Tutorial:
Spring and OSGi Combined with Spring Dynamic Modules

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A few words about myself…

- Martin Lippert
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- Focus
  - Agile software development
  - Refactoring
  - Eclipse technology
- Equinox incubator committer

Agenda

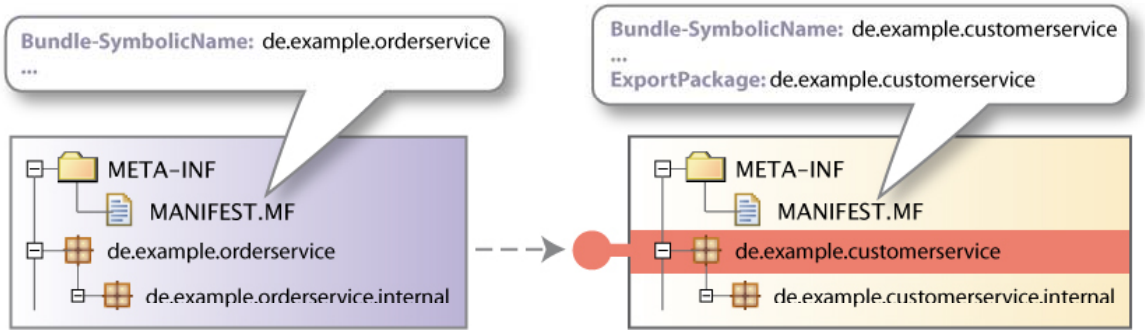
- What is OSGi?
- What is Spring Dynamic Modules?
- Spring Dynamic Modules in Action
- Server-Side Applications
- RCP Applications
- Summary

OSG – What?

- OSGi™:
  - **„A dynamic module system for Java“**

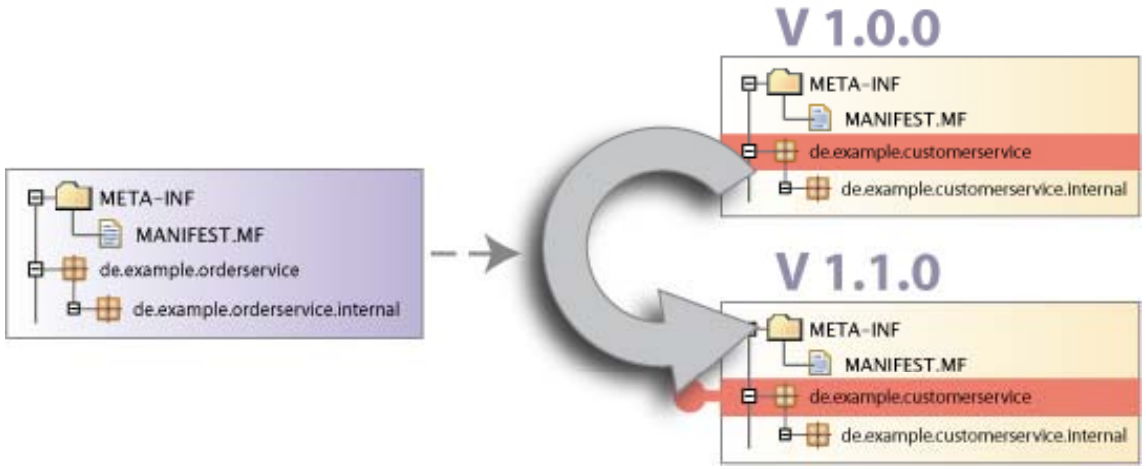
OSGi is …

- … a module system for Java that allows the definition of …
  - **Modules** (called „bundles“),
  - **Visibility** of the bundle contents (public-API vs. private-API)
  - **Dependencies** between modules
  - **Versions** of modules



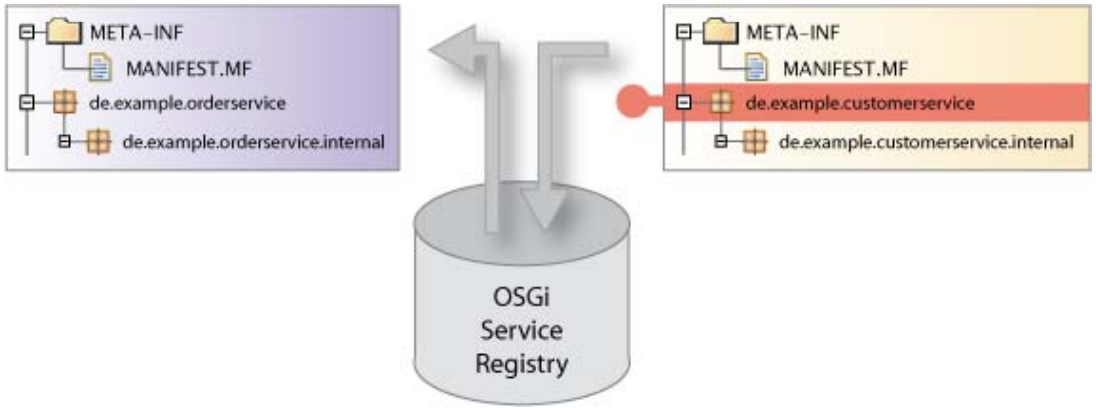
OSGi is …

- … dynamic
  - Bundles can be installed, started, stopped, uninstalled and updated at runtime



OSGi is …

- … service oriented
  - Bundles can publish services (dynamically)
  - Bundles can find and bind to services through a service registry
  - The runtime allows services to appear and disappear at runtime



What does OSGi look like? (Low Level)

Identification

```
Bundle-SymbolicName: org.eclipse.equinox.registry
Bundle-Version: 3.2.100.v20060918
Bundle-Name: Eclipse Extension Registry
Bundle-Vendor: Eclipse.org
```

Classpath

```
Bundle-ClassPath: ., someOtherJar.jar
```

Lifecycle

```
Bundle-Activator: org.eclipse.core.internal.registry.osgi.Activator
```

Dependencies

```
Import-Package: javax.xml.parsers,
 org.xml.sax,
 org.osgi.framework;version=1.3
Require-Bundle: org.eclipse.equinox.common;bundle-version="[3.2.0,4.0.0)"
Bundle-RequiredExecutionEnvironment: CDC-1.0/Foundation-1.0,J2SE-1.3
```

Exports

```
Export-Package: org.eclipse.equinox.registry
```


Implementations

- Open source implementations
  - Eclipse Equinox (http://www.eclipse.org/equinox/)
  - Apache Felix (http://cwiki.apache.org/FELIX/index.html)
  - Knopflerfish (http://www.knopflerfish.org/)
  - ProSyst mBedded Server Equinox Edition (http://www.prosyst.com/products/osgi_se_equi_ed.html)
- Commercial implementations
  - ProSyst (http://www.prosyst.com/)
  - Knopflerfish Pro (http://www.gatespacetelematics.com/)

(not necessarily complete)

What is Spring Dynamic Modules?

- Project Objectives
- Introduction to key Spring concepts
- Bundles and module contexts
- Application design
- The extender pattern
- Who's using it?

Spring Dynamic Modules is...

- A open source project in the Spring portfolio
  - led by SpringSource
  - committers from BEA and Oracle
  - many non-code contributions from the community and from the OSGi EEG and CPEG

http://www.springframework.org/osgi

Project Objectives

- Bring the benefits of OSGi:
  - modularity
  - versioning
  - lifecycle support
- To enterprise application development

Design considerations (raw OSGi)

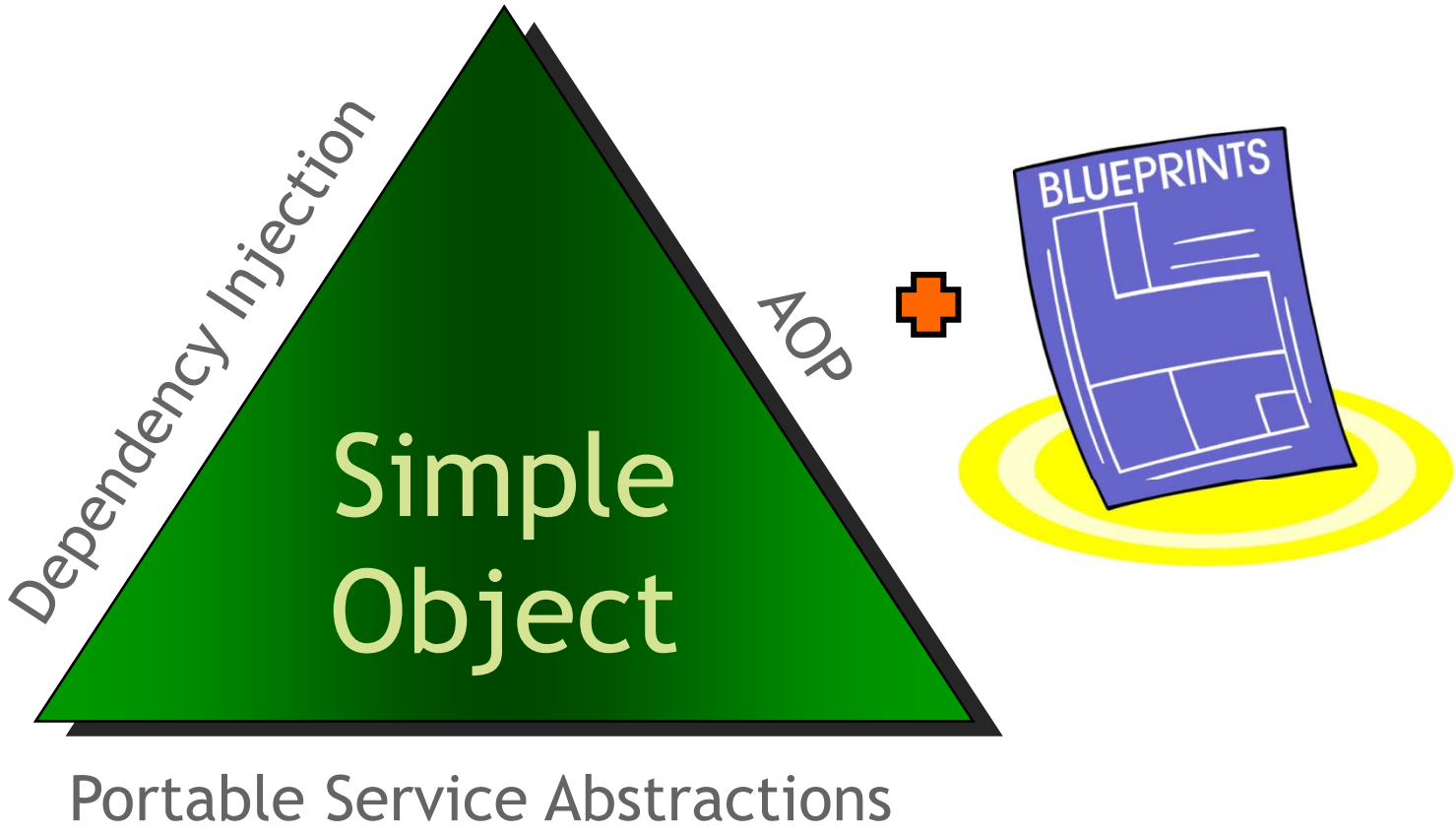
- Platform dynamics
  - services may come and go at any time
  - ServiceTracker
- Asynchronous activation
  - service dependency management
- Testing
- Concurrency and thread management

Project Objectives

- The simplicity and power of Spring...
  - with the dynamic module system of OSGi
- Modules need instantiating, configuring, decorating, assembling, ...
- Need an easy way to manage service references between modules
- Easy unit and integration testing

