CS 635 Advanced Object-Oriented Design & Programming
Fall Semester, 2019
Doc 13 Builder, Dependency Injection, SOLID
Oct 15, 2019

Builder

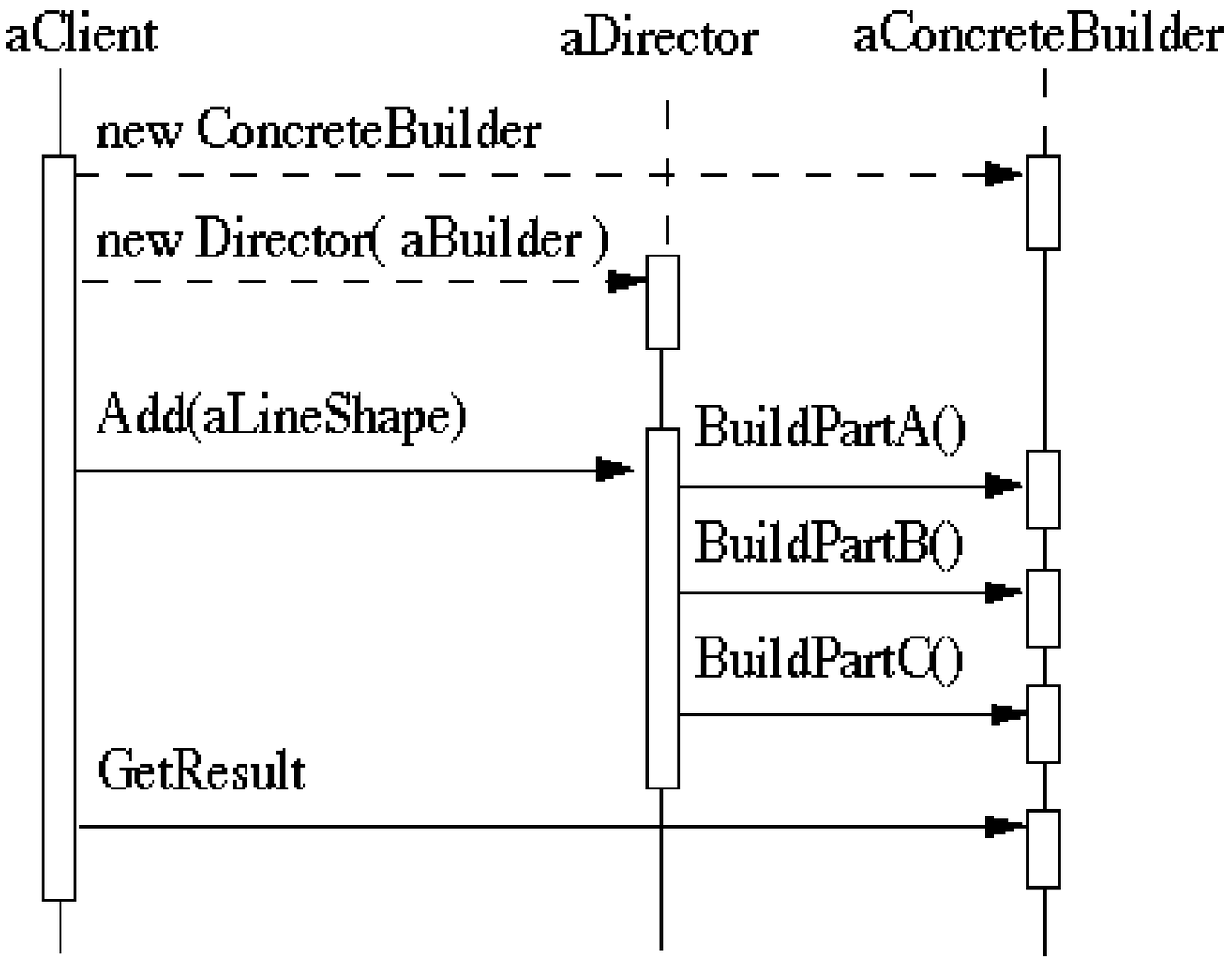
Builder

Separate construction of a complex object from its representation

So same construction process can create different representations

Builder

Client Director Builder



RTF Converter

A word processing document has complex structure

How to convert Rich Text Format (RTF) to

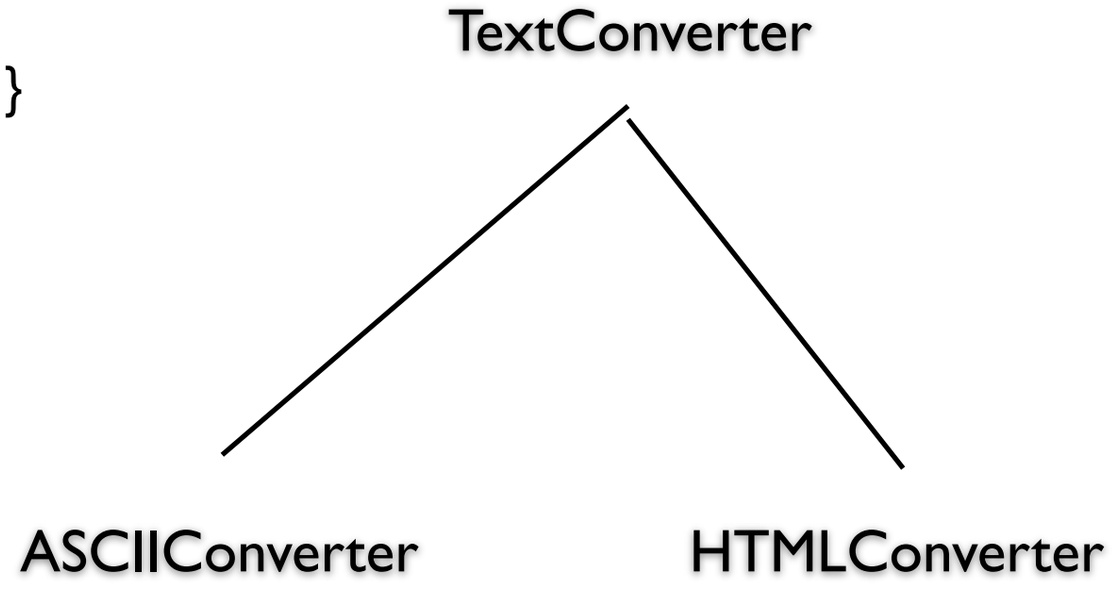
TeX
html
PDF
etc.

Pseudo Solution

```
class RTF_Reader {
   TextConverter builder;
   String RTF_Text;

   public RTF_Reader( TextConverter aBuilder, String RTFtoConvert ){
      builder = aBuilder;
      RTF_Text = RTFtoConvert;
      }

public void parseRTF(){
   RTFTokenizer rtf = new RTFTokenizer( RTF_Text );

   while ( rtf.hasMoreTokens() ){
      RTFToken next = rtf.nextToken();

      switch ( next.type() ){
         case CHAR:    builder.character( next.char() ); break;
         case FONT:    builder.font( next.font() ); break;
         case PARA:    builder.newParagraph( ); break;
         etc.
      }
```

Builder Classes

```
abstract class TextConverter {
   public void character( char nextChar ) { }
   public void font( Font newFont )   { }
   public void newParagraph() {}
}
```



Sample Program

```
main(){
   ASCII_Converter simplerText = new ASCII_Converter();
   String rtfText;

   // read a file of rtf into rtfText

   RTF_Reader myReader =
      new RTF_Reader( simplerText, rtfText );

   myReader.parseRTF();

   String myProduct = simplerText.getText();
