# CS 635 Advanced Object-Oriented Design & Programming
Fall Semester, 2018
Doc 19 Dependency Injection, SOLID
Nov 20, 2018

## Dependency Injection

## Fowler's Movie Example

Find all movies by a given director

Movie data is in colon separated file

ColonDelimitedMovieFinder
- Class that reads movie file
- Structures data so we can search it

## Fowler’s Movie Example

Find all movies by a given director

```
class MovieLister {
 private ColonDelimitedMovieFinder finder =
            new ColonDelimitedMovieFinder("movies1.txt");

 public Movie[] moviesDirectedBy(String arg) {
    List allMovies = finder.findAll();
    for (Iterator it = allMovies.iterator(); it.hasNext();) {
       Movie movie = (Movie) it.next();
       if (!movie.getDirector().equals(arg)) it.remove();
    }
    return (Movie[]) allMovies.toArray(new Movie[allMovies.size()]);
 }
```

MovieLister now depends on (uses) a particular low level service

What if we need to use a different low level service?

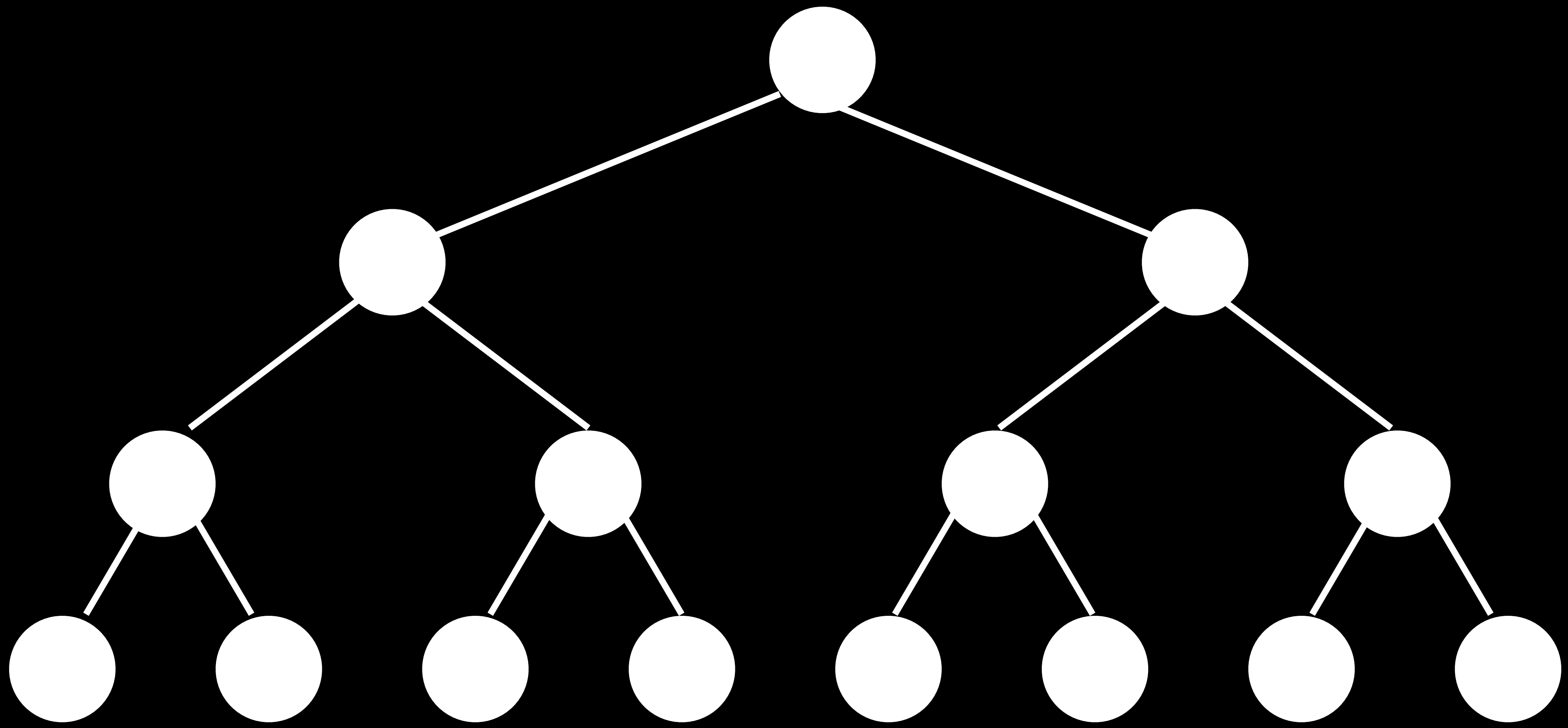
Move data to database

Dependency is inside the MovieLister class

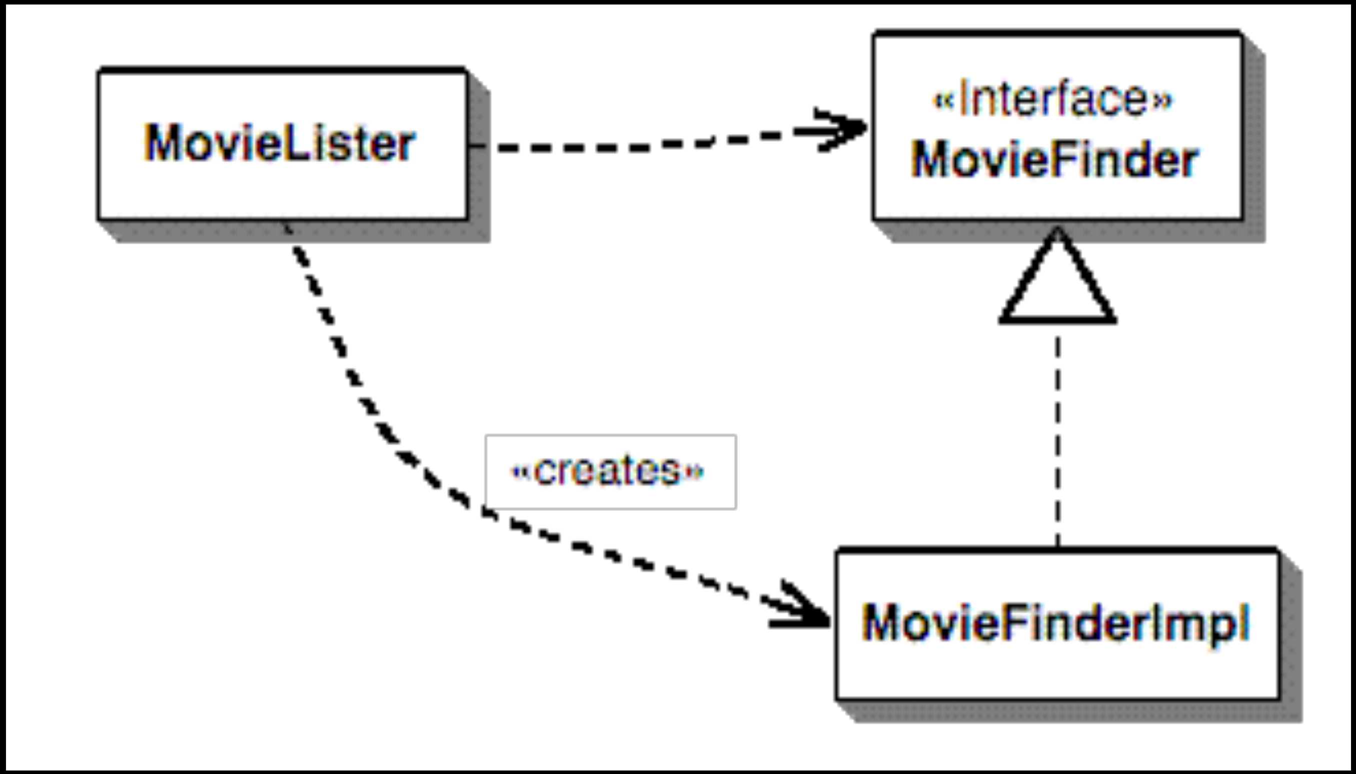
```
class MovieLister {
  private **ColonDelimitedMovieFinder** finder =
            new **ColonDelimitedMovieFinder**("movies1.txt");

  public Movie[] moviesDirectedBy(String arg) {
      List allMovies = finder.findAll();
      for (Iterator it = allMovies.iterator(); it.hasNext();) {
          Movie movie = (Movie) it.next();
          if (!movie.getDirector().equals(arg)) it.remove();
      }
      return (Movie[]) allMovies.toArray(new Movie[allMovies.size()]);
  }
```

- Low level objects are building blocks for the applications
  - Read files
  - Interact with database
  - Display data on screen