Bring the benefits of OSGi to enterprise applications

Key Spring Concepts



The Heart of Spring

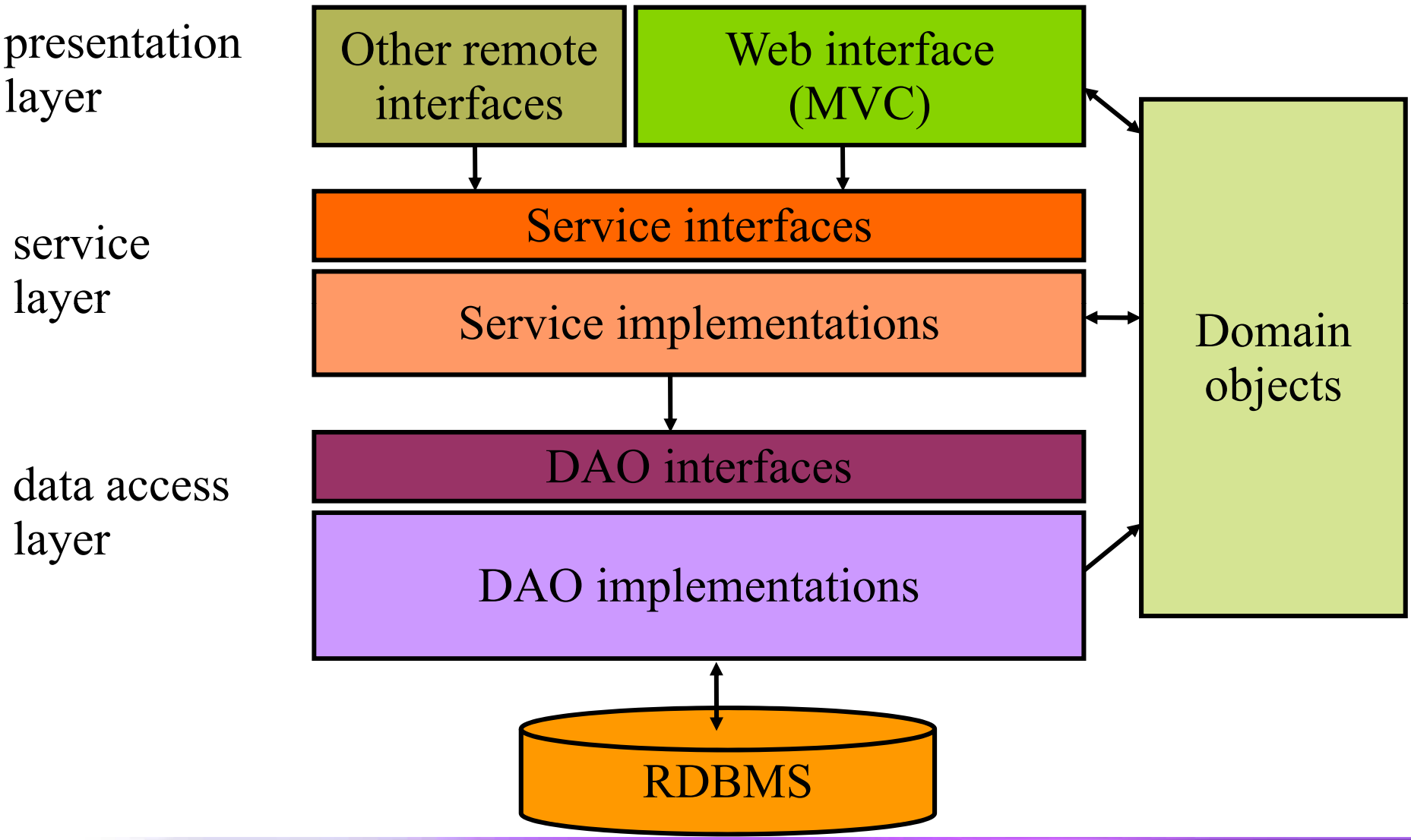
- Lightweight container
  - Full stack, simple object based application development
- Works in any environment
  - web-app, ejb, integration test, standalone
- Provides…
  - a powerful object factory that manages the instantiation, configuration, decoration and assembly of business objects

Spring-based development

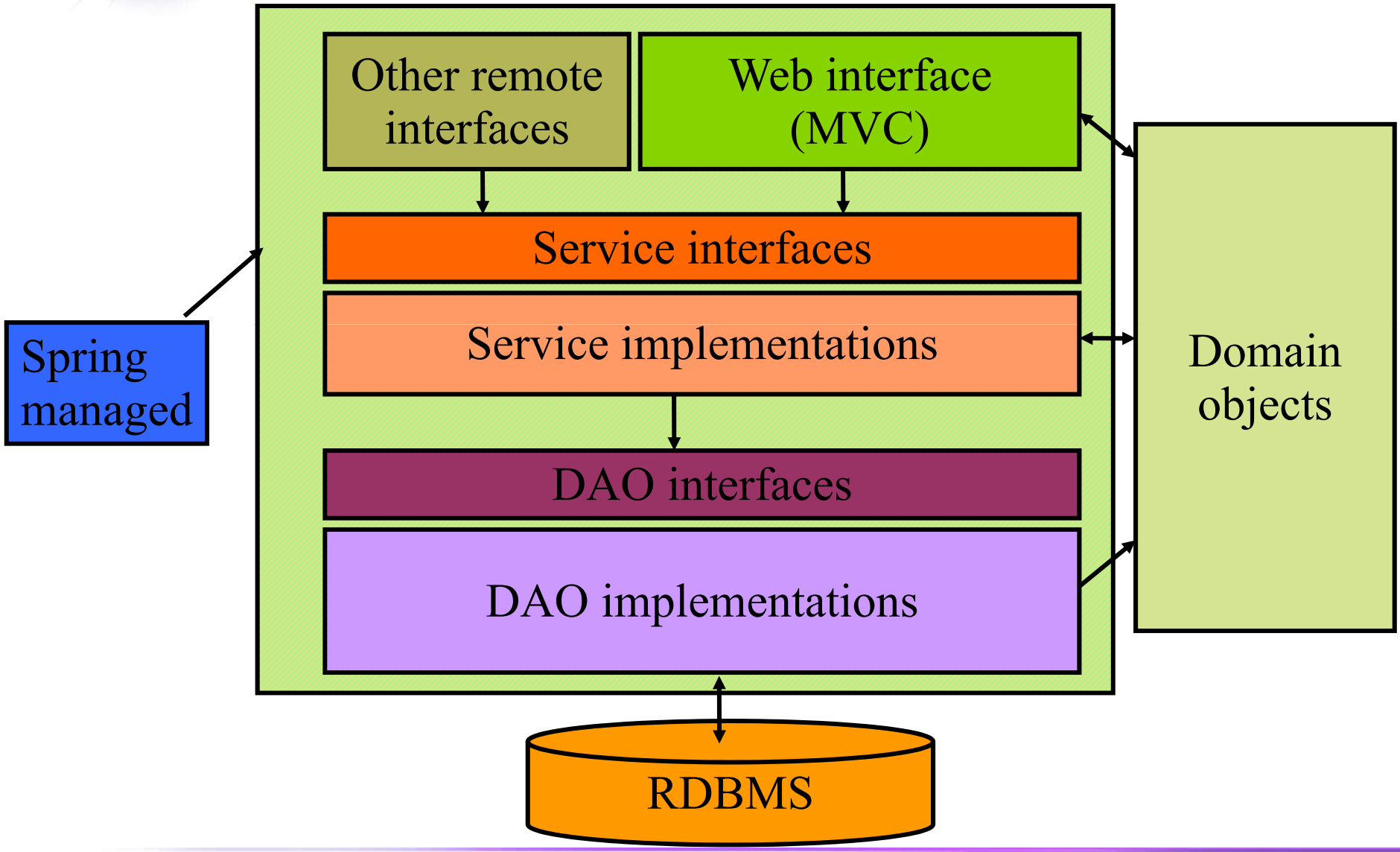
- View application as a set of components
  - with clear layering
- Each component is a simple object
  - Testable in isolation

- Container manages component configuration and assembly
- Container decorates your components at runtime

Typical application layering



Typical application layering



Spring Framework

- Dependency injection
- Integration with persistence technologies (JDBC, Hibernate)
- Web application support Spring MVC, JSF and Struts
- Enterprise service abstractions
  - Transactions
  - Messaging
- Aspect Oriented Programming support

Without dependency injection

```
public class TransferServiceImpl implements TransferService {
    private AccountRepository accountRepository;

    public TransferServiceImpl() {
        DataSource ds = (DataSource)
            ctx.lookup("myAppserverDS");
        accountRepository = new JdbcAccountRepository(ds);
    }
    …
}
```

Tied to Jdbc implementation
Tied to application server JNDI
Hard to test. Hard to reuse

Dependency Injection

```
public class JdbcAccountRepository implements
    AccountRepository {
    …
}
```

Implements a service interface

```
public class TransferServiceImpl implements TransferService {
    private final  AccountRepository accountRepository;

    public TransferServiceImpl(AccountRepository ar) {
        this.accountRepository = ar;
    }
    …
}
```

Depends on service interface;
conceals complexity of implementation;
allows for swapping out implementation

Spring Blueprint

```
<beans>

   <bean id="transferService" class="app.impl.TransferServiceImpl">
      <constructor-arg ref="accountRepository" />
   </bean>

   <bean id="accountRepository" class="app.impl.JdbcAccountRepository">
      <constructor-arg ref="dataSource" />
   </bean>

   <bean id="dataSource" class="com.oracle.jdbc.pool.OracleDataSource">
      <property name="URL" value="jdbc:oracle:thin:@localhost:1521:BANK" />
      <property name="user" value="moneytransfer-app" />
   </bean>

</beans>
```


Bundles and Module Contexts

- OSGi bundle <==> Spring Application Context
  - we call it a *module context*
- *Module context created when bundle is started*
- *destroyed when bundle is stopped*

