NPRG044: OSGi framework

http://d3s.mff.cuni.cz

Department of Distributed and Dependable Systems

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CHARLES UNIVERSITY IN PRAGUE

faculty of mathematics and physics

Step #1:
Download Eclipse 4.2 (Juno) RCP

http://www.eclipse.org/downloads/packages/release/juno/sr2/

Do you use JARs?

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JAR advantages and disadvantages

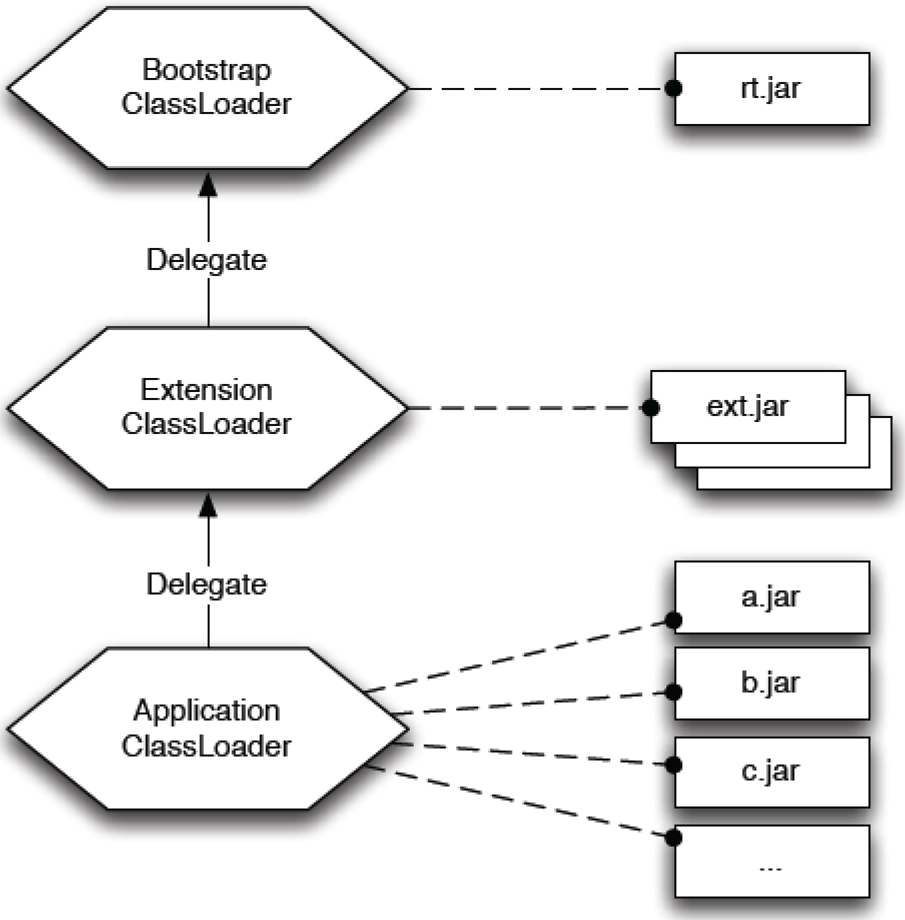
+ Includes class files and additional resources

+ Deployment

- No information hiding
- No runtime meaning
- Cannot specify required JARs
- No versioning

