NPRG044: OSGi framework

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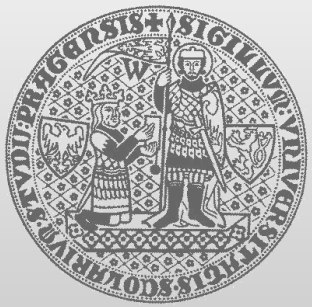

CHARLES UNIVERSITY IN PRAGUE

faculty of mathematics and physics

Step #1:
Download Eclipse RCP
http://www.eclipse.org/downloads/

Do you use JARs?

JAR advantages and disadvantages

+ Includes class files and additional resources
+ Deployment

- No information hiding
- No dynamicity
- Cannot specify required JARs
- No versioning

OK, it's not completely true, but JARs classpath is almost entirely useless

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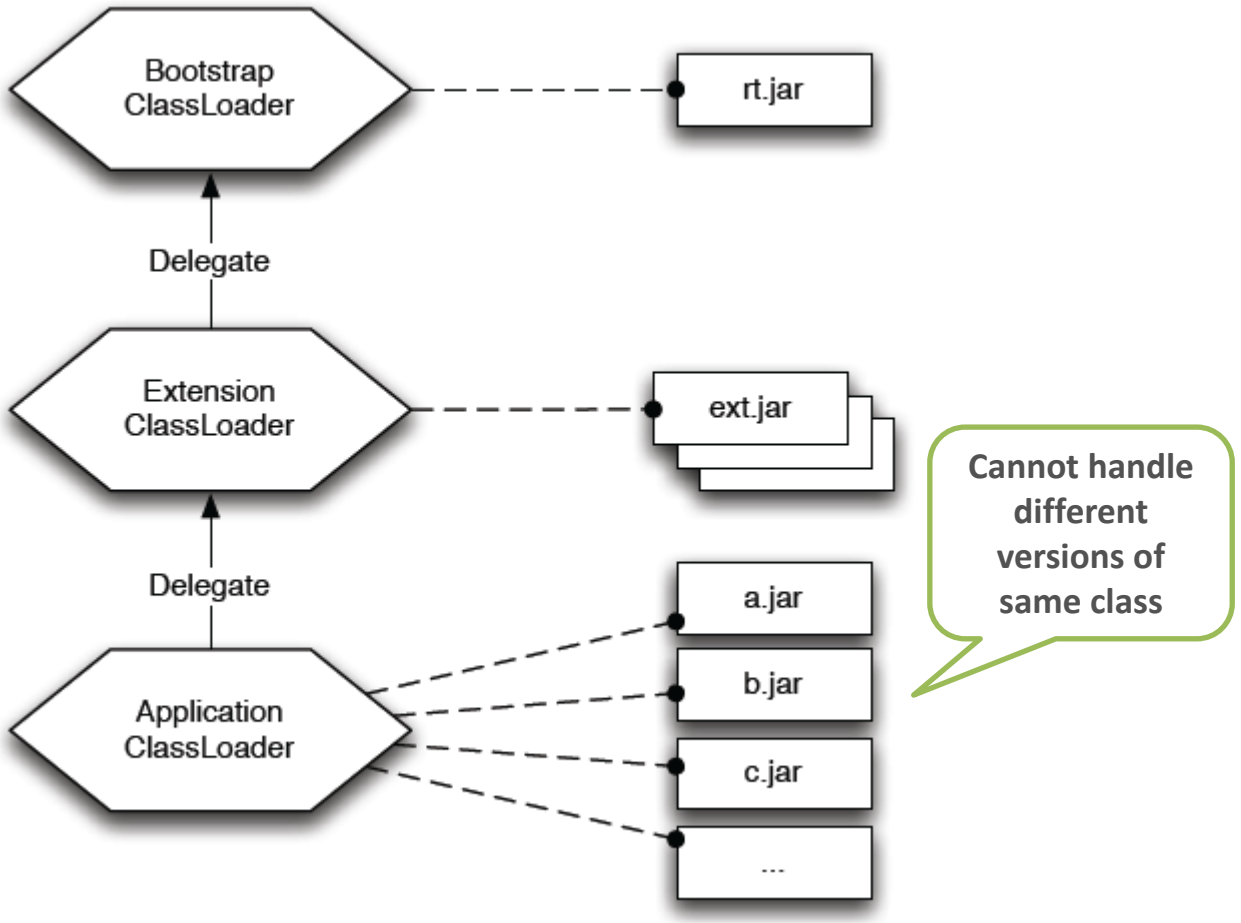
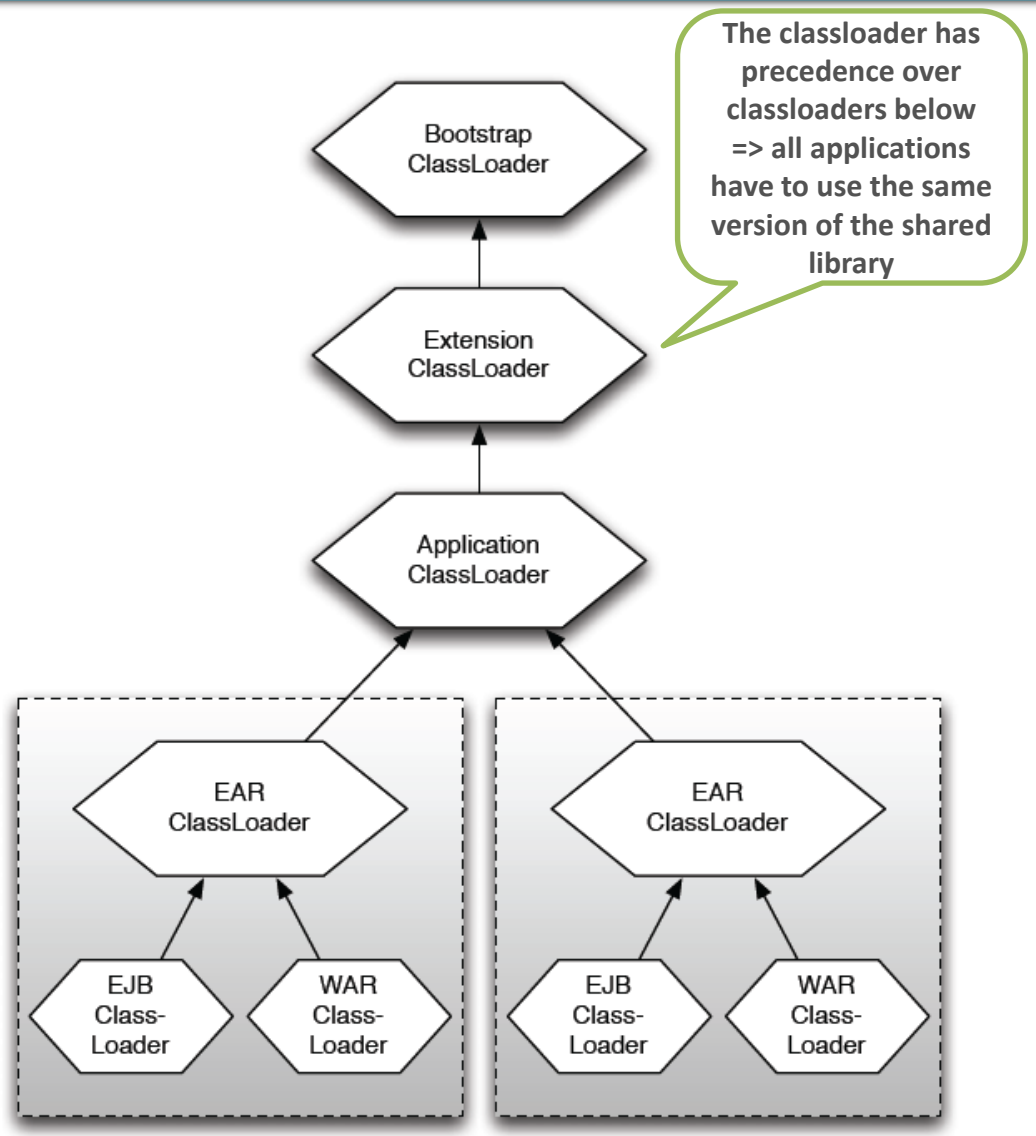
Common Java classloading