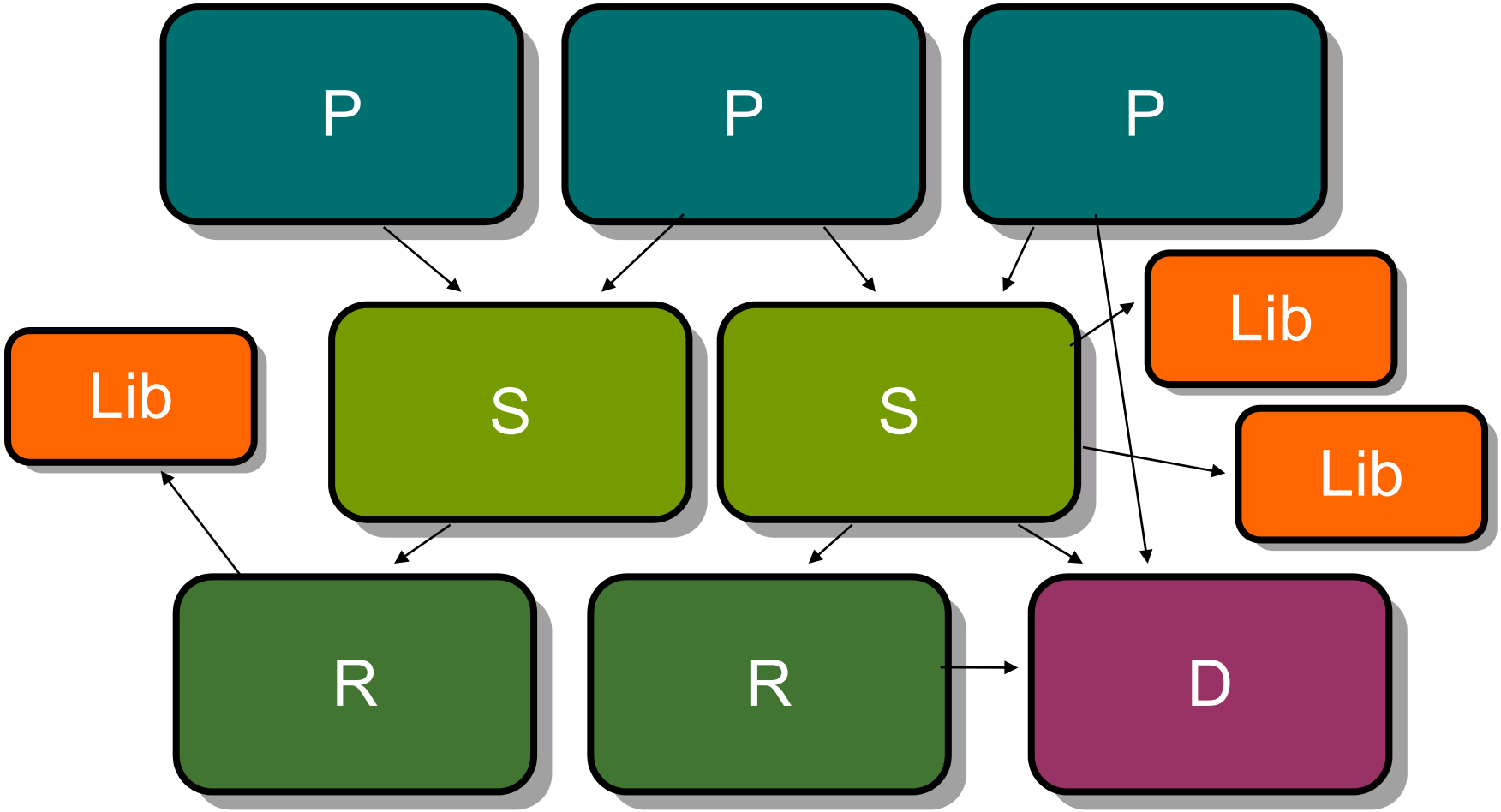
- *Module components <==> Spring beans*
  - *instantiated, configured, decorated, assembled by Spring*

- *Components can be imported / exported from OSGi service registry*

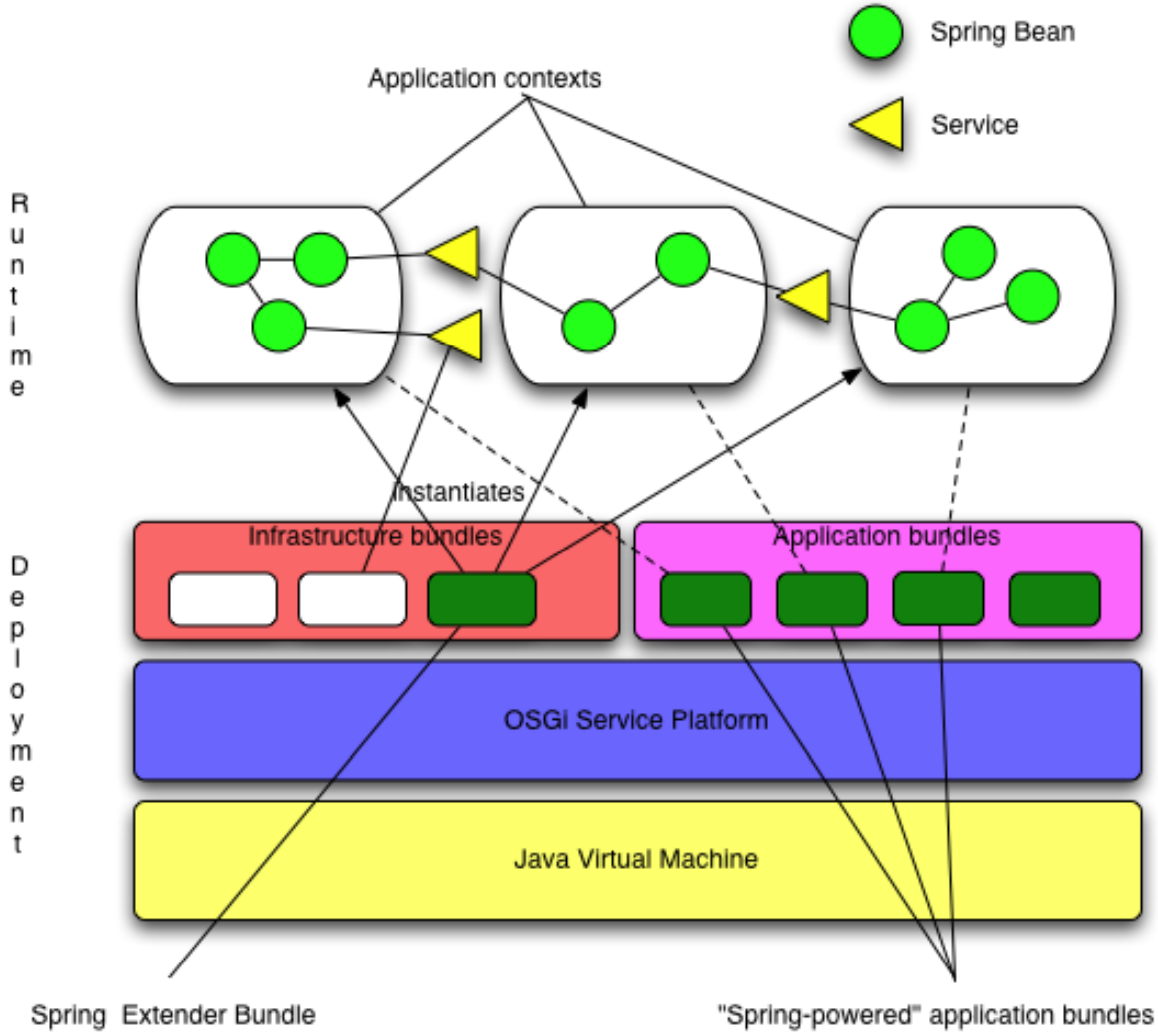
Application Design

- Application becomes a set of co-operating bundles
  - vertical decomposition first
  - then horizontal
- Communication via service registry

Application wiring



Spring Dynamic Modules



The Extender pattern

- "The OSGi Extender Model"
  - Peter Kriens, Feb. 2007
  - http://www.osgi.org/blog/2007/02/osgi-extender-model.html
- [A]synchronous bundle listener
  - listen to install, update, uninstall events
  - inspect bundle content
  - Take appropriate action on behalf of the bundle
- Spring Dynamic Modules extender bundle:
  - org.springframework.osgi.bundles.extender
  - must be installed and active for module contexts to be created

Spring Dynamic Modules Users

- Oracle
  - building next generation middleware platform on OSGi and Spring DM
- BEA
  - WebLogic Event Server 2.0 built on Spring Dynamic Modules
- Over 1000 subscribers on mailing list

http://groups.google.com/group/spring-osgi

Agenda

- What is Spring Dynamic Modules?
- **Spring Dynamic Modules in Action**
- Server-side Applications
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Spring Dynamic Modules in Action

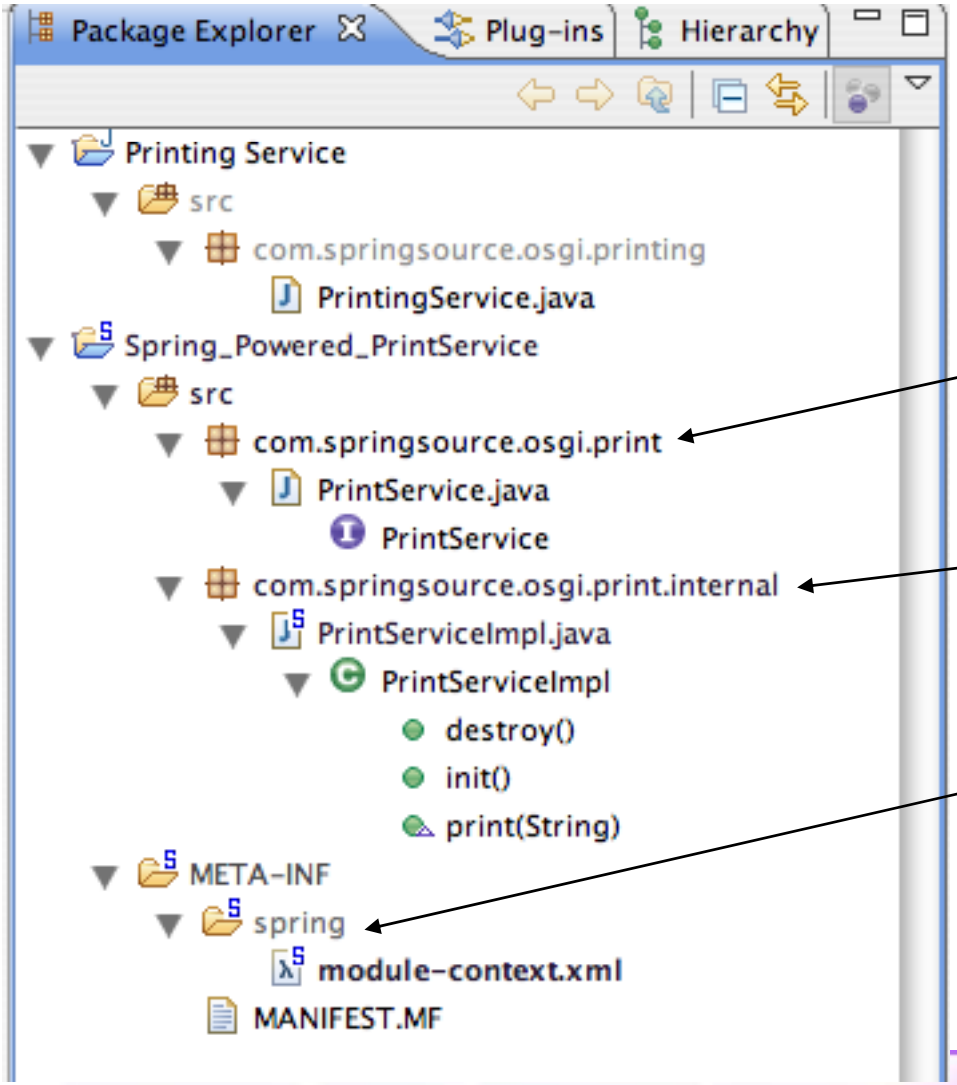
- Creating a Spring-powered bundle
- Importing and exporting services
- The whiteboard pattern
- Dynamics
- Startup and shutdown

Spring-powered bundles

- Spring module context (app context) per bundle (module)
  - created automatically for you by Spring extender bundle
  - no need to depend on any OSGi APIs

- META-INF/spring/*.xml
- or Spring-Context header in MANIFEST.MF

Spring-powered bundles



Published interfaces

Protected implementations

Spring configuration files

Demo/Exercise 1: Spring-powered bundle

- Step 1:
  - Implement a bundle including a bundle activator
  - Try out your bundle via the console
- Step 2:
  - Implement a POJO with a method “hello” and a method “goodbye”
  - Create a spring context and define your POJO as a bean
  - Define your methods as init- and destroy-methods
  - Try out your bundle via the console using Spring DM

Getting log output

- Spring uses Jakarta Commons Logging
- Commons logging doesn't behave well under OSGi
  - Use SLF4J binding instead
    - Simple Logging Facade for Java (http://www.slf4j.org/)
- Bundles:
  - jcl104.over.slf4j (static binding of jcl to slf4j)
  - slf4j.api (the slf4j API)
  - slf4j.log4j12 (implementation of slf4j over log4j)

Getting log output

```
osgi> log4j:WARN No appenders could be found for logger
  (org.springframework.util.ClassUtils).
log4j:WARN Please initialize the log4j system properly.
```

- Where to put log4j.properties?
  - which bundle is it that looks for this file?
  - how do we make it visible to that bundle?