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

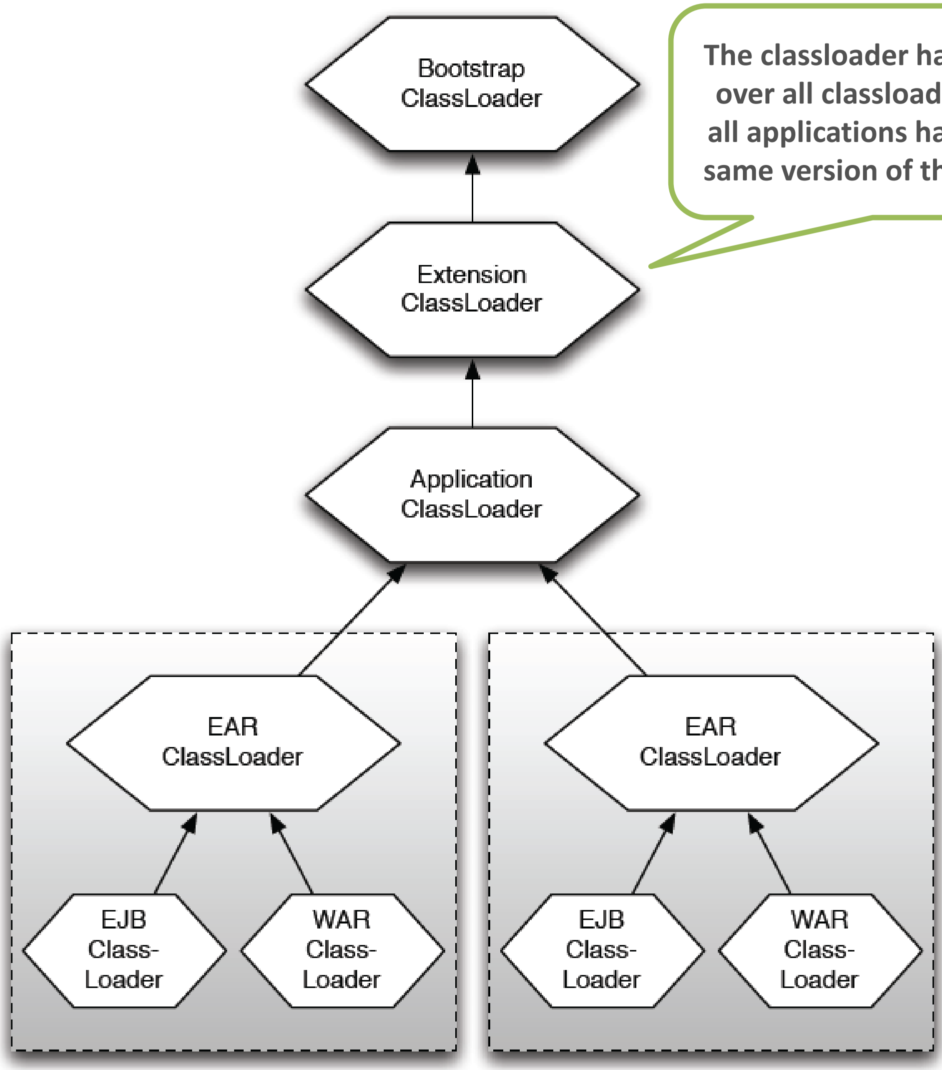
Common Java classloading



Cannot handle different versions of the same class

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

J2EE classloading



The classloader has precedence over all classloaders below => all applications have to use the same version of the core library