  - Easy to reuse elsewhere

- High level objects contain the business logic
  - Main purpose of the application
  - Hard to reuse elsewhere due to dependencies on low level details



## Program to an Interface



```
public interface MovieFinder {
    List findAll();
}
```

## With Factory Method

For each concrete finder need:
- Concrete finder class
- Subclass of MovieLister

```
class MovieLister {
  private MovieFinder finder;

  public MovieLister() {
     finder = createFinder();
   }

  public MovieFinder createFinder() {
       new ColonDelimitedMovieFinder("movies1.txt");
   }

  public Movie[] moviesDirectedBy(String arg) {
     // Same as before
  }
```

## With Constructor

For each concrete finder need:
  Concrete finder class

MovieLister not depend on concrete finder

```
class MovieLister {
  private MovieFinder finder;

  public MovieLister(MovieFinder finder) {
     this.finder = finder;
   }

  public Movie[] moviesDirectedBy(String arg) {
      // Same as before
  }
}


class ColonDelimitedMovieFinder implements MovieFinder {
  private String filename;

  ColonDelimitedMovieFinder(String filename) { this.filename = filename;}

   public List findAll() {...}
}
```

## Manual Injection

```
public class Injector {
  public static void main(String[] args) {
    MovieFinder finder = new ColonDelimitedMovieFinder("movies1.txt");
    MovieLister lister = new MovieLister(finder);
    lister.moviesDirectedBy(“Spielberg”);
  }
```

So we replace

```
MovieLister lister = new MovieLister();
lister.moviesDirectedBy(“Spielberg”);
```

With

```
MovieFinder finder = new ColonDelimitedMovieFinder("movies1.txt");
MovieLister lister = new MovieLister(finder);
lister.moviesDirectedBy(“Spielberg”);
```

