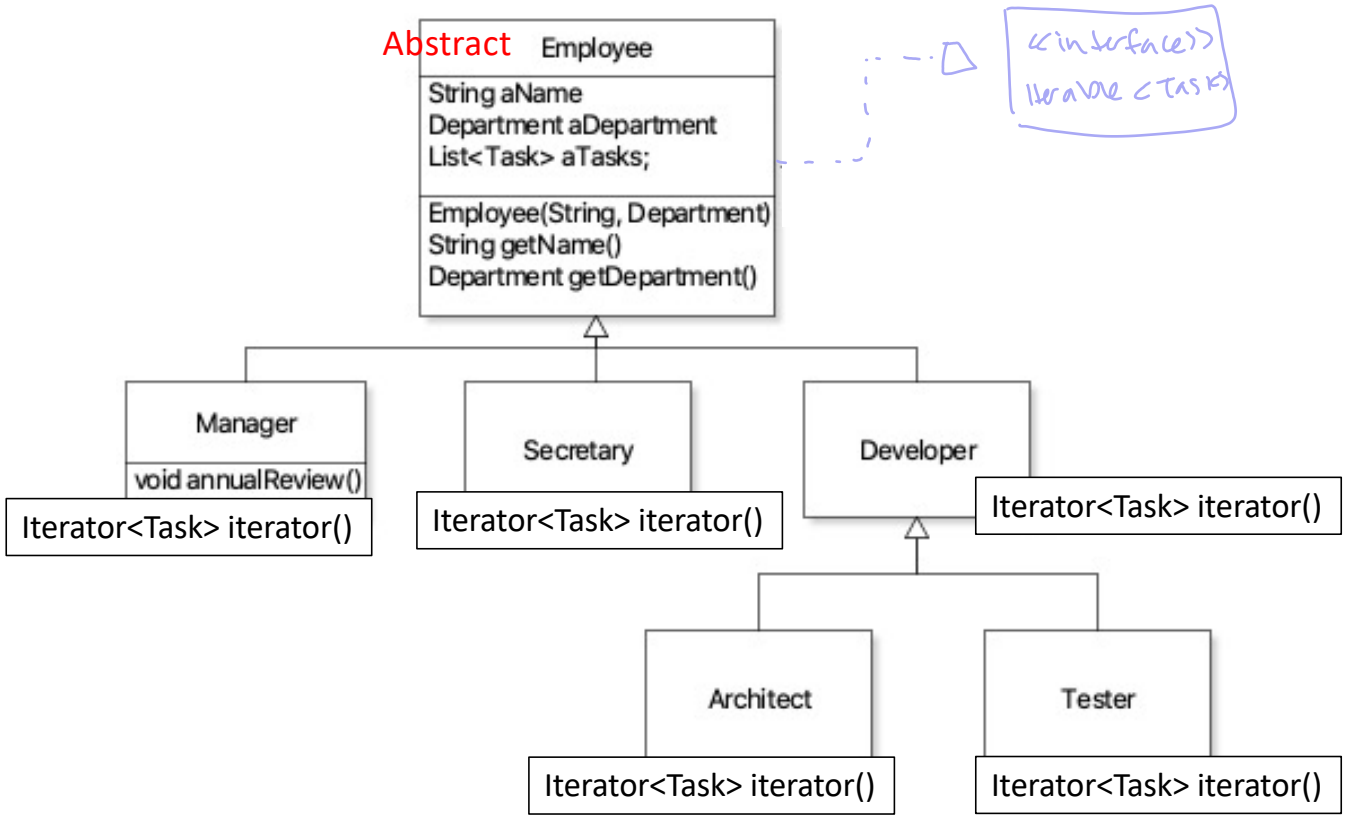
an employee must be one of



Abstract Class

- The class cannot be instantiated
- Can declare abstract methods
  - Subclass needs to implement
- No longer needs to supply implementations to all methods in the interface it declares to implement.
  - Subclass needs to implement

Abstract Class



```
public abstract class Employee implements Iterable<Task>{
    private String aName;
    private Department aDepartment;
    private List<Task> aTasks = new ArrayList<>();

    Employee(String pName, Department pDepartment) {
        aName = pName;
        aDepartment= pDepartment;
    }

    public String getName() {
        return aName;
    }

    public Department getDepartment() {
        return aDepartment;
    }

    public abstract void printNameCard(Printer p);
}
```

Objective

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- Design Techniques:

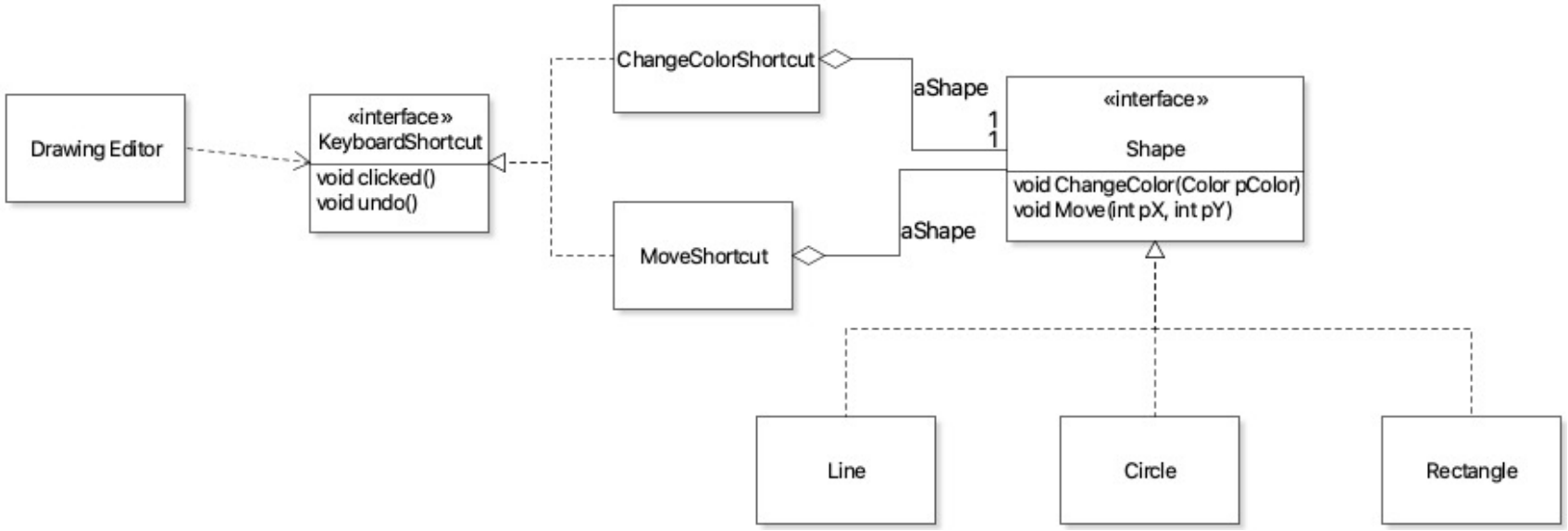
Inheritance-based reuse ← why abstract classes?

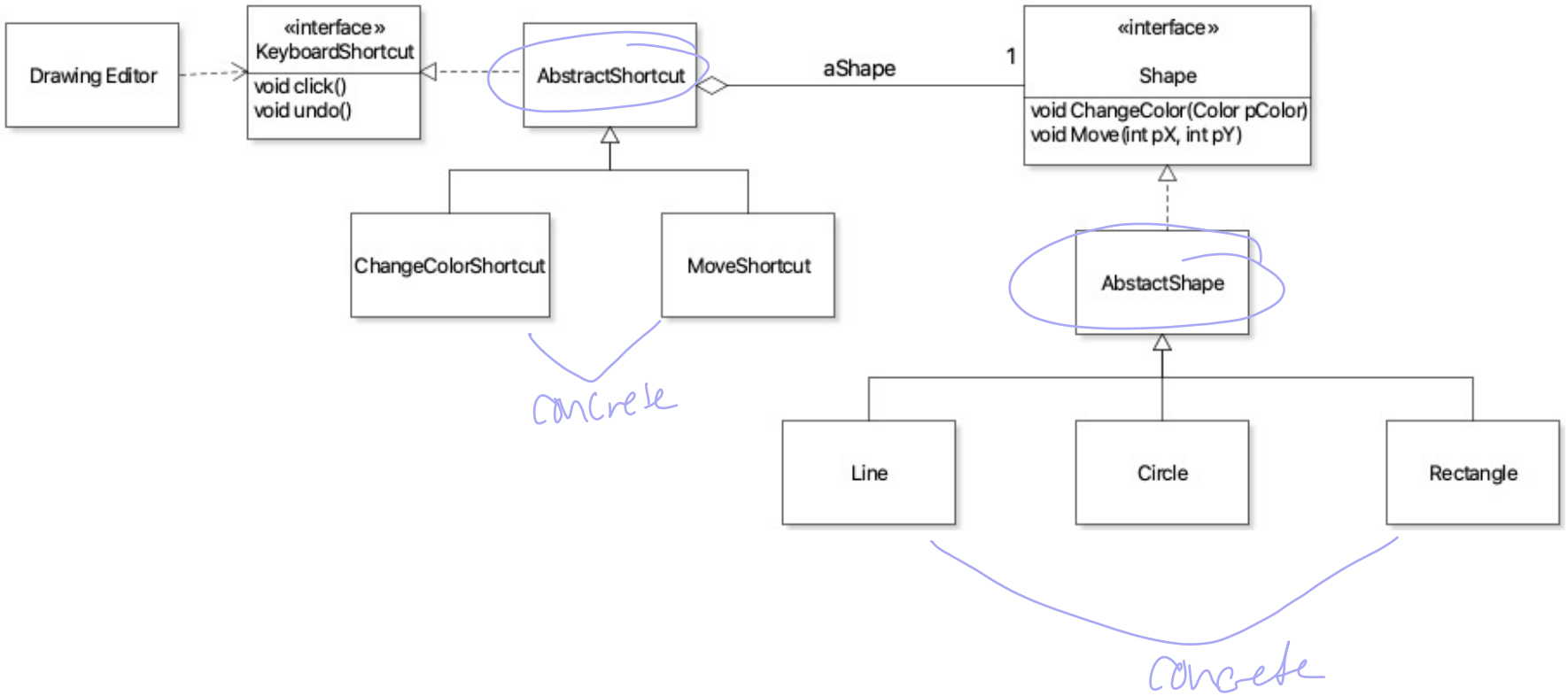
- Patterns and Anti-patterns:

Template Pattern

Activity1:

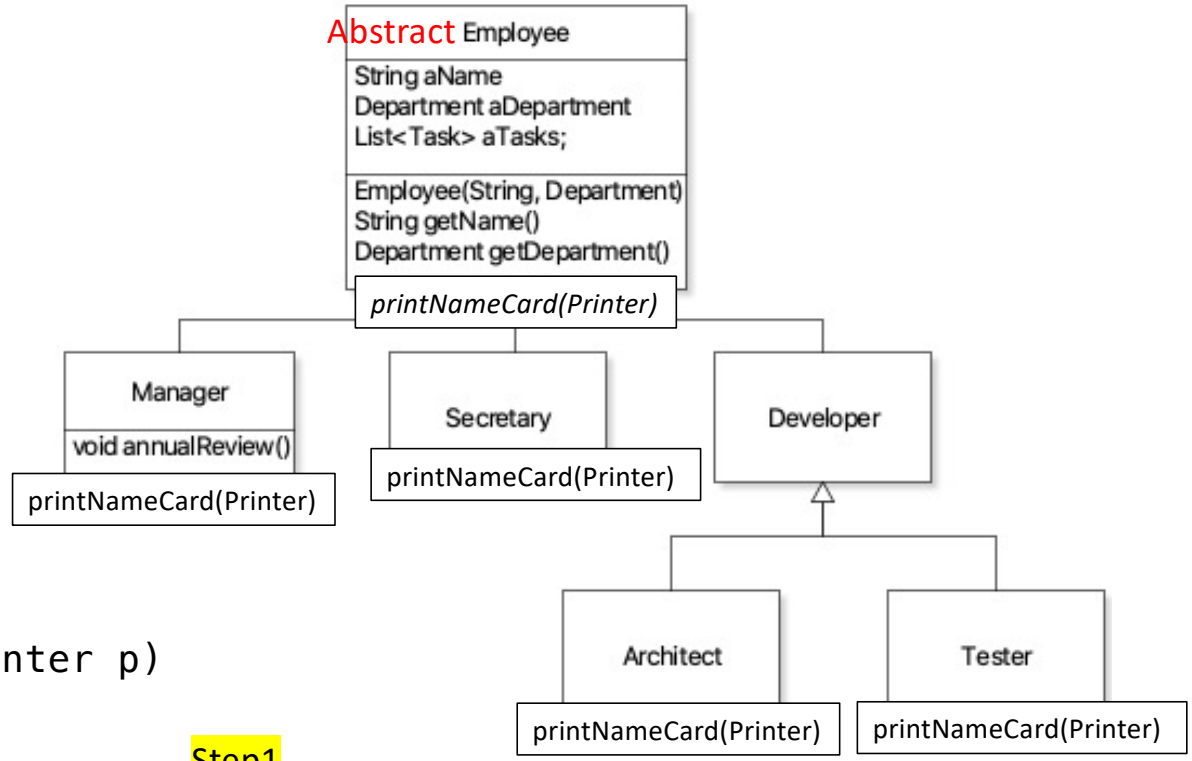
- Use inheritance to remove redundancy in the following design of applying command pattern to drawing editor




Drawing Editor
«interface»
KeyboardShortcut
void click()
void undo()
AbstractShortcut
aShape
1
«interface»
Shape
void ChangeColor(Color pColor)
void Move(int pX, int pY)
ChangeColorShortcut
MoveShortcut
AbstactShape
Concrete
Line
Circle
Rectangle
Concrete

```
public abstract class Employee implements Iterable<Task>{
    private String aName;
    private Department aDepartment;
    private List<Task> aTasks = new ArrayList<>();

    Employee(String pName, Department pDepartment) {
        aName = pName;
        aDepartment= pDepartment;
    }

    public String getName() {
        return aName;
    }

    public Department getDepartment() {
        return aDepartment;
    }

    public abstract void printNameCard(Printer p);
}
```