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

OSGi

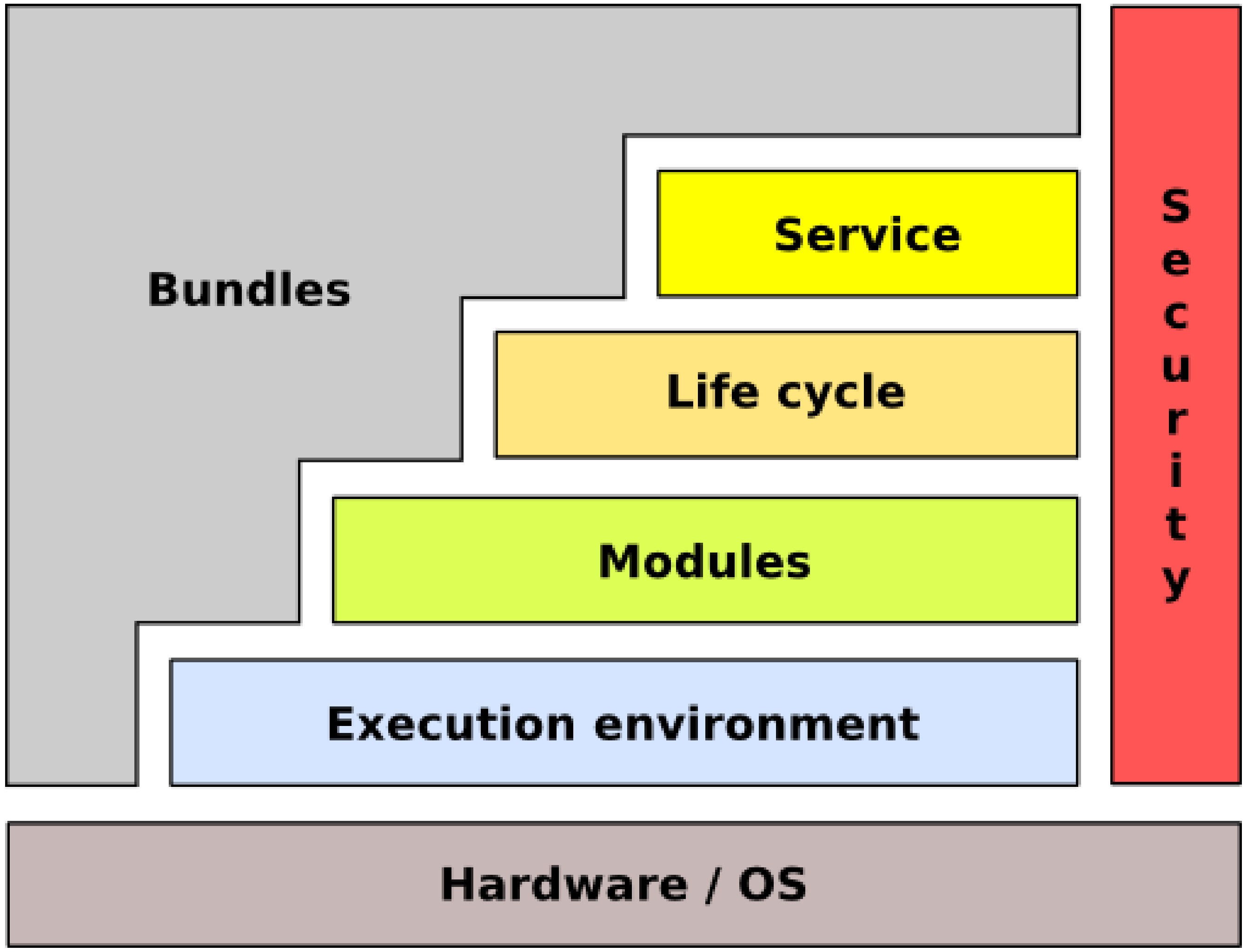
- OSGi is a specification
  - Open Service Gateway Initiative
  - Current version R5 (see http://www.osgi.org/)
  - Three parts + Java API + execution environment specification
    - Core
    - Compendium
    - Enterprise