The picture was taken from the book "OSGi in Practice" written by Neil Bartlett
See http://njbartlett.name/osgibook.html

J2EE classloading



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See http://njbartlett.name/osgibook.html

OSGi

- OSGi is a specification
  - Open Service Gateway Initiative
  - Current version R4.3 (see http://www.osgi.org/)
  - 3 parts + Java API + execution environment specification
    - Core
    - Compendium
    - Enterprise
- Specifies
  - Framework
  - Modules
  - Provided services
  - Additional functionality

OSGi framework

- Framework to build modular applications
  - "LEGO principle"
  - Fine-grained modules which are
    - Reusable
    - Scalable
    - Isolated
    - Bringing separation of concepts
      - Modules should be "easily" testable, manageable, maintainable, repairable, exchangeable
    - Bringing abstraction

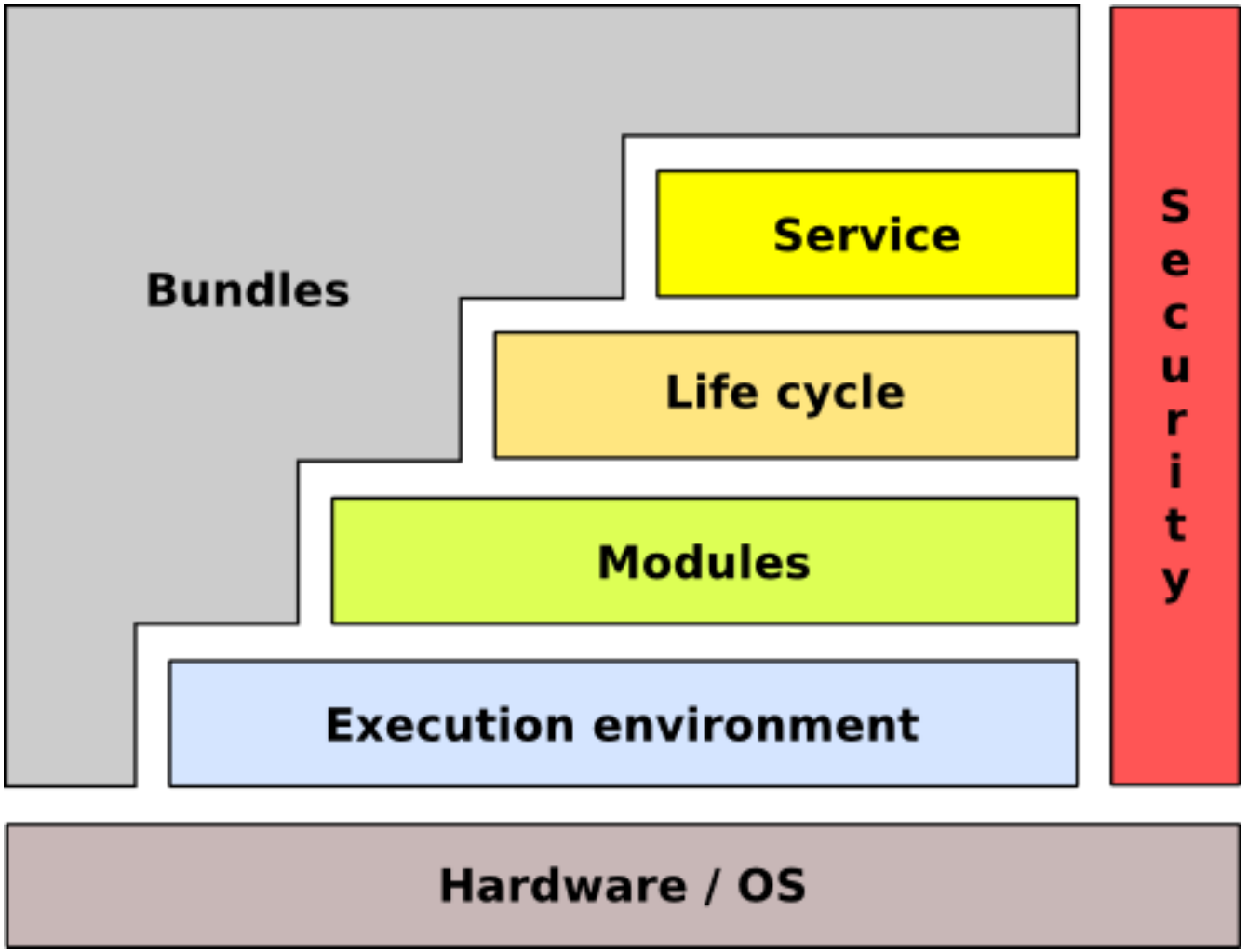
OSGi applications

- Existing applications
  - BMW service platform
  - Eclipse
  - Virgo server (Spring dm Server)
  - GlassFish J2EE application server
  - IBM WebSphere J2EE application server
  - Newton
  - JBoss, JOnAS
  - Apache Karaf
- Users
  - Bombardier, Volvo, Siemens, BMW, IBM, Red Hat, Siemens AG, NEC, Oracle

OSGi implementations

- Open source
  - ***Eclipse Equinox***
    - Many extensions of OSGi, e.g. bundle aspects, extension points
  - *Apache Felix*
    - Based on Oscar (implementation of OSGi R3)
    - Compliant to OSGi specification R4.2
  - *Knopflerfish*
  - *Concierge*
    - Implementation of OSGi R3, optimized for embedded devices
- Commercial
  - ProSyst, Knopflerfish Pro

OSGi framework conceptual architecture



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OSGi Basic concepts

- **Bundle**
  - Module
  - Unit of deployment
- **Service**
  - Communication between components

