An Introduction to OSGi

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Short Bio

- Employed by Oracle Corp.
  - Previously at BEA Systems
- Architect for WebLogic Event Server (rebranded into Oracle CEP)
  - Light-weight application server **just for** event processing
  - Completely built on top of Equinox/OSGi and completely modular
- OASIS BPEL 2.0 spec committee

Agenda

- **History**
- Benefits
- Architecture
- Bundles
- Services
- Conclusion

History

- The OSGi Alliance is an independent non-profit corporation
  - Deutsche Telekom, Nokia, Samsung, etc
  - IBM, Oracle, IONA, etc
- OSGi technology is the *dynamic module system for Java*
  - First release in May 2000
  - Latest version 4.1 was released in May 2007
- OSGi technology provides a
  - service-oriented,
  - component-based environment for developers
  - and offers standardized ways to manage the software lifecycle.

Agenda

- History
- **Benefits**
- Architecture
- Services
- Summary

Benefits

- Problem Domain
  - In large and complex systems, different components need to evolve separately
    - Developed by different teams
    - Re-used from other products
    - Some components need more patches than others
- Solution Domain
  - Organize components as independent versioned modules
    - Modules define public interface and dependencies
    - Design and implement for re-use!
  - Bind modules dynamically and verify constraints

Benefits

- Dynamic **module** system for Java
  - Java does not define the concept of a module
  - Closest to it would be a JAR
    - Has no clear definition of its interfaces, dependencies, or version
- **Dynamic** module system for Java
  - One can load new classes into a Class-Loader, but cannot *un-load*
  - No standard way of loading new features into a running platform
    - Different technology/vendors have different approaches (e.g. JBI, J2EE)

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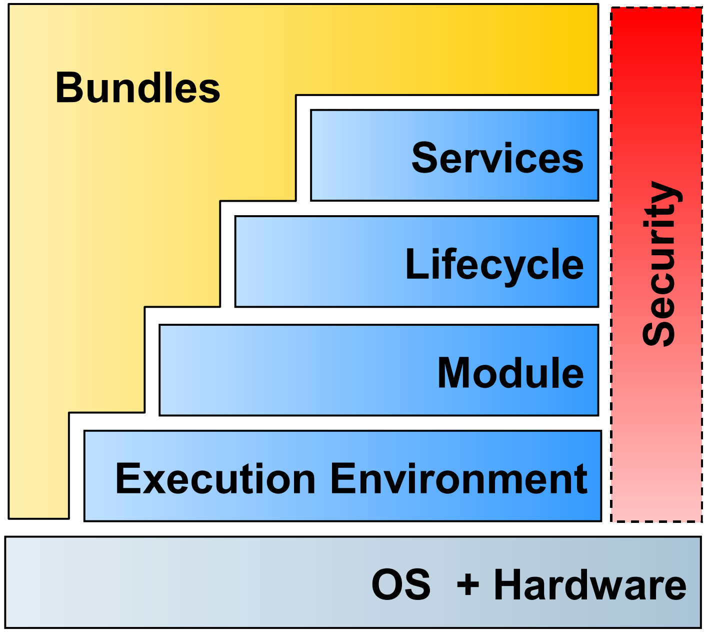
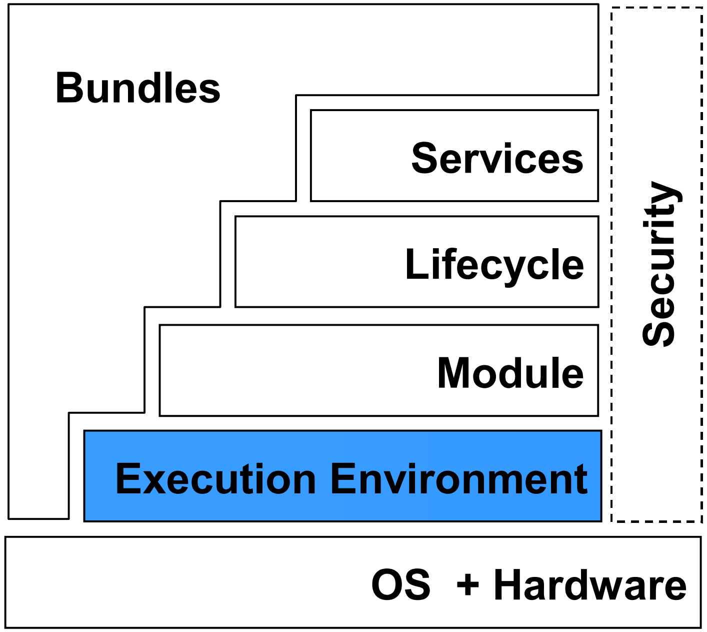
OSGi Framework Layered Architecture