Getting log output

- Use a *Fragment Bundle*
  - *"Fragments are bundles that are attached to a host bundle by the Framework." - OSGi Core Specification, 3.14*

```
Manifest-Version: 1.0
Bundle-ManifestVersion: 2
Bundle-Name: Logging Configuration Fragment
Bundle-SymbolicName: com.springsource.logging.config
Bundle-Version: 1.0.0
Bundle-Vendor: SpringSource
Fragment-Host:  org.springframework.osgi.log4j.osgi;
  bundle-version="1.2.15.SNAPSHOT"
Bundle-RequiredExecutionEnvironment: J2SE-1.5
```


Demo/Exercise 2: log4j configuration

- Create a fragment for the log4j configuration
- Put the log4j configuration into this bundle
- Attach the fragment to the log4j host bundle
- Try it out!

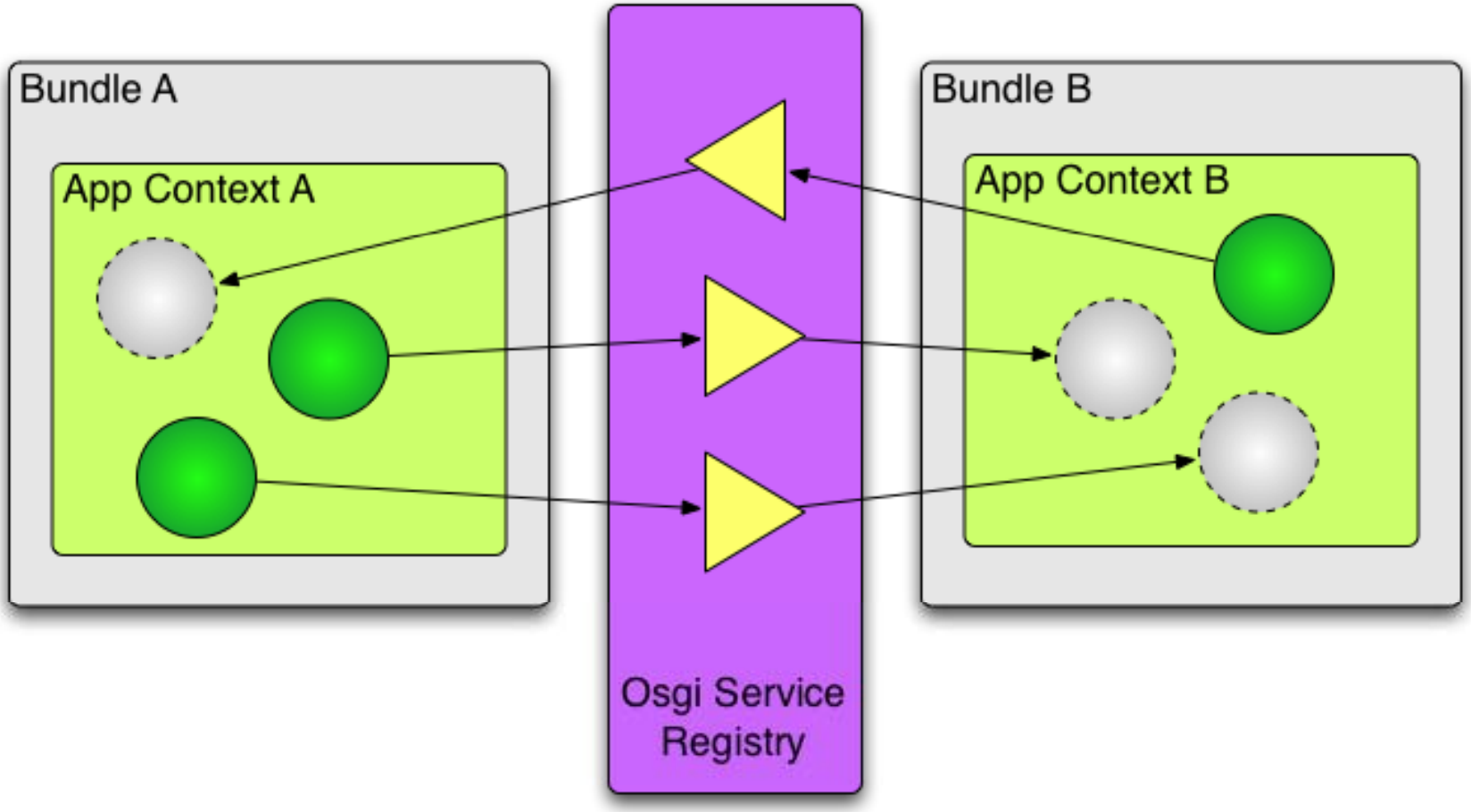
Spring Dynamic Modules in Action

- Creating a Spring-powered bundle
- **Importing and exporting services**
- The whiteboard pattern
- Dynamics
- Startup and shutdown

Services

- Your application is constructed as a set of bundles, each with their own module context
- How do we reference beans in other modules?
  - use the OSGi Service Registry
    - advertise public services
    - import references to external services

Beans and services



Service import/export overview

Exporting context:

```
<bean id="printService"
   class="com.springsource.osgi.print.internal.PrintServiceImpl"
   init-method="init"
   destroy-method="destroy"/>

<osgi:service ref="printService"
        interface="com.springsource.osgi.print.PrintService"/>
```

Importing context:

```
<bean id="printClient"
   class="com.springsource.osgi.print.client.Client"
   init-method="init">
   <property name="printService" ref="printService"/>
</bean>

<osgi:reference id="printService"
        interface="com.springsource.osgi.print.PrintService"/>
```


Exporting a service

```
<bean id="printService"
   class="com.springsource.osgi.print.internal.PrintServiceImpl"
   init-method="init"
   destroy-method="destroy"/>

<osgi:service ref="printService"
        interface="com.springsource.osgi.print.PrintService"/>
```

- *any* Spring bean can be exported as OSGi service
- offers access to the ServiceRegistration object

Importing a service

```
<bean id="printClient"
   class="com.springsource.osgi.print.client.Client"
   init-method="init">
   <property name="printService" ref="printService"/>
</bean>

<osgi:reference id="printService"
        interface="com.springsource.osgi.print.PrintService"/>
```

- locates the best OSGi service that matches the description
- handles the service dynamics internally

Demo/Exercise 3: OSGi services

- Step 1:
  - Define an interface for your bean in a separate package
  - Export only this interface
- Step 2:
  - Export your bean as an OSGi service using the interface
- Step 3:
  - Take a look at the available services at the console

Demo/Exercise 3: OSGi services

- Step 4:
  - Create another bundle including a spring context
  - Define a bean that requires an instance of your service
    - Define the property
    - Import the OSGi service as a bean

Controlling Service Exporting

- Which interface(s) should the service be registered under?
  - a single interface, use the interface attribute
  - multiple interfaces, use the nested interfaces element
  - Or... have Spring Dynamic Modules calculated the exported interface set for you automatically.

```
<osgi:service id="printService" auto-export="interfaces"/>
```

    - auto-export values are interfaces, class-hierarchy, or all-classes.

Controlling Service Exporting

- Service always has service property
  - org.springframework.osgi.bean.name
  - (set to bean name)
- Specify additional service properties explicitly if needed

```
<osgi:service ref="printService"
        interface="com.springsource.osgi.print.PrintService">
  <osgi:service-properties>
    <entry key="aKey" value="someValue"/>
    <entry key="aKey" value-ref="someBeanName"/>
  </osgi:service-properties>
</osgi:service>
```


Controlling Service Importing

- Use filter expressions
  - RFC 1960: A String representation of LDAP Search Filters

```
<osgi:reference id="printService"
    interface="com.springsource.osgi.print.PrintService"
    filter="(colour=true)"/>
```

- Special attribute bean-name matches on org.springframework.osgi.bean.name property
  - condition anded with filter expression if present
- Can specify multiple interfaces using nested interfaces element.

Spring Dynamic Modules in Action

- Creating a Spring-powered bundle
- Importing and exporting services
- **The whiteboard pattern**
- Dynamics
- Startup and shutdown

The Whiteboard Pattern

- "Listeners Considered Harmful: The Whiteboard Pattern"
  - OSGi Alliance Technical Whitepaper, 2004
  - http://www.osgi.org/wiki/uploads/Links/whiteboard.pdf
- Lifecycle issues around listener registration
- Solution: whiteboard
  - event source is not registered as a service
  - listeners register as services using well-known interface
  - event source uses a tracker to track listener services

Importing a set of services

```
<bean id="printClient"
   class="com.springsource.osgi.print.client.Client"
   init-method="init">
   <property name="printService" ref="printService"/>
</bean>

<osgi:set id="printService"
        interface="com.springsource.osgi.print.PrintService"/>
```

- locates *all* OSGi services that match the description
- handles the service dynamics internally
- See also: <osgi:list... />

Demo/Exercise 4: whiteboard pattern

- Step 1:
  - Enhance your second bundle to use a set of services
  - Call these services regularly
    - E.g. via a thread started in the init method
- Step 2:
  - Split your first bundle into an interface bundle (containing just the interface) and an implementation bundle
- Step 3:
  - Create a third bundle that registers a different implementation of the interface as OSGi service

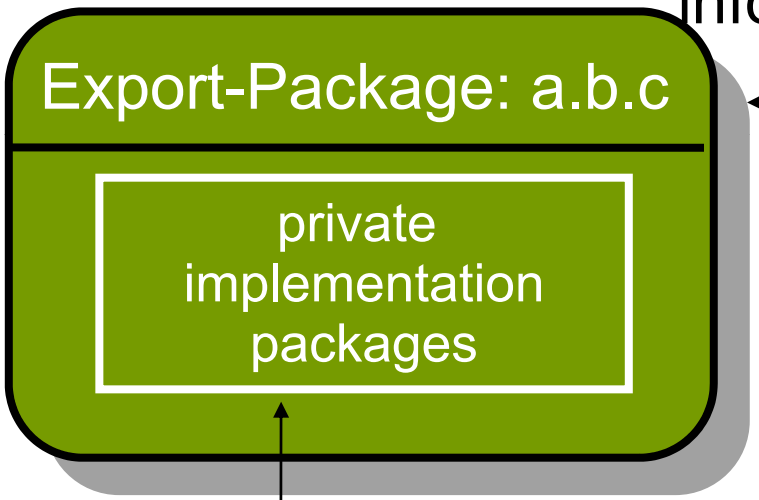
Spring Dynamic Modules in Action

- Creating a Spring-powered bundle
- Importing and exporting services
- The whiteboard pattern
- **Dynamics**
- Startup and shutdown

Dealing with dynamics

A service bundle…

Service interface types exported [with version information]