Bundle

- **Unit of deployment**
  - Classical JAR with meta-information
    - Class files,
    - Additional resources (images, videos, source code, …)
    - META-INF, OSG-INF directories containing meta-information
- **Bundle is versioned**
  - Major, minor, micro, qualifier (1.0.3_rc2)
  - Multiple versions at runtime are allowed
- **Bundle can export/hide packages**
  - *Recommended practice: "*Exposing only API not implementation"
  - Declarative dependencies
    - Bundles
    - Packages
      - Range of version [1.0, 2.0)

Bundle meta-information

- Manifest META-INF/MANIFEST.MF

```
Manifest-Version: 1.0
Bundle-ManifestVersion: 2
Bundle-Name: LogTargetBundle
Bundle-Activator: LogTargetActivator
Bundle-SymbolicName:
cz.cuni.mff.d3s.LogTargetBundle
Bundle-Version: 1.0.0.qualifier
Bundle-Vendor: D3S MFF UK
Bundle-RequiredExecutionEnvironment: JavaSE-1.6
Import-Package:
cz.mff.cuni.d3s.nprg044.tut1.test01.api,
org.osgi.framework;version="1.5.0",
org.osgi.service.component;version="1.1.0",
org.osgi.service.log;version="1.3.0"
Service-Component: OSGI-INF/componentOne.xml, OSGI-
INF/factory.xml
```

Each line is limited 72bytes by design of JVM

Bundle dependencies

```
Export-Package: cz.*;
exclude="*Impl"
```

- Export packages
  - List all of packages + versions + attributes
  - Fine grained package filtering
    - Exclude,include, parameters

```
Import-Package: cz.mff.*;
version="[1.0,1.3.1)";res
olution=optional
```

- Import package
  - Require specific version(s)
    - e.g. [1.0, 2.0)
  - Resolution: **optional/mandatory**

```
Require-Bundle: logger-api-bundle
```

- Require bundle
  - Not recommended because it restricts further changes in API

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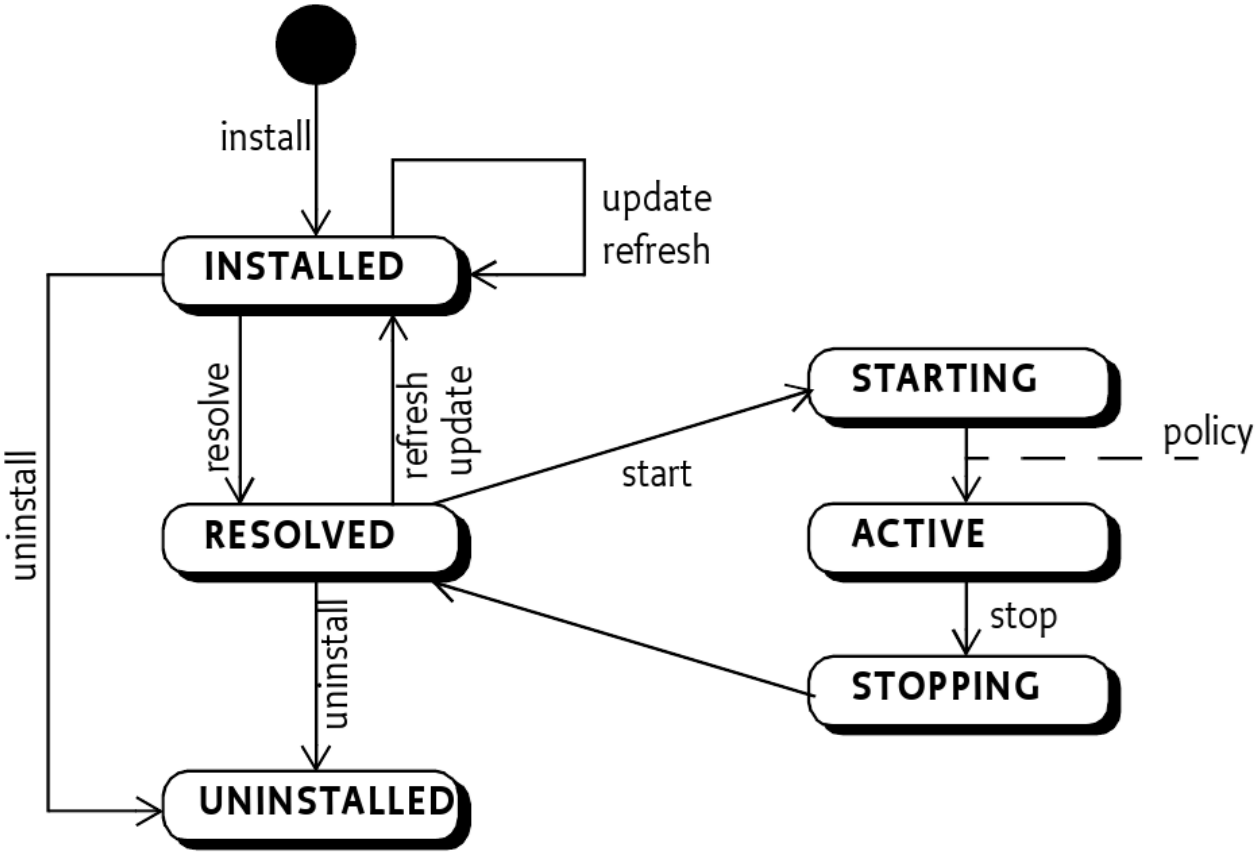
MANIFEST.FM headers

