BUILDING NANO SERVICES WITH OSGI

BOSCH

Building Nano Services with OSGi
Speaker

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Building Nano Services with OSGi
Speaker

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Agenda

1. Overview
2. Tooling
3. Exercise: Simple Service
4. OSGi Console
5. Configuration
6. Exercise: Configurable Service
7. Felix OSGi Web Console
8. Remote Service Admin
9. Exercise: Remote Service

OVERVIEW

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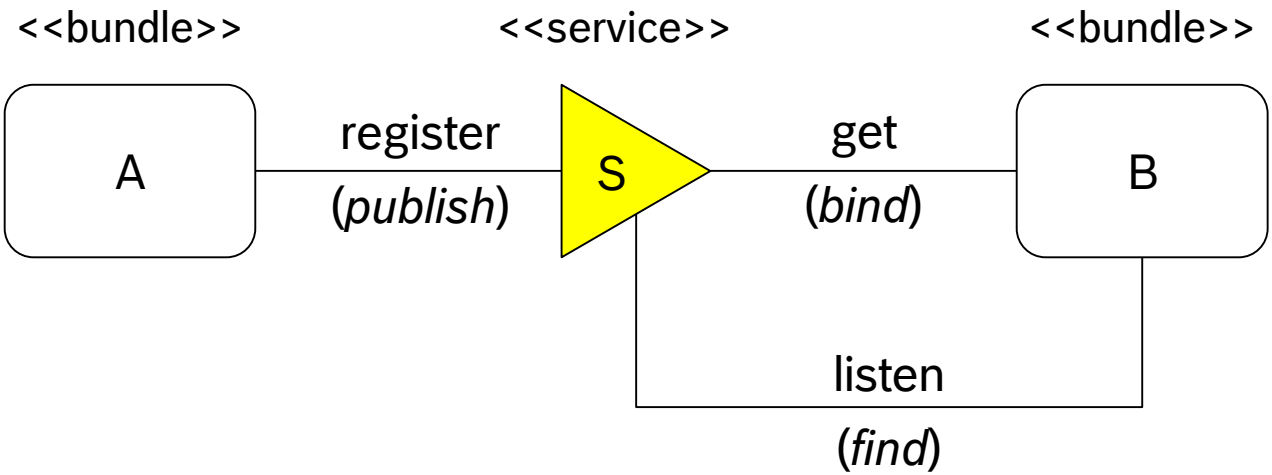
Building Nano Services with OSGi
Publish-Find-Bind

- Bundles **register (publish)** services
- Bundles **get (bind)** services
- Bundles **listen (find)** services



Building Nano Services with OSGi
Components

- **(Service) Component**
  - Java class contained in a bundle
  - Declared via *Component Description*
- **Component Description**
  - XML document to declare a *Service Component*
- **Component Configuration**
  - *Component Description* that is parameterized with component properties
  - Tracks the component dependencies and manages the component instance
- **Component Instance**
  - Instance of the component implementation class
  - Created when a *Component Configuration* is activated
  - Discarded when the *Component Configuration* is deactivated

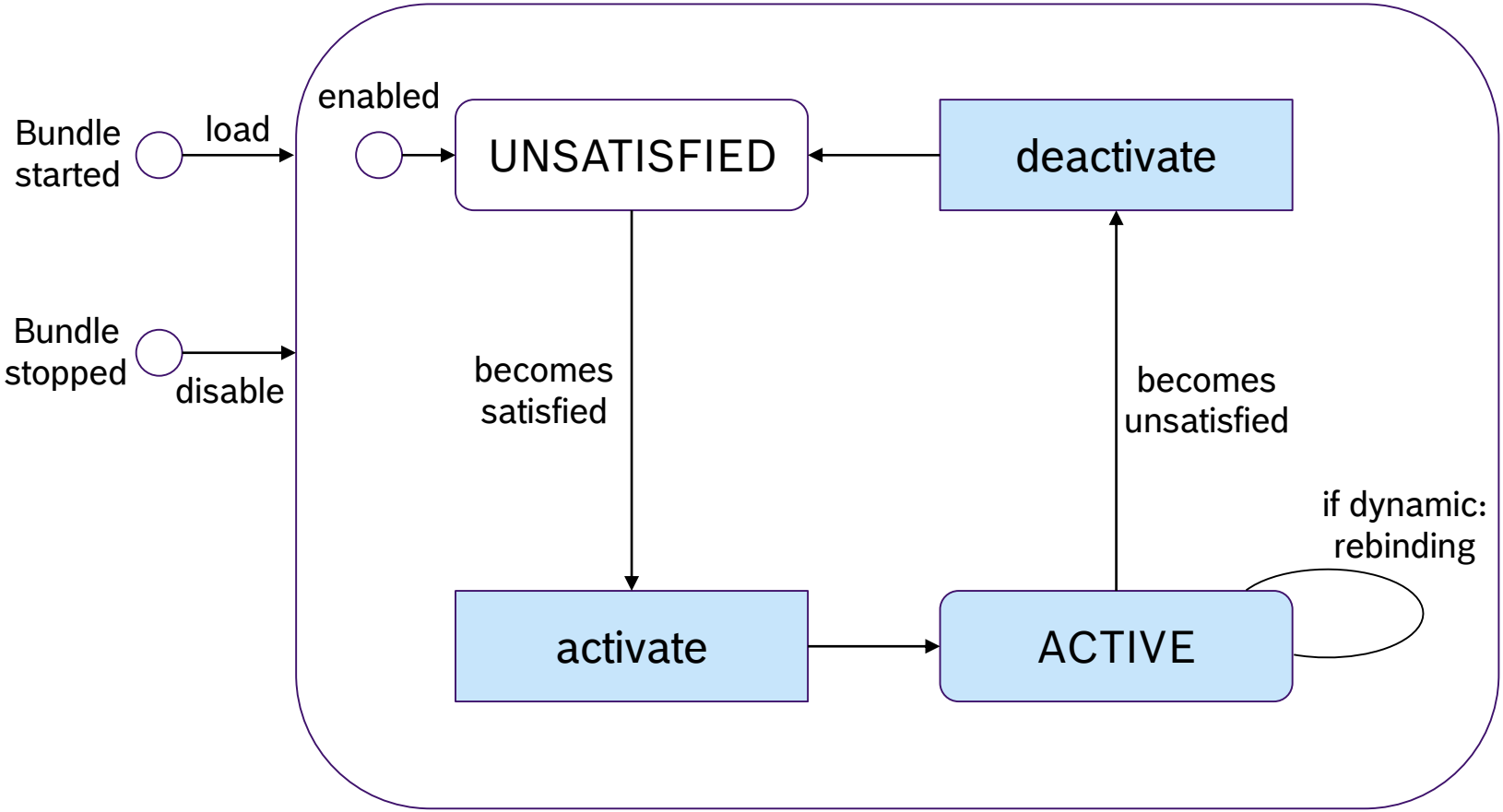
Building Nano Services with OSGi
References