- 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 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, …)
    - Directories containing meta-information (META-INF, OSGI-INF)
- **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
```

The length of each line is limited to 72 bytes by the 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**

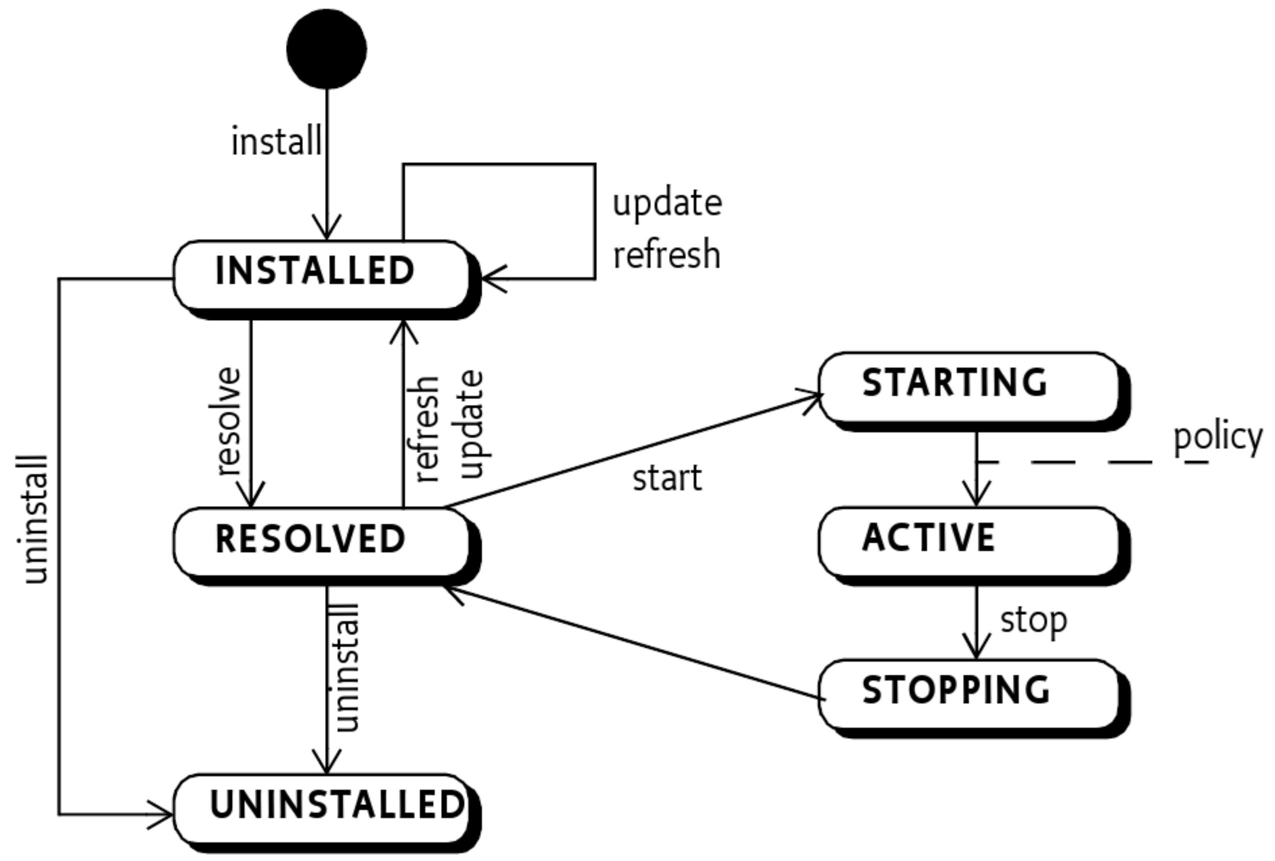
```
Require-Bundle: logger-api-bundle
```

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

MANIFEST.MF headers