## Problems with Manual Injection

Scaling is hard

- Same dependency is needed in multiple places
- Multiple different dependencies in multiple places

Program is still dependent on the dependencies

## Plugin Pattern

Links classes during configuration rather than compilation

Code runs in multiple runtime environments

Each environment requires different implementations of particular service

Plugin provides centralized runtime configuration

## Plugin Pattern - How it works

- Separated Interface
  - Define an interface in a separate package from its implementation
  - Program needs the interface at compile time
  - Program will load the implementation at runtime

## Plugin Pattern - How it works

Plugin uses a factory to create the service

Plugin reads file to determine which implementation of service to create

With Reflection (Java)

- Plugin reads the class of the needed service from file
- Plugin factory creates instance of service class
- Plugin source code does not have reference class of the service

Without Reflection

- Plugin reads which service is needed from file
- Plugin factory uses conditional logic to create service instance
- Plugin source code needs to reference class of all service implementations

## Plugin Pattern - How it works

How to load class at runtime

```
Class.forName("edu.sdsu.cs.whitney.BinarySearchTree")
```

Converts a string to the Class represented by the string

## Dependency Injection & Plugin Pattern

- Use the plugin pattern to provide
  - Central location to handle dependency injection
  - Configure the application from external data at runtime

- Injector - add services to client
  - Also known as:
    - assembler
    - provider
    - container
    - factory
    - builder
    - spring
    - construction code

## Type of Dependency Injection

Constructor

Setter

Interface

## Constructor Injection with PicoContainer

```
  class MovieLister {
    public MovieLister(MovieFinder finder) { this.finder = finder;}

  class ColonDelimitedMovieFinder implements MovieFinder {
    ColonDelimitedMovieFinder(String filename) { this.filename = filename;}


private MutablePicoContainer configureContainer() {
    MutablePicoContainer pico = new DefaultPicoContainer();
    Parameter[] finderParams =  {new ConstantParameter("movies1.txt")};
    pico.registerComponentImplementation(MovieFinder.class,
                                         ColonMovieFinder.class,
                                         finderParams);
    pico.registerComponentImplementation(MovieLister.class);
    return pico;
}
```

```
pico.registerComponentImplementation(MovieFinder.class,
                                     ColonMovieFinder.class,
                                     finderParams);
```

When you need a MovieFinder instance return an instance of ColonMovieFinder

Use finderParams as argument for ColonMovieFinder constructor

Reflection is used to do this

```
pico.registerComponentImplementation(MovieLister.class);
```

Container can now create MovieLister instance

Its constructor needs a MovieFinder object,
Container already knows how to create a MovieFinder object

## Using the Container

```
public void testWithPico() {
    MutablePicoContainer pico = configureContainer();
    MovieLister lister = (MovieLister) pico.getComponentInstance(MovieLister.class);
    Movie[] movies = lister.moviesDirectedBy("Sergio Leone");
    assertEquals("Once Upon a Time in the West", movies[0].getTitle());
}
```

So replaced

```
MovieFinder finder = new ColonDelimitedMovieFinder("movies1.txt");
MovieLister lister = new MovieLister(finder);
lister.moviesDirectedBy(“Spielberg”);
```

With

```
private MutablePicoContainer configureContainer() {
    MutablePicoContainer pico = new DefaultPicoContainer();
    Parameter[] finderParams =  {new ConstantParameter("movies1.txt")};
    pico.registerComponentImplementation(MovieFinder.class, ColonMovieFinder.class,
                                          finderParams);
    pico.registerComponentImplementation(MovieLister.class);
    return pico;
}

public void testWithPico() {
    MutablePicoContainer pico = configureContainer();
    MovieLister lister = (MovieLister) pico.getComponentInstance(MovieLister.class);
    Movie[] movies = lister.moviesDirectedBy("Sergio Leone");
    assertEquals("Once Upon a Time in the West", movies[0].getTitle());
}
```

## How to configure from a file?

```
Class.forName("edu.sdsu.cs.whitney.BinarySearchTree")
```

Converts a string to the Class represented by the string

## Setter Injection with Spring

Each class needs a setter method

```
class MovieLister...
  private MovieFinder finder;
  public void setFinder(MovieFinder finder) {
     this.finder = finder;
   }

class ColonMovieFinder...
  public void setFilename(String filename) {
      this.filename = filename;
  }
```

## XML Configuration File

Spring.xml

```
<beans>
    <bean id="MovieLister" class="spring.MovieLister">
        <property name="finder">
            <ref local="MovieFinder"/>
        </property>
    </bean>
    <bean id="MovieFinder" class="spring.ColonMovieFinder">
        <property name="filename">
            <value>movies1.txt</value>
        </property>
    </bean>
</beans>
```

## Using the injector

```
ApplicationContext ctx = new FileSystemXmlApplicationContext("spring.xml");
MovieLister lister = (MovieLister) ctx.getBean("MovieLister");
Movie[] movies = lister.moviesDirectedBy("Sergio Leone");
assertEquals("Once Upon a Time in the West", movies[0].getTitle());
```