- **References**
  - The definition of dependencies to other services.
- **Target Services**
  - The services that match the reference interface and target property filter.
- **Bound Services**
  - The services that are bound to a *Component Configuration*.
- **Access Strategies**
  - Event Strategy
  - Lookup Strategy
  - Field Strategy (1.3)

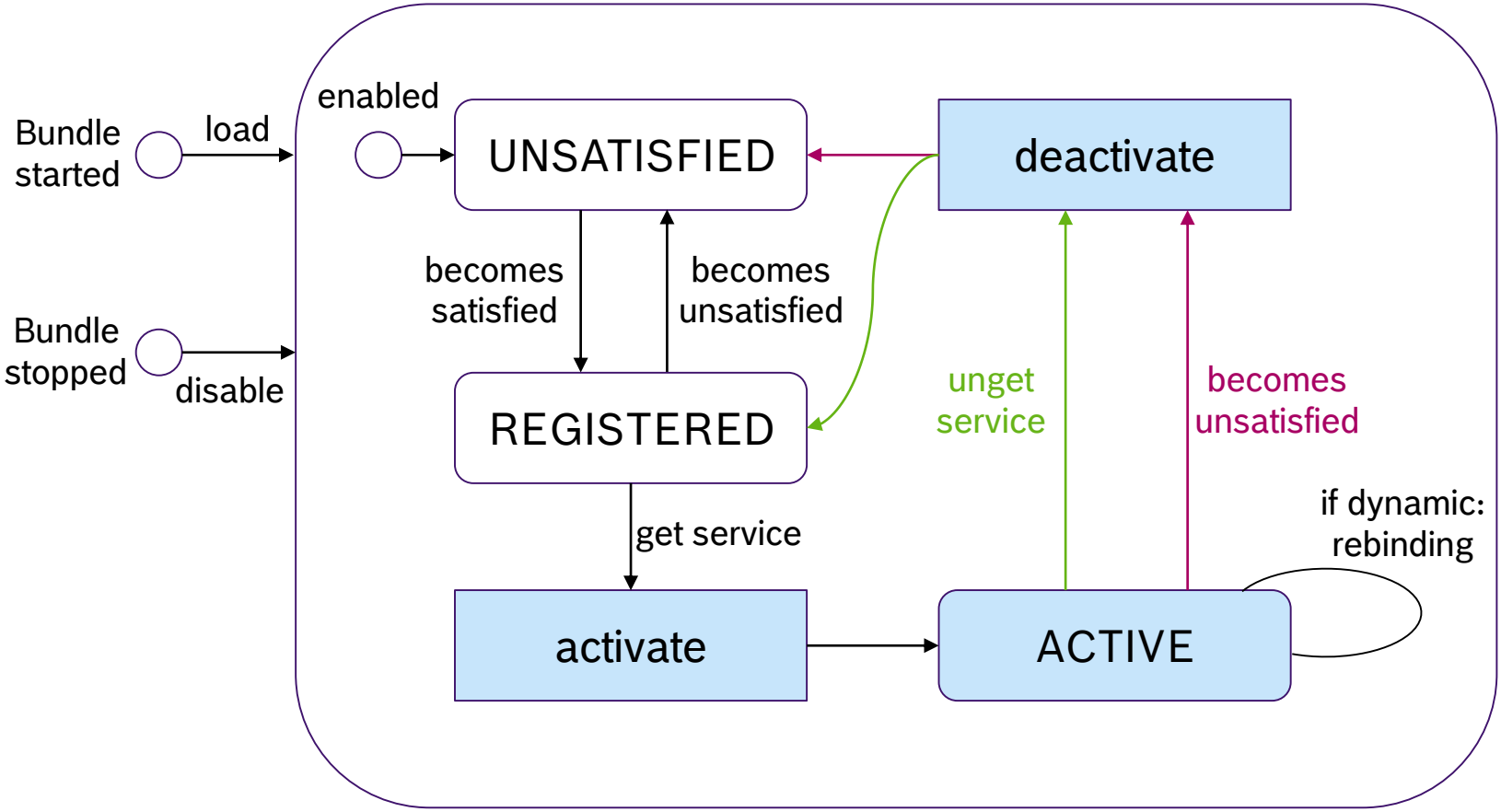
Building Nano Services with OSGi
Component Types

- **Delayed Component**
  - Activated when the service is requested
  - Needs to specify a service
- **Immediate Component**
  - Activated as soon as all dependencies are satisfied
  - Does not need to specify a service
- **Factory Component**
  - Creates and activates Component Configurations