- Bundle-ClassPath
  - Way to bundle third-party JAR libraries
- Bundle-Activator
  - Name of the 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 the bundle lifecycle

- class ***BundleActivator***
  - ***void start(BundleContext ctx)***
    - Register services and listeners, look for services
  - ***void stop(BundleContext ctx)***
    - Stop trackers and listeners, …

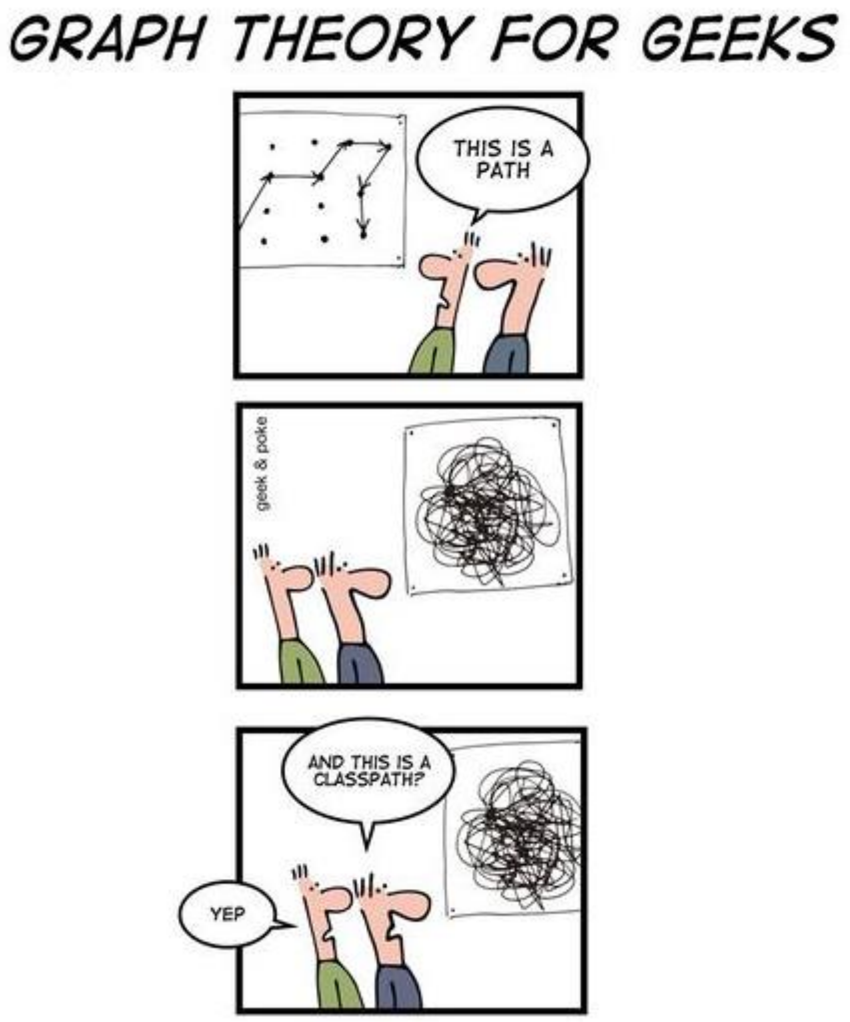
- class ***BundleContext***
  - Properties
  - Services
  - Bundles
  - Filters
  - Listeners

