# Dependency Injection

Kenneth M. Anderson
University of Colorado, Boulder
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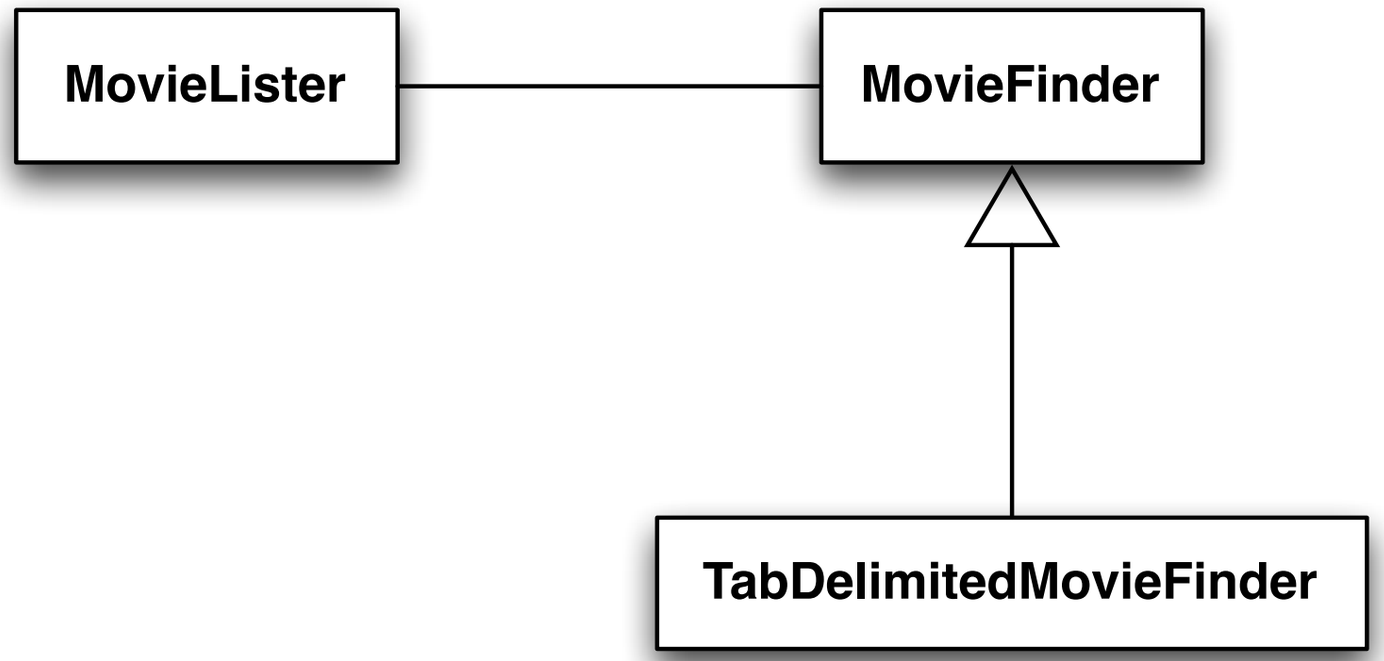
# Goals of the Lecture

- Introduce the topic of dependency injection
- See examples using the Spring Framework
  - Note: I'm using Spring 2.5.6 for this lecture
    - The latest production release is 3.2.0.RC2
    - The latest development release is 3.1.3
  - I'm only going to scratch the surface of Spring's capabilities
    - It is an extremely powerful framework that provides TONS of functionality (more than just dependency injection)
- Note: you need to download the "with-dependencies" .zip file in order to acquire all of the .jar files you need to run the examples

# Dependency Injection

- Dependency Injection is
  - a technique for assembling applications
    - from a set of concrete classes
      - that implement generic interfaces
        - without the concrete classes knowing about each other
- This allows you to create loosely coupled systems as the code you write only ever references the generic interfaces that hide the concrete classes
- Dependency Injection is discussed in a famous blog post by Martin Fowler
  - <http://martinfowler.com/articles/injection.html>

