Building Secure OSGi Applications

Karl Pauls
Marcel Offermans

luminis

Who are we?

luminis

think broad, act bright

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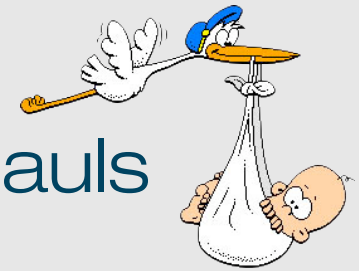

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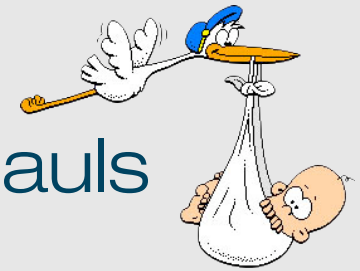

- Karl Pauls
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Agenda

- Introduction to OSGi layers and Security
- Java and OSGi Security
- Enabling Security in Equinox and Apache Felix
- PermissionAdmin and OSGi specific permissions
- ConditionalPermissionAdmin
- Signed Bundles and Local Permissions
- Custom and postponed conditions

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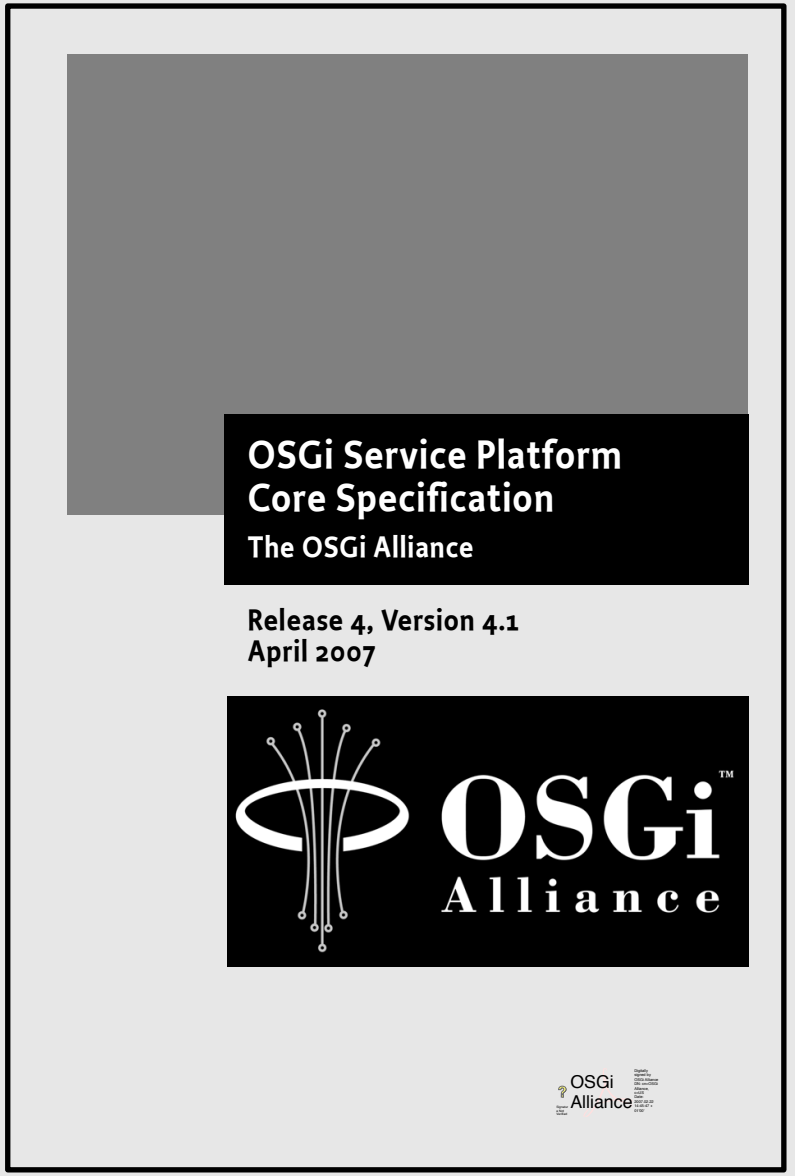
OSGi today

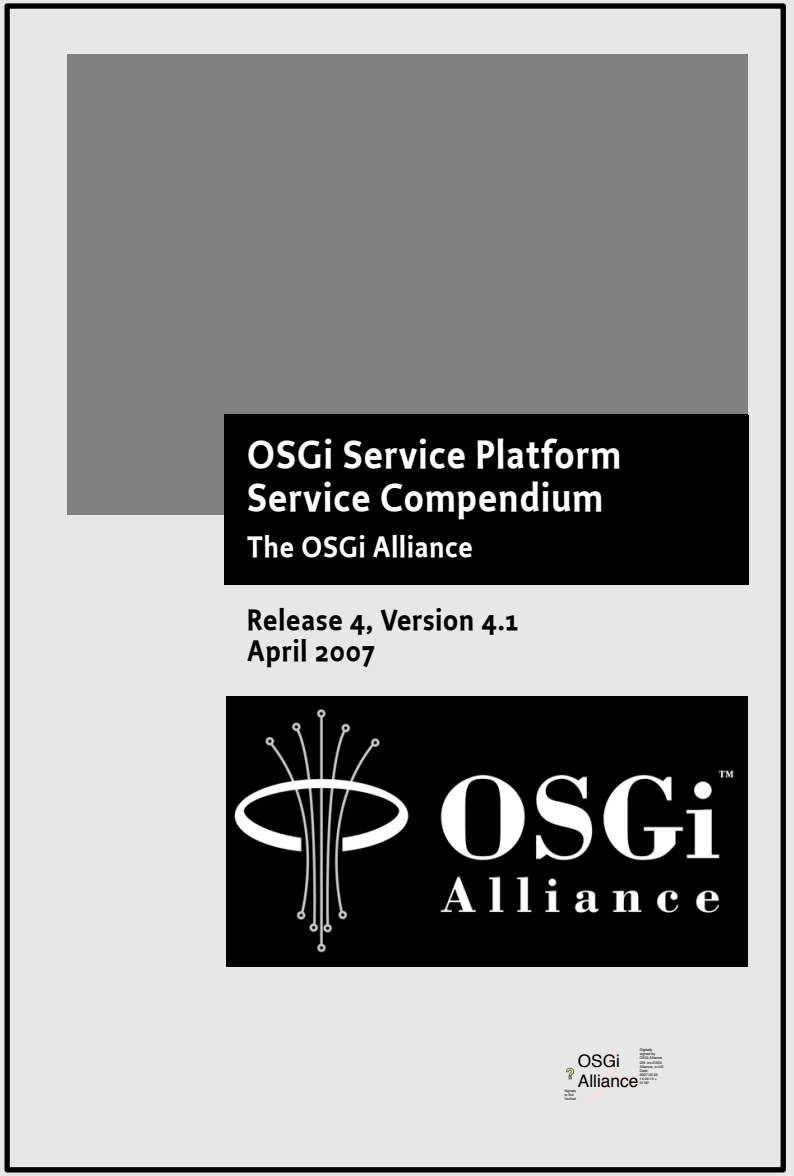
OSGi technology is the dynamic module system for Java™

OSGi technology is Universal Middleware.

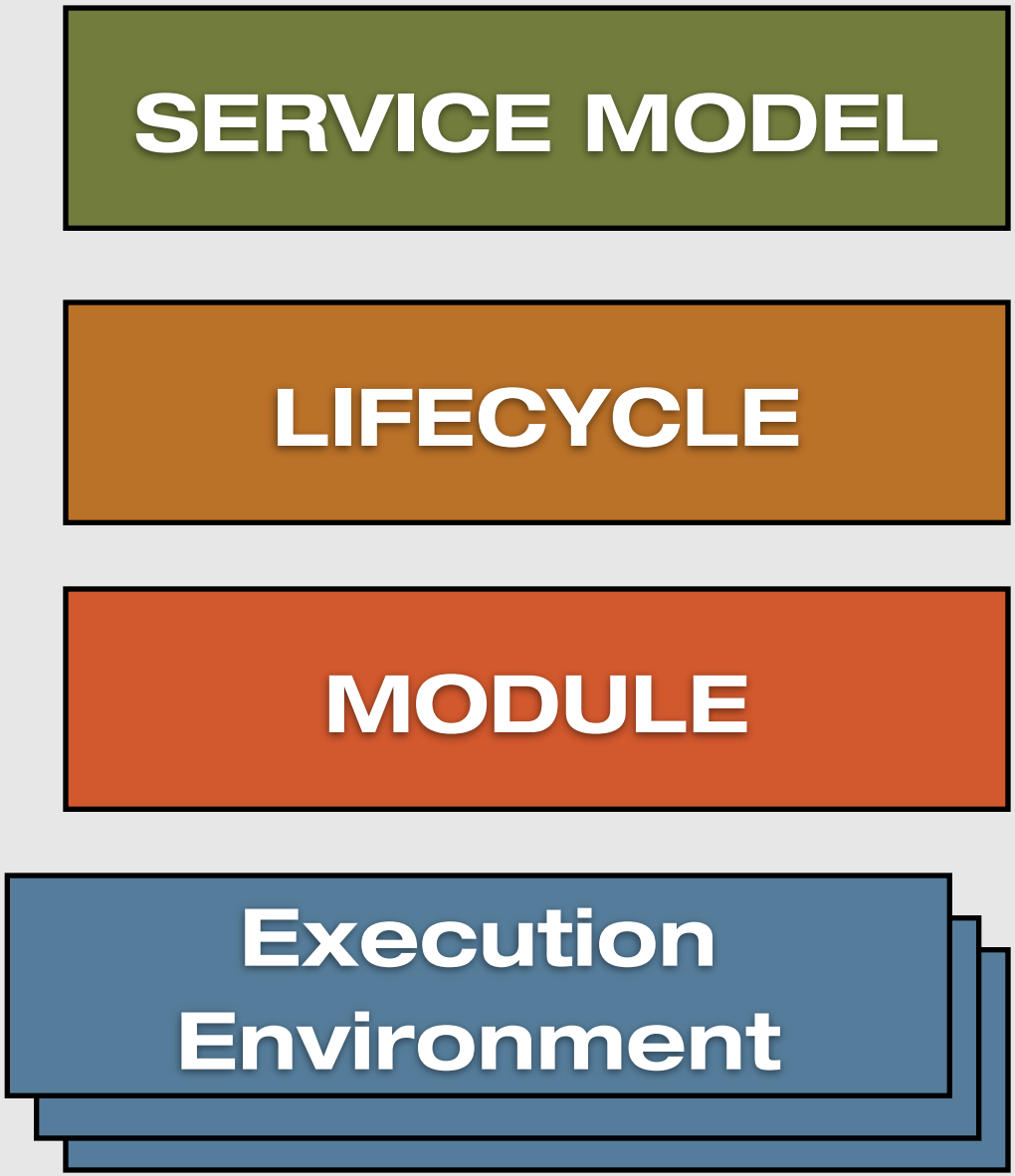
OSGi technology provides a service-oriented, component-based environment for developers and offers standardized ways to manage the software lifecycle. These capabilities greatly increase the value of a wide range of computers and devices that use the Java™ platform.