## Interface Injection

Define an interface for doing the injection

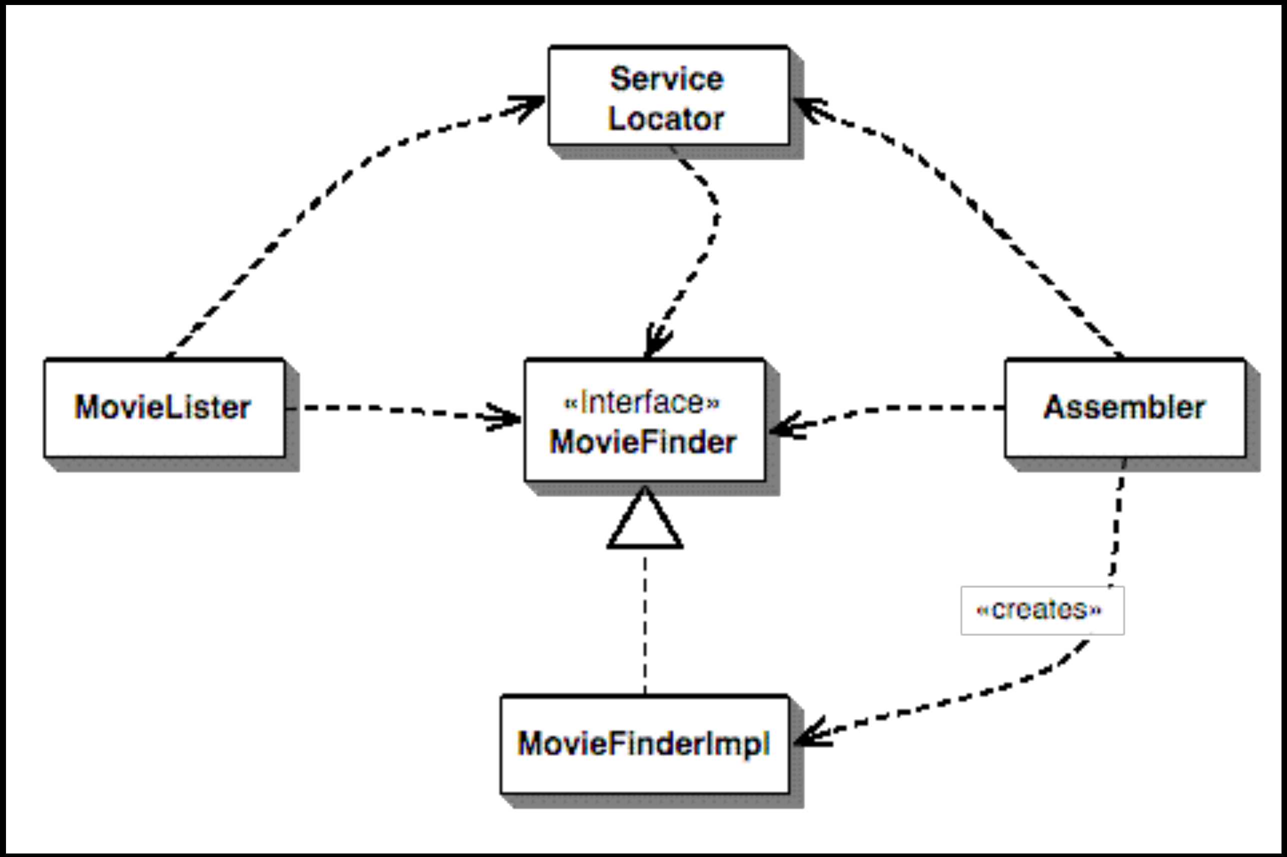
```
public interface InjectFinder {
    void injectFinder(MovieFinder finder);
}

class MovieLister implements InjectFinder
  public void injectFinder(MovieFinder finder) {
      this.finder = finder;
  }
```

The injector can be anything

Framework uses the interface to find & use the injector

## Service Locator

Object that knows how to get all the services that an application needs



```
class MovieLister...
  MovieFinder finder = ServiceLocator.movieFinder();

class ServiceLocator...
  public static MovieFinder movieFinder() {
      return soleInstance.movieFinder;
  }
  private static ServiceLocator soleInstance;
  private MovieFinder movieFinder;
```

## How to configure the service locator?

In code

From file

## Service Locator vs Dependency Injection

Clients are dependent on Service Locator

Dependency Injection makes it easier to see component dependencies

If building an application dependency on Service Locator is ok

If providing component for others to use Dependency Injection is easier

## SOLID

## OO Design Principle by Robert Martin

**S**ingle Responsibility Principle

**O**pen Closed Principle

**L**iskov Substitution Principle

**I**nterface Segregation Principle

**D**ependency Inversion Principle

http://www.butunclebob.com/ArticleS.UncleBob.PrinciplesOfOod

## Single Responsibility Principle (SRP)

A class should have only one reason to change

Responsibility -> Reason to change

Simplest principle

Hardest to get right

## SRP - Modem Example

```
public interface Modem {
   public void dial(String phoneNumber);
   public void hangup();
   public void send(char c);
   public char receive()
}
```