# Fowler's Example




A MovieLister class is able to list movies with certain characteristics after being provided a database of movies by an instance of MovieFinder

MovieFinder is an interface; TabDelimitedMovieFinder is a concrete class that can read in a movie database that is stored in a tab-delimited text file

# The Goal: Loosely-Coupled Systems

- Our goal (even with the simple system on the previous slide) is to avoid having our code depend on concrete classes
  - In other words, we do **NOT** want to see something like this
    - public class MovieLister {
      - private MovieFinder finder;
      - public MovieLister() {
        - this.finder = new TabDelimitedMovieFinder(“movies.txt”);
      - }
      - …
    - }

**Dependency on Concrete Class**

**Dependency on hard-coded string**

# Discussion

- The code on the previous slide has two concrete dependencies
  - a reference to a concrete class that implements MovieFinder
  - a reference to a hard-coded string
- Both references are brittle
  - The name of the movie database cannot change without causing MovieLister to be changed and recompiled
  - The format of the database cannot change without causing MovieLister to be changed to reference the name of the new concrete MovieFinder implementation

# Our Target (I)

- For loose-coupling to be achieved, we need code that looks like this
- public class MovieLister {
    - private MovieFinder finder;
    - public MovieLister(MoveFinder finder) {
        - this.finder = finder;
    - }
    - …
- }
- and, furthermore, nowhere in our source code should the strings “TabDelimitedMovieFinder” or “movies.txt” appear… nowhere!

# Our Target (II)

- As much as possible, get rid of code with the form
  - Foo f = new ConcreteFoo();
- Indeed, for the MoveLister system, we would even like to see code like this
  - public class Main {
    - private MovieLister lister;
    - public void setMovieLister(MovieLister lister) { this.lister = lister;}
    - public List<Movie> findWithDirector(String director) {
      - return lister.findMoviesWithDirector(director);
    - }
    - public static void main(String[] args) {
      - new Main().findWithDirector(args[0]); // add code to print list of movies
    - }
- }

**We want this to work even with no explicit call to setMovieLister();**

# Two types of dependency injection

- In the previous two slides, we've seen (implied) examples of two types of dependency injection
  - **Constructor Injection**
    - public MovieLister(MoveFinder finder) {
      - this.finder = finder;
    - }
  - **Setter Injection**
    - public void setMovieLister(MovieLister lister) { this.lister = lister;}
- In the former, the MovieLister class indicates its dependency via its constructor ("I need a MovieFinder"); In the second, the Main class indicated its dependency via a setter ("I need a MovieLister")

# So, what is dependency injection?

- The idea here is that classes in an application indicate their dependencies in very abstract ways
  - MovieLister NEEDS-A MovieFinder
  - Main NEEDS-A MovieLister
- and then a **third party injects (or inserts) a class that will meet that dependency at run-time**

- The “third party” is known as a “Inversion of Control container” or a “dependency injection framework”
  - There are many such frameworks; one example is Spring which has been around in some form since October 2002

# The basic idea

- Take
  - a set of components (concrete classes + interfaces)
- Add
  - a set of configuration metadata
- Provide that to
  - a dependency injection framework
- And finish with
  - a small set of bootstrap code that gets access to an IoC container, retrieves the first object from that container by supplying the name of a generic interface, and invokes a method to kick things off

# Example

- For instance, Fowler's example uses the following Spring-specific code to create an instance of MovieLister
- public void testWithSpring() throws Exception {
    - ApplicationContext ctx = new FileSystemXmlApplicationContext("spring.xml");
    - MovieLister lister = (MovieLister) ctx.getBean("MovieLister");
    - Movie[] movies = lister.moviesDirectedBy("Terry Gilliam");
- }
- "spring.xml" is a standard-to-Spring XML file containing metadata about our application; it contains information that specifies that MoveLister needs a TabDelimitedMovieFinder and that the database is in a file called "movies.txt"
    - Spring then ensures that TabDelimitedMovieFinder is created using "movies.txt" and inserted into MovieLister when ctx.getBean() is invoked