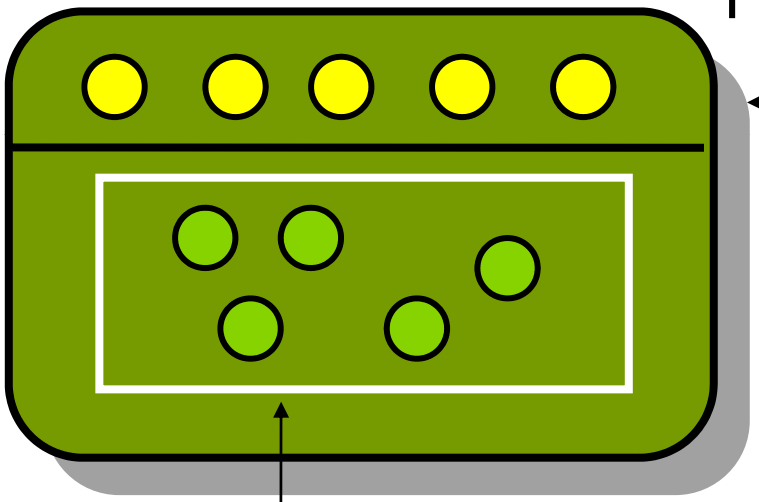


Service implementation locked away

"Passive" contribution
- types added to type space
- bundles see new version on resolution after install/refresh

Dealing with dynamics

A service bundle…

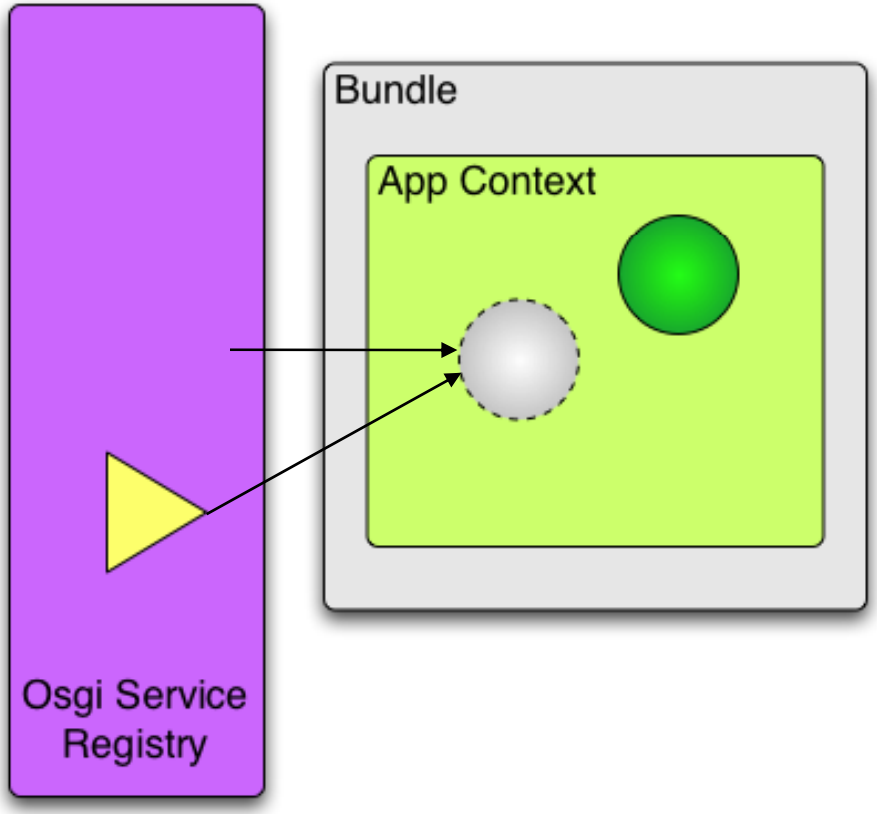


"Active" contribution
- services published in registry
- bundles see service changes immediately

Service Dynamics

- What happens when a service goes away?
  - osgi:reference cardinality=”0..1”
    - track replacement and retarget proxy when suitable target found
    - ServiceUnavailableException after timeout if invoked
  - osgi:reference cardinality=”1..1”
    - as above, plus
    - unregister any exported services that depend on the unsatisfied reference

Cardinality (single reference)



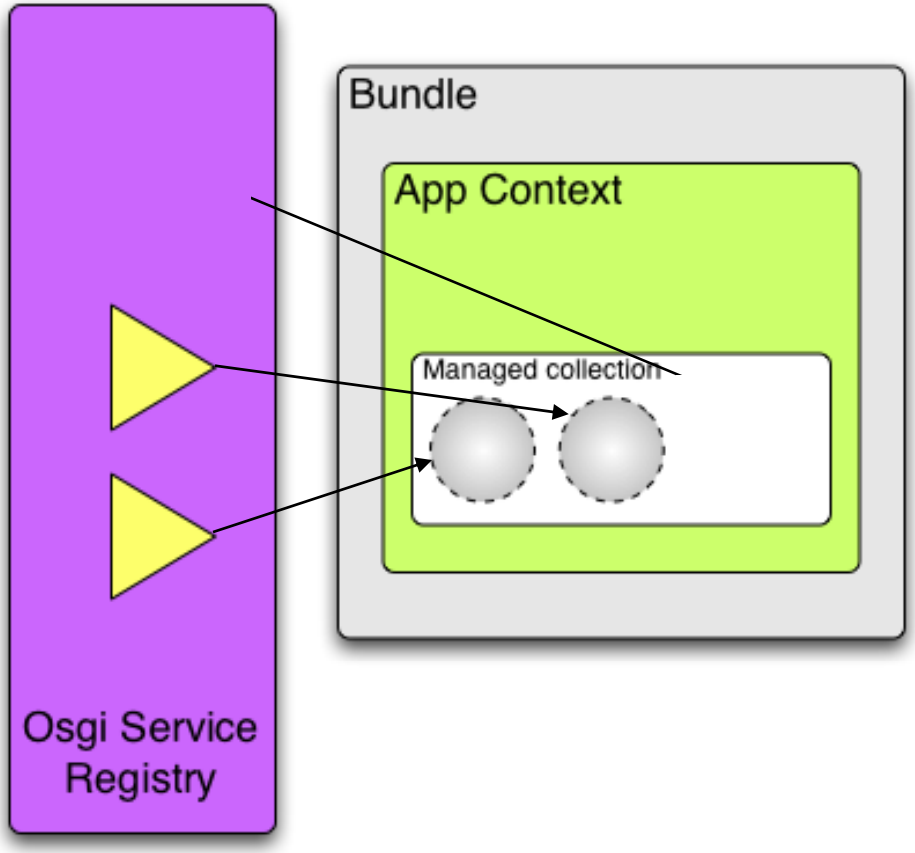
Registration management

```
<osgi:service id="myService" ref="exposedBean"/>

<bean id="exposedBean" class="...">
   <property name="myHelper" ref="helperBean"/>
</bean>

<bean id="helperBean" class="...">
   <property name="fooService" ref="fooService"/>
</bean>

<osgi:reference id="fooService" interface="..."/>
```


Service Dynamics

- What happens when a service goes away?
  - osgi:set/list cardinality=”0..n”
    - service is removed from the set
    - Iterator contract is honored
  - osgi:set/list cardinality=”1..n”
    - as above, plus
    - unregister any exported services that depend on the unsatisfied service reference

Cardinality - many



Demo/Exercise 5: Dynamics

- Play with the two implementation bundles via the console
  - Starting and stopping the different bundles and see what happens

Listening

- You work with a constant reference
  - Proxy / Set / List
- Spring Dynamic Modules manages the target backing service(s) for you
- You can optionally listen to bind / unbind events
- You can optionally listen to register / unregister events

Reference listeners

```
<osgi:reference id="printService"
        interface="com.springsource.osgi.print.PrintService">

  <osgi:listener bind-method="onBind"
                 unbind-method="onUnbind">
    <beans:bean class="MyCustomListener"/>
  </osgi:listener>

</osgi:reference>
```

```
class MyCustomListener {

  public void onBind(PrintService service, Map serviceProperties) {...}

  public void onBind(FastPrintService service, Map serviceProps) {...}

  public void onUnbind(ColorPrintService service, Map props) {...}

}
```


Registration listeners

```
<osgi:service id="printService"
        interface="com.springsource.osgi.print.PrintService">

  <osgi:registration-listener
      registration-method="registered"
      unregistration-method="unregistered"
      ref="printServiceListener"/>

</osgi:service>
```

```
class MyCustomListener {

  public void registered(PrintService service, Map serviceProps) {...}

  public void unregistered(PrintService service, Map serviceProps) {...}

}
```


Spring Dynamic Modules in Action

- Creating a Spring-powered bundle
- Importing and exporting services
- The whiteboard pattern
- Dynamics
- **Startup and shutdown**

Startup

- Context creation
  - blocks until all mandatory service references are satisfied
  - simply start your bundles and let Spring Dynamic Modules figure it out
- Control via Spring-Context manifest header directives
  - wait-for-dependencies:=[true|false]
  - timeout:=[seconds]
- E.g.
  - Spring-Context: *;wait-for-dependencies:=false

Shutdown

- Module contexts disposed when bundle is stopped
- Stopping the extender bundle disposes of all module contexts created by it
  - First those bundles that do not export any referenced services (in reverse bundle id order)
  - Cycles broken first by ranking, then by service id

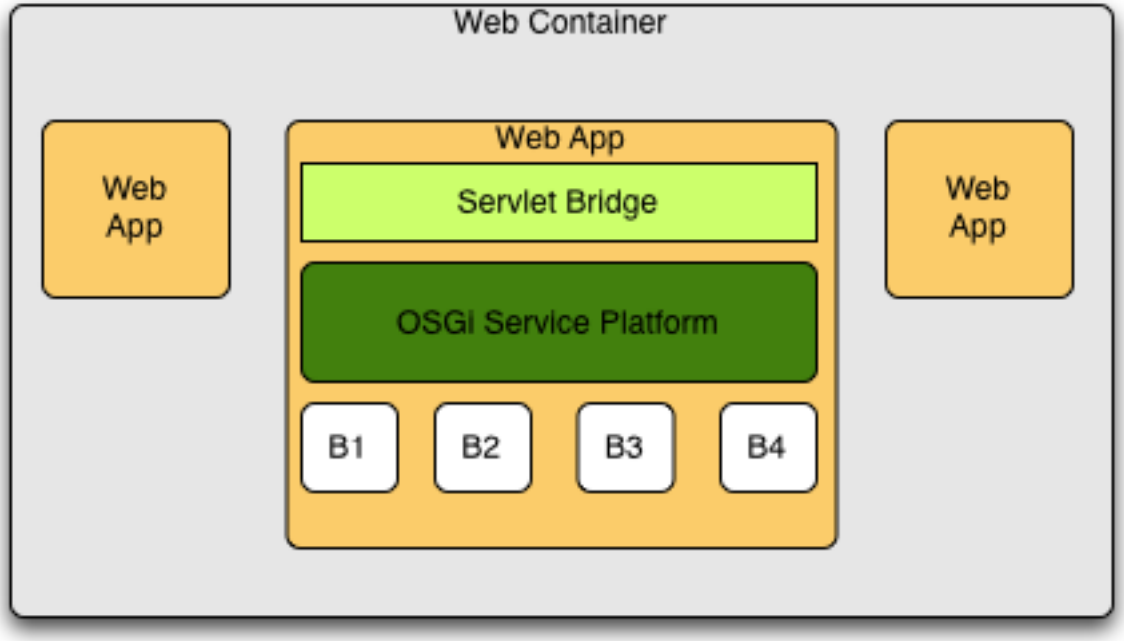
Agenda

- What is Spring Dynamic Modules?
- Spring Dynamic Modules in Action
- **Server-side Applications**
- RCP Applications
- Summary