Building Nano Services with OSGi
Component Lifecycle – Immediate



Building Nano Services with OSGi
Component Lifecycle – Delayed



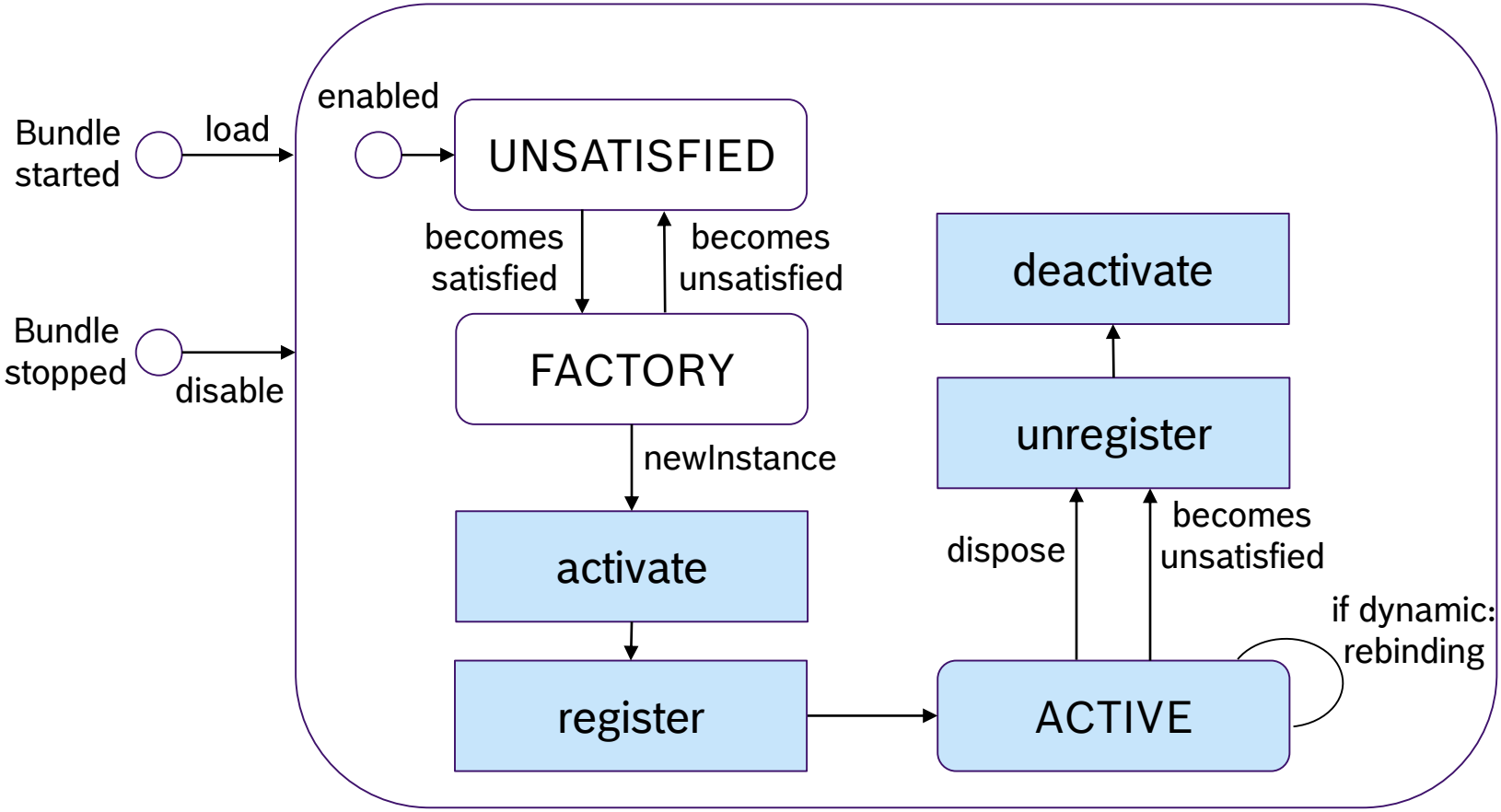
Building Nano Services with OSGi
Component Lifecycle – Activation

- Activation consists of the following steps:
  1. Load the component implementation class
  2. Create the component instance and component context
  3. Bind the target services
  4. Call the activate method if present

- For **Delayed Components** the load time is moved to the first request (including reference bindings)

(see Declarative Services Specification Version 1.3 – 112.5.6 Activation)

Building Nano Services with OSGi
Component Lifecycle – Factory



TOOLING

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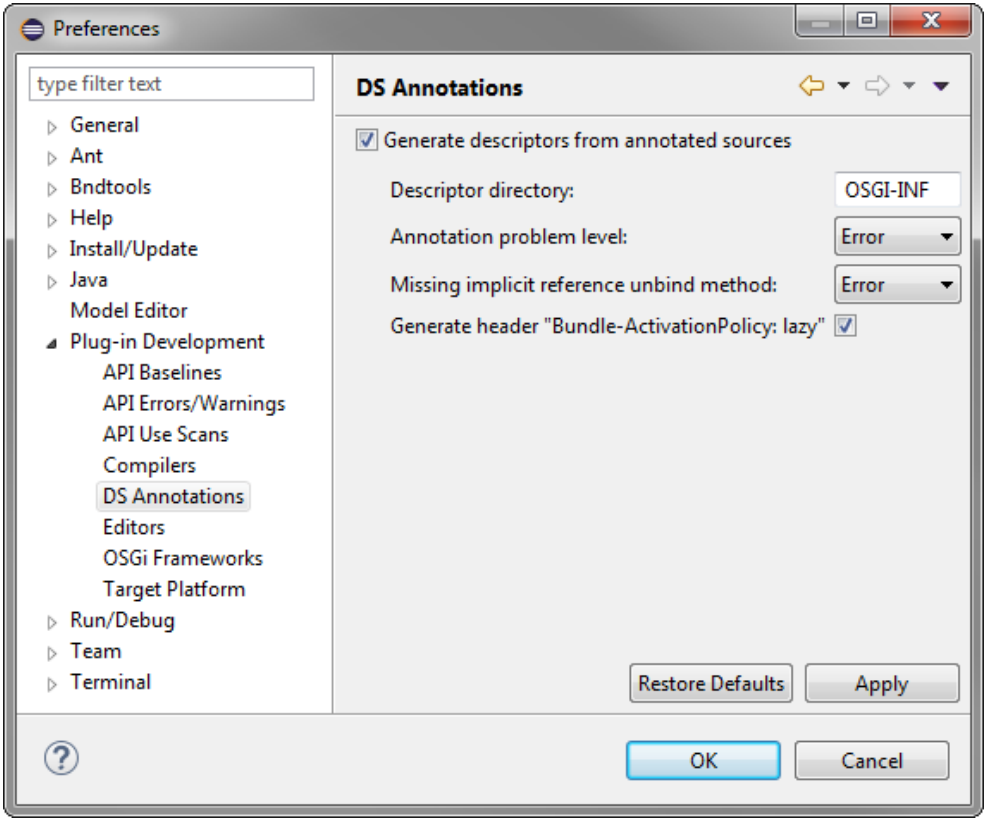
Building Nano Services with OSGi
Tooling

- **Since Eclipse Neon**
  - PDE - DS Annotations Support
  - Contribution by Peter Nehrer (@*pnehrer*)

- **Eclipse <= Mars**
  - Declarative Services Annotations Support (Eclipse Marketplace)
    https://marketplace.eclipse.org/content/declarative-services-annotations-support

Building Nano Services with OSGi
PDE – DS Annotations Support

- **Activate *DS Annotations Support* via *Preferences***



Building Nano Services with OSGi
Bndtools

- Additional Eclipse Plug-ins (bundles)
  - Focus on bnd configurations
  - OSGi metadata is generated

- Installation via Eclipse Marketplace or Update Site
  http://bndtools.org/installation.html

Building Nano Services with OSGi
PDE vs. Bndtools

Topic	PDE	Bndtools
Project layout	Special PDE project layout	Default Java project layout
MANIFEST.MF handling	Explicit editing	Generated out of meta-data
Package imports	Manually (manual triggered calculation)	Bytecode-based import calculation
Import/export package versions	Explicit properties	Implicit conventions
Launch defaults	Persisted, No Update	Clean, Hot Bundle Deploy
Bundle handling	IDE uses „virtual bundle“ Explicit export	Instant bundle creation
One Eclipse project	One bundle	Can become multiple bundles