# getBean()?

- In Spring, POJOs (plain old java objects) are referred to as “beans”
  - This is a reference to J2EE’s notion of a JavaBean
    - which is a Java class that follows certain conventions
      - a property “foo” of type String is accessible via
        - public String getFoo();
      - and
        - public void setFoo(String foo);
- Once you have specified what objects your application has in a Spring configuration file, you pull instances of those objects out of the Spring container via the getBean method

# Spring's Hello World example

- I shall now possibly horrify you with a "Hello World" example written using Spring
  - I say "horrify" because it will seem horribly complex for a Hello World program
  - The complexity is reduced however when you realize that Spring is architected for really large systems
- and the "complexity tax" imposed by the framework pays off when you are dealing with large numbers of objects that need to be composed together
  - the "complexity tax" pays dividends when you are able to add a new type of object to a Spring system by adding a new .class file to your classpath and updating one configuration file

# Spring's Hello World (I)

- Note: example taken from the Apress book "Pro Spring 2.5"
- First, define a MessageSource class

```
 1 public class MessageSource {
 2
 3   private String message;
 4
 5   public MessageSource(String message) {
 6     this.message = message;
 7   }
 8
 9   public String getMessage() {
10     return message;
11   }
12
13 }
14
```

# Spring's Hello World (II)

- Second, define a MessageDestination interface and a concrete implementation

```
1  public interface MessageDestination {
2
3    public void write(String message);
4
5  }
6
```

```
1  public class StdoutMessageDestination implements MessageDestination {
2
3    public void write(String message) {
4      System.out.println(message);
5    }
6
7  }
8
```

# Spring's Hello World (III)

- Third, define a MessageService interface

```
1  public interface MessageService {
2
3    public void execute();
4
5  }
6
```

# Spring's Hello World (IV)

- Fourth, define a concrete implementation of MessageService

```
1  public class DefaultMessageService implements MessageService {
2
3    private MessageSource source;
4    private MessageDestination destination;
5
6    public void setSource(MessageSource source) {
7      this.source = source;
8    }
9
10   public void setDestination(MessageDestination destination) {
11     this.destination = destination;
12   }
13
14   public void execute() {
15     destination.write(source.getMessage());
16   }
17
18 }
19
```

# Spring's Hello World (IV)

- Fifth, create a main program that gets a Spring container, retrieves a MessageService bean, and invokes the service

```
1  import org.springframework.beans.factory.support.BeanDefinitionReader;
2  import org.springframework.beans.factory.support.DefaultListableBeanFactory;
3  import org.springframework.beans.factory.support.PropertiesBeanDefinitionReader;
4  import org.springframework.core.io.FileSystemResource;
5
6  import java.io.File;
7
8  public class DISpringHelloWorld {
9
10   public static void main(String[] args) {
11     DefaultListableBeanFactory bf = new DefaultListableBeanFactory();
12     BeanDefinitionReader reader = new PropertiesBeanDefinitionReader(bf);
13     reader.loadBeanDefinitions(
14       new FileSystemResource(
15         new File("hello.properties")));
16
17     MessageService service = (MessageService) bf.getBean("service");
18     service.execute();
19   }
20
21 }
22
```

**Spring Init Code**

**Where the magic happens**

# Spring's Hello World (V)

- I say "magic" on the previous slide, because with that call to getBean(), the following things happen automatically
    - an instance of MessageSource is created and configured with a message
    - an instance of StdoutMessageDestination is created
    - an instance of MessageService is created
        - the previous two instances (message source, message destination) are plugged into MessageService
- In short, you got back an instance of MessageService without having to create any objects; and, the object you got back was ready for use
    - you just had to invoke "execute()" on it

# Spring's Hello World (VI)

- How does the magic happen?
  - With the hello.properties file

```
1 source.(class)=MessageSource
2 source.$0=Hello Spring
3 destination.(class)=StdoutMessageDestination
4 service.(class)=DefaultMessageService
5 service.source(ref)=source
6 service.destination(ref)=destination
```

- It defines three beans: source, destination, and service
  - $0 refers to a constructor argument; (class) sets the concrete class of the bean; (ref) references a bean defined elsewhere
- With this information, the "service" bean can be created and configured