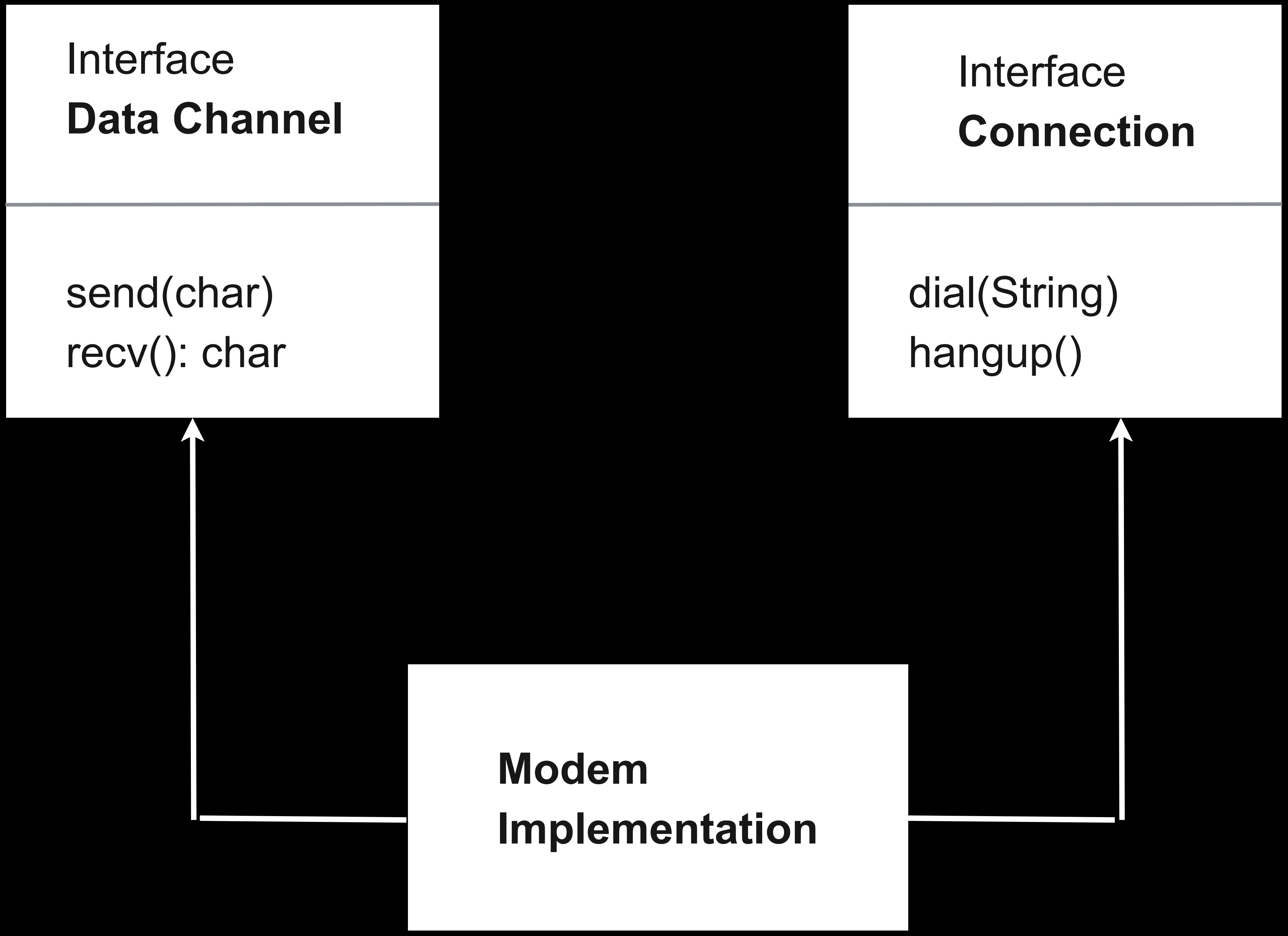
Two responsibilities

Connection management
Data communication

If need to change signature of connection functions then
classes that call send and receive will have to be recompiled more often than needed

If app not changing in ways that cause the two responsibilities to chanage at different times then no need to separate them

An axis of change is only an axis of change if the changes actually occur


Interface
Data Channel
send(char)
recv(): char
Interface
Connection
dial(String)
hangup()
Modem
Implementation

## Separating Coupled Responsibilities

He kept both responsibilities in ModemImplementation class

Not desirable but may be necessary

By separating the interfaces we have decoupled them as far as the app is concerned

Nobody but main need to know it exists

## The Open Closed Principle

You should be able to extend a classes behavior, without modifying it.

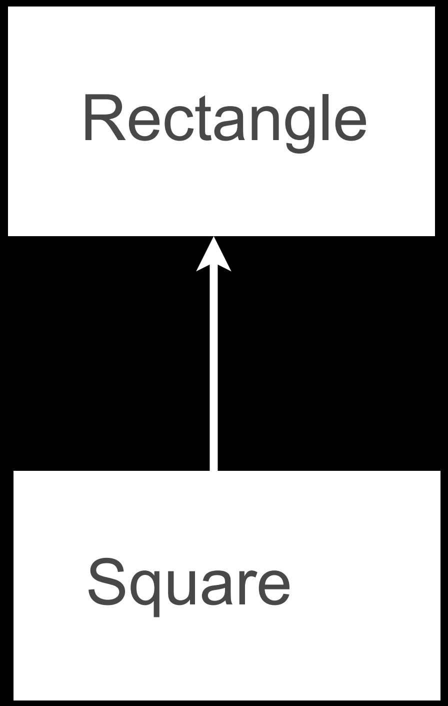
No significant program can be 100% closed

