OSGi Best Practices!

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OSGi Best Practices!

Learn how to prevent common mistakes and build robust, reliable, modular, and extendable systems using OSGi™ technology
Agenda

Introduction to OSGi Technology

Module Layer Best Practices
Lifecycle Layer Best Practices
Service Layer Best Practices
General Best Practices
Conclusion
Q&A
Introduction to OSGi Technology
The Dynamic Module System for Java™ Platforms

• It’s a module system for the Java platform
  • Includes visibility rules, dependency management and versioning of bundles, the OSGi modules
• It’s dynamic
  • Installing, starting, stopping, updating, uninstalling bundles, all dynamically at runtime
• It’s service oriented
  • Services can be registered and consumed inside a VM, again all dynamically at runtime
• A specification of the OSGi Alliance, a non profit organization http://www.osgi.org
OSGi Technology Key Benefits
The Dynamic Module System for Java™ Platforms

- Avoids Java Archive (JAR) file hell
- Reuse code “out of the box”
- Simplifies multi-team projects
- Enables smaller systems
- Manages deployments local or remotely
- Extensive tool support
- No lock in, many providers of core technology including many open source
- Very high adoption rate
OSGi Layering

- Applications (bundles)
- Services
- Life Cycle
- Module
- Execution Environment
- OS + Hardware
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Portable Code

Problem

• You compile your code using source level 1.3 on a Java 5 platform compiler, assuming you are safe to run on older VMs

• But then it fails to run when you deploy to a Java platform 1.3 or CDC/Foundation 1.0 environment

• It turns out that despite your 1.3 source level, you were still linked to new parts in the Java 5 class library

```
java.lang.NoSuchMethodError: java.lang.StringBuffer: method append(Ljava/lang/StringBuffer;)Ljava/lang/StringBuffer; not found
```
Portable Code

Best Practice

• Compile your code against the minimum suitable class libraries

• OSGi specification defines Execution Environments (EE)
  • OSGi Minimum—Absolute minimum, suitable for API design
  • Foundation—Fairly complete EE, good for most applications; Used for Eclipse
  • JAR files available from OSGi website

• Java platforms are backward compatible so you should always compile against the lowest version you are comfortable with
  • New features are good, but there is a cost!
  • At least think about this
Proper Imports

Problem

• You develop and test your bundles on an OSGi Service Platform that you have configured yourself

• Your colleague tries these bundles on another OSGi Service Platform and complains of a ClassNotFoundError in your bundles
Proper Imports

Problem

Code:
import org.osgi.framework.*;
import javax.xml.parsers.**;

public class Activator implements BundleActivator {
    public void start(BundleContext ctxt) {
        SAXParserFactory factory =
            SAXParserFactory.newInstance();
        SAXParser parser = factory.newSAXParser();
        ...
    }
}

Manifest:
Import-Package: org.osgi.framework

Missing an import forjavax.xml.parsers inthe manifest
Proper Imports

Best Practice

- Do not assume that everything in the Java Runtime Environment (JRE) will be available to your bundle
  - Only java.* packages are reliably available from the boot class path.
- Your bundle must import all packages that it needs
  - Except: java.* does not need to be imported
- Why?
  - Enables bundles to provide substitute implementations of JRE implementation release software version packages.
- The org.osgi.framework.bootdelegation system property may be set differently on different configurations, so you should never rely on its setting
Minimize Dependencies

Problem

• You find an interesting bundle and want to use it
• You install it in an OSGi framework
• You find it has dependencies on other bundle
• So you find and install those bundles
• Those bundles end up depending on still other bundles …
  • Ad nauseum …
Minimize Dependencies

Best Practice

• Use **Import-Package** instead of **Require-Bundle**
  • Require-Bundle can have only one provider—the named bundle
  • Import-Package can have many providers
  • Allows for more choices during resolving
  • Has a lower fan out, which gain adds up quickly

• Use version ranges
  • Using precise version numbers gives the dependency resolver less choice

• Design your bundles
  • Don’t put unrelated things in the same bundle
  • Low coupling, high cohesion
Hide Implementation Details