```
public class SimpleLogTargetActivator
                      extends Activator {

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

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

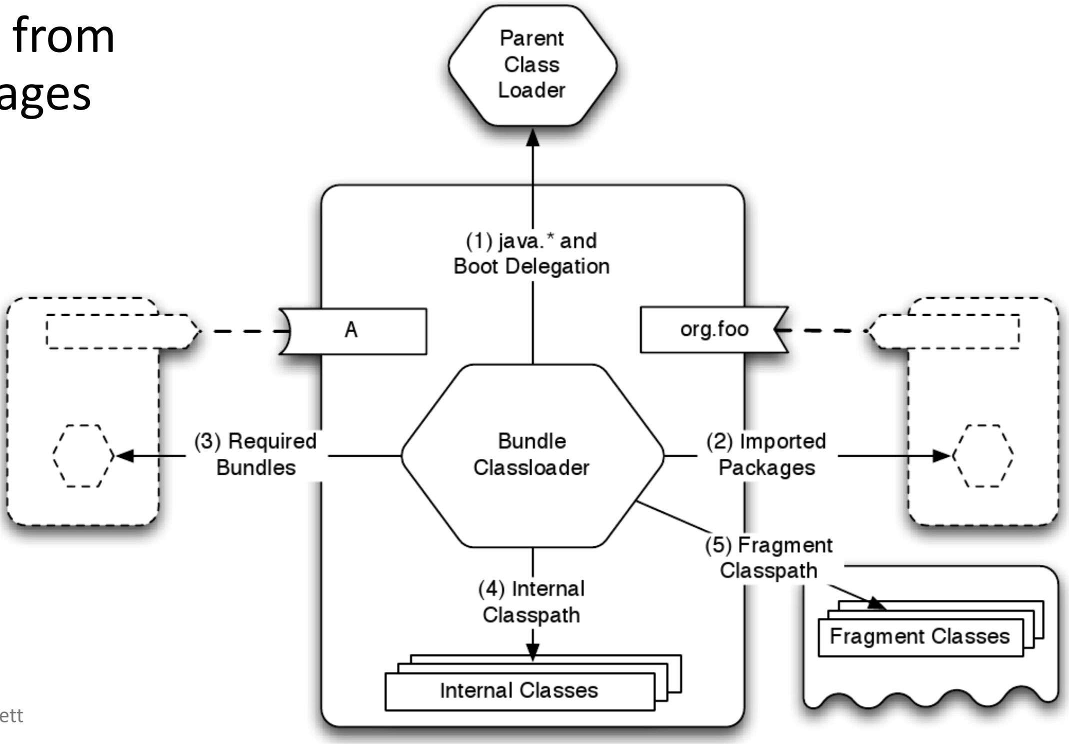
OSGi classloading



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

OSGi classloading

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



The picture was taken from the book "OSGi in Practice" written by Neil Bartlett
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*

OSGi Console

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

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Demo #01

- Download Eclipse 4.2 (Juno) RCP
  - http://www.eclipse.org/downloads/packages/release/juno/sr2/
- Create a simple bundle with activator
  - Via wizard in *"New > Project > …"*
- Run the 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

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 service
    - The service has additional properties (e.g., 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
  - Semantics spread over the code
    - dependencies, properties, implementation versus interface

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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 a separate XML file in the *OSGI-INF* directory

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

- *MANIFEST.FM*
  - *has to contain component file reference: Service-Component: OSGI-INF/component.xml*

- Activation
  - Declared method
    - Parameters: ComponentContext, BundleContext, Map

- Service provider
  - Specify name of the provided service

Component factories

- A component can be declared as a factory
  - ***ComponentFactory*** service is registered
    - ***newInstance(Dictionary d)*** method
  - The user tracks for the ComponentFactory service and creates a new instance

- A component factory can provide a service
  - Registered for each created instance

Demo #02

- Create a bundle that defines some API
  - API: a set of Java interfaces
- Implement two bundles implementing the API
- Register API services
  - Programmatically
  - Declaratively
- Launch configuration has to contain the bundle *‘org.eclipse.equinox.ds’*
- Observe provided services in console (command *services)*

Service consumption (1)