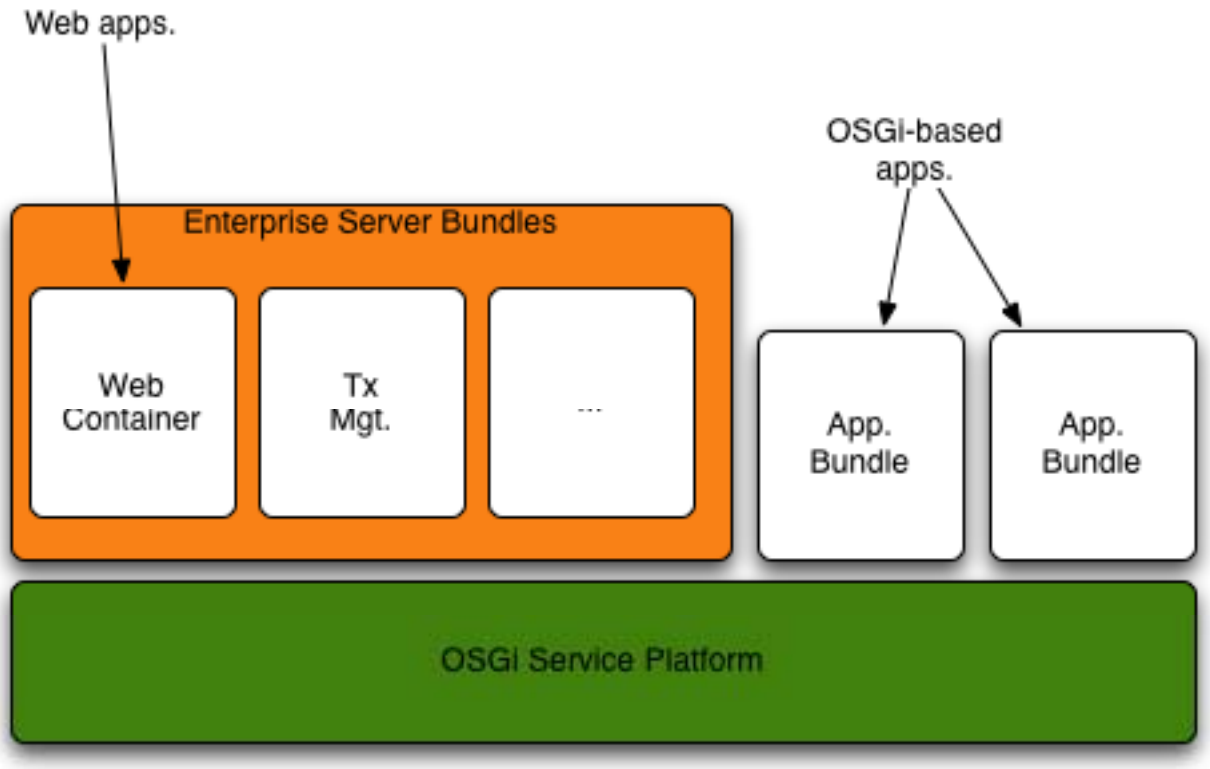
Server-side Applications

- Options for using OSGi on the server-side
- Enterprise library "gotchas"
- Context class loader management

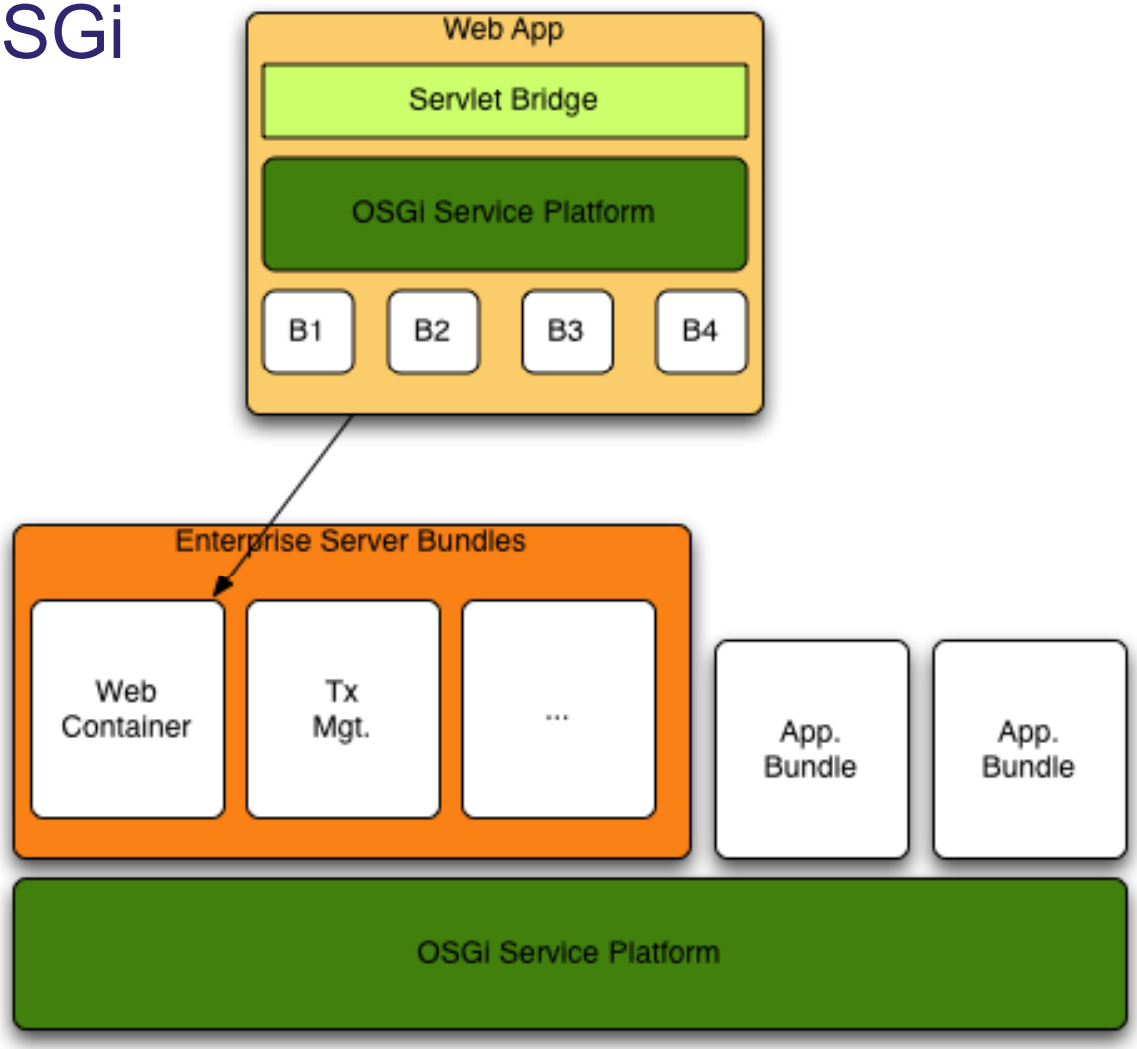
Embedded OSGi



OSGi as a server platform



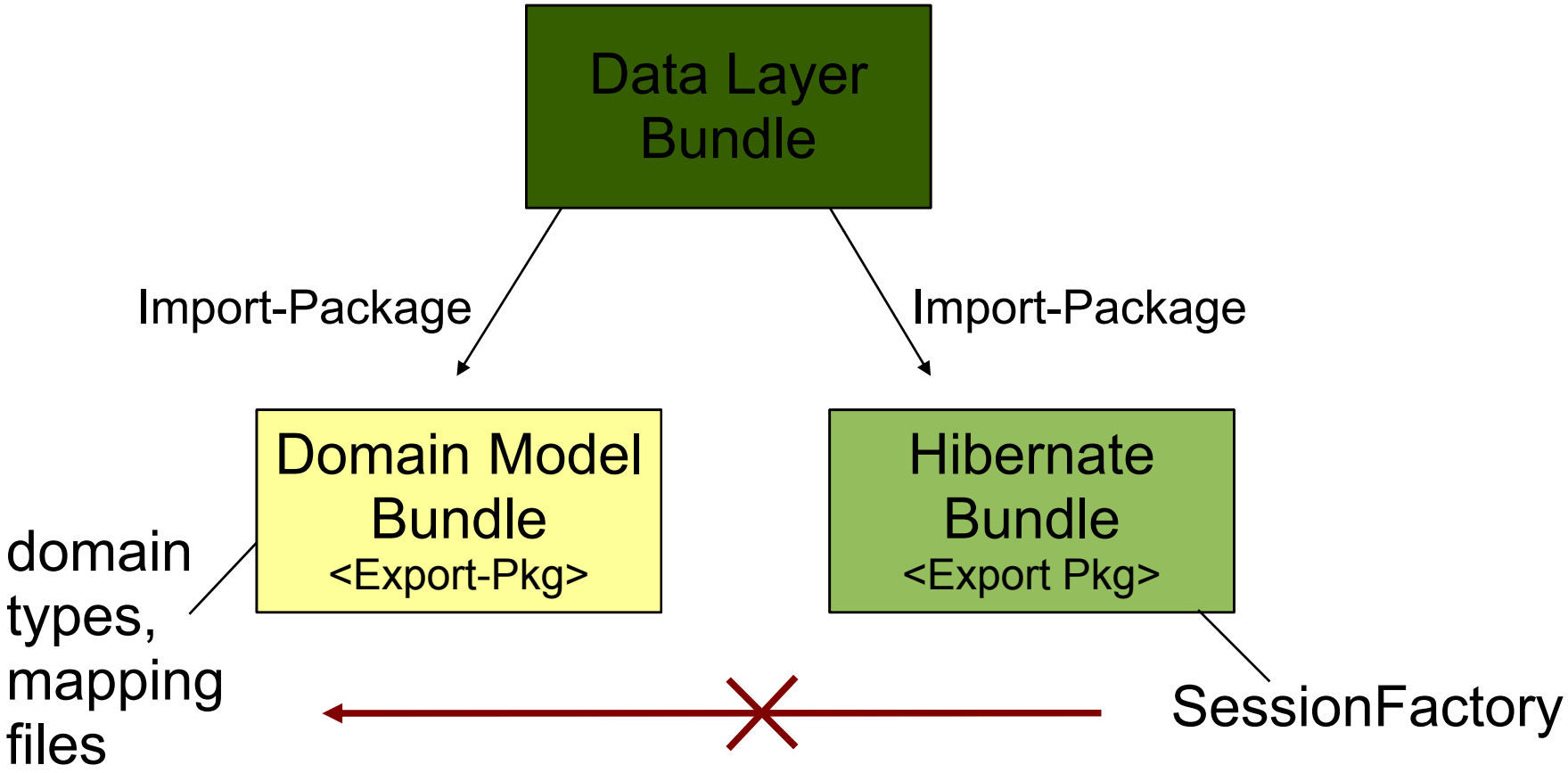
Nested OSGi



Enterprise Libraries under OSGi

- class and resource-loading problems
  - class visibility
  - Class.forName
  - context class loader
- Good news: Spring 2.5 is OSGi-ready
  - modules shipped as bundles
  - all class loading behaves correctly under OSGi