}
```

The Hard Part

The builder interface

XML Example

```
<?xml version="1.0" encoding="UTF-8"?>
<RootElement param="value">
    <FirstElement>
        Some Text
    </FirstElement>
    <SecondElement param2="something">
        Pre-Text <Inline>Inlined text</Inline> Post-text.
    </SecondElement>
</RootElement>
```

SAX - Builder Pattern

Director	XMLReader
Builder	ContentHandler

ContentHandler Interface

void characters(char[] ch, int start, int length)
Receive notification of character data.

void endDocument()
Receive notification of the end of a document.

void endElement(java.lang.String uri, java.lang.String localName, java.lang.String qName)
Receive notification of the end of an element.

void endPrefixMapping(java.lang.String prefix)
End the scope of a prefix-URI mapping.

void ignorableWhitespace(char[] ch, int start, int length)
Receive notification of ignorable whitespace in element content.

void processingInstruction(java.lang.String target, java.lang.String data)
Receive notification of a processing instruction.

void setDocumentLocator(Locator locator)
Receive an object for locating the origin of SAX document events.

void skippedEntity(java.lang.String name)
Receive notification of a skipped entity.

void startDocument()
Receive notification of the beginning of a document.

void startElement(java.lang.String uri, java.lang.String localName, java.lang.String qName, Attributes att
Receive notification of the beginning of an element.

void startPrefixMapping(java.lang.String prefix, java.lang.String uri)
Begin the scope of a prefix-URI Namespace mapping.