- Bundle-ClassPath
  - Way to bundle 3rd party JAR libraries
- Bundle-Activator
  - Name of class implementing BundleActivator
  - The class is called when the bundle is activated
- Bundle-SymbolicName
  - Bundle ID
- Bundle-Version
  - 1.0.3.qualifier (*qualifier* corresponds to timestamp)
- Bundle-RequiredExecutionEnvironment
  - Enforces the execution context
- DynamicImport-Package
  - On-the-fly import
- Bundle-NativeCode
  - Import .so, .dll

Bundle lifecycle



The picture was taken from the book "OSGi in Practice" written by Neil Bartlett
See http://njbartlett.name/osgibook.html

Bundle lifecycle - activation

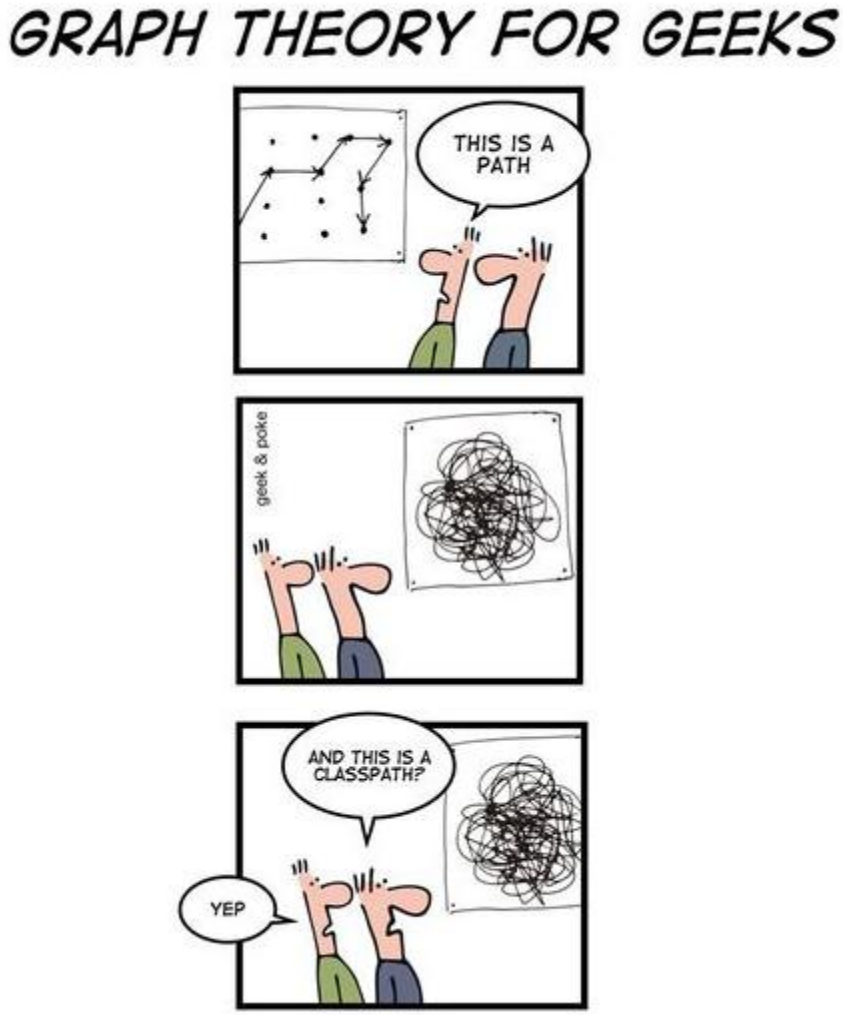
- Manage bundle lifecycle
- class ***BundleActivator***
  - ***void start(BundleContext ctx)***
    - Register service, listeners, look for services
  - ***void stop(BundleContext)***
    - Stop trackers, listeners, …
- class ***BundleContext***
  - Properties
  - Services
  - Bundles
  - Filters
  - Listeners

```
public class SimpleLogTargetActivator
                    extends Activator {

  @Override
  public void start(BundleContext context){
   /* ... */
  }

  @Override
  public void stop(BundleContext context) {
   /* ... */
  }
}
```