Designer must choose the kinds of changes against which to close the design

## Liskov Substitution Principle

Child classes must be substitutable for their parent classes

```
Rectangle a = new Square();
```



```
class Rectangle {
  double width;
  double height;

  public double width()            {return width; }
  public double height()           {return height; }
  public void width(double w)    {width = w; }
  public void height(double h)   {height = h; }
  public double area()             {return height * width; }
}

public Square extends Rectangle {
  public void width(double w)    {
    super.width(w);
    super.height(w);
  }
  public void height(double h)   {
    super.width(h);
    super.height(h);
  }
}
```

```
public void foo(Rectangle r) {
  r.width(5);
  r.height(2);
  assert( r.area() == 4);
}
```

## What Went Wrong?

Behavior of a square is not the same as the behavior of a rectangle

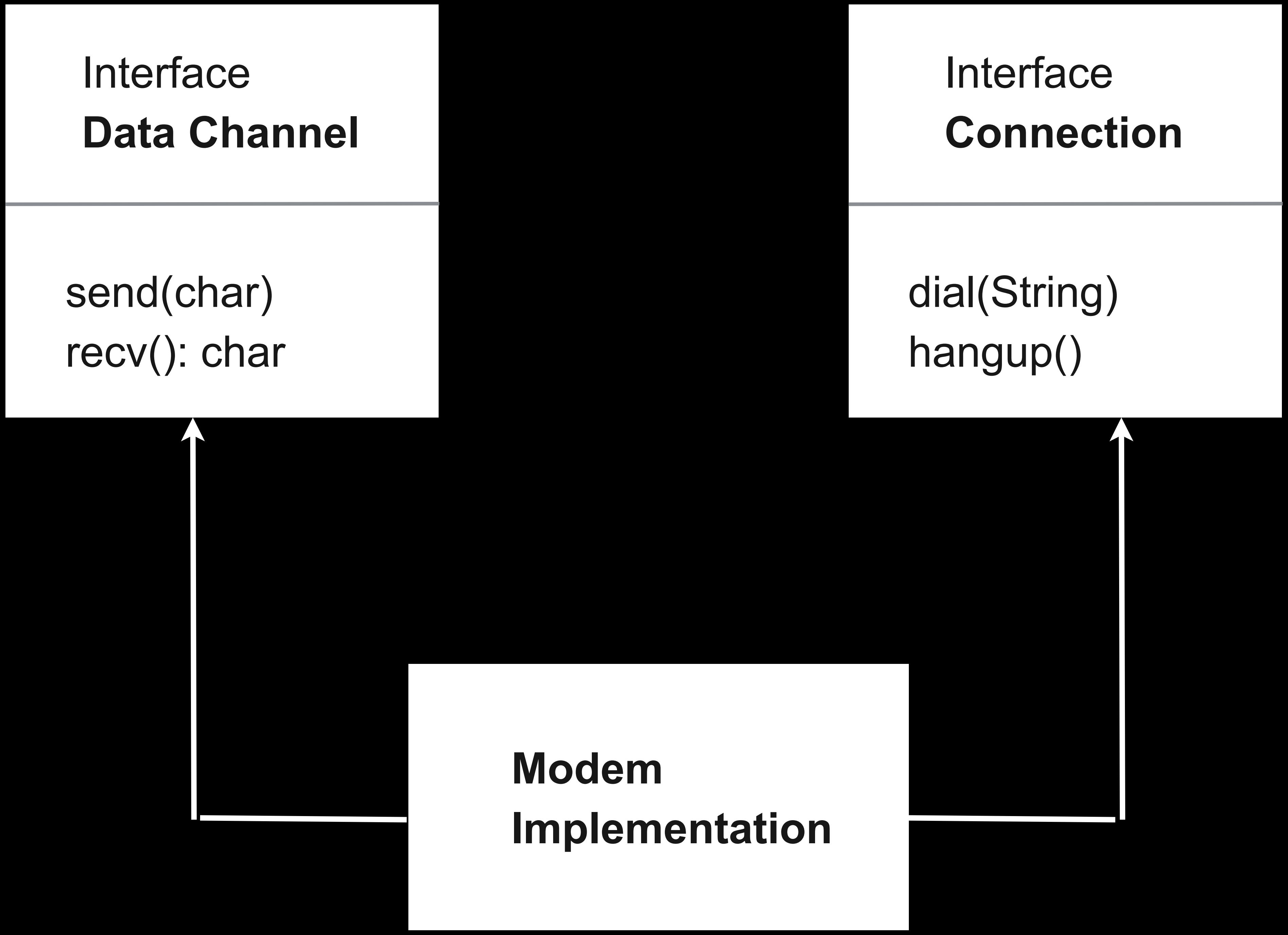
Behavior is what software is about

The ISA relationship pertains to behavior

View a design in terms of the reasonable assumptions made by users

## Interface Segregation Principle

Make fine grained interfaces that are client specific



## Bad Design

Rigidity

Every change affects too many parts of the system

Fragility

When you make a change, unexpected parts of the system break

Immobility

Hard to reuse in another application because it can’t be disentangled from the current application

## Causes of Bad Design

Interdependence of the modules

## Dependency Inversion Principle

High level modules should not depend upon low level modules.
Both should depend upon abstractions.