Simple API XML (SAX)

```
public static void main (String args[]) throws Exception {
  XMLReader director = XMLReaderFactory.createXMLReader();
  ContentHandler builder = new MySAXApp();
  director.setContentHandler(builder);
  director.setErrorHandler(builder);

  FileReader source = new FileReader("Foo.xml");
director.parse(new InputSource(source));
handler.getResult();
}
```

Examples - VW Smalltalk

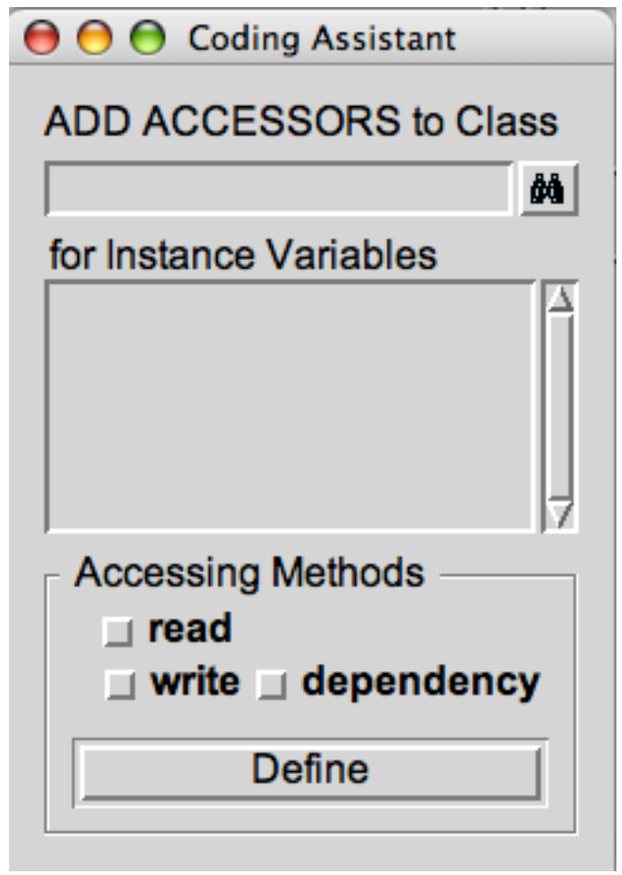
ClassBuilder

MenuBuilder

UIBuilder

UIBuilder

```
#(#{UI.FullSpec}
    #window:
    #(#{UI.WindowSpec}
      #label: #(#{Kernel.UserMessage} #key: #CodingAssistant
            #defaultString: 'Coding Assistant' #catalogID: #UIPainter)
      #min: #(#{Core.Point} 242 320 )
      #max: #(#{Core.Point} 242 320 )
      #bounds: #(#{Graphics.Rectangle} 279 140 521 460 ) )
    #component:
    #(#{UI.SpecCollection}
      #collection: #(
        #(#{UI.LabelSpec}
          #layout: #(#{Graphics.LayoutOrigin} 14 0 12 0 )
          #label: #(#{Kernel.UserMessage} #key: #ADDACCESSORSToClass
            #defaultString: 'ADD ACCESSORS to Class' #catalogID: #UIPainter) )
        #(#{UI.LabelSpec}
          #layout: #(#{Graphics.LayoutOrigin} 16 0 65 0 )
          #label: #(#{Kernel.UserMessage} #key: #forInstanceVariables
              #defaultString: 'for Instance Variables' #catalogID: #UIPainter) )
```



Simplified Builder Pattern

More common the standard Pattern

Used to set multiple fields

Replaces using constructor with many parameters

Person Example

```
public class Person
{
   private final String lastName;
   private final String firstName;
   private final String middleName;
   private final String salutation;
   private final String suffix;
   private final String streetAddress;
   ...
   private final boolean isEmployed;
```

