Java Language Modularity With Superpackages

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TS-2401

Goal

In the Next 60 Minutes...

Discover how superpackages will ease information hiding and promote encapsulation in your Java™ applications

Agenda

Modularity

Information Hiding

Superpackages

Package Interfaces

Java Specification Request (JSR) 294

Q&A

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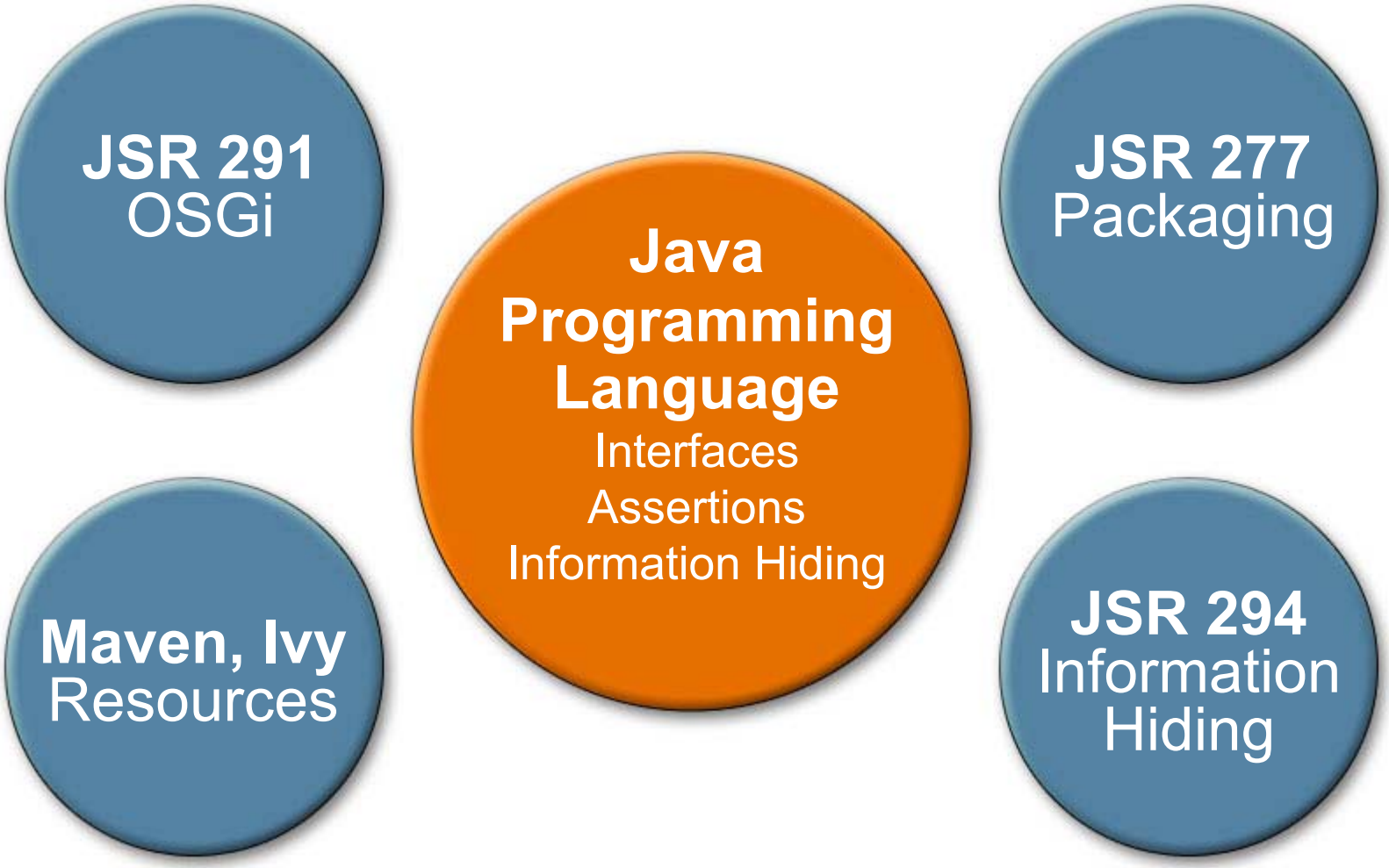
Q&A

What Makes a Program Modular?

- Interfaces
  - Don’t rely on implementations
- Protocols
  - Enforce good idioms
- Information hiding
  - If you can’t see it, you can’t use it
- Contracts
  - If you use it, use it right
- Versions, resource declarations, centralized exception handling, etc.

Standards for Modularity



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Information Hiding Circa 1972

“ Each module is characterized by its knowledge of a design decision which it hides from all others. Its interface is chosen to reveal as little as possible about its inner workings. ”