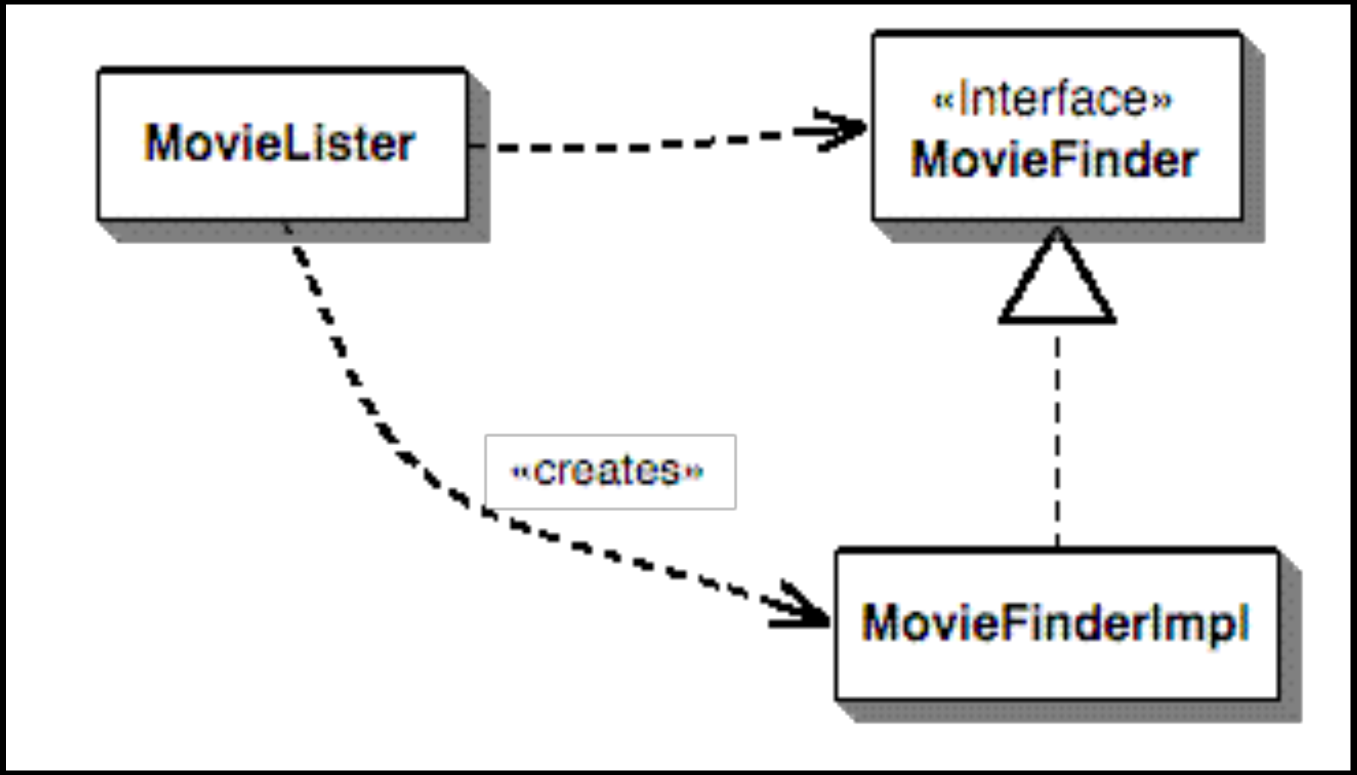
Abstractions should not depend upon details.
Details should depend upon abstractions.

## Violation

MovieLister depends on ColonDelimitedMovieFinder

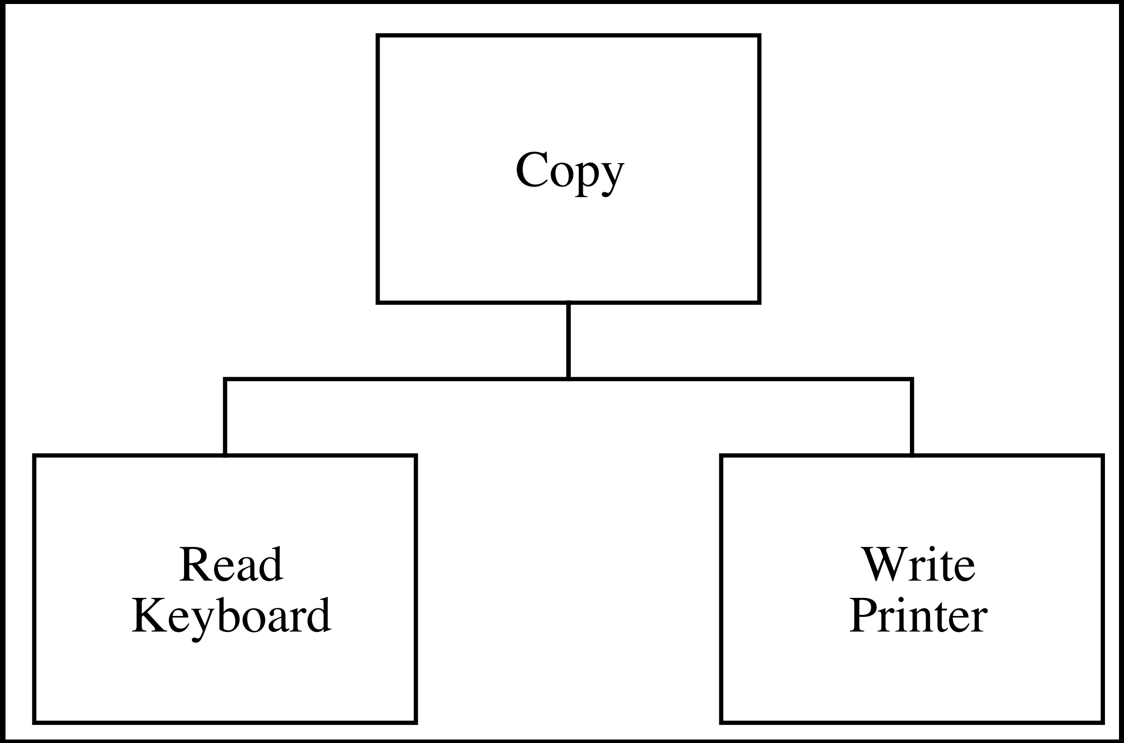
```
class MovieLister {
  private ColonDelimitedMovieFinder finder =
            new ColonDelimitedMovieFinder("movies1.txt");

  public Movie[] moviesDirectedBy(String arg) {
      List allMovies = finder.findAll();
      for (Iterator it = allMovies.iterator(); it.hasNext();) {
          Movie movie = (Movie) it.next();
          if (!movie.getDirector().equals(arg)) it.remove();
      }
      return (Movie[]) allMovies.toArray(new Movie[allMovies.size()]);
  }
```