PersonBuilder

```
public class PersonBuilder
{
   private String newLastName;
   private String newFirstName;
   private String newMiddleName;
   private String newSalutation;
   private String newSuffix;
   private String newStreetAddress;
   ...
   private boolean newIsEmployed;

   public PersonBuilder setLastName(String newLastName) {
      this.newLastName = newLastName;
      return this;
   }

   public PersonBuilder setFirstName(String newFirstName) {
      this.newFirstName = newFirstName;
      return this;
   }
```

PersonBuilder - Continued

```
public PersonBuilder setMiddleName(String newMiddleName) {
      this.newMiddleName = newMiddleName;
      return this;
   }
```

The rest of the set methods

```
public Person createPerson() {
      return new Person(newLastName, newFirstName, newMiddleName, newSalutation,
newSuffix, newStreetAddress, newCity, newState, newIsFemale, newIsEmployed,
newIsHomeOwner);
   }
```

Building a Person

```
Person test = new PersonBuilder().
        setLastName("Whitney").
        setFirstName("Roger").
        ...
        setIsEmployed(true).
        createPerson();
```

Improvements

Make Builder an inner class (Java)

Group fields into separate classes

- Name Class
  - firstName
  - lastName
  - middleName
  - salutation
  - suffix

Android Example

Building a Notification

```
Notification note = new Notification.Builder(mContext)
        .setContentTitle("New mail from " + sender.toString())
.setContentText(subject)
.setSmallIcon(R.drawable.new_mail)
.setLargeIcon(aBitmap)
.build();
```