OSGi Specification





OSGi Framework Layering



L3 - Provides a publish/find/bind service model to decouple bundles

L2 - Manages the life cycle of a bundle in a framework without requiring the vm to be restarted

L1 - Creates the concept of a module (aka. bundles) that use classes from each other in a controlled way according to system and bundle constraints

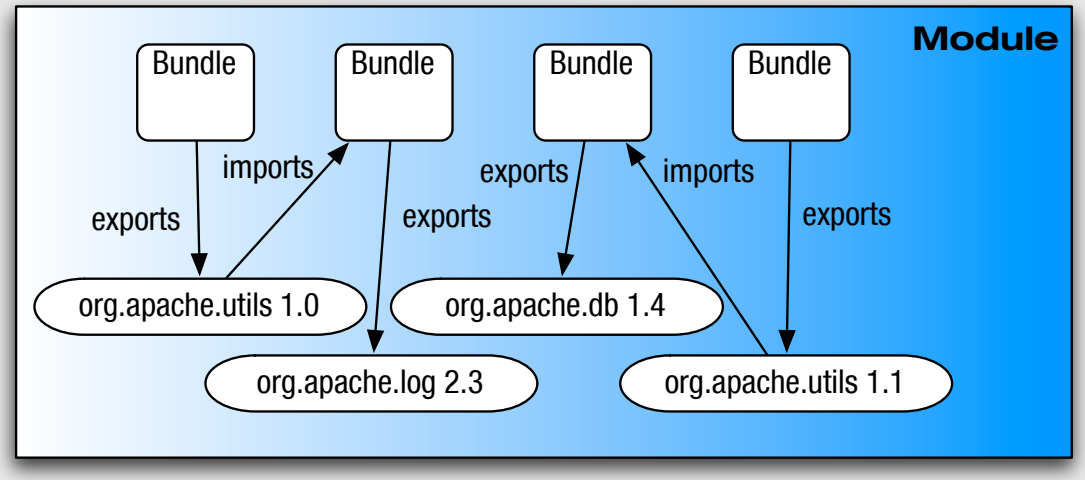
L0 -

OSGi Minimum Execution Environment
CDC/Foundation
JavaSE

Module Layer (1/3)

- Unit of deployment
  is the bundle i.e., a JAR
- Separate class loader
  per bundle
  - Class loader graph
  - Independent namespaces
  - Class sharing at the Java package level

Module Layer (1/3)



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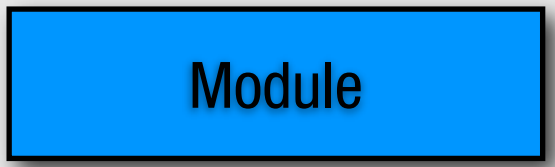
Module

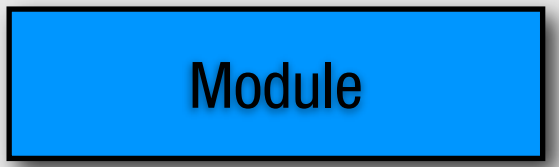
Module Layer (2/3)

- Multi-version support
  - i.e., side-by-side versions
- Explicit code boundaries and dependencies
  - i.e., package imports and exports
- Support for various sharing policies
  - i.e., arbitrary version range support
- Arbitrary export/import attributes
  - Influence package selection



Module Layer (3/3)

- Sophisticated class space consistency model
  - Ensures code constraints are not violated
- Package filtering for fine-grained class visibility
  - Exporters may include/exclude specific classes from exported package
- Bundle fragments
  - A single logical module in multiple physical bundles
- Bundle dependencies
  - Allows for tight coupling when required

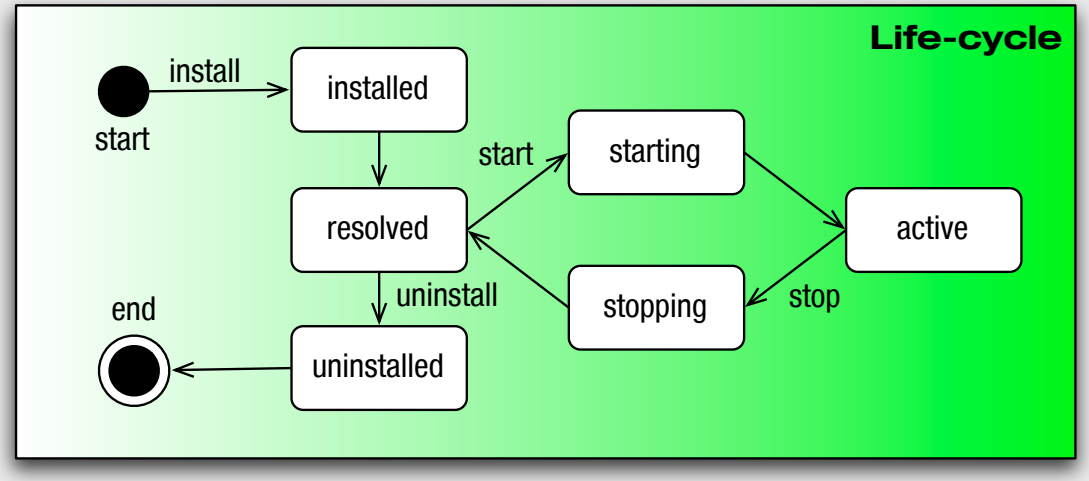


Life-cycle Layer

- Managed life cycle
  - States for each bundle;
- Allows updates of existing bundles.
  - Dynamically install, start, update, and uninstall

Module

Life-cycle Layer



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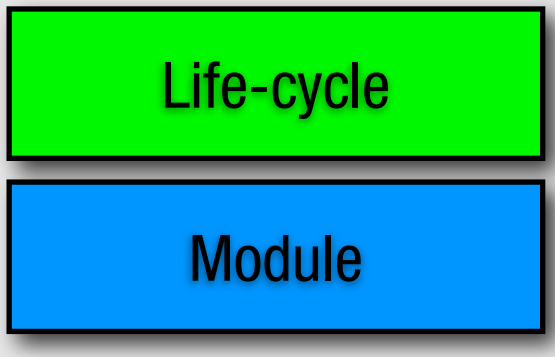
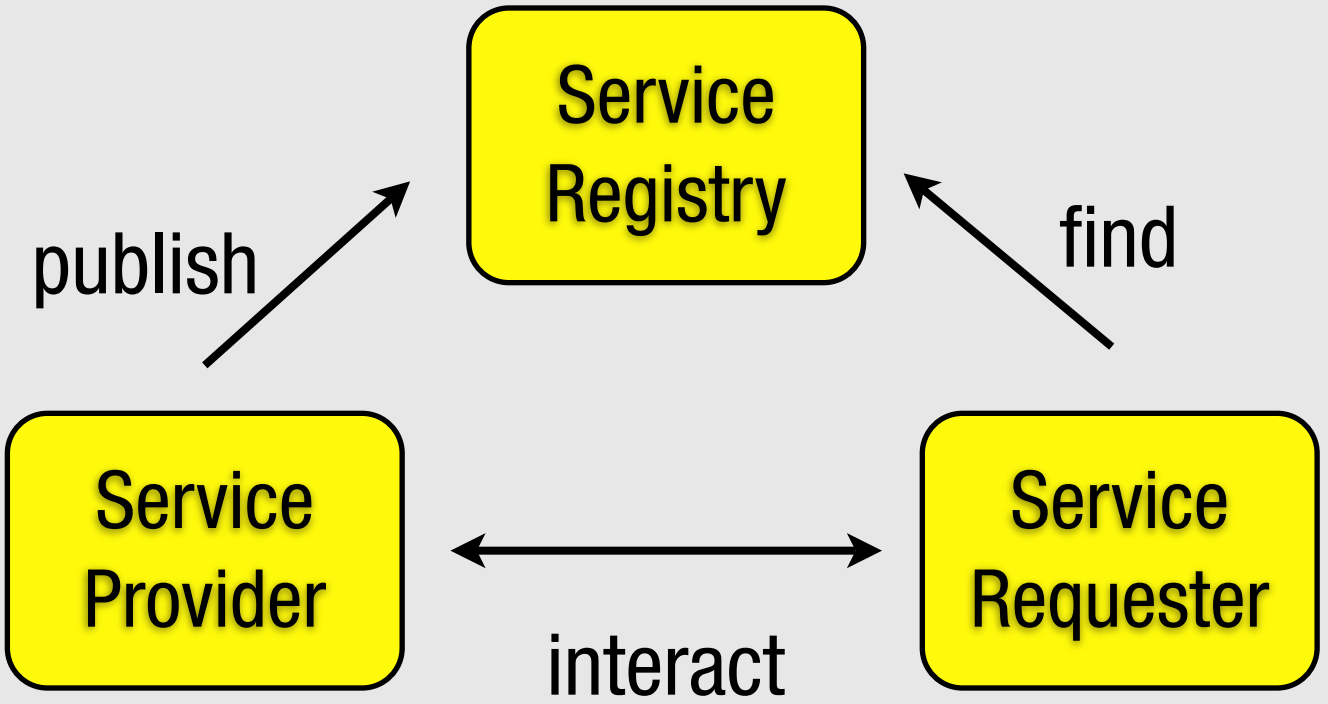
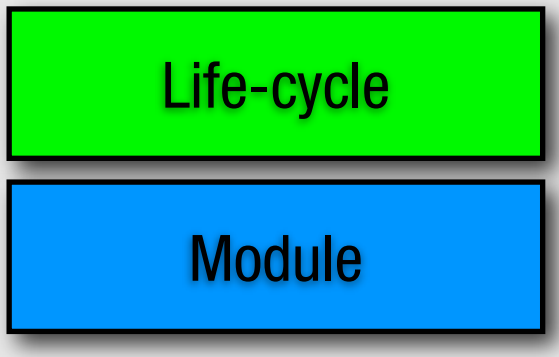