Building Nano Services with OSGi
Provided Tooling

- IDEfix – Oomph Setup
  - Eclipse Committers Oxygen M2
  - Bndtools 3.3.0

- Added the following bundles to the installation to avoid p2 target definition
  - ECF Remote Services SDK 3.13.2
  - Equinox Target Components 3.12.0
  - Apache Felix Webconsole All 4.2.16

EXERCISE: SIMPLE SERVICE

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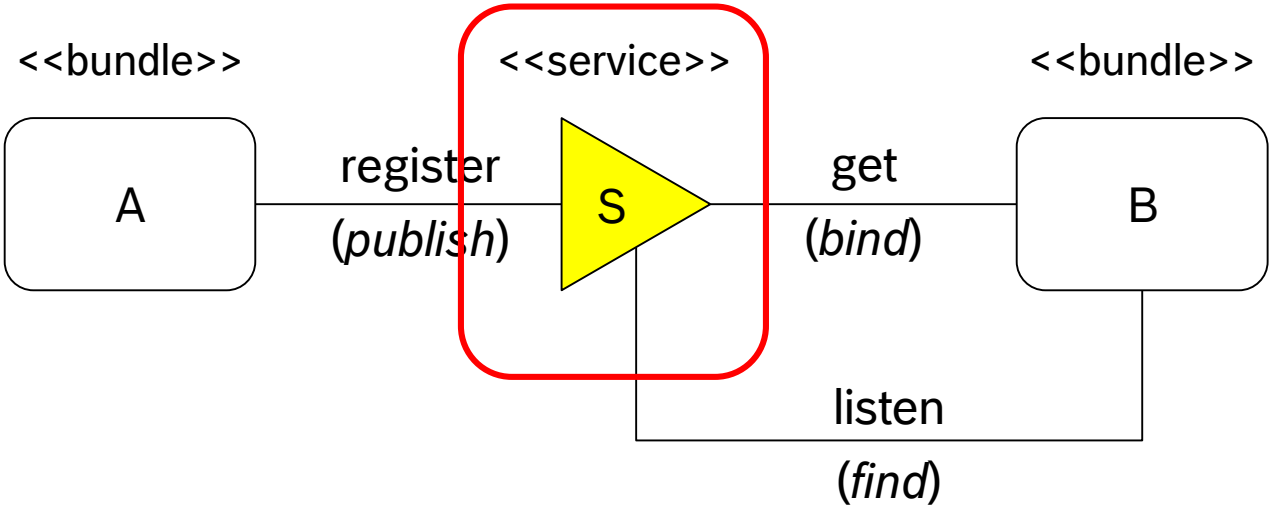
Building Nano Services with OSGi
Service API



Building Nano Services with OSGi
Service API

- Create a bundle for the service API (e.g. *examples.service.api*)
- Create the service interface

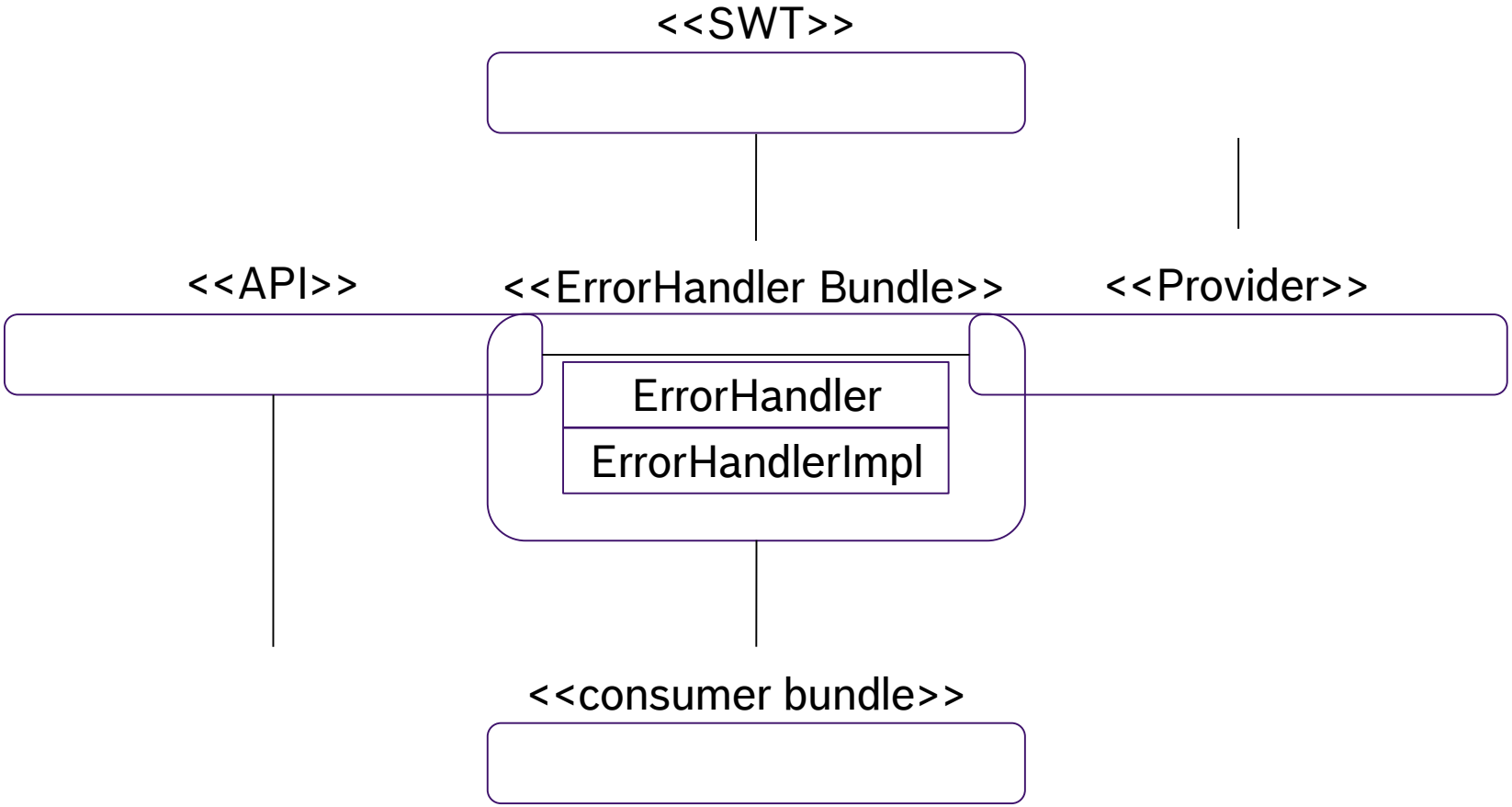
```
public interface StringModifier {
    String modify(String input);
}
```