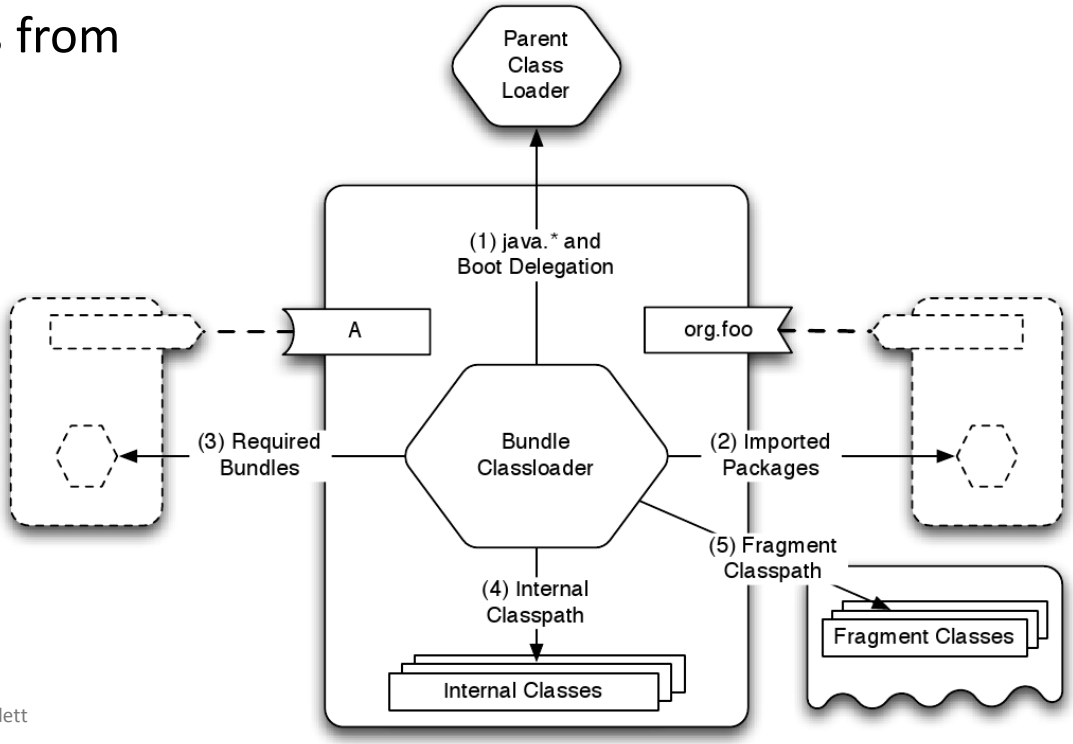
OSGi classloading



The picture was taken from the OSGi wiki
See http://wiki.osgi.org/wiki/Main_Page

OSGi classloading

- Separated class loader per bundle
  - Classloaders do not compose a tree, but a general graph
- Lookup order
  - Parent
    - only for classes from java.* package
  - Imported packages
  - Required bundles
  - Local bundle classpath



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See http://njbartlett.name/osgibook.html

Bundle classpath

- Bundle classpath is composed of classes from
  - Imported packages
  - Provisions of required bundles
  - Local classpath specified via *Bundle-Classpath*

Demo #01

- Download Eclipse RCP
  - http://www.eclipse.org/downloads/
- Create a simple bundle with activator
  - Via wizard in *"New > Project > …"*
- Bundle the bundle
- Deploy bundle
  - Create new OSGi launch configuration & launch it
    - Package *org.eclipse.osgi* is required to be selected
    - Use "Add required bundles"
- Observe its state in the console

OSGi Console

- Important commands
  - *help*
  - *ss*
    - Display installed bundles
  - *services*
    - Display published services
  - *status*
  - *exit*
    - Shutdown OSGi framework
  - *start/stop <bundle-id>*
  - *Update <bundle-id>*
  - *packages*
    - *Shows exported packages*
  - *diag*
    - *Run diagnostic*

Service

- **Communication layer for bundles**
  - Well-defined communication points
  - Inherent dynamic nature
    - Can appear/disappear any time at runtime
  - Multiple providers can provide the same services
    - The service has additional properties which can for example specify its priority
- **Service**
  - Service is an object registered by a bundle in a *ServiceRegistry*
    - Programmatically
    - Declaratively
  - Service has associated properties
    - E.g., *service.ranking*

Registering service (1)

- Programmatically in BundleActivator

```
public void start(BundleContext context) {
  SimpleLogTargetImpl logTargetImpl = new SimpleLogTargetImpl();

  registration = context.registerService(
              ILogTarget.class.getName(),
              logTargetImpl,
              null);
}
```

- Problems
  - Code
    - Services semantics is spread over code
      - dependencies, properties, implementation v. provided interface

Registering service (2)