- The Framework is split up into different layers
  - Execution Environment – the VM
  - Module Layer – Module system for the Java Platform
  - Lifecycle Layer – Dynamic support
  - Service Layer – Module collaboration



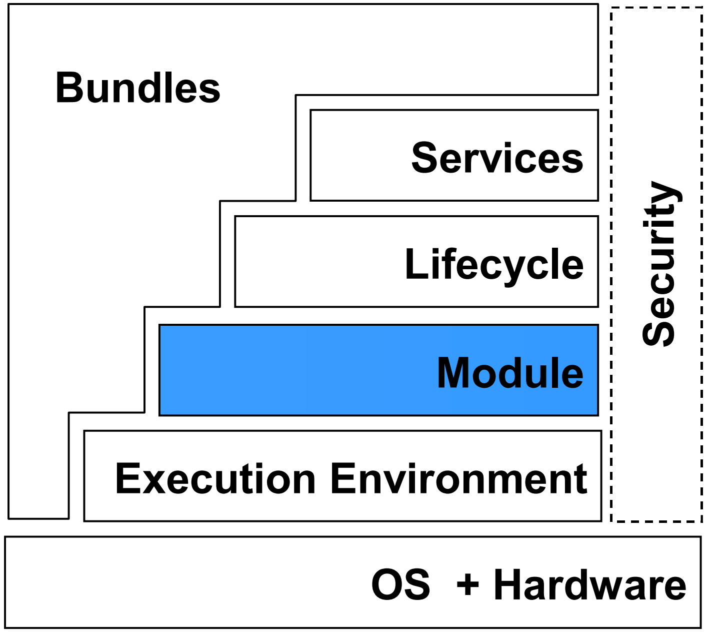
Execution Environment

- Execution Environment
  - The VM used to launch the Framework
  - The OSGi specification originated on the J2ME platform
  - Framework implementations can scale down to small devices and scale up to large server environments



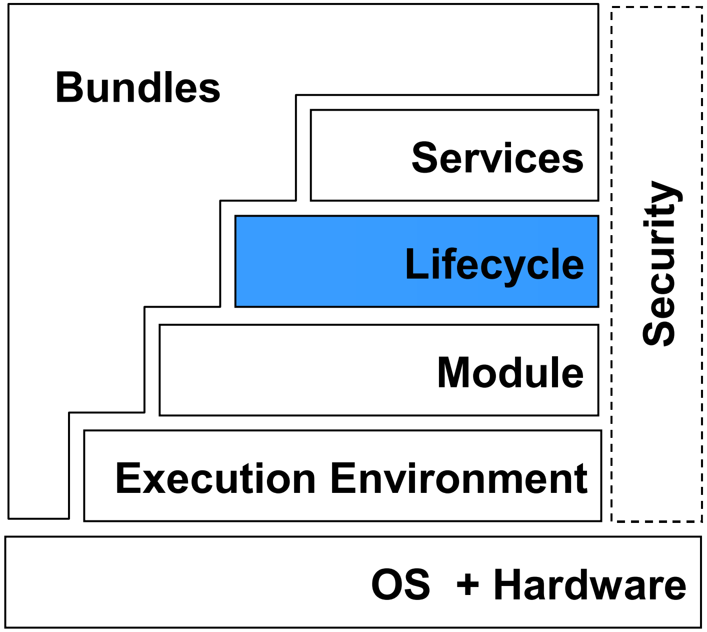
Module Layer

- Module system for the Java Platform
  - Enforces visibility rules
  - Dependency management
  - Supports versioning of bundles, the OSGi modules
- Sophisticated modularity framework
  - provides for class space consistency for bundles
  - supports multiple versions of packages and bundles