Service Layer

- OSGi framework promotes service oriented interaction pattern among bundles





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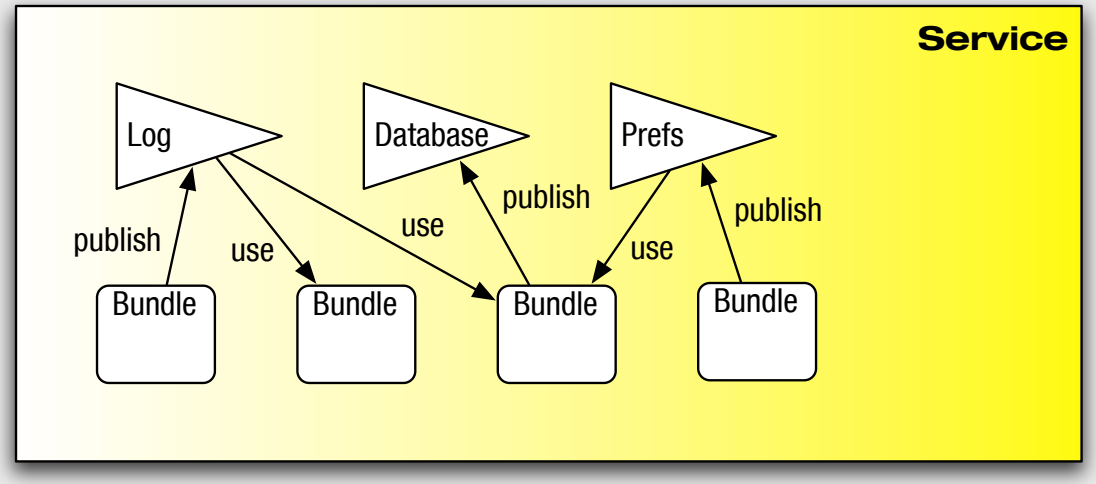
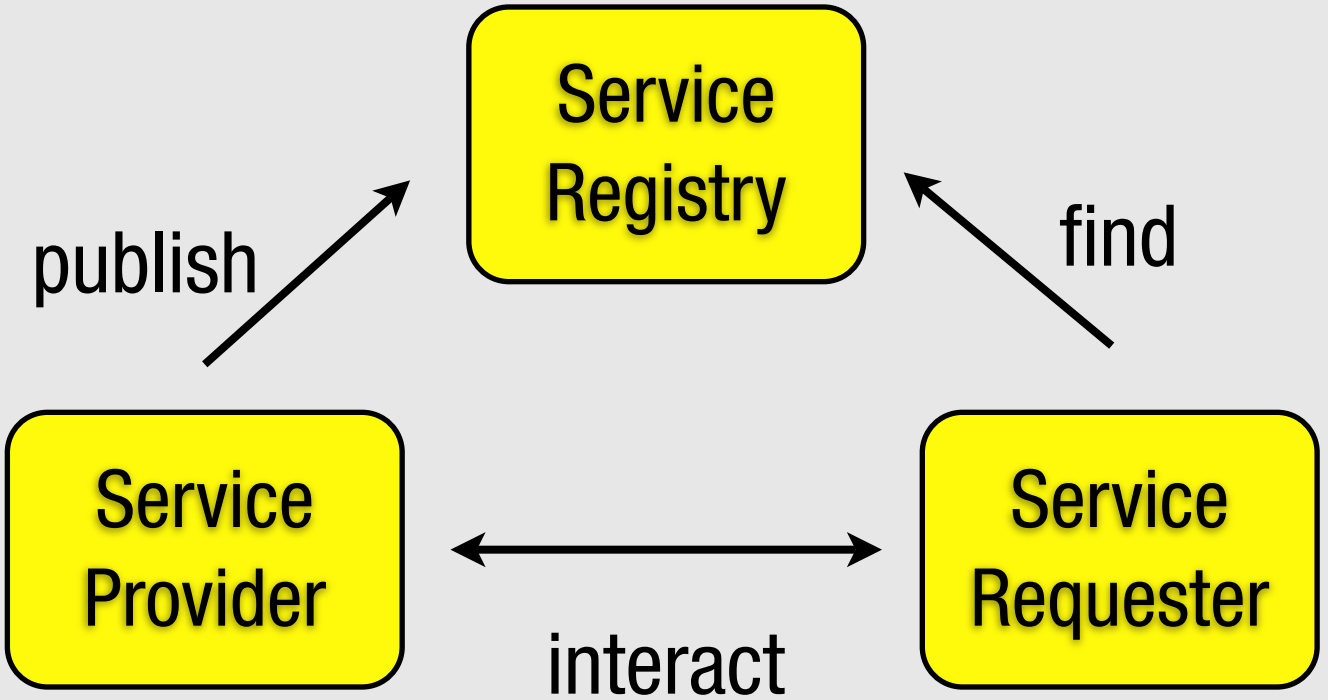
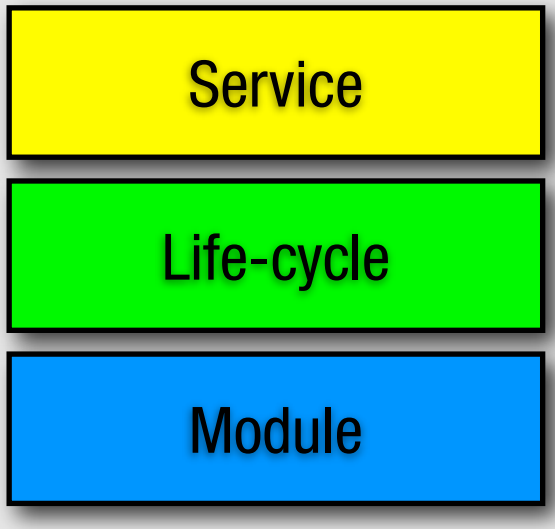
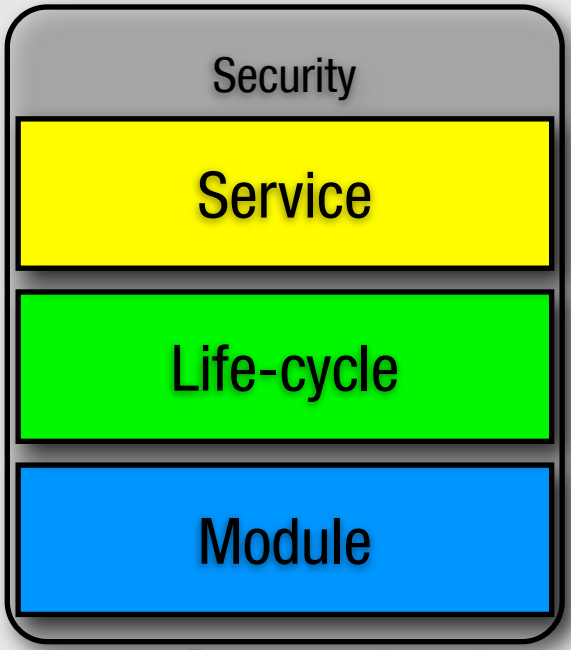






Security

- Optional Security Layer based on Java permissions
- Infrastructure to define, deploy, and manage fine-grained application permissions
- Code authenticated by location or signer
- Well defined API to manage permissions
  - PermissionAdmin
  - ConditionalPermissionAdmin



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Security Concepts Overview

- OSGi uses codebased security following the Java Security Model
  - Makes use of Protection Domain
  - The stack walk based Permission Check
  - Signed bundles
- User based security is supported by the UserAdmin service but not integrated in the standard permission check as with JAAS
- Additionally, PermissionAdmin and ConditionalPermissionAdmin provide sophisticated management infrastructure

Protection Domain

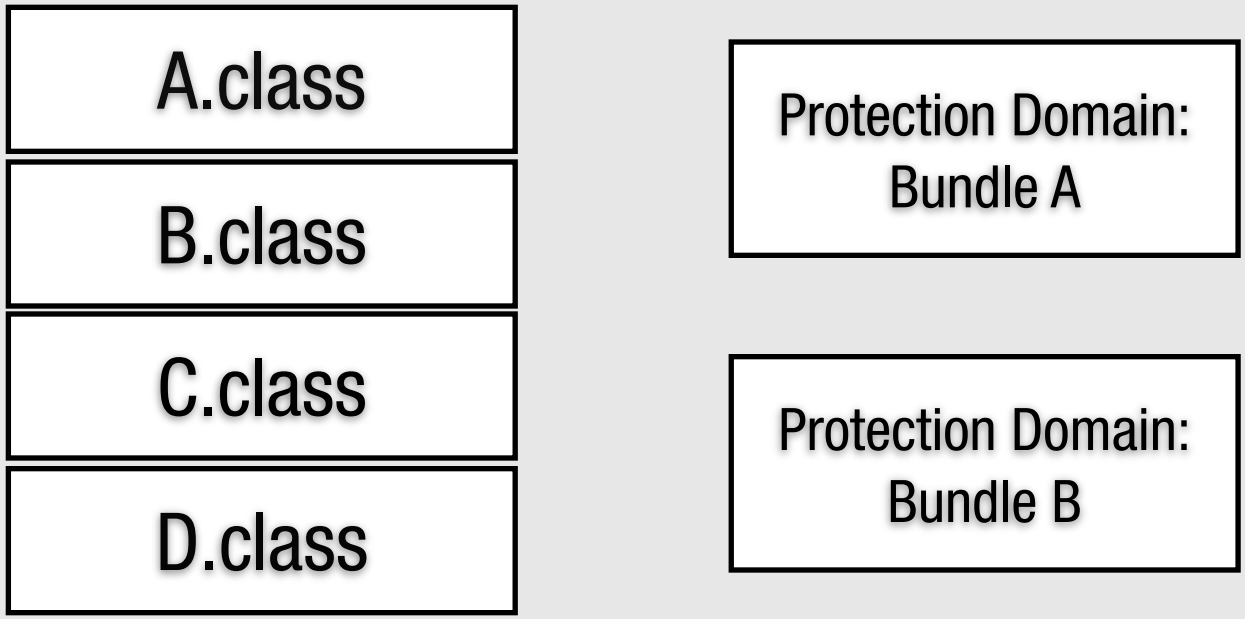
- Encapsulates characteristics of a domain
  - One protection domain per bundle
- Encloses a set of classes whose instances are granted a set of permissions
  - Set of permissions associated with each bundle
- Permission check consults all protection domains on the stack

Permission Check

- Invoked either by call to SecurityManager.check* or AccessController.checkPermission
  - SecurityManager is old way to do it
  - OSGi requires usage of the SecurityManager for full functionality
- Privileged calls used to cut off stack walk
  - Disregard code on the stack earlier then the latest privileged call.
- Merges context of parent thread as well

Algorithm

AccessController.checkPermission(Permission p)