M(ost) **U**(seless) **S**(ervice) **E**(ver)

→ Make the service implementation exchangeable
→ Clean dependency hierarchy

Building Nano Services with OSGi

Service API – Motivation



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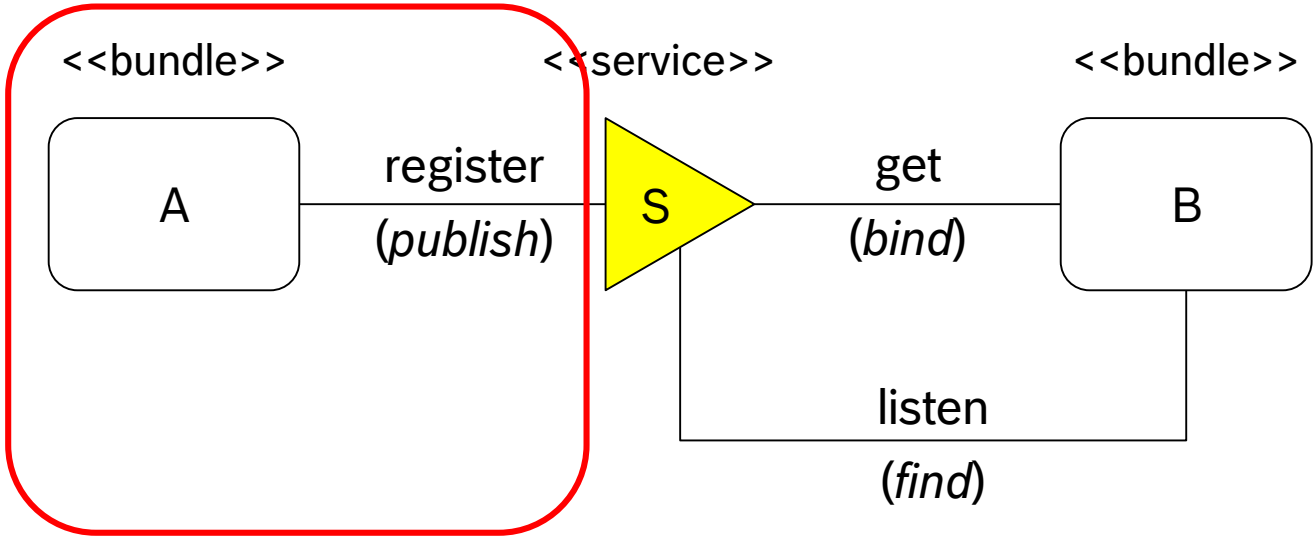
Building Nano Services with OSGi
Service Implementation



Building Nano Services with OSGi
Service Implementation

- Create the *Service Component*
- Let the *Component Description* be generated via `@Component`

```
@Component
public class StringInverterImpl implements StringModifier {

    @Override
    public String modify(String input) {
            return new StringBuilder(input).reverse().toString();
    }
}
```

Building Nano Services with OSGi
@Component

- **Annotation to mark a Java class as a *Service Component***
- **Generates (general)**
  - Generation of *Component Description* XML file
  - Generation of `Service-Component` header in *MANIFEST.MF*
- **Generates (PDE)**
  - `Bundle-ActivationPolicy: lazy` header in *MANIFEST.MF*
  - Adds *Component Description* XML file to *build.properties*
- **Generates (Bndtools)**
  - `Provide-Capability` header for `osgi.service`
  - `Require-Capability` header for `osgi.extender` (*DS 1.3*)

Building Nano Services with OSGi
Capabilities

- Capability = non-code dependency
- `osgi.extender=osgi.component`

```
Require-Capability: osgi.extender;
 filter:="(&(osgi.extender=osgi.component)(version>=1.3)(!(version>=2.0)))"
```

  - added to spec with DS 1.3
  - Equinox DS adapted for DS 1.2 with Eclipse Neon

- `osgi.service`
  - specify the provided service implementations

```
Provide-Capability: osgi.service;
 objectClass:List<String>="org.fipro.inverter.StringInverter"
```

The p2 resolver does not support OSGi capabilities!

Building Nano Services with OSGi
@Component

Type Element	Default	Type Element	Default
configurationPid	full qualified class name of the component	**property**	empty
configurationPolicy	optional	**service**	full qualified class names of all ***directly*** implemented interfaces
enabled	`true`	**servicefactory** (*depr. in 1.3*)	`false`
factory	empty String	**xmlns**	lowest DS XML namespace that supports used features
immediate	`false` if *factory* or *service* `true` otherwise		
name	full qualified class name of the component	**reference** (*since 1.3*)	empty
properties	empty	**scope** (*since 1.3*)	SINGLETON

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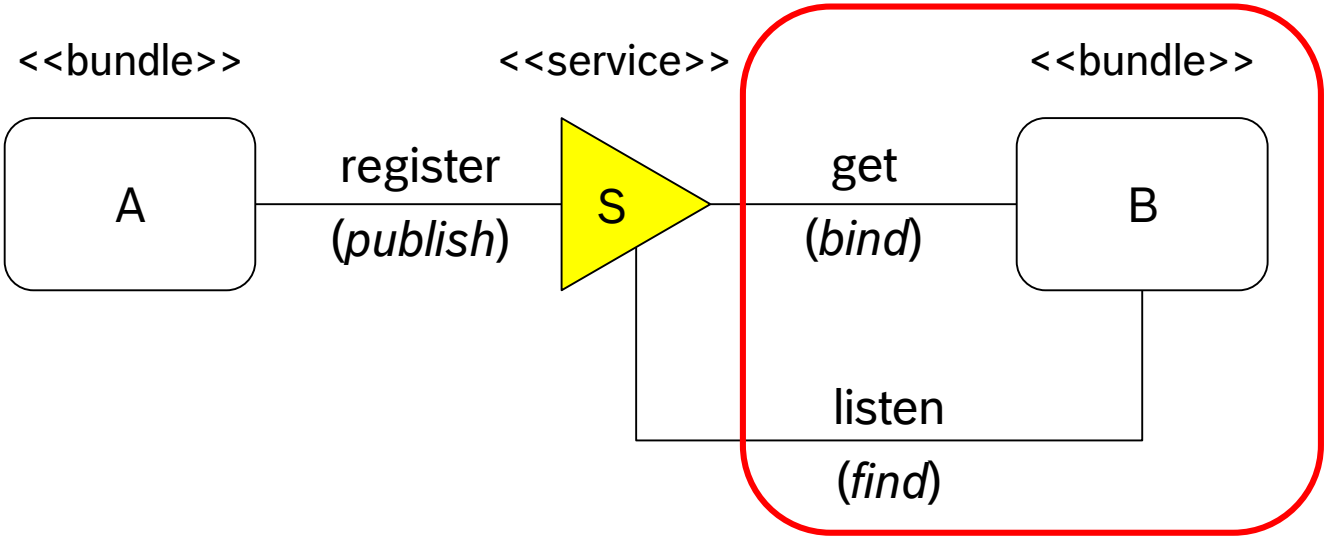
Building Nano Services with OSGi
Service Consumer