Problem

• You wrote a bundle that has a public API and associated implementation code
  • This implementation code defines public classes because it needs to make cross-package calls and references

• You exported all the packages in your bundle

• In the future, you release an update to the bundle with the same public API but a vastly different implementation

• You then get an angry call because you broke some customer’s code
  • And you told them not to use the implementation packages …
Hide Implementation Details

Best Practice

• Put implementation details in separate packages from the public API
  • \texttt{org.example.foo} - exported API package
  • \texttt{org.example.foo.impl} - private implementation package
• Do not export the implementation packages
  • Export and/or import the public details while keeping the implementation details private
  • \texttt{Export-Package: org.example.foo; version=1.0}
Avoid Class Loader Hierarchy Dependencies

Problem

• You are designing a multimedia system and want to allow other bundles to provide plugin codecs

• Your design requires them to pass names of the codec classes which you load via `Class.forName`
  • Either by method call or configuration file

• This design works in a traditional tree based class loader model since the multimedia system’s class loader has visibility to the codec classes

• However, in an OSGi environment, the multimedia system gets `ClassNotFoundException` since it does not have visibility to the codec classes
Avoid Class Loader Hierarchy Dependencies

Best Practice

- Better to use a safe OSGi model like services or the Extender Model to have bundles contribute codecs
  - More dynamic, you can add new services on the fly by installing bundles
- Workaround for using `Class.forName`
  - Use `DynamicImport-Package: *` and have the contributing bundles export their codec package
  - This may work but can result in unintended side effects since your bundle may import packages it did not expect
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Avoid Start Ordering Dependencies

Problem

- You develop a bundle that uses the Http Service and get the service in your BundleActivator

```java
public class Activator implements BundleActivator {
    HttpService http;
    public void start(BundleContext ctxt) {
        ServiceReference ref = ctxt.getServiceReference(HttpService.class.getName());
        http = ctxt.getService(ref);
        http.registerServlet();
    }
}
```

- Your bundle works fine on your workstation but fails with a NullPointerException on the call to getService when integrated into the build
Avoid Start Ordering Dependencies

Best Practice

• Do not assume that you can always obtain a service during initialization
  • Bundles can start in different orders on different systems and you usually do not have control over the order

• Use ServiceTracker to track services and respond to their publication by subclassing or via a ServiceTrackerCustomizer

• Use a declarative service model like OSGi Declarative Services or Spring OSGi
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Handle Service Dynamism

Problem

• You develop a bundle with a servlet
• You get the HttpService and register your servlet
• After deployment, you receive problem reports that your servlet seems to vanish after working for a while
• It turns out the HttpService was unpublished temporarily when the HttpService bundle was stopped and restarted during an update
• Your bundle did not react and re-register the servlet
Handle Service Dynamism

Best Practice

• A service is a dynamic entity and can be unpublished after you get it
  • A bundle must respond to the lifecycle of a dependent service

• The OSGi framework provides an API to handle these dynamics but they are rather low level

• There are helpers, based on this API, like:
  • Service Tracker and Service Activator Toolkit (SAT)
  • Declarative models like Declarative Services, iPOJO and Spring OSGi
Whiteboard Pattern

Problem

• You design a service provided by your bundle to use the familiar addListener and removeListener methods

• In practice, you find that other bundles forget to call removeListener when they stop or you stop, or forget to call addListener when you restart

• Both bundles need special code to track the other bundle or events are not properly delivered

• The OSGi LogReaderService design is an example of this problem 😞
Whiteboard Pattern

Best Practice

• Design your API to have the listener registered as a service
  • Simple
  • More robust
  • Leverages the OSGi service model and its life cycle model awareness

• The event source tracks the listener services and calls them when there is an event to deliver

• This is called the Whiteboard Pattern
  • It can be considered an Inversion of Control pattern