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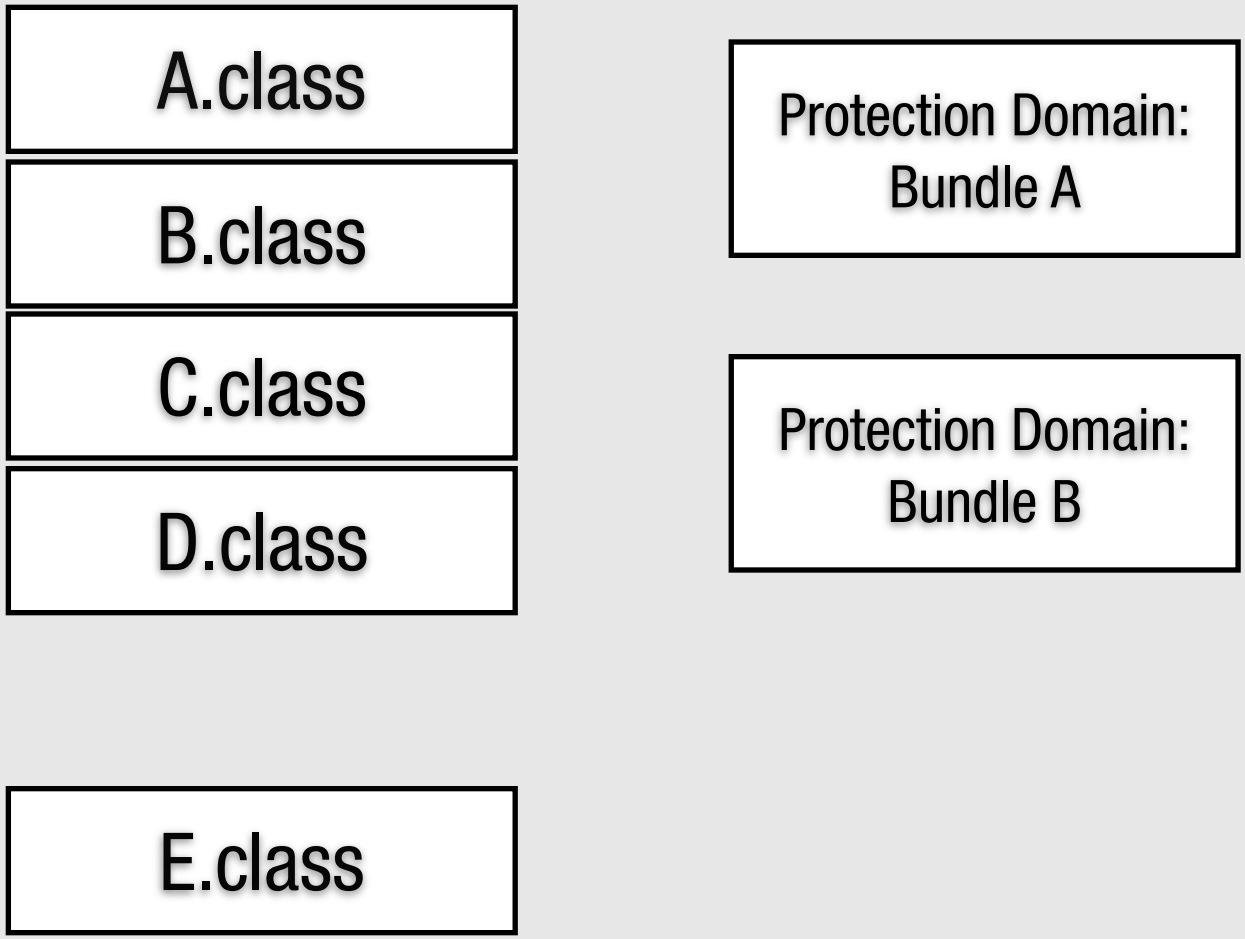

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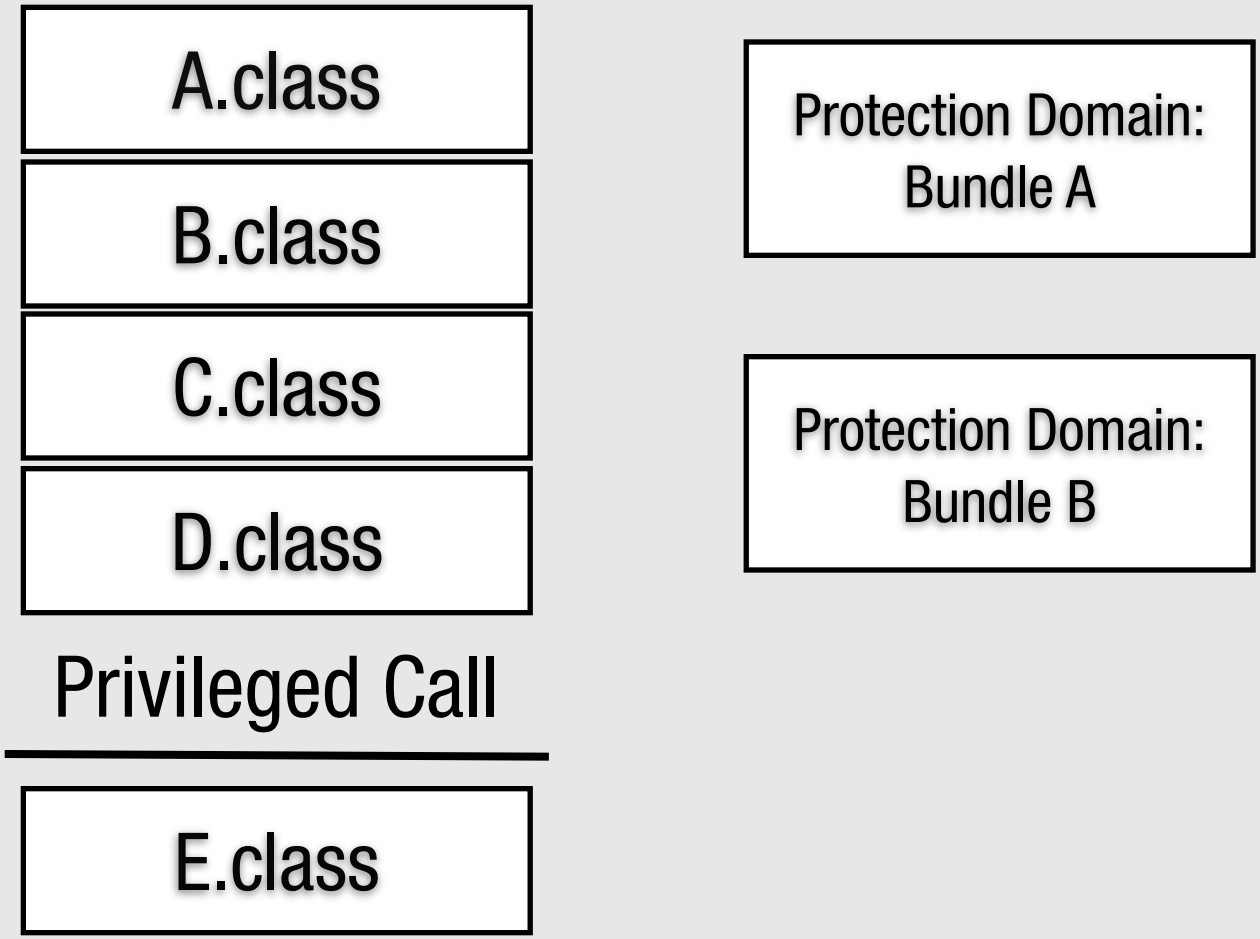

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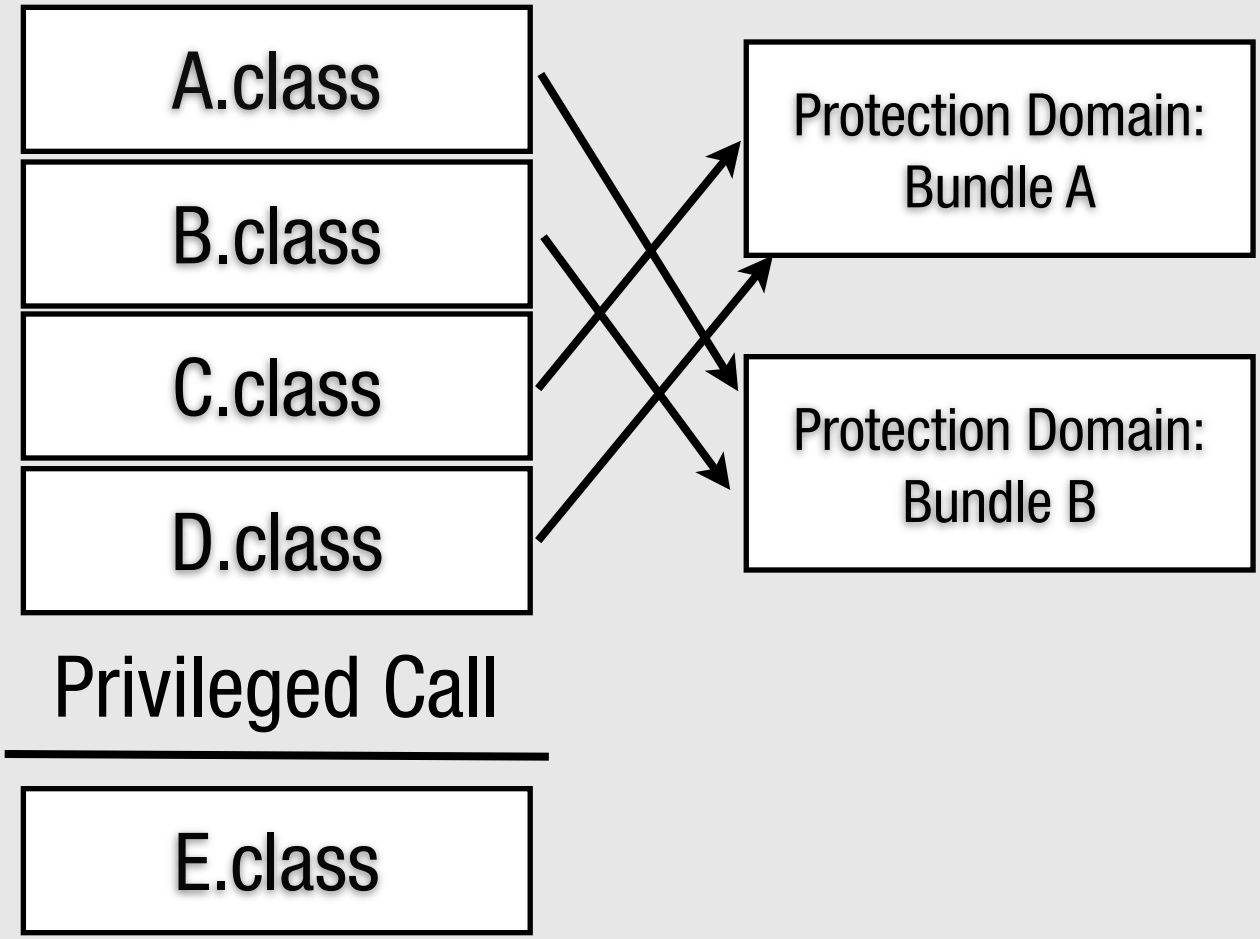