Building Nano Services with OSGi
Service Consumer

- Create the service consumer as *Service Component*
- Reference the *Service Component* that should be consumed via `@Reference`

```
@Component(property= {"osgi.command.scope:String=examples",
                      "osgi.command.function:String=modify"},
   service=StringModifierCommand.class
)
public class StringModifierCommand {

   private StringModifier modifier;

   @Reference
   void bindStringModifier(StringModifier modifier) { this.modifier = modifier; }

   public void modify(String input) { System.out.println(modifier.modify(input)); }
}
```

Building Nano Services with OSGi
@Reference

- **Specify dependency on other <u>services</u>**
- **Resolving references is required to satisfy a component**
  (if the reference is not optional)
- **Different strategies for accessing services**
  - *Event Strategy*
  - *Field Strategy (DS 1.3)*
  - *Lookup Strategy*

Building Nano Services with OSGi
@Reference – Event Strategy

- ***Event Strategy*** – using event methods for *bind/updated/unbind*

```
@Component(...)
public class StringModifierCommand {

    private StringModifier modifier;

    @Reference
    void bindStringModifier(StringModifier modifier) { this.modifier = modifier; }

    void updatedStringModifier(
            StringModifier modifier, Map<String, ?> properties) { //do something }

    void unbindStringModifier(StringModifier modifier) { this.modifier = null; }

    public void modify(String input) { System.out.println(modifier.modify(input)); }
}
```

Building Nano Services with OSGi
@Reference - Event Method Parameter

- `ServiceReference`

```
void bindStringModifier(ServiceReference<StringModifier> reference)
```

- <service type>

```
void bindStringModifier(StringModifier modifier)
```

- <service type> + `Map<String, ?>`

```
void bindStringModifier(
    StringModifier modifier, Map<String, Object> properties)
```

With DS 1.3

- `ComponentServiceObjects`
- Different variations of the parameter list

Building Nano Services with OSGi
@Reference – Field Strategy

- ***Field Strategy*** (*DS 1.3*) – using instance fields

```
@Component(...)
public class StringModifierCommand {

    @Reference
    private StringModifier modifier;

    public void modify(String input) {
            System.out.println(modifier.modify(input));
    }
}
```

Building Nano Services with OSGi
@Reference – Lookup Strategy (DS 1.2)

- ***Lookup Strategy*** *(DS 1.2)* – lookup everytime needed, do not store

```
@Component(...)
public class StringModifierCommand {

   private ComponentContext context;
   private ServiceReference<StringModifier> reference;

   @Activate
   void activate(ComponentContext context) { this.context = context; }

   @Reference
   void setStringModifier(ServiceReference<StringModifier> reference) { this.reference = reference; }

   public void modify(String input) {
           StringModifier modifier =
                       (StringModifier) context.locateService("StringModifier", reference);
           ...
   }
}
```

Building Nano Services with OSGi
@Reference – Lookup Strategy (DS 1.3)

- ***Lookup Strategy*** *(DS 1.3)* – lookup everytime needed, do not store

```
@Component(...
    reference=@Reference(name="modifier", service=StringModifier.class)
)
public class StringModifierCommand {

    private ComponentContext context;

    @Activate
    void activate(ComponentContext context) { this.context = context; }

    public void modify(String input) {
        StringModifier modifier = (StringModifier) context.locateService("modifier");
        ...
    }
}
```

Building Nano Services with OSGi
@Reference

Type Element	Default	Type Element	Default

cardinality	• 1:1 for event methods
	• 1:1 for non-collection fields, 0..n for collections
		unbind	`unbind<name>`
			`unset<name>`
			`remove<name>`

name	• bind event method name without bind prefix • name of the field	**updated**	`updated<name>` if such a method exists
policy	STATIC		
policyOption	RELUCTANT	**bind** (*since 1.3*)	the name of the annotated method or empty
service	full qualified class name of the referenced service	**field** (*since 1.3*)	the name of the annotated field or empty
target	empty String	**fieldOption** (*since 1.3*)	REPLACE
		scope (*since 1.3*)	BUNDLE

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Building Nano Services with OSGi
Launch in IDE / standalone runtime

- Required bundles

  - *examples.pde.command*
  - *examples.pde.impl.inverter*
  - *examples.pde.service.api*

  } Application Bundles

  - *org.apache.felix.gogo.command*
  - *org.apache.felix.gogo.runtime*
  - *org.apache.felix.gogo.shell*
  - *org.eclipse.equinox.console*

  } OSGi Console

  - *org.eclipse.equinox.ds* → Equinox DS Impl
  - *org.eclipse.equinox.util* → Equinox Utils
  - *org.eclipse.osgi* → Equinox OSGi Impl
  - *org.eclipse.osgi.services* → Equinox OSGi Service Interfaces

OSGI CONSOLE (GOGO SHELL)

BOSCH

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Building Nano Services with OSGi
OSGi Console – Commands

Function	Equinox Console	Felix Gogo Shell
Framework Commands		
List installed bundles	`ss` | `lb` *[bundle-id | bundle-name]*	`lb` *[bundle-id | bundle-name]*
Start a bundle	`start` <bundle-id>	`start` <bundle-id>
Stop a bundle	`stop` <bundle-id>	`stop` <bundle-id>
List all available commands	`help` *[sub-command]*	`help` *[sub-command]*
Exit the runtime	`exit`	`exit 0`
SCR Commands		
List all components	`list` | `ls` *[bundle-id]*	`scr:list` *[bundle-id]*
Print all component information	`component` | `comp` <component-id>	`scr:info` <component-id>
Enable a component	`enable` | `en` <component-id>	`scr:enable` <component-name>
Disable a component	`disable` | `dis` <component-id>	`scr:disable` <component-name>

<xxx> = mandatory parameter

[xxx] = optional parameter

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Building Nano Services with OSGi
@Activate / @Modified / @Deactivate

- **Component life cycle methods**
- **Method parameters**
  - `ComponentContext`
  - `BundleContext`
  - `Map<String, ?>`
    Map containing component properties
  - `int / Integer` for (`@Deactivate`)
  - *<Component Property Type> (DS 1.3)*
    Type safe access to component properties

```
@Activate
private void activate(
    ComponentContext c,
    BundleContext b,
    Map<String, ?> properties) {

    //do some initialization stuff
}
```