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

```
ServiceReference ref =
context.getServiceReference("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

- Service dependencies
  - Content provider versus 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* captures the service life-cycle
    - via *ServiceTrackerCustomizer*
      - Captures the process of adding/removing/modifying services

Service tracker

- **Service Tracker**
  - Tracking for services
    - 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*
    - Parameter: *ServiceReference rf*
    - Interface ***ServiceTrackerCustomizer***
    - Can be overridden by the user

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Service consumption (2)

- Declaratively via **service components**

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

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

Service lookup

- Lookup strategy
  - Look for the service during component activation

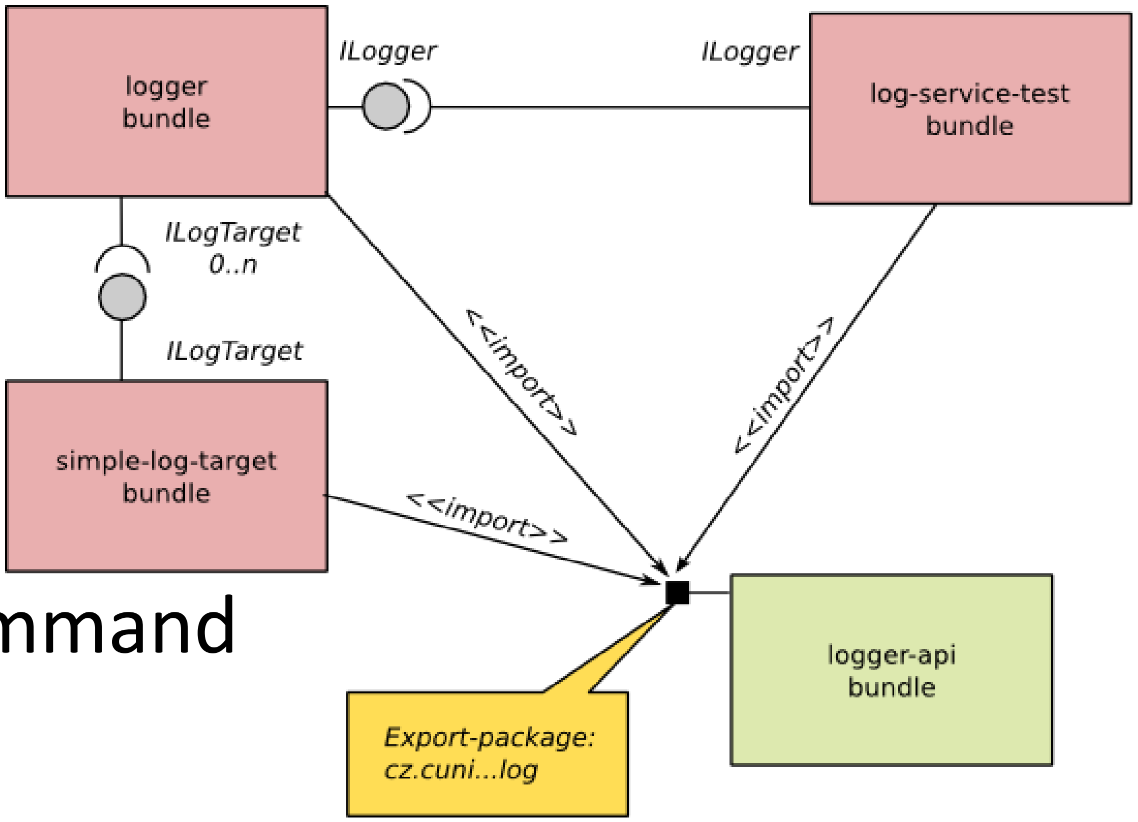
```
<?xml version="1.0" encoding="UTF-8"?>
<scr:component name="example.listen"
   xmlns:scr="http://www.osgi.org/xmlns/scr/v1.1.0">
  <implementation class="com.acme.LogLookupImpl"/>
  <reference name="LOG"
     interface="org.osgi.service.log.LogService"/>
</scr:component>
```

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

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

Demo #03

- Write a new bundle with a tester component consuming declared services
- Possible scenario
- Try to call the *update* command in the 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 resources (bundles, data,...)
    - Can be deployed/installed
- 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
  - Don’t forget on
    - javax.servlet
    - org.eclipse.equinox.http.servlet
    - org.eclipse.equinox.http.jetty
    - org.eclipse.jetty.*
    - ... and few others (check the error messages)

- 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 the OSGi API
- Capabilities
- Weaving hook
  - Bytecode modification

- and many others

OSGi 5 features

- OSGi Bundle Repository (OBR)
- Integration with Java ServiceLoader

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

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OSGi implementations

- Open source
  - *Eclipse Equinox*
    - Many extensions of OSGi (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

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/
- Wikipedia
  - http://en.wikipedia.org/wiki/OSGi
- NPRG044 source code
  - http://code.google.com/a/eclipselabs.org/p/nprg044-eclipse-platform/

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