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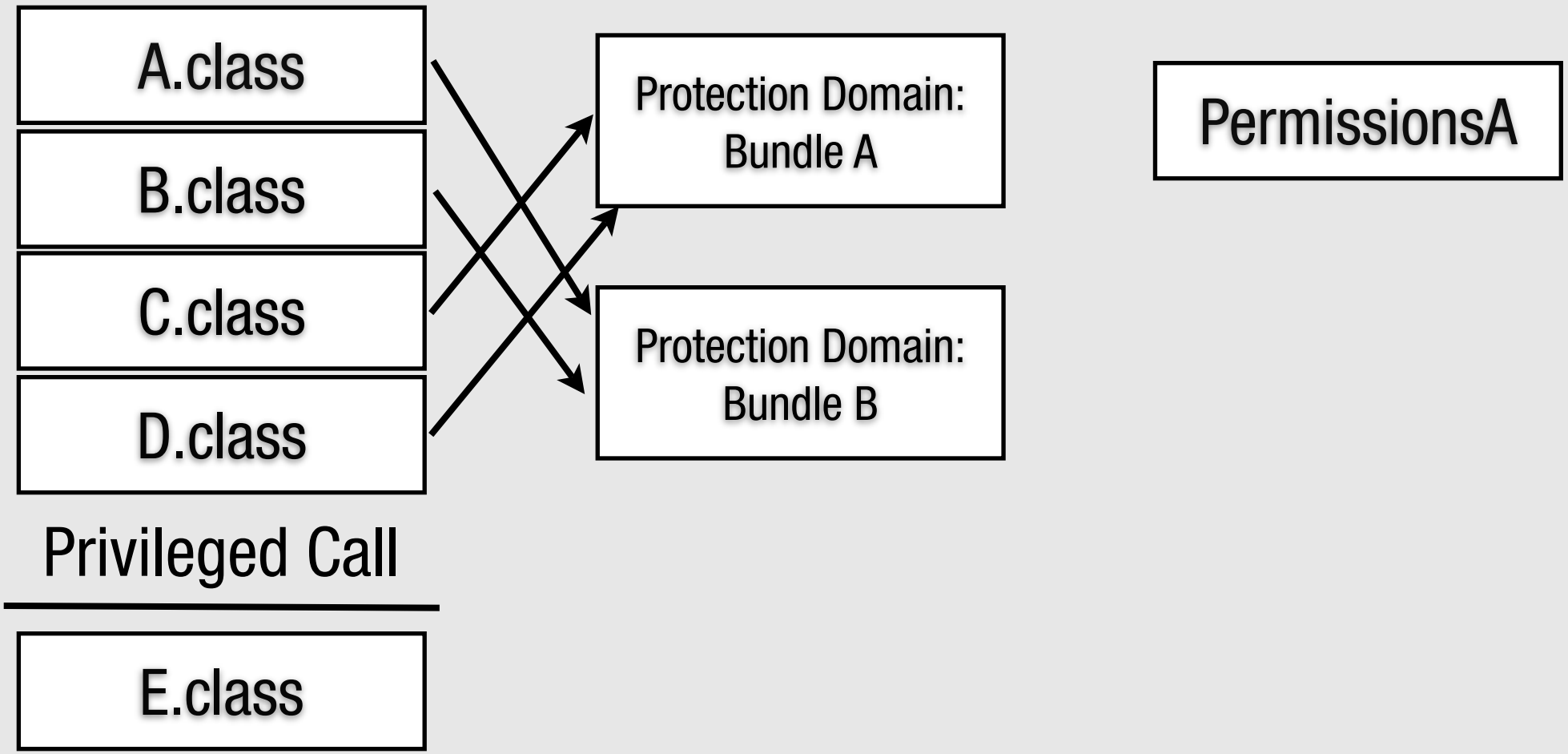

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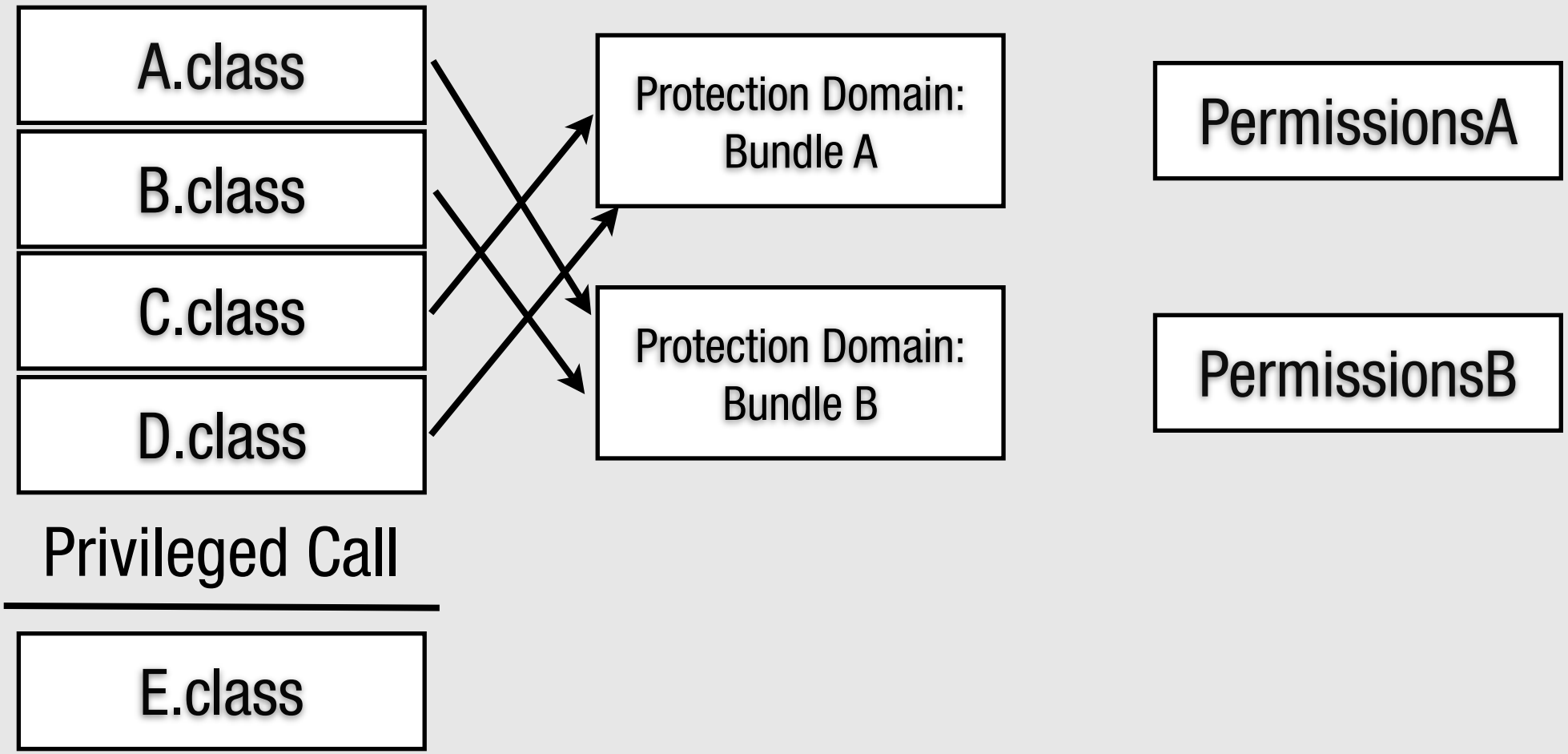

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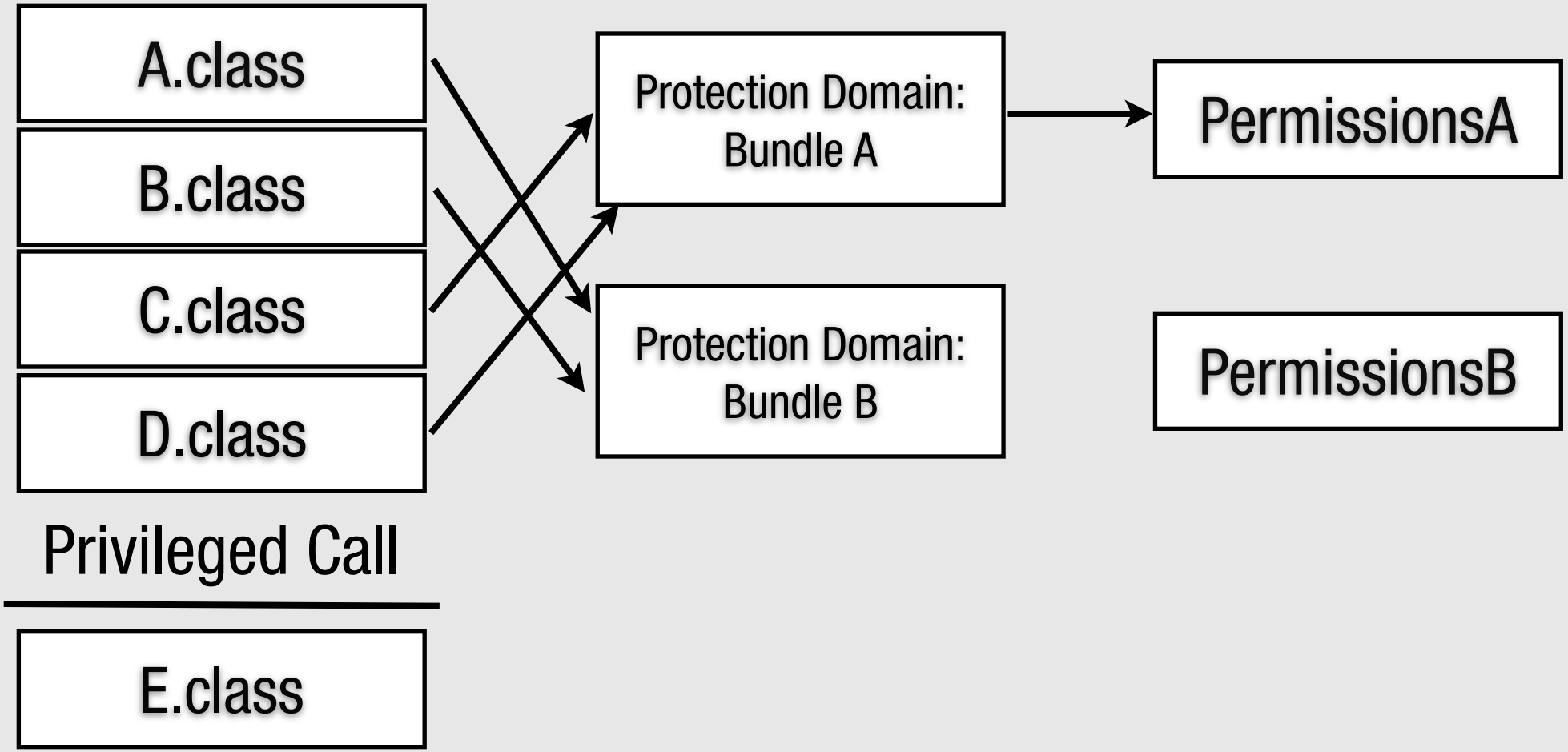

