OSGi Best Practices!

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Session TS-1419

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

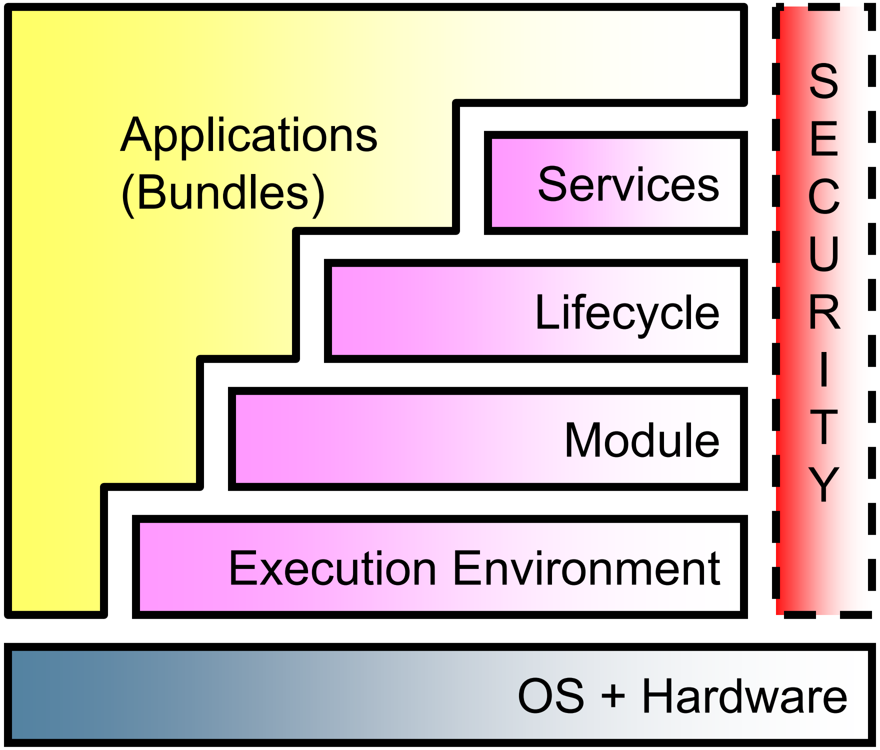
- It's a module system for the Java platform
  - Includes visibility rules, dependency management and versioning of bundles, the OSGi modules
- It's dynamic
  - Installing, starting, stopping, updating, uninstalling bundles, all dynamically at runtime
- It's service-oriented
  - Services can be registered 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



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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 for javax.xml.parsers in the 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
  - `org.example.foo` – exported API package
  - `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
  - `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 plug-in 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 `ClassNotFoundErrors` 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

```
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 lifecycle 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 lifecycles is much like the one solved by the Whiteboard Pattern
  - But there is a 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 lifecycle 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 bundle 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 up front activation
- 1s per bundle (think DNS name lookup)
    - → 1 minute with 60 bundles
    - → 5 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
    - 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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