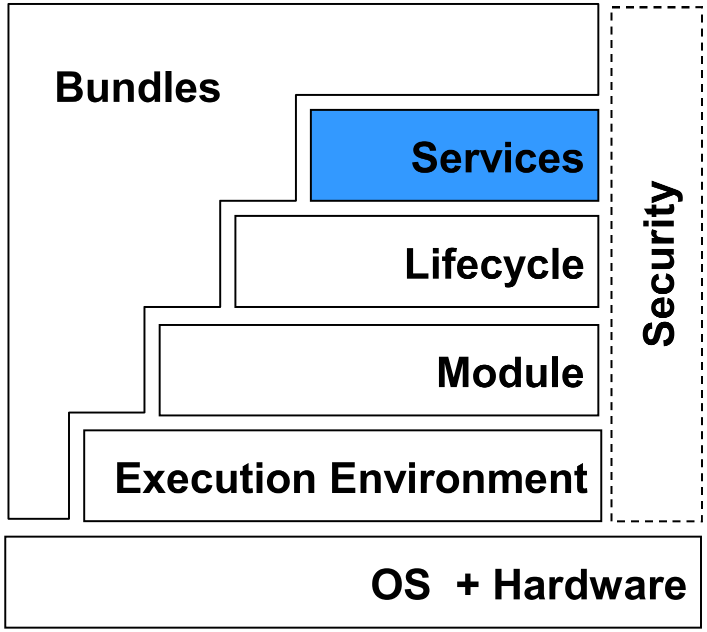
Lifecycle Layer

- Lifecycle Layer provides API to manage bundles
  - Installing
  - Starting
  - Stopping
  - Updating
  - Uninstalling
  - All dynamically supported at runtime



Service Layer

- Provides an in-VM service model
  - Services can be registered and consumed inside a VM
  - Again all operations are dynamic
  - Extensive support for notification of the service lifecycle



Key Concepts

- For most users, there are really just two main concepts to learn
  - Bundles
    - Supported by Execution Environment, Module, and Lifecycle layers
  - Services
    - Supported by the Lifecycle and Service layers

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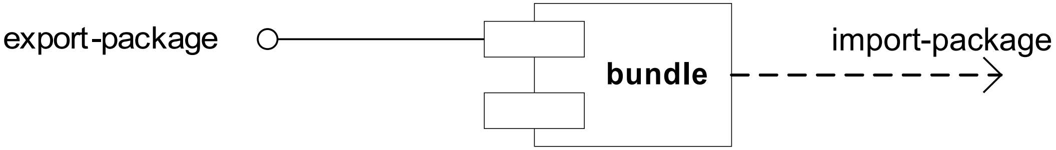
Bundle as Module

- OSGi technology’s modularity unit
  - Or, in enterprise terms, OSGi technology’s deployment unit
  - Again, main advantage of bundles is to achieve better re-use
- Regular JAR file
  - Java code
  - Resources
  - OSGi specific entries in MANIFEST.MF

Bundle Definition

- MANIFEST.MF
  - Bundle-SymbolicName:
  - Bundle-Version:
  - Bundle-Classpath:
  - Bundle-Activator:
  - Import-Package:
  - Export-Package:



Importing and Exporting Packages

- Import-Package/Export-Package
  - Explicit dependency model
    - Rigid documentation of public interface of module, which can be shared amongst development teams
    - Helps with build automation (don’t under-estimate the effort of building large systems)
  - Allows dynamic selection (i.e. resolve) of dependencies
    - Allows framework to find best suitable provider of a feature
    - Allows framework to dynamically change provider, useful for patching system

Bundle Versioning

- Versioning
  - Import-Package: com.acme.foo;version="[1.0.0.1, 2.1)“

    ==> *1.0.0.1* <= *version* < *2.1*
  - Import-Package: com.acme.foo;version="1.0.0.1“

    ==> *1.0.0.1* <= *version* < ∞
  - Import-Package: com.acme.foo;version="1.0“

    ==> *1.0.0.0* <= *version* < ∞

Importing and Exporting Packages

- Attribute matching
  - Declarative way of influencing resolving
  - Example:
    - Bundle A: Import-Package: com.acme.foo;company=ACME
    - Bundle B: Export-Package: com.acme.foo
    - Bundle C: Export-Package: com.acme.foo; company="ACME";

Bundle Life-cycle

- INSTALLED:
  - Framework has bits installed
- RESOLVED:
  - Framework has resolved all dependencies successfully
- STARTING:
  - Framework is starting bundle, and invokes registered activators in the process
- ACTIVE:
  - Bundle is running
- STOPPING:
  - Framework is shutting down bundle, and invokes registered activators in the process