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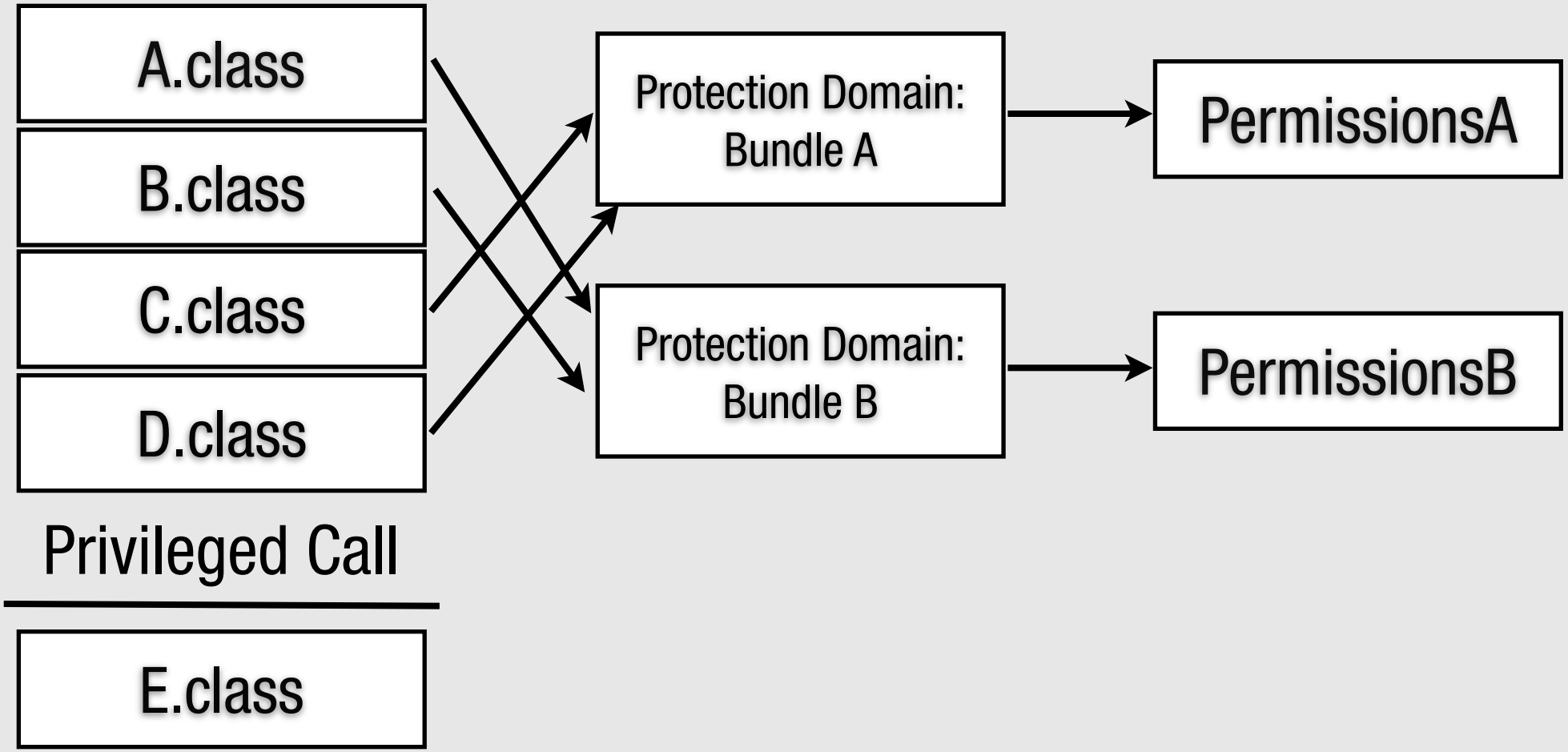

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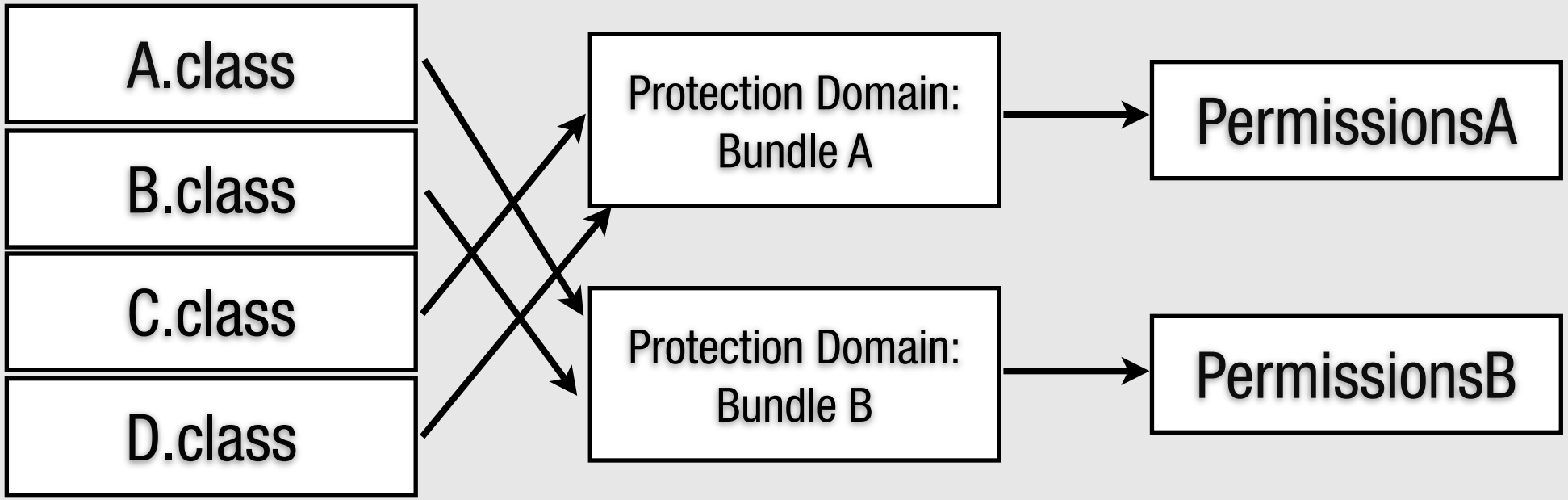
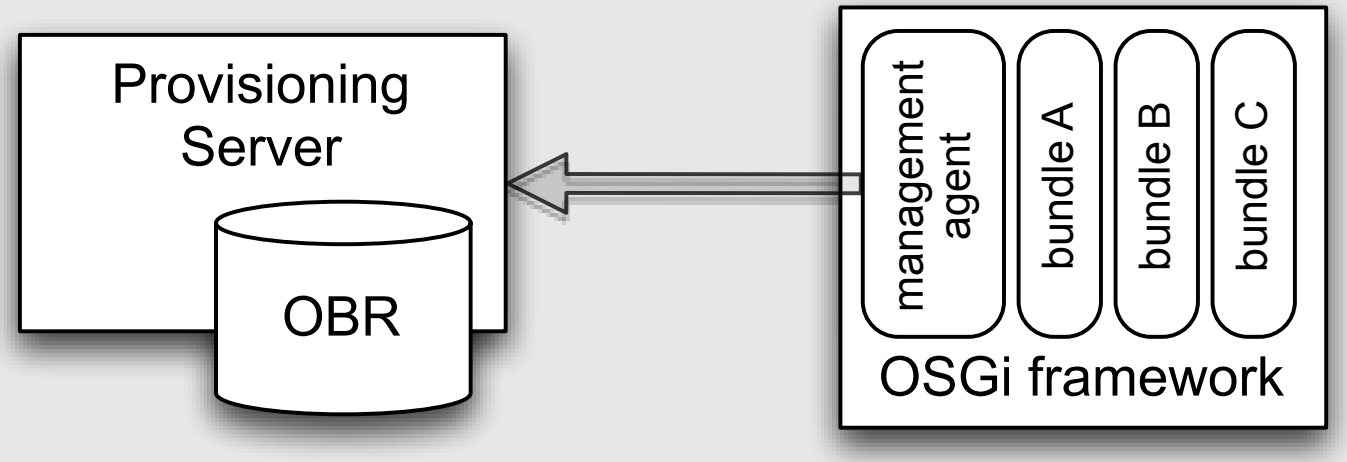


Privileged Call

E.class

```
if (!(PermissionsA.implies(p) &&
      PermissionsB.implies(p))
{
      throw new SecurityException();
}
```

Deployment Topology



- Management Agent, responsible for:
  - life cycle management of the framework
  - security
  - Can use SynchronousBundleListener for on the fly configuration

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Enable Security: Equinox

- Properties for security manager, keystore, signed bundles support
  - -Djava.security.manager=""
  - -Dosgi.framework.keystore=file:lib/keystore.ks
  - -Dosgi.signedcontent.support=true
- Java Security Policy must give AllPermission
  - -Djava.security.policy=all.policy
    - grant { permission java.lang.AllPermission };

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```
java -Djava.security.manager="" -Djava.security.policy=all.policy \
   -Dosgi.framework.keystore=file:keystore.ks -Dosgi.signedcontent.support=true
   -jar org.eclipse.equinox.launcher.jar -noExit
```

Enable Security: Felix

- Felix security is still experimental
  - Not all permission checks implemented
  - Configuration and documentation needs improvements
- Properties for security manager, keystore, keystore password, keystore type
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  - -Djava.security.policy=all.policy
    - grant { permission java.lang.AllPermission };

```
java -Djava.security.manager -Djava.security.policy=all.policy
  -Dfelix.keystore=keystore.ks -Dfelix.keystore.pass=luminis -jar felix.jar
```

Example - Running Secure

```
public class Activator implements BundleActivator {
    public void start(BundleContext context) throws Exception {
        // Check for a security manager
        SecurityManager sm = System.getSecurityManager();

        if (sm == null) {
            throw new BundleException("No SecurityManager installed");
        }