# XML Configuration Files

- The use of property files are now deprecated; instead, configuration metadata is stored in XML files; Here's an XML file equivalent to hello.properties:

```
1  <?xml version="1.0" encoding="UTF-8"?>
2  <beans xmlns="http://www.springframework.org/schema/beans"
3         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
4         xmlns:lang="http://www.springframework.org/schema/lang"
5         xsi:schemaLocation="
6  http://www.springframework.org/schema/beans http://www.springfr
7  http://www.springframework.org/schema/lang http://www.springfra
8
9    <bean id="source" class="MessageSource">
10     <constructor-arg index="0" value="Hello XML Spring" />
11   </bean>
12
13   <bean id="destination" class="StdoutMessageDestination" />
14
15   <bean id="service" class="DefaultMessageService">
16     <property name="source" ref="source" />
17     <property name="destination" ref="destination" />
18   </bean>
19
20 </beans>
```

# Spring's Hello World (VII)

- To use hello.xml, the main program is simplified to:

```
1  import org.springframework.beans.factory.xml.XmlBeanFactory;
2  import org.springframework.core.io.FileSystemResource;
3
4  import java.io.File;
5
6  public class DIXMLSpringHelloWorld {
7
8    public static void main(String[] args) {
9      XmlBeanFactory bf =
10       new XmlBeanFactory(
11         new FileSystemResource(
12           new File("hello.xml")));
13
14     MessageService service = (MessageService) bf.getBean("service");
15     service.execute();
16   }
17
18 }
19
```

# The Infamous Zoo Example

- Way back in Lecture 4, I mentioned that it was possible to create a version of the Zoo program that would only reference “Animal” and not any of its subclasses (Dog, Cat, Hippo, etc.)
- To do this in Spring, we make use of its ability to specify collection classes in its configuration XML files (see next slide)
- The main routine is simply a variant on what we’ve seen before
  - we will load a “zoo.xml” configuration file
  - retrieve the “zoo” bean
  - and invoke its “exerciseAnimals()” method

# The zoo.xml file

```
 8
 9   <bean id="zoo" class="Zoo">
10     <constructor-arg index="0">
11       <list>
12         <ref local="bat" />
13         <ref local="cat" />
14         <ref local="dog" />
15         <ref local="elephant" />
16         <ref local="hippo" />
17         <ref local="lion" />
18         <ref local="rhino" />
19         <ref local="tiger" />
20         <ref local="wolf" />
21       </list>
22     </constructor-arg>
23   </bean>
24
25   <bean id="bat" class="Bat" />
26   <bean id="cat" class="Cat" />
27   <bean id="dog" class="Dog" />
28   <bean id="elephant" class="Elephant" />
29   <bean id="hippo" class="Hippo" />
30   <bean id="lion" class="Lion" />
31   <bean id="rhino" class="Rhino" />
32   <bean id="tiger" class="Tiger" />
33   <bean id="wolf" class="Wolf" />
```

Here, we define that there is a bean called “zoo” and it takes a parameter to its constructor that is a list of beans, in this case beans that reference the Animal subclasses below

Here we define instances of animal subclasses; this is where the subclass names are referenced (nowhere else)

# Wrap Up

- This represents a barebones introduction to dependency injection frameworks
  - You've seen only a smidgen of Spring's functionality
- But, you've seen the core feature of dependency injection frameworks
  - The ability to remove the names of concrete classes out of your source code while having those classes automatically instantiated and injected into your system based on configuration metadata

# Semester Wrap-Up

- Reviewed core OO A&D concepts and techniques
- Covered design patterns and saw examples of how they can be integrated into OO A&D life cycles
  - Saw a wide range of patterns (there are many more out there)
- Covered features of the Android and iOS mobile application frameworks
  - Saw the use of design patterns in these frameworks
- Covered refactoring, object-relational mapping and dependency injection
- Provided you an opportunity to build a mobile app and/or web service and make use of design patterns in your prototypes

# Coming Up Next Time

- All done!
    - There is no “next time”
- Have a great winter break!