Strategy
vs
Builder

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

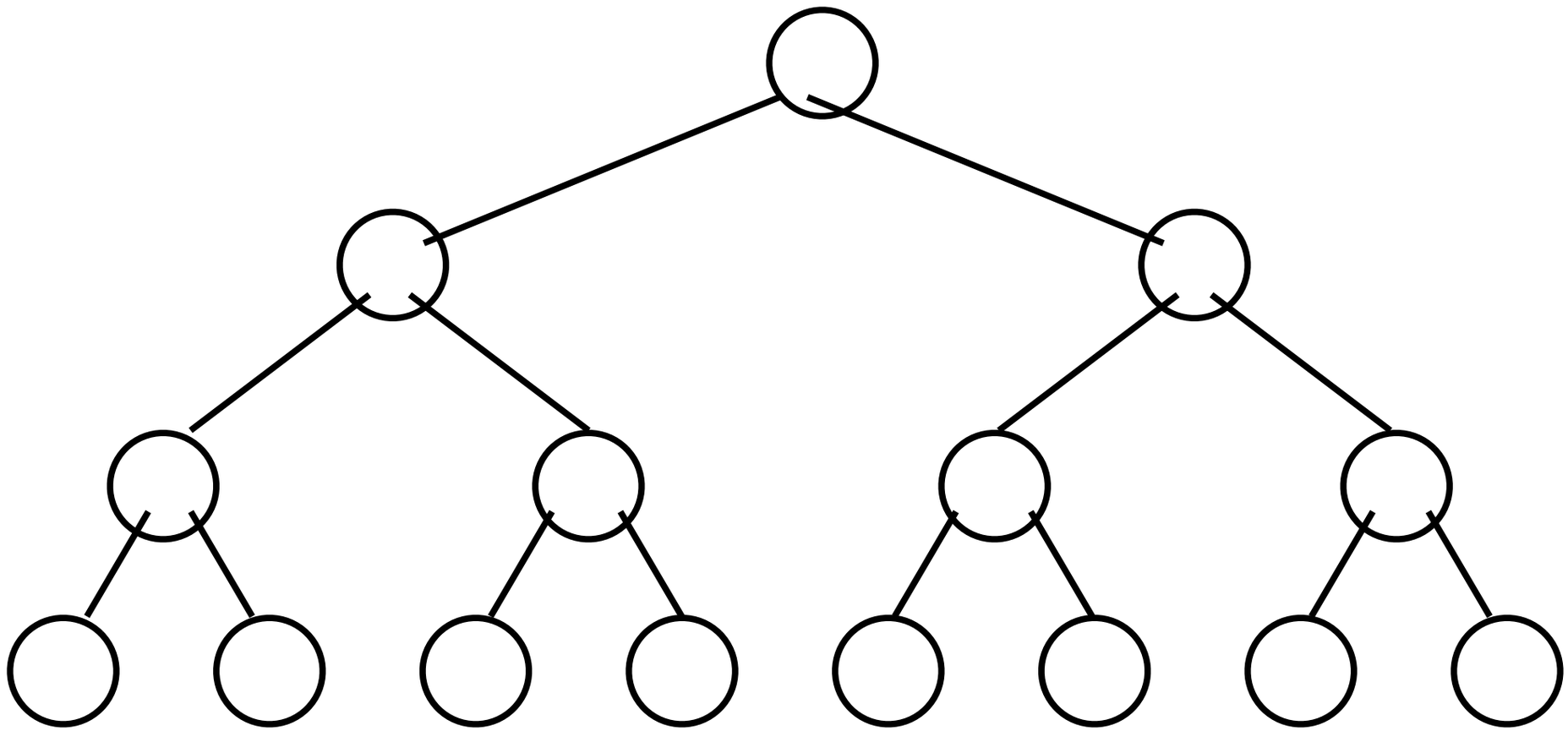
```
class MovieLister {
  private ColonDelimitedMovieFinder finder =
            new ColonDelimitedMovieFinder("movies1.txt");

  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