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CONFIGURATION

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Building Nano Services with OSGi
Component Properties

- Set of properties → key-value-pairs
- Can be specified via
  - **Component Description** (directly vs. Java Properties file)
    Static configuration of default values or for usage by referencing components
  - **Configuration Admin Service**
    Dynamic configuration
  - **Component Factory**
    Dynamic configuration per created *Component Instance*
- Can be consumed
  - in lifecycle methods (*Component Properties*)
  - in event methods (*Service Properties*)

Building Nano Services with OSGi
Component Properties – Definition

- Direct
  - *<name>(:<type>)?=<value>*
  - Type is optional, defaults to String

```
@Component(
    property = {
        "osgi.command.scope:String=examples",
        "osgi.command.function:String=modify"
    },
    service = StringModifierCommand.class)
public class StringModifierCommand {
```

- Java Properties file
  - Only values of type String
  - Properties file needs to be located in the bundle

```
@Component(
    properties = OSGI-INF/config.properties,
    service = StringModifierCommand.class)
public class StringModifierCommand {
```

Building Nano Services with OSGi
Component Properties – Consume DS 1.2

- Via *Component Properties* `Map<String, Object>` in lifecycle methods

```
@Activate
private void activate(Map<String, Object> properties) {
    // do some initialization stuff
}
```

- Via *Service Properties* `Map<String, Object>` in event methods

```
@Reference
void bindModifier(StringModifier modifier, Map<String, Object> properties) {
   // check properties
   this.modifier = modifier;
}
```

Building Nano Services with OSGi
Component Properties – Consume DS 1.3

- Component Property Types
  - Type safe access to *Component Properties*
  - Only usable in lifecycle methods
  - Implemented as annotation (although not used as such)
    - no-argument methods
    - limited return types supported
    - support of default values
  - Can be combined with `Map<String, Object>`

```
@interface Config {
   String message() default "";
   int iteration() default 0;
}
```

```
@Activate
private void activate(Config config) {
    // do some initialization stuff
}
```

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Building Nano Services with OSGi
Configuration Admin Service

- *Component Configuration* attributes
  - `configurationPid`
    PID (Persistent IDentity) = key for components that need a Configuration object
    default: PID → Component Name → fully qualified class name
  - `configurationPolicy`
    Relationship between *Component* and Configuration object
    - `OPTIONAL` – use if available, but be satisfied even without (default)
    - `REQUIRE` – Component can only be satisfied if a Configuration object is available
    - `IGNORE` – Never use an available Configuration object

Building Nano Services with OSGi
Configuration Admin Service - Configuration

- Get a `Configuration` object via `ConfigurationAdmin#getConfiguration(String)`
  - get an existing object from the persistent store or creates a new one
- Check if the Configuration already contains properties
  - If yes, use them to ensure all configuration values are set
  - If not, create a new `Dictionary`
- Update the properties of the `Configuration`

```
Configuration config = cm.getConfiguration("PID");
Dictionary<String, Object> props = null;
if (config != null && config.getProperties() != null) {
   props = config.getProperties();
} else {
   props = new Hashtable<>();
}
...
config.update(props);
```

Building Nano Services with OSGi
Configuration Admin Service – Location Binding

- `Configuration` objects can be bound to a bundle
  - Bundles can't access `Configuration` objects that are bound to another bundle
- Creation of the `Configuration` object can influence the binding
  - `ConfigurationAdmin#getConfiguration(<PID>)`
    Configuration object is bound to the calling bundle
  - `ConfigurationAdmin#getConfiguration(<PID>, null)`
    Configuration object is bound to the first requestor of the Configuration
  - `ConfigurationAdmin#getConfiguration(<PID>, "?")`
    Multi-location-binding – Configuration object is bound to all targest with the matching PID

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Building Nano Services with OSGi
Configuration Change Notifications

- Inside the configurable component – `@Modified` lifecycle method

```
@Modified
void modified(Map<String, Object> properties) {
    // do something with the change properties
}
```

- Inside the referencing component – updated event method

```
void updatedStringModifier(
        StringModifier modifier, Map<String, Object> properties) {
    // do something with the reference and properties
}
```

EXERCISE: CONFIGURABLE SERVICE

Building Nano Services with OSGi
Launch in IDE / standalone runtime

- Additional required bundles:
  - *examples.pde.impl.configurable* → Application Bundle
  - *org.eclipse.equinox.cm* → Equinox Configuration Admin Service
  - *org.eclipse.equinox.metatype* → Equinox Metatype Service

FELIX WEBCONSOLE

BOSCH

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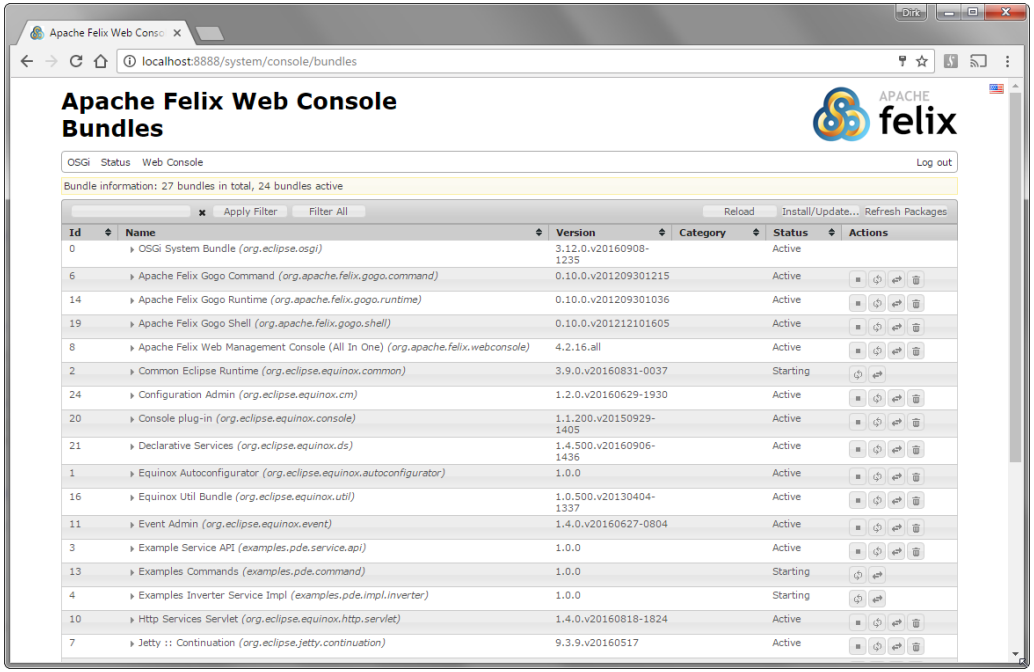
Building Nano Services with OSGi
Felix Webconsole – Introduction