Bundle Activation

- Use Bundle Activator to:
  - Contribute to start and stop of bundle
  - Allows bundle to manage resources (e.g. start thread, read file)
  - Specify Bundle-Activator and import org.osgi.framework
  - Should perform work async, or return quickly
  - Provides bundle implementer access to BundleContext object
- Note-worthy: there is no standard way of installing/un-installing bundle from remote agent

Bundle Activation

```
Bundle-SymbolicName: example.mybundle
Bundle-Version: 1.0.0
Bundle-Activator: example.MyBundleActivator
Import-Package: org.osgi.framework
```

```
public class MyBundleActivator implements BundleActivator {
    public void start(BundleContext c) {
        // Initialize
    }
    public void stop(BundleContext c) {
        // Shutdown
    }
}
```

Bundle Activation

- Another approach is to use Spring-DM
  - Specify bundle as a Spring-DM application context
    - Spring-Context: META-INF/spring-context.xml
  - Use standard Spring-bean life-cycle interfaces
    - InitializingBean
    - DisposableBean
  - By default, context is created asynchronously
- IMO, cleaner and simpler

Bundle Activation

```
Bundle-SymbolicName: example.mybundle
Bundle-Version: 1.0.0
Spring-Context: META-INF/spring-context.xml
Import-Package:
```

```
<bean id=“bundleBean” class=“example.myBundleBean”
   init-method=“init” destroy-method=“destroy” />
```

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Services

- SOA deals with programming-in-the-large
  - Interaction between system components (e.g. WS-clients and WS-providers through WSDL)
- OSGi Service Layer allows one to bring SOA concepts (e.g. re-use, implementation abstraction) into the system component implementation level (e.g. programming-in-the-small)
- Main benefit: de-coupling of interface and implementation allows the selection of different implementation providers
  - Authentication/Authorization providers: LDAP, file-system

Service Definition

- Services are regular Java classes
  - No need to implement technology-specific interfaces
- A Service is made of three components:
  - Service name(s)
    - “example.AuthenticationService”
  - Service implementation
    - example.LDAPAuthenticationServiceImpl
  - *Service (reference) properties (optional)*
    - String property *type* = (*‘file-system”* | *‘ldap”)*

Service Interaction

- Service-provider bundles:
  - Register service name(s), implementation, and properties into a Service Registry
- Service-consumer bundles:
  - Query Service Registry for a particular service name(s)
    - May do additional filtering by properties
  - Communicates through returned *class/interface*, does not see implementation
- Service Registry:
  - Similar to a map of services

Service Registration

```
AuthenticationService serviceImpl = new
  LDAPAuthenticationServiceImpl();

Dictionary properties = new Dictionary();

properties.put(“type”, “LDAP”);

ServiceRegistration reference =

  bundleContext.registerService(

          new String [] {AuthenticationService.class.getName()},

          serviceImpl,

          properties);
```

Service Registration

- Or alternatively using Spring-DM:

```
<bean name=“ldapService”
  class=“LDAPAuthenticationServiceImpl” />
<osgi:service ref=“ldapService“
  interface="example.AuthenticationService">
  <osgi:service-properties>
    <beans:entry key=“type" value=“LDAP"/>
  </osgi:service-properties>
</osgi:service>
```

Referencing Services

```
ServiceReference reference =
   bundleContext.getServiceReference(

            AuthenticationService.class.getName());


AuthenticationService service =

   (AuthenticationService)

   bundleContext.getService(reference);
```

Referencing Services

- Or

```
<osgi:reference id=“authenService"
   interface="example.AuthenticationService"/>
```

Services are Dynamic

- Services are dynamic, they may come and go
  - Service reference/service may be null/stale
  - Should not cache references
- ServiceListener used to keep track
  - ServiceTracker raises the ServiceListener abstraction
- Spring-DM proxies services, and will do the right thing

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Challenges

- Mind-set:
  - Understand that it is more work to create a modular solution, but it pays off long-term
- Design-time:
  - Very large Import-Packages
    - Error-prone
  - Non-intuitive Import-Packages
    - Hard to get correct when reflection is used (e.g. Kodo)