Example: Class visibility

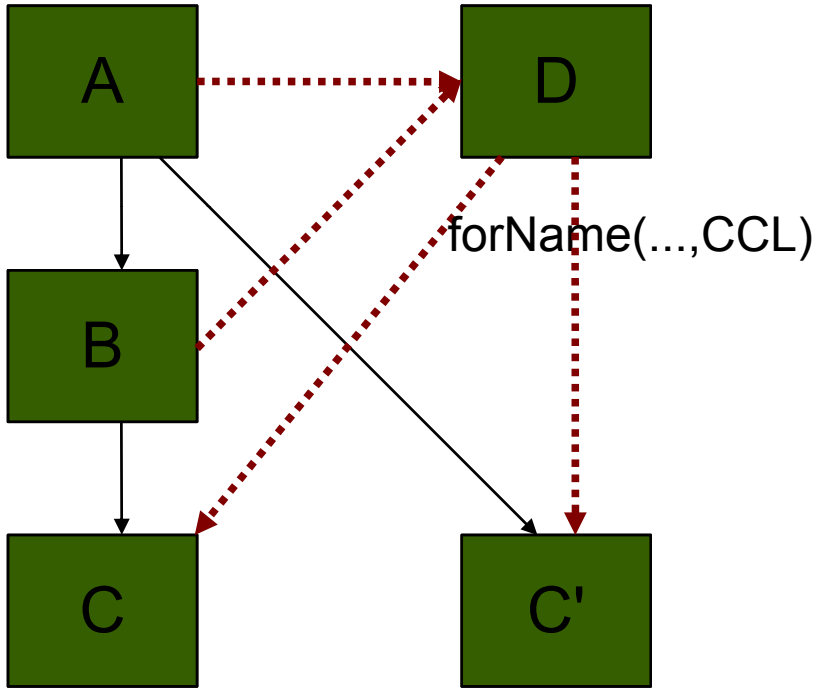


Class visibility solutions

- Dynamic-ImportPackage
  - a last resort, too broad a scope
  - does not affect module resolution
- Equinox Buddy Policy
  - In Hibernate bundle manifest:
    - Eclipse-BuddyPolicy : registered
  - In domain model bundle manifest:
    - Eclipse-RegisterBuddy : org.hibernate
    - Import-Package: org.hibernate
- Attach a Fragment Bundle
  - With required Import-Package headers

Class.forName

- Caches the returned class in the initiating class loader
  - native, vm-level cache
- Can cause class loading errors
- Prefer ClassLoader.loadClass



Context Class Loader

- Heavily used in enterprise Java
- Expected to have visibility of application types + classpath
- ContextClassLoader is undefined in OSGi!
  - No notion of “context”; No notion of “application”
- Solutions:
  - Eclipse Equinox: Context Finder
  - Spring Dynamic Modules : CCL management

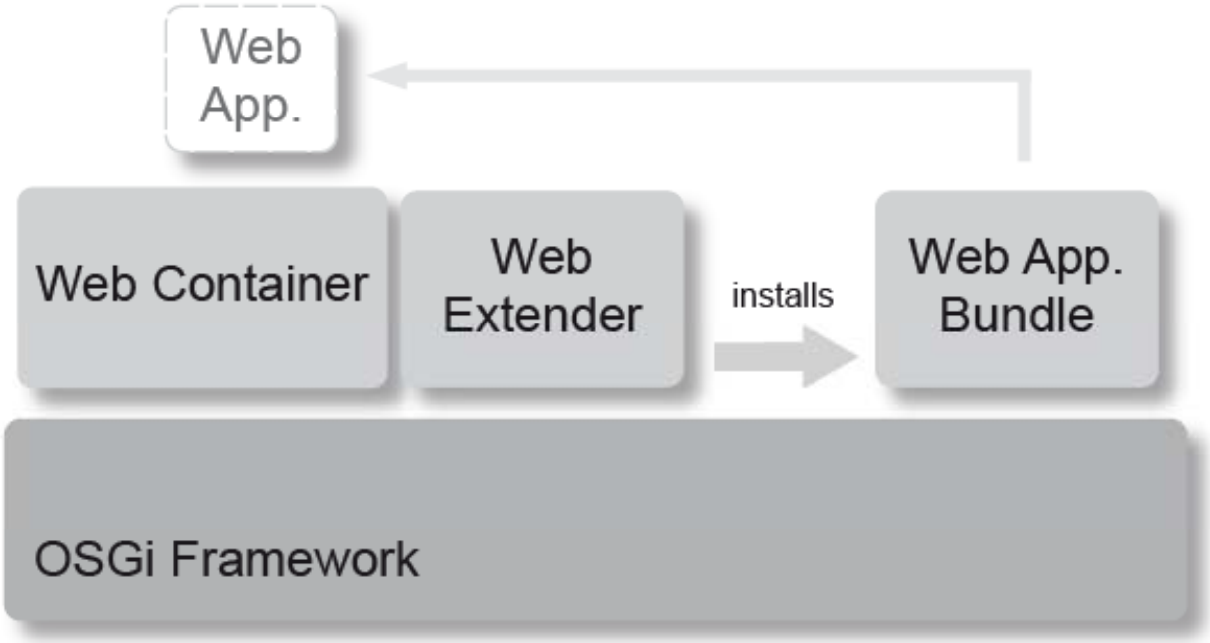
Context ClassLoader Management

- Context ClassLoader guaranteed to have visibility of bundle classpath when the module context for a bundle is created
- Control CCL on service invocation:
  - client-side (attribute of reference element)
    - context-class-loader=”client|service-provider|**unmanaged**”
  - service-side (attribute of service element)
    - context-class-loader=”service-provider|**unmanaged**”

Web Applications

- OSGi HttpService (Servlet 2.1 - 1998)
  - registerServlets and resources under aliases
  - programmatic configuration
- Equinox Http Registry bundle
  - register servlets and resources using eclipse extension registry
- OPS4J
  - (http://wiki.ops4j.org/confluence/display/ops4j/Pax)
  - Pax Web (Servlet 2.5, based on Jetty)
  - Pax Web Extender – War
- Focus of Spring Dynamic Modules v1.1

The Spring DM 1.1 way…



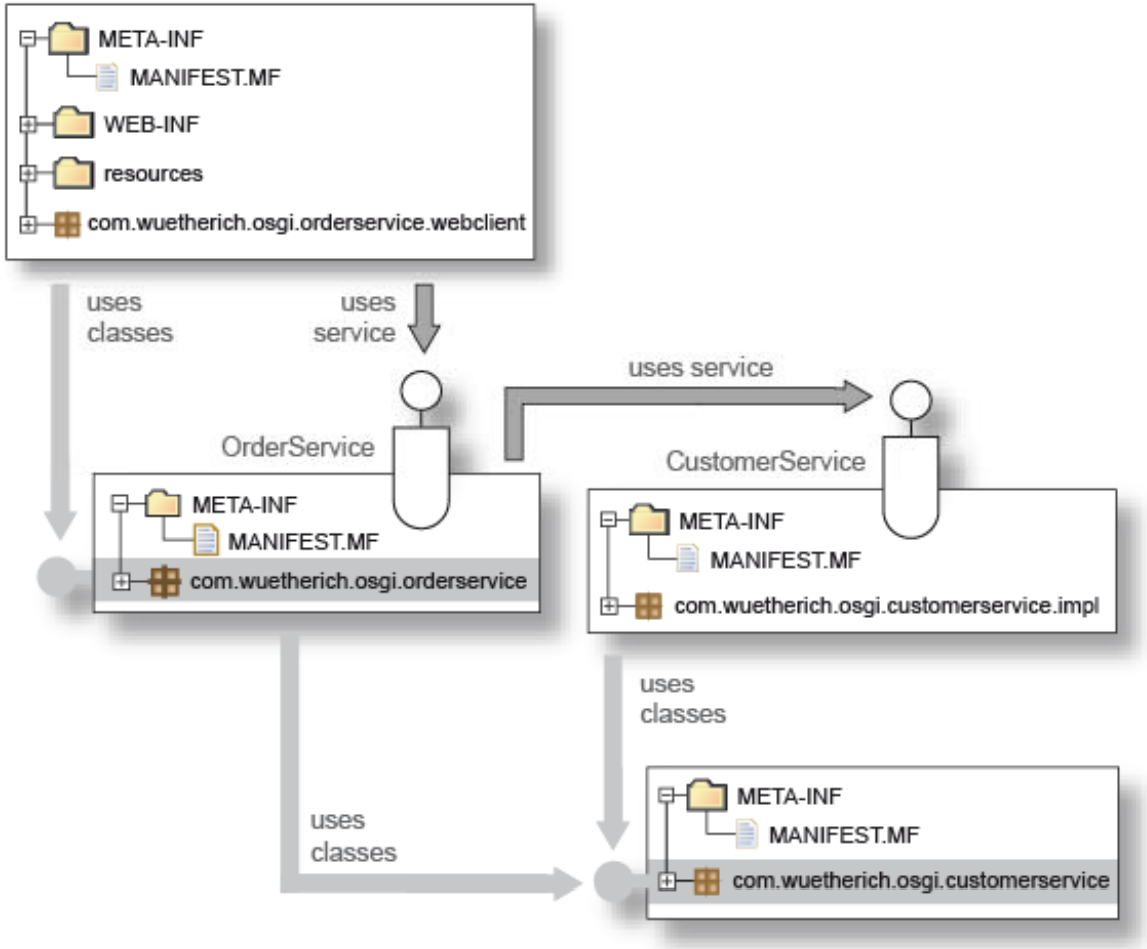
Web applications as Bundles

- “Regular” WAR files
- Additional Bundle-Manifest

- web.xml shows how Spring DM is integrated

```
<context-param>
  <param-name>contextClass</param-name>
  <param-value>org.springframework.osgi.web.context.
    support.OsgiBundleXmlWebApplicationContext</param-value>
</context-param>

<listener>
   <listener-class>
     org.springframework.web.context.ContextLoaderListener
   </listener-class>
</listener>
```


Spring DM Web Support by Example



Demo/Exercise 6: Web front-end

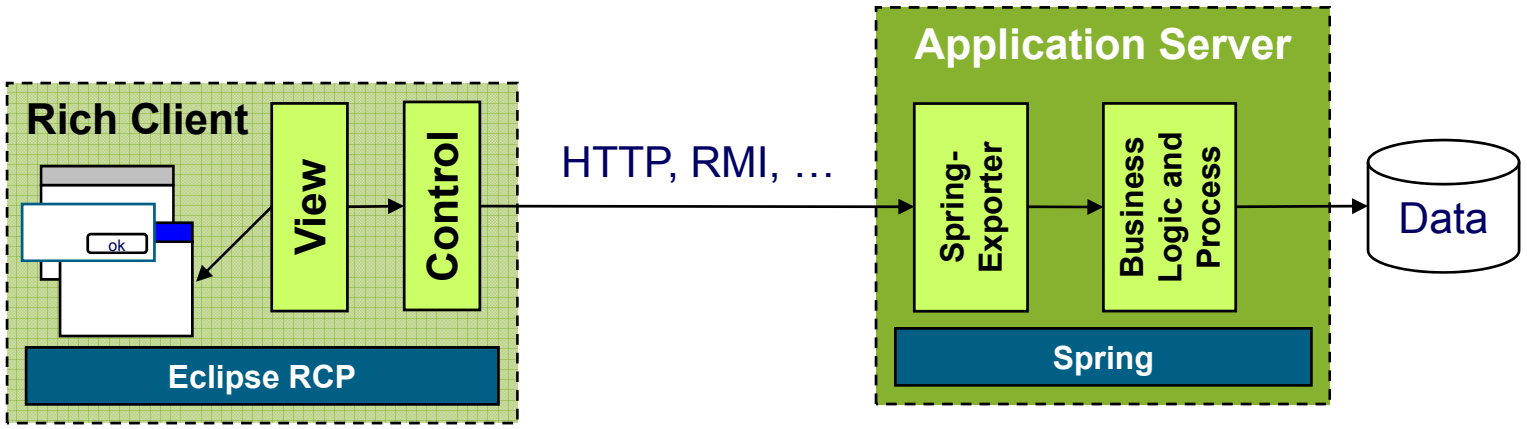
- Step 1:
  - Import the example projects into your workspace
- Step 2:
  - Start the server runtime
  - Take a look at the console
- Step 3:
  - Try out the web-front-end