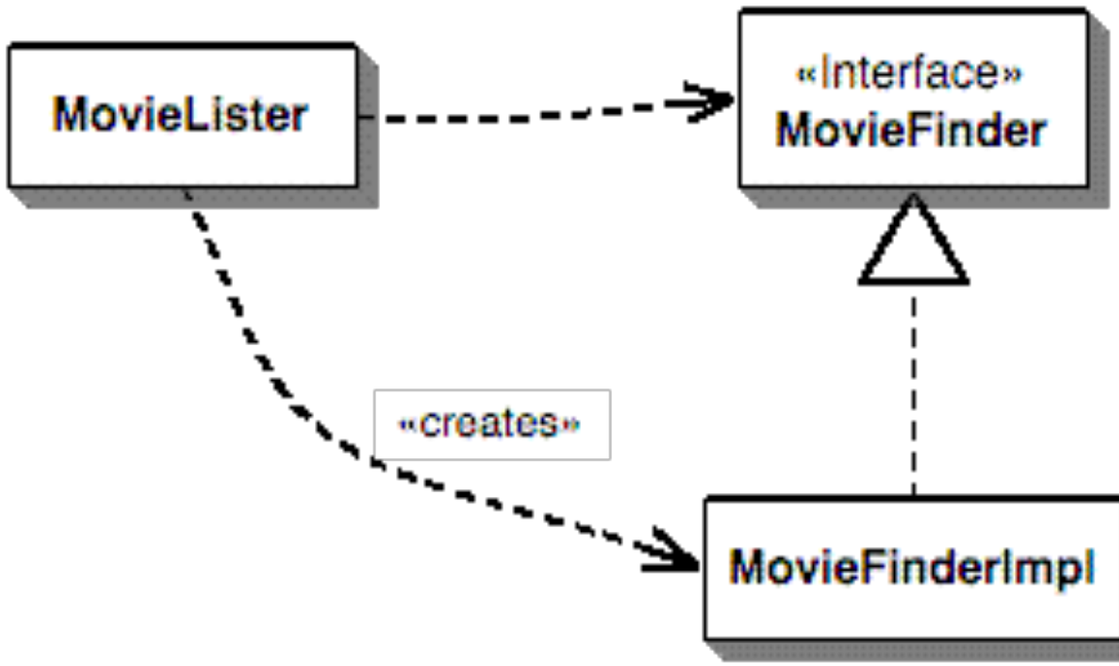
- Read files
- Interact with database
- Display data on screen
- Easy to reuse elsewhere

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

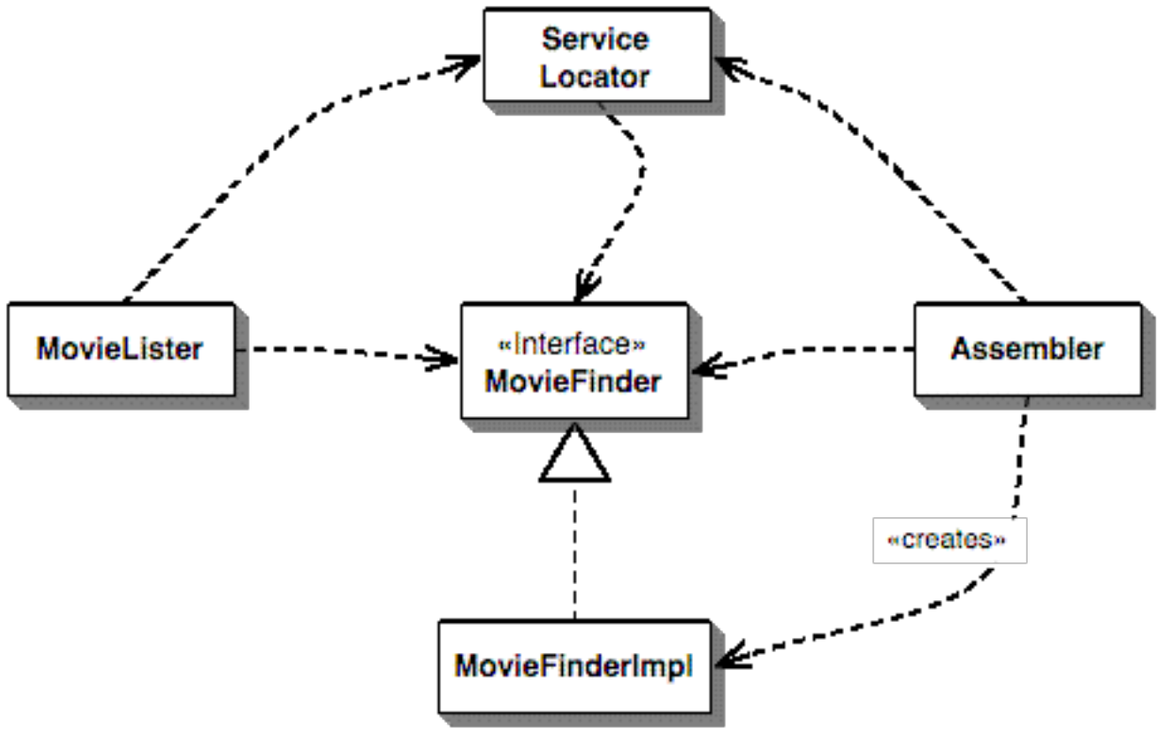
```
public interface InjectFinder {
    void injectFinder(MovieFinder finder);
}