• The OSGi EventAdmin design is an example of this best practice
Extender Model

Problem

• You design a Help System where other bundles contribute help content to your bundle
• The other bundles need to track the Help System bundle and contribute their Help content
• The Help System bundle must clean up when the bundles that contribute Help content are stopped
• This problem of tracking bundle life cycles is much like the one solved by the Whiteboard Pattern
  • But there is another pattern to address this use case
• The OSGi HttpService design is an example of this problem 😞
Extender Model

Best Practice

- The bundle being "extended" specifies a data schema
- Contributing bundles define this data in their bundle
- The extender bundle will track the bundles via certain life cycle event and process the data, if present
  - This can include loading classes from the contributing bundle
- Extenders have more advantages
  - Lazy—less time pressure on startup and less memory later
  - More robust in case of failures—extender bundle can make consistent and policy driven choices
- Many bundles use this pattern
  - Declarative Services, iPOJO, Spring OSGi and Eclipse Extension Point Registry
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Avoid OSGi Framework API Coupling

Problem

- You wrote your code and packaged it in a bundle
- Your code publishes an OSGi service for other bundles to use and also uses services provided by other bundles
- Your code uses the OSGi service layer API in quite a number of classes and is now coupled to the OSGi API
- You no longer can easily use your code in a non-OSGi environment
Avoid OSGi Framework API Coupling

Best Practice

• Write your code as POJOs (Plain Old Java Objects)
• Program against interfaces, not concrete classes
• Isolate the use of OSGi API to a minimal number of classes
• Let these coupled classes inject dependencies into the POJOs
• Make sure none of your domain classes depend on these OSGi coupled classes
• Use an OSGi ready IoC container like Declarative Services or Spring OSGi to express these dependencies in a declarative form
  • Let the IoC containers handle all of the OSGi API calls
Return Quickly from Framework Callbacks

Problem

• You work in a large team building an enterprise OSGi based system
• Each developer develops their part of the system in a modular fashion and does extensive and continuous unit testing
• When all bundles are put together for integration test, a week before deadline, it takes too long to bring up the whole system
• It turns out that each bundles spent a long time in their activator and the cumulative effect on the complete system was significant
Return Quickly from Framework Callbacks

Best Practice

• Bundle developers have a tendency to do too much upfront activation
• 1s per bundle (think DNS name lookup)
  • => One minute with 60 bundles
  • => Five minutes with 300 bundles
• Lazy is good
  • See new lazy activation features in Release 4 Version 4.1
• Framework callbacks need to return quickly
• If you need to do something that takes some time then either:
  • Use eventing, or
  • Spin off a background thread to perform the long running work
Thread Safety

Problem

• You develop a bundle and test it extensively
• However when deployed in the field with a set of other bundles, your bundle fails with exceptions in strange places
• Ultimately your realize that these other bundles are triggering events
  • Which your bundle receives and processes
  • But the events are being delivered on many different threads
• Time to consult a concurrency expert…
Thread Safety

Best Practice

• In an OSGi environment, framework callbacks to your bundle can occur on many different threads simultaneously

• Your code must be thread-safe!
  • Callbacks are likely running on different threads and can occur really simultaneously
  • Do not hold any locks when you call a method and you do not know the implementation, they might call back to bite you
  • Java platform monitors are intended to protect low level data structures; use higher level abstractions with time outs for locking entities
  • In multi-core CPUs, memory access to shared mutable state must always be synchronized
Conclusion

- We have presented a number of pitfalls and showed the best practices to prevent those pitfalls
  - Some are common sense and apply to other Java environments as well
  - Some are needed because of the characteristics of the OSGi environment
- Despite these pitfalls, OSGi technology provides a robust environment for software development that gives a tremendous amount of advantages
  - Many OSGi mechanisms were designed to prevent common pitfalls in traditional Java technology programming
OSGi Service Platform

For More Effective Software Development!
For More Information

- If you have further question on these or want to discuss other issues in developing for OSGi
  - Please try the osgi-dev@www2.osgi.org mail list
  - http://www2.osgi.org/mailman/listinfo/osgi-dev

- OSGi Developer Website
  - http://www2.osgi.org/
Q&A

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