Agenda

- What is Spring Dynamic Modules?
- Spring Dynamic Modules in Action
- Server-side Applications
- **RCP Applications**
- Summary

Pure RCP Client for a Spring Backend

- Server provides REST/SOAP services, client consumes via HTTP
- Server provides services via RMI, client consumes via RMI



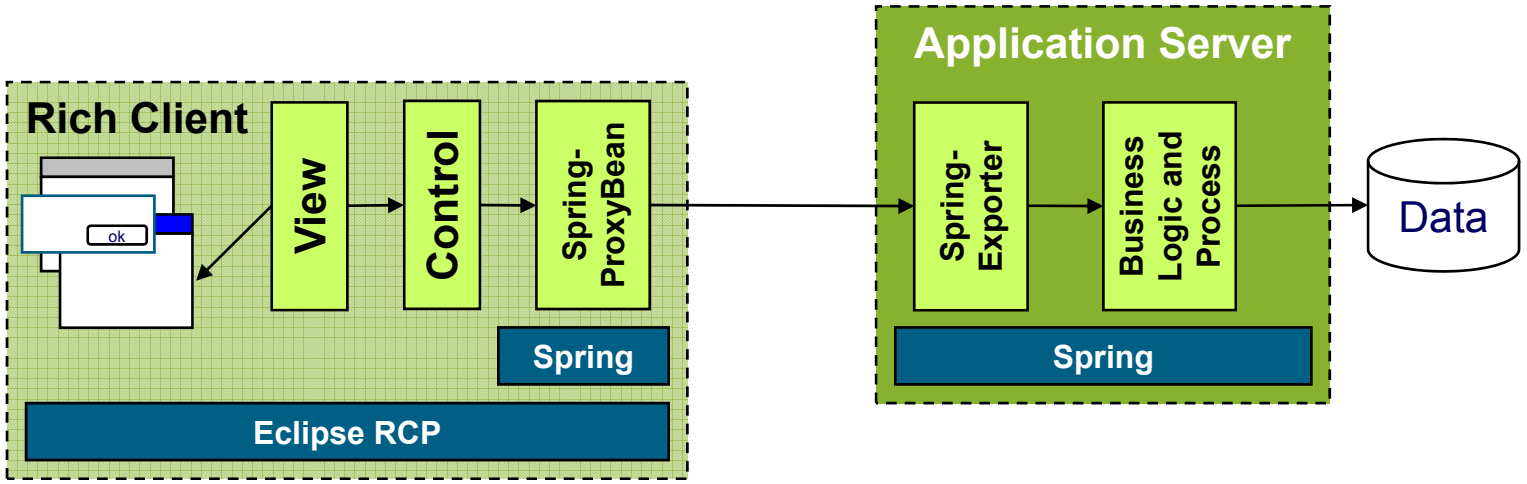
Evaluation

+ Unrestricted usage of Spring on the server
+ Unrestricted usage of RCP on the client

− Different deployment and programming models (OSGi bundles on the client, typical WAR/EAR files on the server)
  - Good for highly decoupled systems
  - Difficult for more integrated systems

RCP & Spring on the Client, Spring Backend

- Uses Spring/Remoting for remote communication
- With all the possible variations (RMI, HTTPInvoker, Hessian, Burlap, etc.)



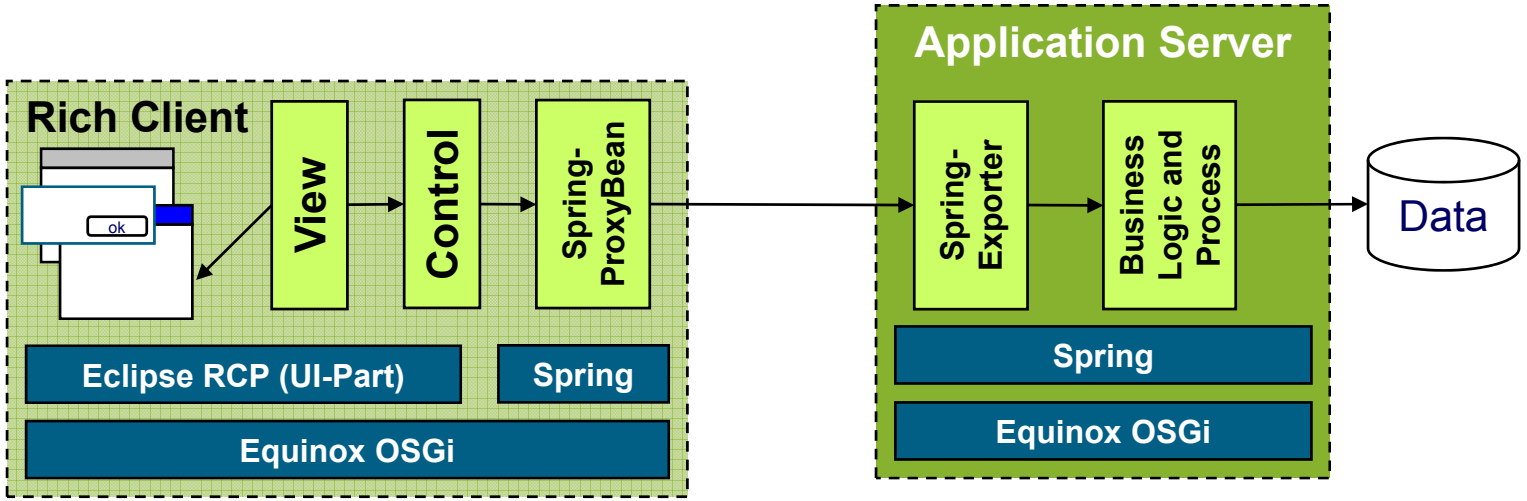
Evaluation

+ Unrestricted usage of Spring on the client **and** the server
+ Unrestricted usage of RCP on the client
+ Easy remote communication via Spring/Remoting

– Still different deployment and programming models (OSGi bundles on the client, typical WAR/EAR files on the server)
  - Although most likely classes are shared between client and server

Spring & OSGi everywhere

- Equinox/OSGi can be used to implement middle-tiers
  - Same component model on both sides
  - Same extensibility for both sides
- Client and server shares components



Evaluation

- Full OSGi power on client and server
- Full Spring power on client and server
- Homogeneous programming model for client and server

More Spring on the Rich Client

- Dependency injection and all other technology abstractions usable as well
  - Just straight forward using Spring Dynamic Modules
- How to incorporate this with the Extension-Registry?
  - For example, inject dependencies into views and editors?

Alternative 1: Views with dependencies

- Define the view in the Spring context
  - Using Spring for dependency injection
- Define the Extension using an extension factory
  - Which delegates the creation to the Spring context

\+ Dependency injection for general extensions

\- Cumbersome manual programming for each extension

Alternative 2: Auto wiring

- Define the view in the Spring context
  - Using Spring for dependency injection
- Add a call to the auto wiring factory from the views constructor

+ Dependency injection for general extensions
− Still some manual extra code for each extension

Alternative 3: Spring-Extension-Bridge

- Define the view in the Spring context
  - Using Spring for dependency injection
- Define the SpringExtensionFactory as implementation class in the extension (generic variant of alternative 1)

+ Dependency injection for general extensions
+ No additional code
+ Easy to use
− Need to change extension definition

Alternative 4: @Configurable

- Define the view in the Spring context
  - Using Spring for dependency injection
- Add the @Configurable annotation to the view implementation
  - And use Equinox Aspects to load-time weave the spring aspects

+ Dependency injection for general extensions
+ No additional code, unchanged extensions
− Adds load-time weaving overhead
− More difficult infrastructure setup

Demo: Spring-powered RCP

Summary

Summary

- OSGi: the dynamic module system for Java
- Benefits: modularity, versioning, operational control
- The server-side is coming to OSGi
- Spring Dynamic Modules brings the familiar Spring model to the OSGi platform
- Enterprise application development path to be smoothed during 2008
  - e.g. SpringSource Application Platform

Thank you for your attention

- **Q&A**

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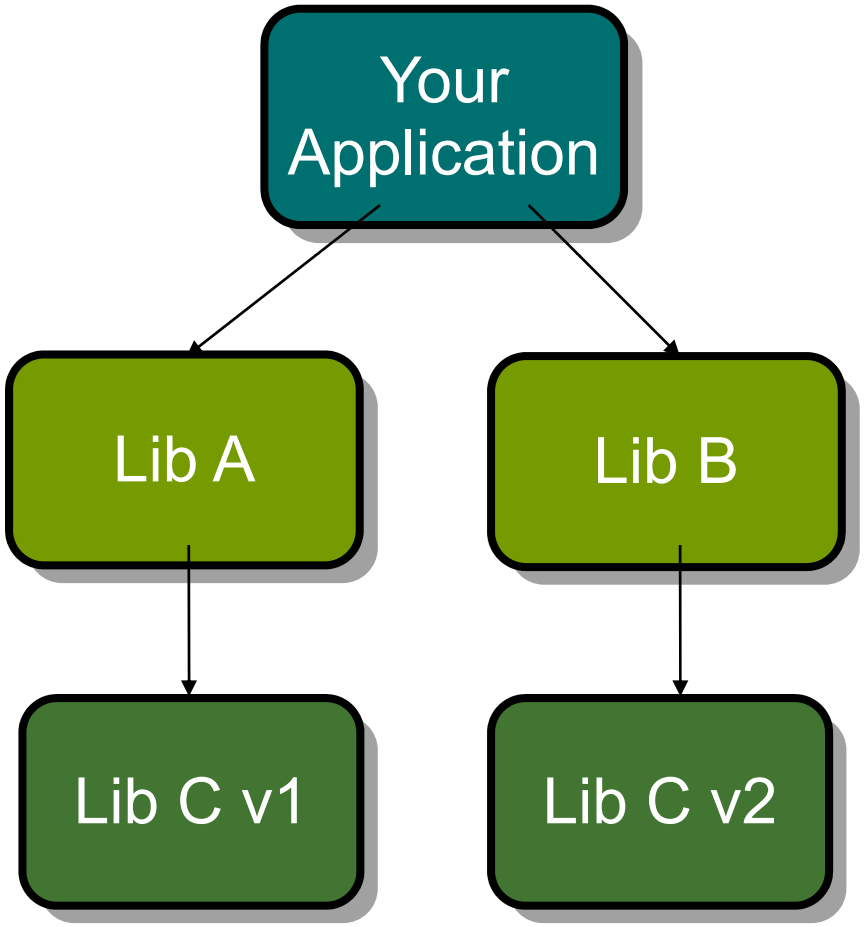
Backup Materials

Versioning

- Packages are imported
  - optionally with version information
- Can have multiple versions of same package concurrently



Try it: versioning