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

Single Responsibility Principle

Open Closed Principle

Liskov Substitution Principle

Interface Segregation Principle

Dependency 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

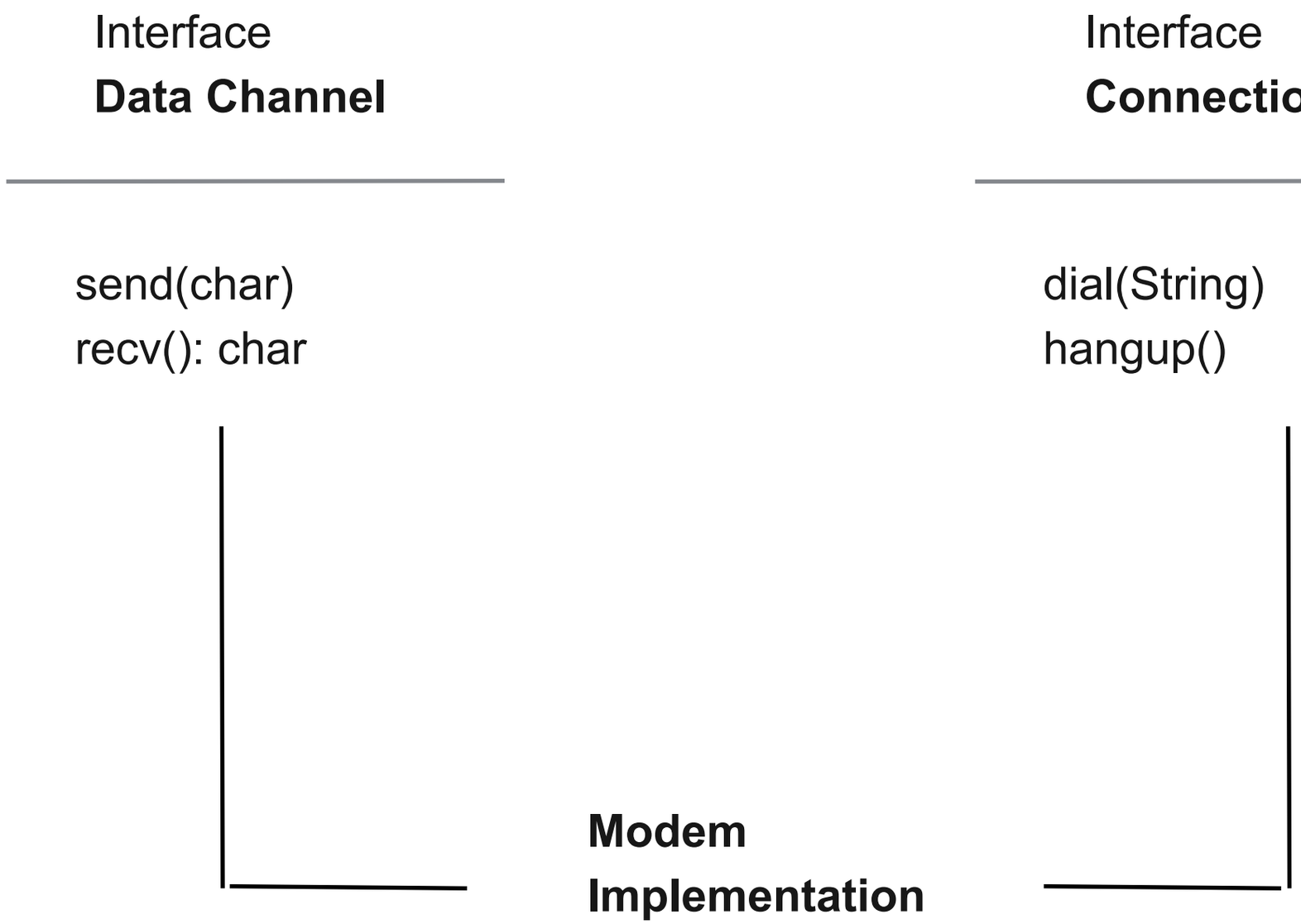
Behavior is what software is about

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.

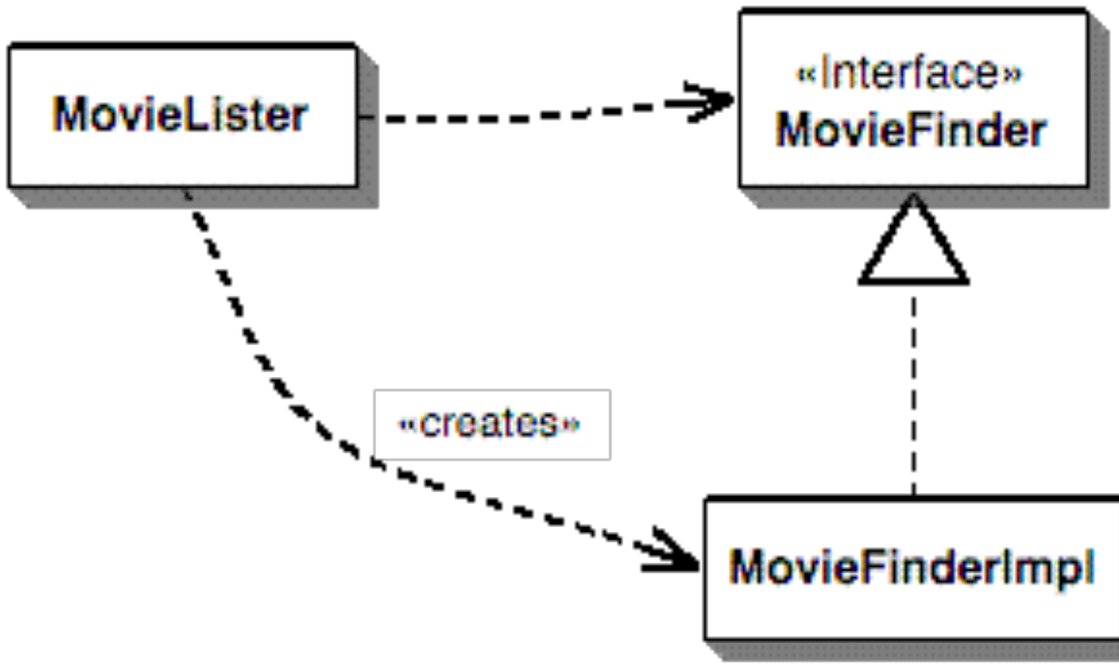
Abstractions should not depend upon details.
Details should depend upon abstractions.

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