        // Check for AllPermission
        sm.checkPermission(new AllPermission());
    }

    public void stop(BundleContext context) throws Exception {
    }
}
```

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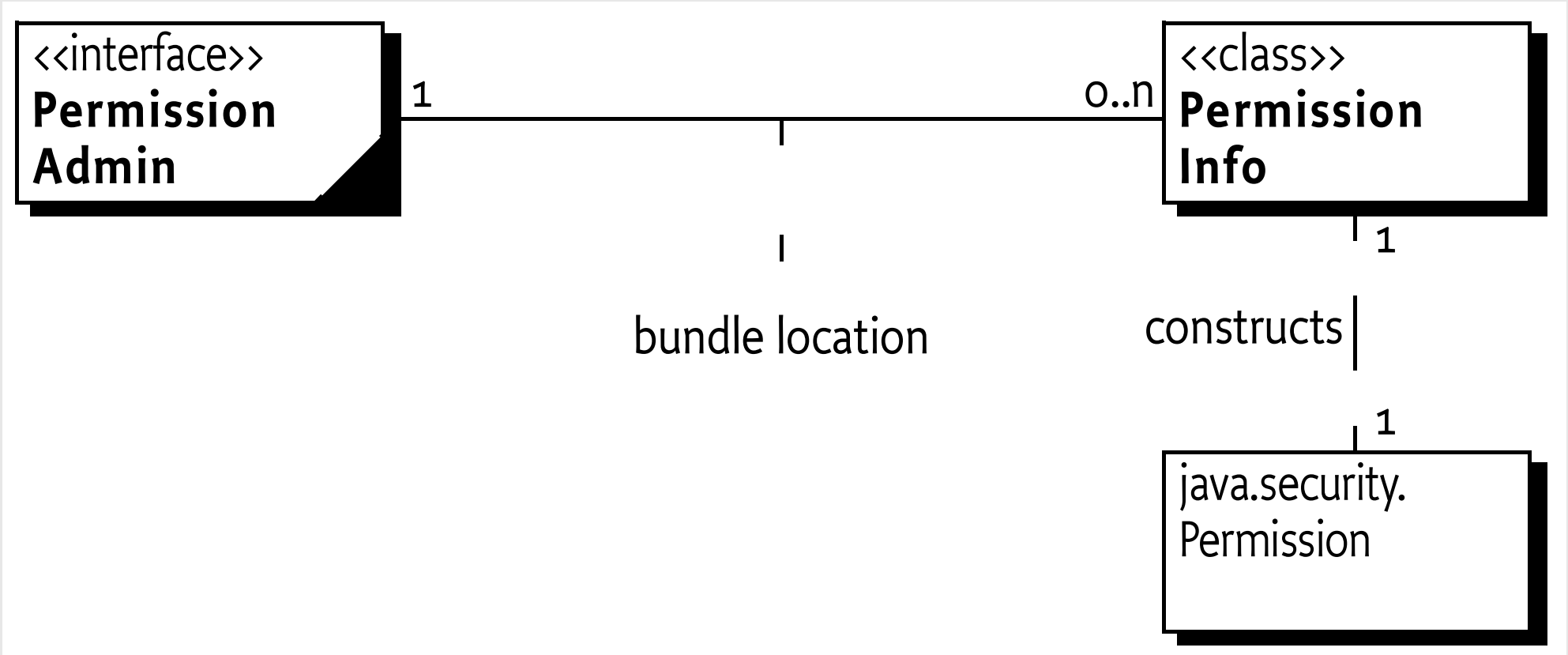
Permission Admin (1/3)

- Old (pre 4.0) way of managing permissions
- Provides information about current permissions
- Allows a management agent to set permissions per bundle
- Permissions are based on bundle locations with a fallback to a set of default permissions

PermissionAdmin (2/3)



PermissionAdmin (3/3)

- Relative FilePermissions are assumed to be relative to the bundle storage area
- All permission changes need AllPermission
  - the first thing a management agent has to do is give itself AllPermission
- If ConditionalPermissionAdmin is present (as is the case in our environment) then default permissions are ignored unless the ConditionalPermissionAdmin has not been set-up with at least one entry

PermissionInfo

- Permission representation used
- Encapsulates three pieces of information
  - type - class name of the permission
  - name - name argument of the permission
  - actions - actions argument of the permission

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```
new PermissionInfo(
    AdminPermission.class.getName(), "(id=10)",
    AdminPermission.EXECUTE);
```

Example

```
PermissionAdmin admin = getPermissionAdmin();


admin.setPermissions(
  context.getBundle().getLocation(),
  new PermissionInfo[]{
    new PermissionInfo(
        AllPermission.class.getName(), "", "")});

PermissionInfo[] previous = admin.getDefaultPermissions();

admin.setDefaultPermissions(new PermissionInfo[0]);

// unset
admin.setDefaultPermissions(previous);
```

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OSGi specific permissions

- OSGi specifications define special permissions for framework and service related tasks
- The core framework specification defines:
  - AdminPermission - for all framework specific actions
  - PackagePermission - for package import and export
  - ServicePermission - for service providing and usage
  - BundlePermission - for extensions/fragments
- Custom permissions can be used if they have been exported by a bundle or the classpath

PackagePermission

- A bundle‘s authority to import/export a package
- Name is the package as dot-separated string
  - Wildcards are supported
- Two actions: EXPORT and IMPORT.
  - EXPORT implies IMPORT

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```
Import-Package: net.luminis.pub.foo, net.luminis.bar
Export-Package: net.luminis.bar
```

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Import-Package: net.luminis.pub.foo, net.luminis.bar
Export-Package: net.luminis.bar

```
System.getSecurityManager().checkPermission(
    new PackagePermission("net.luminis.pub.foo", PackagePermission.IMPORT));
System.getSecurityManager().checkPermission(
    new PackagePermission("net.luminis.bar", PackagePermission.EXPORT));
```

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System.getSecurityManager().checkPermission(
    new PackagePermission("net.luminis.pub.foo", PackagePermission.IMPORT));
System.getSecurityManager().checkPermission(
    new PackagePermission("net.luminis.bar", PackagePermission.EXPORT));

new PackagePermission("net.luminis.pub.*", PackagePermission.IMPORT);
new PackagePermission("net.luminis.bar", PackagePermission.EXPORT);
```

ServicePermission

- A bundle‘s authority to register/get a service
- Name is the name of the service interface as a dot separated string
  - Wildcards may be used for the classname
- Two Actions: GET and REGISTER

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```
context.getServiceReference("net.luminis.pub.Foo");
context.registerService("net.luminis.pub.Bar", new Bar(), null);
```

ServicePermission

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```
  context.getServiceReference("net.luminis.pub.Foo");
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System.getSecurityManager().checkPermission(
   new ServicePermission("net.luminis.pub.Foo", ServicePermission.GET));
System.getSecurityManager().checkPermission(
   new ServicePermission("net.luminis.pub.Bar", ServicePermission.REGISTER));
```

ServicePermission

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  context.getServiceReference("net.luminis.pub.Foo");
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System.getSecurityManager().checkPermission(
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System.getSecurityManager().checkPermission(
   new ServicePermission("net.luminis.pub.Bar", ServicePermission.REGISTER));

new ServicePermission("net.luminis.pub.*", ServicePermission.GET);
new ServicePermission("net.luminis.pub.Bar", ServicePermission.REGISTER);
```

BundlePermission

- A bundle‘s authority to require/provide/attach a bundle/fragment
- Name is the bundle symbolic name
  - Wildcards may be used
- Four Actions: PROVIDE, REQUIRE, HOST, and FRAGMENT
  - PROVIDE implies REQUIRE

AdminPermission (1/3)

- A bundle‘s authority to perform specific privileged administrative operations or get sensitive informations about a bundle.
- Name is a filter expression. The filter gives access to the following parameters:
  - signer - A DN chain of bundle signers
  - location - The location of a bundle
  - id - The bundle ID of the bundle
  - name - The symbolic name of a bundle

AdminPermission (2/3)

- There are eleven Actions:
  - class - load a class from a bundle
  - execute - start/stop bundle and set bundle startlevel
  - extensionLifecycle - manage extension bundle
  - lifecycle - manage bundle (update/uninstall/etc.)
  - listener - add/remove synchronous bundle listeners
  - metadata - get manifest and location
  - resolve - refresh and resolve a bundle
  - resource - get/find resources from a bundle
  - startlevel - set startlevel and initial bundle startlevel
  - context - get bundle context

AdminPermission (3/3)

```
context.installBundle("file:bundle.jar").start();
```

AdminPermission (3/3)

```
context.installBundle("file:bundle.jar").start();


System.getSecurityManager().checkPermission(
      new AdminPermission(bundle));
```

AdminPermission (3/3)

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```

```
System.getSecurityManager().checkPermission(
      new AdminPermission(bundle));
```

```
new AdminPermission(
    "(&(signer=o=luminis)(name=net.luminis.*)(location=file://*)(id>=10))",
    AdminPermission.LIFECYCLE + "," + AdminPermission.EXECUTE);
```

Example - Configure Security

```
admin.setDefaultPermissions(
   new PermissionInfo[] {
     new PermissionInfo(PackagePermission.class.getName(), "*",
          PackagePermission.IMPORT)
});

admin.setPermissions(context.getBundle(1).getLocation(),
   new PermissionInfo[] {
      new PermissionInfo(AdminPermission.class.getName(), "*", "*")
     , new PermissionInfo(ServicePermission.class.getName(), "*",
          ServicePermission.GET )
     , new PermissionInfo(ServicePermission.class.getName(), "org.apache.felix.shell.*",
          ServicePermission.REGISTER)
     , new PermissionInfo(PackagePermission.class.getName(), "org.apache.felix.shell",
          PackagePermission.EXPORT)
     , new PermissionInfo(PropertyPermission.class.getName(), "*", "read")
     , new PermissionInfo(NetPermission.class.getName(), "specifyStreamHandler", "")};
```

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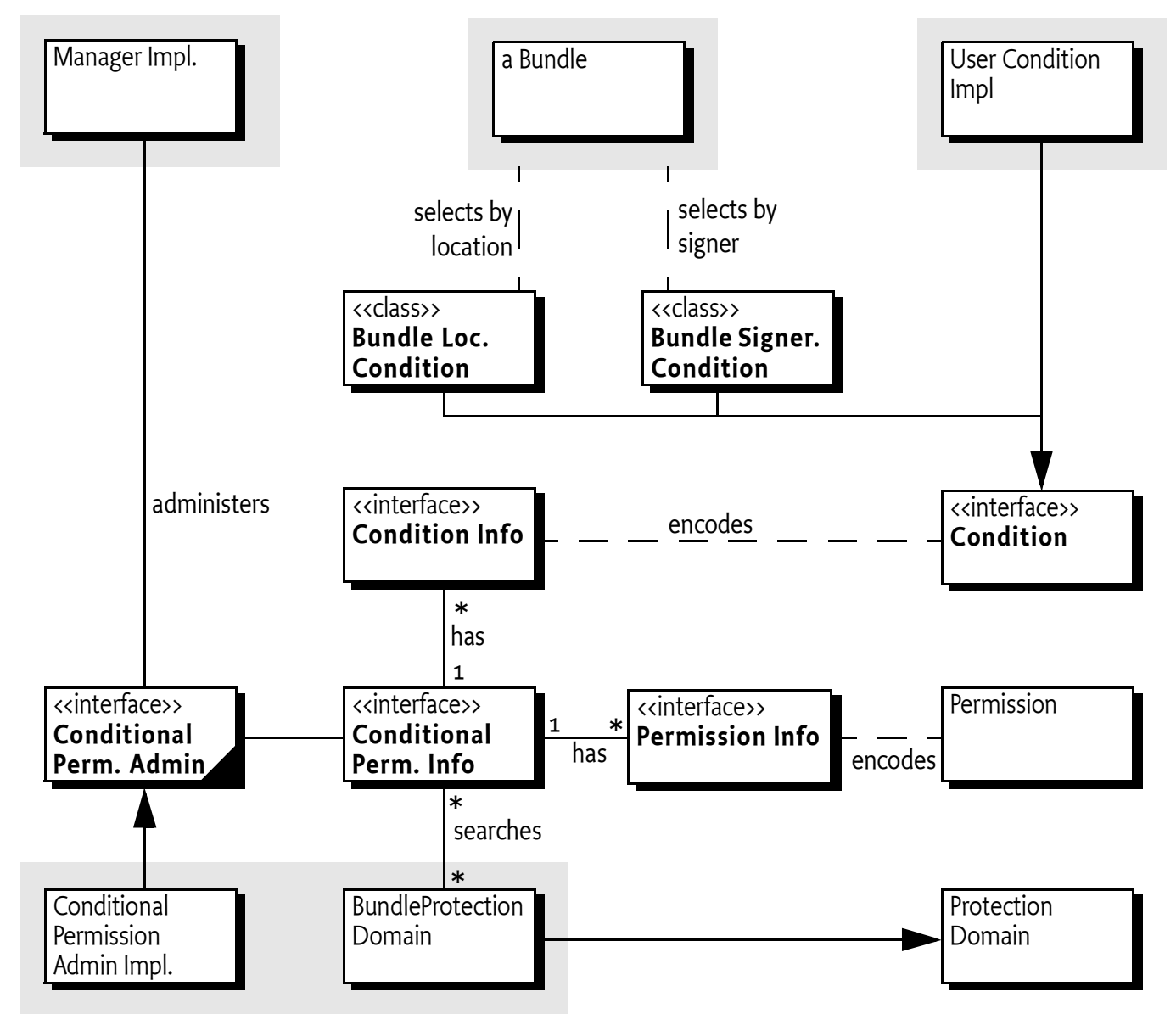
- Signed Bundles and Local Permissions
- Custom and postponed conditions

Conditional Permission Admin

- New (4.0) way of doing permission management
  - use this exclusively for new implementations
  - interoperability when both PA and CPA are present
- IF all conditions of a set of conditions match THEN apply the supplied permissions
  - More flexible, extensible model
- Conditions evaluation is highly optimized

CondPermAdmin (1/4)



Conditions

- Purpose is to decide if a permission set is applicable or not.
- Can be postponed or immutable
  - allows optimized evaluations
- Custom conditions can be used for more advanced use-cases

BundleLocationCondition

- Condition to test if the location of a bundle matches a pattern.
  - matching is done based on filter string matching rules

BundleLocationCondition

- Condition to test if the location of a bundle matches a pattern.
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```
new ConditionInfo(BundleLocationCondition.class.getName(),
  new String[] {context.getBundle().getLocation()});
new ConditionInfo(BundleLocationCondition.class.getName(),
  new String[] {"*://www.luminis.nl/*"});
```