What if only part of a method needs to be deferred to the subclass?




```
public void printNameCard(Printer p)
{
    p.printTemplate();                    Step1

    /*  print customized content*/        Step2

    p.printReceipt();                     Step3
}
```

split into smaller methods

only certain steps need to be customized and don't want to be redundant or not guaranteed

A multi-step method

```
public abstract class Employee implements Iterable<Task>{
    private String aName;
    private Department aDepartment;
    private List<Task> aTasks = new ArrayList<>();

    public final void printNameCard(Printer p)
    {
        p.printTemplate();

        p.print(getPrintContent());

        p.printReceipt();
    }

    public abstract String getPrintContent();
}
```

final

Subclass cannot override this method

Step1

Step2

Step3

make this final so it can't be changed

only this part needs to be different

```java
public class Manager extends Employee {
    private List<Review> aReviews = new ArrayList<>();


    public Manager(String pName, Department pDepartment) {
        super(pName, pDepartment);
    }



    @Override
    public String getPrintContent() {
        return getName() + getDepartment().toString();
    }
}
```

Step 2

Objective

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Template Pattern

Template Method Pattern

- Intent:
  - Define the skeleton of an algorithm in an operation, deferring some steps to subclasses. Template Method lets subclasses redefine certain steps of an algorithm without changing the algorithm's structure.
- Participants:
  - AbstractClass

    implements a template method defining the skeleton of an algorithm

    defines abstract operations that concrete subclasses define to implement steps of an algorithm.
  - ConcreteClass

    implements the operations to carry out subclass-specific steps of the algorithm.

Template Method Pattern

```
public abstract class Employee implements Iterable<Task>{
    private String aName;
    private Department aDepartment;
    private List<Task> aTasks = new ArrayList<>();

    public void printNameCard(Printer p)
    {
        p.printTemplate();

        p.print(getPrintContent());

        p.printReceipt();
    }

    public abstract String getPrintContent();
}
```

final

Abstract step method

Avoid same names for template and abstract methods

who needs to use it outside of template

Protected or **Public**

Not necessarily abstract (define default behavior)

Examples of Abstract classes and Template Method Pattern in Java

- java.util.AbstractList
- java.util.AbstractSet
- java.util.AbstractMap
- java.io.InputStream
- java.io.OutputStream
- java.io.Reader
- java.io.Writer

… …

java.util.AbstractList

- Implemented Interfaces:

Iterable<E>, Collection<E>, List<E>

- Direct Subclasses:

AbstractSequentialList, ArrayList, Vector

java.util.AbstractList

This class provides a skeletal implementation of the List interface to minimize the effort required to implement this interface backed by a "random access" data store (such as an array).

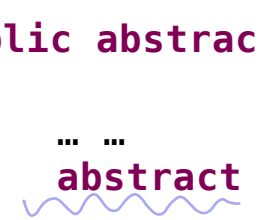
To implement an unmodifiable list, the programmer needs only to extend this class and provide implementations for the get(int) and size() methods.

To implement a modifiable list, the programmer must additionally override the set(int, E) method (which otherwise throws an UnsupportedOperationException).

… …

```
public abstract class AbstractList<E> extends AbstractCollection<E> implements List<E>
{
     … …
     abstract public E get(int index);

     public E next() {
          checkForComodification();
          try {
               int i = cursor;
               E next = get(i);
               lastRet = i;
               cursor = i + 1;
               return next;
          } catch (IndexOutOfBoundsException e) {
               checkForComodification();
               throw new NoSuchElementException();
          }
     }
     … …
}
```



template pattern

regardless of get, this is how next works

Activity 2:

- Using inheritance to design a class representing an unmodifiable list of Card that is constructed through a card array.
- What methods do you need to override? ← get()
- How to override them?

```
public class CardList extends AbstractList<Card>
{
    private final Card[] aCards;

    CardList(Card[] pCards)
    {
        assert pCards!= null;
        aCards = pCards;
    }

        get(int)

        size()



}
```

```
public static void main(String[] pArgs)
{
    Card[] cards = new Card[2];
    cards[0] = new Card(Rank.ACE, Suit.CLUBS);
    cards[1] = new Card(Rank.FIVE, Suit.DIAMONDS);
    CardList cardList = new CardList(cards);

    System.out.println(cardList.contains(cards[1]));

    for (Iterator<Card> iter=cardList.iterator();
        iter.hasNext(); )
    {
        Card element = iter.next();
        System.out.println(element);
    }
}
```