Challenges

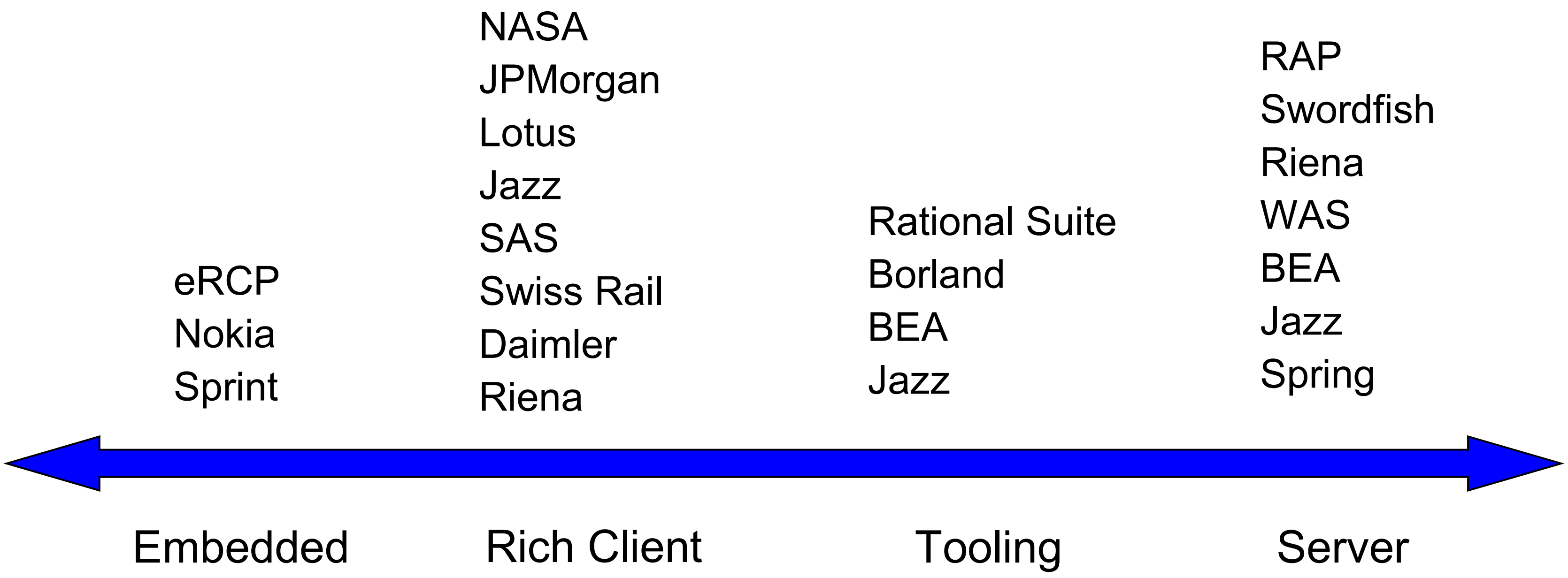
- Runtime:
  - Hard to debug complex class-path resolving
    - instanceof just fails sometimes…
  - Service availability race-conditions
    - Client applications referencing to services that have not been bound it
    - Particularly a problem during start-up
- Certain features are missing or too hard to use:
  - Security, Configuration support, Transaction support

Adoption

- Many framework implementations
  - Equinox – Open source
  - Felix – Open source
  - Knopflerfish – Open source
  - Concierge – Open source
  - ProSyst
- Spring Dynamic Modules for OSGi
- All Eclipse-based systems run on Equinox
  - Runtimes (e.g., RAP, Swordfish, Riena, ECF, EclipseLink)
  - RCP, eRCP
  - Tooling

Adoption

- Equinox OSGi as a component runtime
- Consistent programming model from embedded to server
- Reuse components across the spectrum



Embedded	Rich Client	Tooling	Server
eRCP Nokia Sprint	NASA JPMorgan Lotus Jazz SAS Swiss Rail Daimler Riena	Rational Suite Borland BEA Jazz	RAP Swordfish Riena WAS BEA Jazz Spring

Lessons Learned when using OSGi

- There are always opportunities for re-use
  - Re-use within organization
  - Re-use of standard services
    - HTTP Service
    - Service Tracker
    - Initial Provisioning
    - Declarative Services using Spring-DM
    - Start Level Service
- Modularize at all levels
  - WL-EvS programming model itself is a separate bundle, de-coupled from other services, which means WL-EvS could in theory support other programming models, such as SCA, etc.

Conclusion

- Standard
  - Several different implementations are available
- Mature
  - Proven technology
  - Over 8 years-old (versus JSR-277/294)
- Key-concepts
  - Bundles: re-usability
  - Service: flexibility, extensibility

Q/A

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