Example

```
ConditionalPermissionAdmin condPermAdmin = getConditionalPermissionAdmin();

condPermAdmin.addConditionalPermissionInfo(
    new ConditionInfo[] {
        new ConditionInfo(
            BundleLocationCondition.class.getName(),
            new String[]{"*://www.luminis.nl/*"})
        },
    new PermissionInfo[] {
        new PermissionInfo(
            AdminPermission.class.getName(),
            "(!(id=" + context.getBundle().getBundleId() + "))",
            "*")
        });
```

Example - Use Conditions

```
condPermAdmin.addConditionalPermissionInfo(new ConditionInfo[]{
  new ConditionInfo(BundleLocationCondition.class.getName(),
  new String[]{context.getBundle().getLocation()})
  }, ALLPERMISSION_INFO);

condPermAdmin.addConditionalPermissionInfo(new ConditionInfo[] {
    // we use an empty condition set for default permissions
}, new PermissionInfo[] {
  new PermissionInfo(PackagePermission.class.getName(), "*",
    PackagePermission.IMPORT)
});
```

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Signed Bundles

- Authenticates the signer
- Ensures that the content has not been modified
- Bundle (jar) can be signed by multiple signers
- Basically, normal java jar signing with a few extras
  - All entries must be signed except META-INF
- certificate chains represented as ; separated lists
- matching done using * and - wildcards

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- matching done using * and - wildcards

cn=marrs,o=iQ,c=NL;cn=hans,o=luminis,c=NL

cn=marrs,o=IQ

***;cn=*,o=luminis**

cn=marrs;-;cn=*,o=luminis

Signing bundles in Eclipse

Signing bundles manually

```
jarsigner -keystore file:lib/keystore.ks  \
    -storepass luminis bundle.jar luminis
```

```
<macrodef name="sign-bundle">
    <attribute name="name" />
    <attribute name="location" default="deploy/@{name}.jar" />
    <sequential>
        <exec executable="jarsigner">
            <arg line="-keystore file:lib/keystore.ks" />
            <arg line="-storepass luminis" />
            <arg line="@{location}" />
            <arg line="luminis" />
        </exec>
    </sequential>
</macrodef>
```

Certificates and Keystores

```
keytool -genkey -keystore keystore.ks -alias marrs -storepass luminis  \
  -keypass luminis -dname "CN=Marcel, OU=iQ, O=luminis, L=Arnhem, C=NL"

keytool -selfcert -keystore keystore.ks -alias marrs -storepass luminis \
  -keypass luminis -dname "CN=Marcel, OU=iQ,  O=luminis, L=Arnhem, C=NL"

keytool -export -v -keystore keystore.ks -alias marrs -file luminis.cert \
  -storepass luminis -keypass luminis

keytool -import -v -keystore keystore.ks -alias luminis -file luminis.cert \
  -storepass luminis -keypass luminis

 keytool -list -keystore keystore.ks -storepass luminis


 marrs, Mar 13, 2008, keyEntry,
 luminis, Mar 13, 2008, trustedCertEntry
```

BundleSignerCondition

- Condition to test if the signer of a bundle matches a pattern
- Uses the wildcard matching

BundleSignerCondition

- Condition to test if the signer of a bundle matches a pattern
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```
new ConditionInfo(BundleSignerCondition.class.getName(),
                  new String[]{"*,o=luminis"})
```

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Local Permissions

- Defined in a resource inside the bundle
- Defines a set of permissions that are enforced by the framework
- A bundle can get less than these permissions, but never more
- Defaults to All Permissions
- Good way for operators to “audit” the permissions of a bundle

LocalPermissions

- OSGI-INF/permissions.perm

```
# Friday, Feb 24 2005
# ACME, chess game
( ..ServicePermission "..log.LogService" "GET" )
( ..PackagePermission "..log" "IMPORT" )
( ..ServicePermission "..cm.ManagedService" "REGISTER" )
( ..PackagePermission "..cm" "IMPORT" )
( ..ServicePermission "..useradmin.UserAdmin" "GET" )
( ..PackagePermission "..cm" "SET" )
( ..PackagePermission "com.acme.chess" "IMPORT,EXPORT" )
( ..PackagePermission "com.acme.score" "IMPORT" )
```

Tip: local permissions tracing with Apache Felix

```
import java.security.Permission;

public class SecMan extends SecurityManager {
    public void checkPermission(Permission perm, Object context) {
        System.out.println(perm);
        try {
            super.checkPermission(perm, context);
        }
        catch (Exception ex) {
            ex.printStackTrace();
        }
    }

    public void checkPermission(Permission perm) {
        System.out.println(perm);
        try {
            super.checkPermission(perm);
        }
        catch (Exception ex) {
            ex.printStackTrace();
        }
    }
}
```

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            super.checkPermission(perm);
        }
        catch (Exception ex) {
            ex.printStackTrace();
        }
    }
}
```

```
java -Djava.security.manager=SecMan -Djava.security.policy=all.policy \
    -cp .:felix.jar org.apache.felix.main.Main
```

Example - Signed bundles

```
condPermAdmin.addConditionalPermissionInfo(new ConditionInfo[]{
    new ConditionInfo(BundleSignerCondition.class.getName(),
      new String[]{"*,o=luminis"})
    }, ALLPERMISSION_INFO);
```

```
# Friday, Feb 24 2005
# task4.test, local
( org.osgi.framework.PackagePermission "org.osgi.framework" "IMPORT" )
( java.io.FilePermission "/" "read,write" )
```

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Custom Condition

- Conditions must come from the classpath/ system bundle
- Are constructed from ConditionInfo objects
  - static getCondition(Bundle,ConditionInfo) method
  - constructor with (Bundle, ConditionInfo) signature

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```
class BeforeDateCondition implements Condition {
     private final long m_date;

     public static Condition getCondition(Bundle bundle,
         ConditionInfo info) {
          return new BeforeDateCondition(bundle, info);
     }

     public BeforeDateCondition(Bundle bundle,
         ConditionInfo info) {
          m_date = Long.parseLong(info.getArgs()[0]);
     }

     public boolean isMutable() {
          return m_date > System.currentTimeMillis();
     }

     public boolean isPostponed() {
          return false;
     }

     public boolean isSatisfied() {
          return System.currentTimeMillis() < m_date;
     }

     public boolean isSatisfied(Condition[] conditions,
         Dictionary context) {
          return false;
     }
}
```

Extension Bundles

- Extension bundles can deliver optional parts of the Framework implementation
- Necessary to add custom conditions because they have to come from the classpath
- No Import-Package, Require-Bundle, Bundle-NativeCode, DynamicImport-Package, or Bundle-Activator allowed

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```
Fragment-Host: system.bundle; extension:=framework
```

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Postponed Conditions

- Optimize condition evaluation on multiple evaluations during the same permission check
  - context map can be used to pass settings during evaluation
- Use if evaluation is expensive

```
public boolean isPostponed() {
    return true;
}

public boolean isSatisfied(Condition[] conditions, Dictionary context) {
    // do evaluation for all conditions involved
}
```

Example - Custom Postponed

```
condPermAdmin.addConditionalPermissionInfo(new ConditionInfo[]{
    new ConditionInfo(AskUserCondition.class.getName(), new String[]{""})
}, ALLPERMISSION_INFO);
```

```
  public boolean isSatisfied(Condition[] conditions, Dictionary context) {
      StringBuilder buffer = new StringBuilder("Do you grant bundles: ");
      for (Condition condition : conditions) {
          buffer.append(
           (AskUserCondition) condition).bundle.getBundleId()).append(" ");
      }
      buffer.append("AllPermission?");
      return ask(buffer.toString());
  }
```

Demo

- Shows a custom condition that:
  - is postponed, because it's "expensive"
  - asks the user for permission

Discussion

- We've showed:
  - how security is integrated into OSGi
  - the relation between Java 2 Security and OSGi
  - how to use both Permission Admin and Conditional Permission admin
  - how to use signed bundles, local permissions, and add custom permissions and conditions at runtime

Links

- Apache Felix and OSGi:
  http://felix.apache.org/
  http://www.osgi.org/
- Sample code:
  http://opensource.luminis.net/
- Karl Pauls: karl.pauls@luminis.nl
  Marcel Offermans: marcel.offermans@luminis.nl

Questions?!

? & !