- Declarative services (DS)

```
<scr:component name="logger-component"
            enable="true" activate="activate">
        <implementation class="cz.cuni...LoggerImpl"/>
        <service>
                <provide interface="cz...ILogger"/>
        </service>
</scr:component>
```

- Declaratively
  - Services provided by *components*
  - Automated service management by DS framework
    - Dependency injection of required services
    - Life-cycle management

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Service components

- Component is a normal Java class contained within a bundle
- Defined in separated XML file in *OSGI-INF* directory
  - *MANIFEST.FM*
    - Has to contain component file reference: *Service-Component: OSGI-INF/component.xml*

```
<scr:component name="logger-component"
           activate="activate">
        <implementation class="cz.cuni...LoggerImpl"/>
        <service>
                <provide interface="cz...ILogger"/>
        </service>
</scr:component>
```

- Activation
  - Declared method
    - ComponentContext, BundleContext, Map as parameters
- Service provider
  - Specify name of provided service

Demo #02

- Implement a bundle with API
- Implement two bundles implementing API
- Register API services
  - Programmatically
  - Declaratively
- Launch configuration has to contain *'org.eclipse.equinox.ds'* bundle
- Observe provided services in console (command *services)*

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Service consumption (1)

- Bundle can search for service which implements specific interface
- Several bad solution
  - context.getService(...)
    - Nasty code with active waiting
  - Service registry listeners

```
Service reference ref =
context.getServiceRef("cz.bar");
if (ref!=null) {
  Bar bar = (Bar) context.getService(ref);
  if (bar != null) {
   ...
   context.ungetService(ref)
  }
}
```

- Recommended solutions (thread-safe)
  - **Service tracker**
  - **Components**

Service tracker – white board pattern

- Services dependencies
  - Content provider v. consumers
    - e.g., consume a new service if and only if the specified service appears
  - *“Don't look for content providers, let them to register as services and track for the services”*
  - *ServiceTracker* capture service life-cycle
    - via *ServiceTrackerCustomizer*
      - Capture process of adding/removing/modifying service

Service tracker

- **Service Tracker**
  - Tracking for service
    - Filters (name, id, property, owning bundle, ...)
      - LDAP syntax (e.g. *(&(objectName=”foo”)(property1=”Xyz”))*)

```
//In Bundle Activator - start
tracker = new ServiceTracker(context,
  ILogger.class.getName(), null);

tracker.open();

// get the service(s)
ILogger log = (ILogger)tracker.getService();
ILogger log = (Ilogger) tracker.waitForService(1000);

// stop tracking
tracker.close();
```

Service tracker

- Construction determines attributes

```
ServiceTracker(
        BundleContext context,
        java.lang.String clazz,
        ServiceTrackerCustomizer customizer)
```

- ServiceTracker methods
  - *open()/close()* – start/stop tracking for a service
  - *getService()*
  - *addingService/removedService/modifiedService(ServiceReference rf)*
    - Interface ***ServiceTrackerCustomizer***
    - Can be overridden by user

Service consumption (2)

- Declaratively via **service components**

- Service reference
  - Name
  - Interfaces
  - Bind/unbind method
  - Target
  - Policy: static/dynamic
  - Cardinality: M..N
    - 1..1 – if multiple services is accessible then the one with the highest *service.ranking* is used

```
<scr:component name="getServiceComp">
 <implementation class="GetLoggerService">
 <reference name="log"
   interface="org.osgi...LogService"
   bind="setLog"
   unbind="unsetLog"
</scr:component>
```

Services lookup

- Lookup strategy
  - Look for service during component activation

```
<?xml version="1.0" encoding="UTF-8"?>
<scr:component name="example.listen"
  xmlns:scr="http://www.osgi.org/xmlns/scr/v1.1.0">
 <implementation class="com.acme.LogLookupImpl"/>
 <reference name="LOG"
    interface="org.osgi.service.log.LogService"/>
</scr:component>
```

```
public class LogLookupImpl {
 private void activate(ComponentContext ctxt) {
  LogService log = (LogService)
            ctxt.locateService("LOG");
  }
}
```

- Event strategy
  - Let the DS framework to inject the service via defined methods
  - Bind/unbind attributes of reference declaration