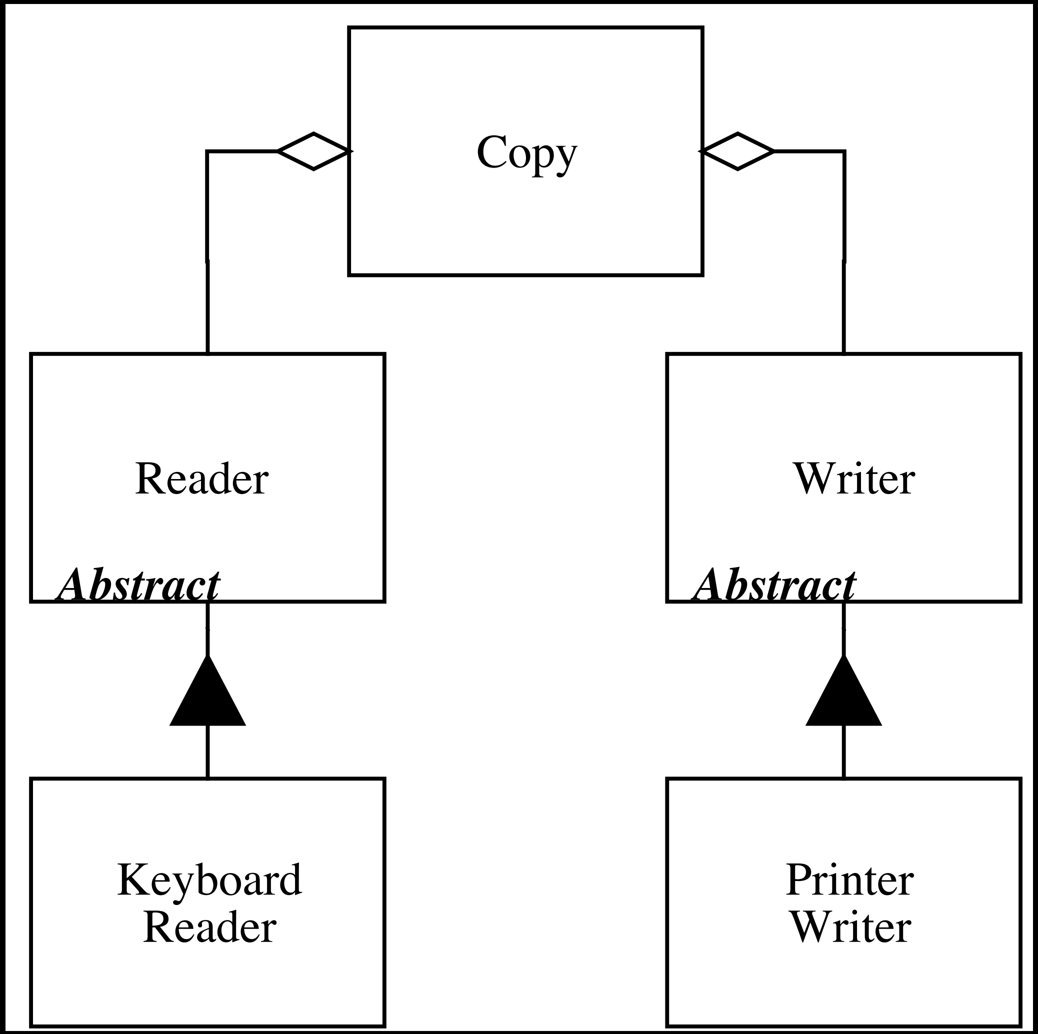
## Program to an Interface



```
public interface MovieFinder {
    List findAll();
}
```

## Copy Program


Copy
Read Keyboard
Write Printer


Copy
Reader
Abstract
Writer
Abstract
Keyboard Reader
Printer Writer