- Tool to **inspect** and **manage** OSGi framework instances using a browser
- Requires a running OSGi Http Service implementation



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Building Nano Services with OSGi
OSGi Metatype

- Dynamic typing system for *Configuration Properties*
- Purpose: dynamic construction of reasonable User Interfaces
- DS 1.2 – Manual creation of metatype XML file in *OSGI-INF/metatype*
  Example

- DS 1.3 – Generation of metatype XML file in combination with *Component Property Type*

```
@ObjectClassDefinition
public @interface ModifierConfig {
    String prefix() default "";
    String suffix() default "";
    int iteration() default 0;
    boolean uppercase default false;
}
```

Agenda

1. Overview
2. Tooling
3. Exercise: Simple Service
4. OSGi Console
5. Configuration
6. Exercise: Configurable Service
7. **Felix OSGi Web Console**
   1. Introduction
   2. Interlude: Metatype
   3. **Launch in IDE**
   4. **Launch in standalone runtime**
8. Remote Service Admin
9. Exercise: Remote Service

Building Nano Services with OSGi
Launch in IDE / standalone runtime

- Additional required bundles:
  - *javax.servlet* → Servlet API
  - *org.apache.felix.webconsole* → Felix WebConsole (all)
  - *org.eclipse.equinox.http.jetty*
  - *org.eclipse.equinox.http.servlet*

    } Equinox OSGi Http Service
  - *org.eclipse.jetty.continuation*
  - *org.eclipse.jetty.http*
  - *org.eclipse.jetty.io*
  - *org.eclipse.jetty.security*
  - *org.eclipse.jetty.server*
  - *org.eclipse.jetty.servlet*
  - *org.eclipse.jetty.util*

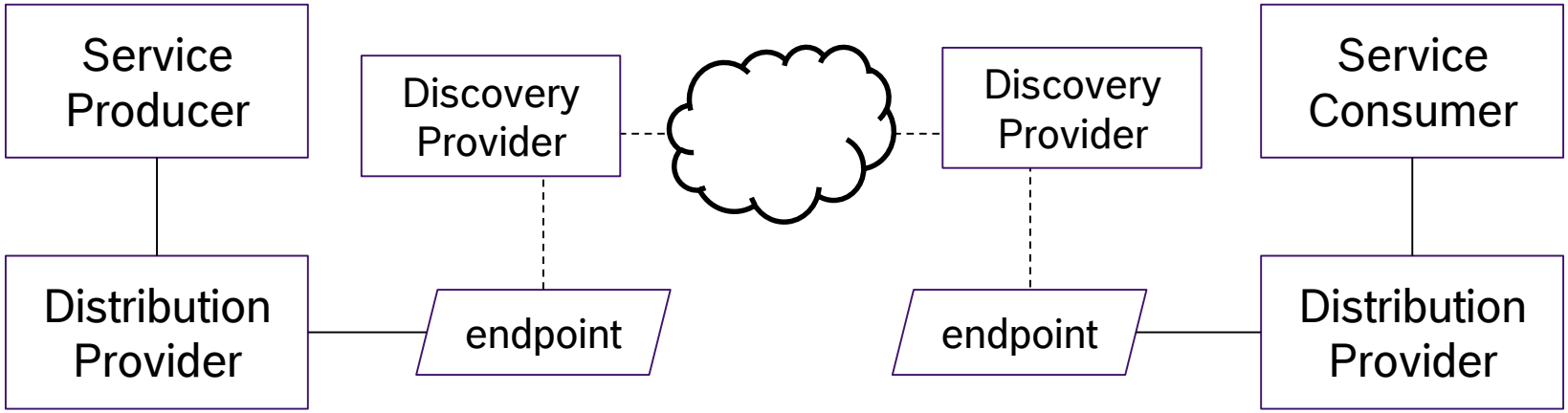
    } Eclipse Jetty

REMOTE SERVICE ADMIN

BOSCH

Building Nano Services with OSGi
Remote Service Admin - Overview

- Export an OSGi service as a remote service
- Discovery Provider
  - Publish/Consume endpoints
- Distribution Provider
  - Export/Import services via endpoints



Building Nano Services with OSGi
Remote Service Admin – Service Properties

- `service.exported.interfaces=*`
  Required property to specify which service interfaces should be exported. Using the wildcard it says that all the interfaces that are registered should be exported.

- `service.exported.configs`
  The ECF container type/container factory name for the desired provider. The ECF project provides several distribution providers, e.g.
  - ECF Generic Provider = `ecf.generic.server`
  - ECF r-OSGi Provider = `ecf.r_osgi.peer`
  - and several more

https://wiki.eclipse.org/Distribution_Providers

EXERCISE: REMOTE SERVICE

Building Nano Services with OSGi
Launch in IDE / standalone runtime

- Additional required bundles:
  - ***javax.servlet*** → Servlet API
  - ***org.eclipse.core.jobs***
  - ***org.eclipse.equinox.common***
  - ***org.eclipse.equinox.concurrent***

    } Eclipse / Equinox Concurrency
  - ***org.eclipse.ecf***
  - ***org.eclipse.ecf.discovery***
  - ***org.eclipse.ecf.identity***
  - ***org.eclipse.ecf.osgi.services.distribution***
  - ***org.eclipse.ecf.osgi.services.remoteserviceadmin***
  - ***org.eclipse.ecf.osgi.services.remoteserviceadmin.proxy***
  - ***org.eclipse.ecf.provider***
  - ***org.eclipse.ecf.provider.jmdns***
  - ***org.eclipse.ecf.provider.remoteservice***
  - ***org.eclipse.ecf.remoteservice***
  - ***org.eclipse.ecf.remoteservice.asyncproxy***
  - ***org.eclipse.ecf.sharedobject***
  - ***org.eclipse.osgi.services.remoteserviceadmin***

    } ECF

Building Nano Services with OSGi
Further information

- OSGi Compendium Specification
  https://www.osgi.org/developer/specifications/

- enRoute Documentation
  http://enroute.osgi.org/book/210-doc.html

- Blog posts
  Getting Started with OSGi Declarative Services
  http://blog.vogella.com/2016/06/21/getting-started-with-osgi-declarative-services/
  OSGi Component Testing
  http://blog.vogella.com/2016/07/04/osgi-component-testing/
  Configuring OSGi Declarative Services
  http://blog.vogella.com/2016/09/26/configuring-osgi-declarative-services/

Evaluate the Sessions

Sign in and vote at **eclipsecon.org**

-1 0 +1