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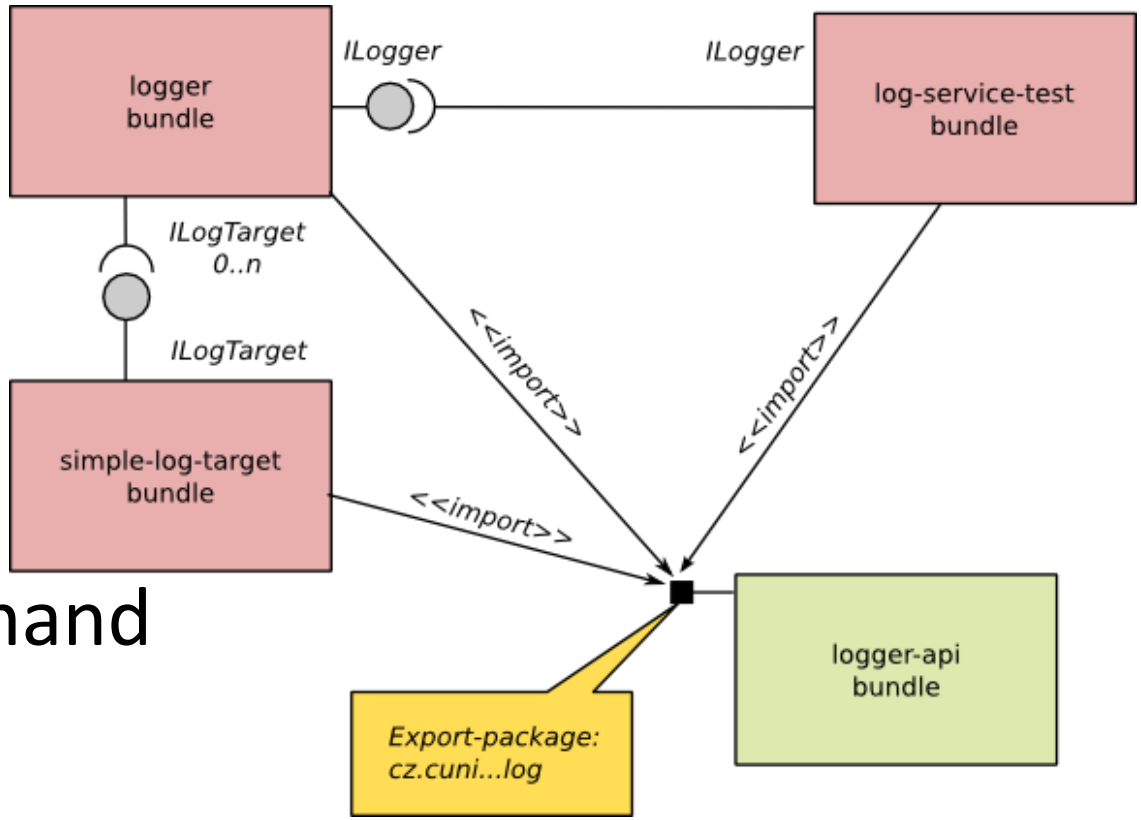
Component factories

- A component can be declared as a factory
  - ***ComponentFactory*** service is registered
    - ***newInstance(Dictionary d)*** method
  - The user tracks for Component Factory service and create a new instance
- A component factory can provide a service
  - Registered for each created instance

Demo #03

- Write a new bundle with a tester component consuming declared services in demo #02
- Possible scenario
- Try to call *update* command in console



OSGi services

- Logging (*LogService*)
- Http (*HttpService*)
  - Exposing registered servlets
- Event
  - Messaging Producer <-> Consumer
- Device manager
- Diagnostics/Monitoring
  - JMX
- Application manager
  - Application package – set of resource (bundles, data,...)
    - Can be deployed/install
- Location/measurement services
- Remote services

Demo #04

- Use HttpService as an additional implementation of ILogTarget
  - Introduce a new bundle with a component exposing ILogTarget and requiring HttpService
- Register HTTP servlet
- Launch configuration has to introduce web-server bundles (e.g., Jetty). Don't forget on
  - javax.servlet
  - org.eclipse.equinox.http.servlet
  - org.eclipse.equinox.http.jetty
- Specify JVM property:
  -Dorg.osgi.service.http.port=8080

OSGi 4.2 features

- Framework launching
- Remote services
- Blueprint services
- Bundle tracker
- Service hooks
- Conditional permissions

- Enterprise features – bundling (WAR), JPA, JNDI, JDBC integration

OSGi 4.3 features

- Introduction of generics into OSGi API
- Capabilities
- Requirements
- Adapt concept
  - Bundle can be adapted to another type
- Weaving hook
  - Bytecode modification
- Resolver, bundle, service events hooks

Bundles repositories

- OBR
  - http://bundles.osgi.org
  - OSGi compendium implementation
- Spring
  - http://sigil.codecauldron.org/spring-external.obr
  - http://sigil.codecauldron.org/spring-release.obr
- Knopflerfish
  - http://www.knopflerfish.org/repo/bindex.xml

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Resources

- OSGi specification
  - http://www.osgi.org/
- OSGi tooling
  - http://en.wikipedia.org/wiki/OSGi-Tooling
- NPRG044 source code
  - http://code.google.com/a/eclipselabs.org/p/nprg044-eclipse-platform/

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OSGi tools

- Pax
- Bnd
- Scribids