D.L.Parnas
http://www.acm.org/classics/may96/

Information Hiding Circa 2007

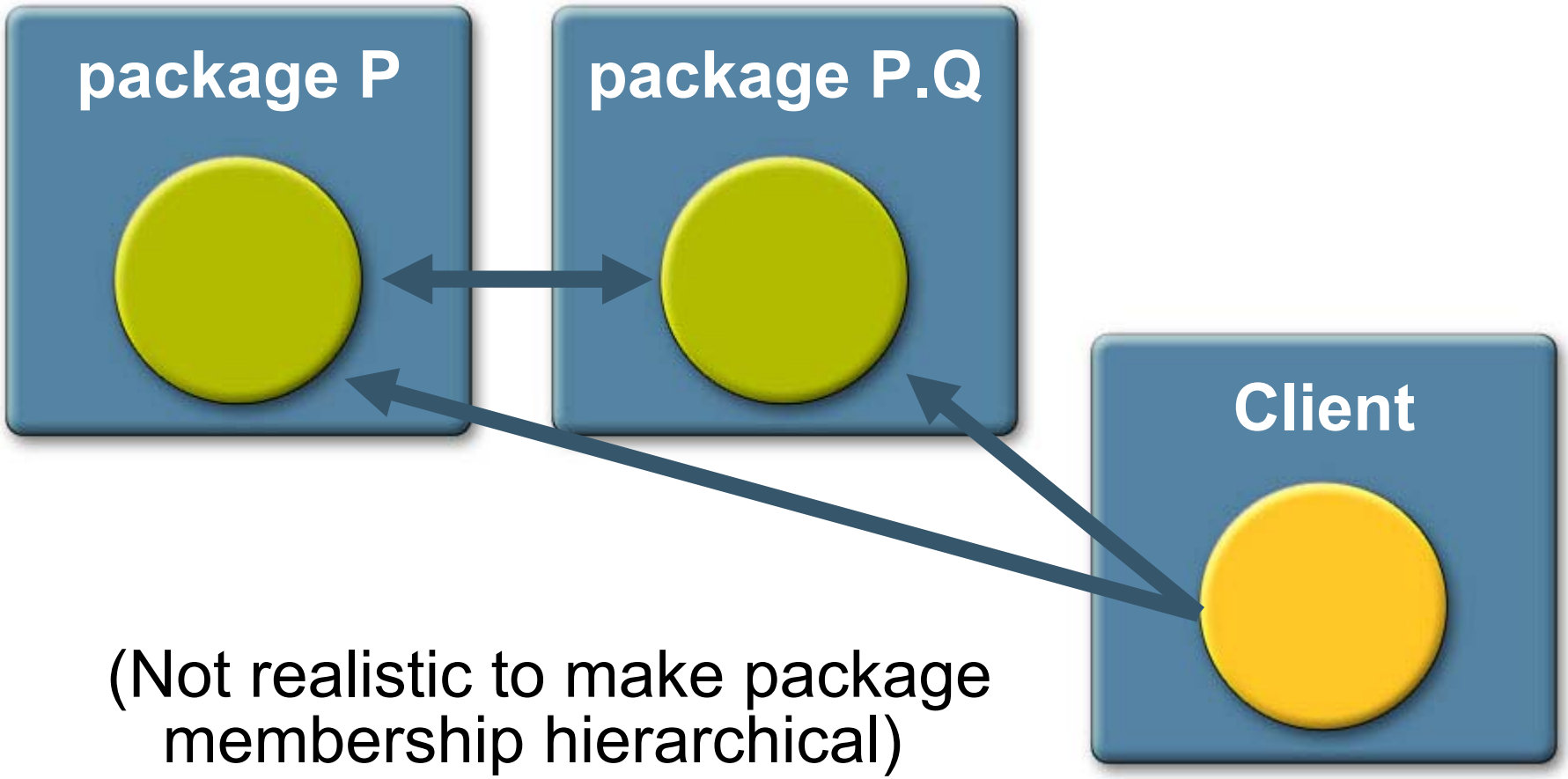
- Information hiding supports encapsulation
- Encapsulation supports reliable software

- Information hiding is an issue of *program design*
- Should be enabled by the language itself
- Accessibility modifiers strike a good balance
  - Simple
  - No overlap (Witness removal of `private protected`)

Packages for Information Hiding

- Packages help to prevent name conflicts
  - But are not namespaces
- Packages support information hiding
  - But do not follow its central tenet: Provide an interface
- Package names are hierarchical
  - But package membership is not hierarchical
  - Member of package P.Q is not member of package P
- Projects are often larger than a single package
  - But packages cannot be composed into a larger entity
  - "`public` is too public"

"`public` is too public"



(Not realistic to make package membership hierarchical)

Existing Approaches

- Lack of documentation
- Class loaders
- Static classes

Information Hiding via Lack of Documentation

- Idea: Do not document “internal” packages
- Hope nobody will find them
- Problems are obvious

Information Hiding via Class Loaders

- Idea: two class loaders per “component”
  - Internal class loader—Resolves all classes
  - Public class loader—Resolves only exported classes
- Problems
  - Does not address compile time
  - Does not prevent access via reflection
  - Breaks down if internal class loader object is “leaked”
  - Sometimes unclear which class loader should be used
    - What should the context class loader be set to?
- Not what class loaders were designed for

Information Hiding via Static Classes

- Instead of creating multiple packages, put all classes into one package
  - Each package becomes a top-level public class
  - Each class becomes a static nested class
    - Public, package private, or private as desired
- Problems
  - Non-intuitive
  - At the VM level, there are no private nested classes
    - They are realized as package private classes
  - Converting existing code requires renaming classes
  - Many classes in each source file

Goal: A language Construct for Information Hiding

- An entity bigger than a package
  - Accessibility within the entity is wider than package-private but narrower than public
- Hierarchical names guide accessibility
  - Entity P.Q can be a [hidden] member of entity P
- Run-time access control
  - Universally understood
- Interfaces for packages and these new entities
- A basis for deployment modules

What We Don't Want to Do

- Introduce `friend`
  - Appropriate in C++ (operator overloading, no packages)
  - Offers no higher-level entity for composing types
  - Offers no basis for deployment modules
- Embed deployment modules in the language
- Burden programmers who don't use the new entity
- Have compile-time and run-time behavior differ
  - No leaky abstractions!

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Definition

- A superpackage is a named collection of one or more packages or superpackages and their types
- Public types can be declared as exported to make them accessible outside the superpackage
- Public types that are not exported are accessible only to other types in the superpackage
- Declared in a Java source file (`super-package.java`) and compiled by the Java compiler

What a Superpackage Is Not

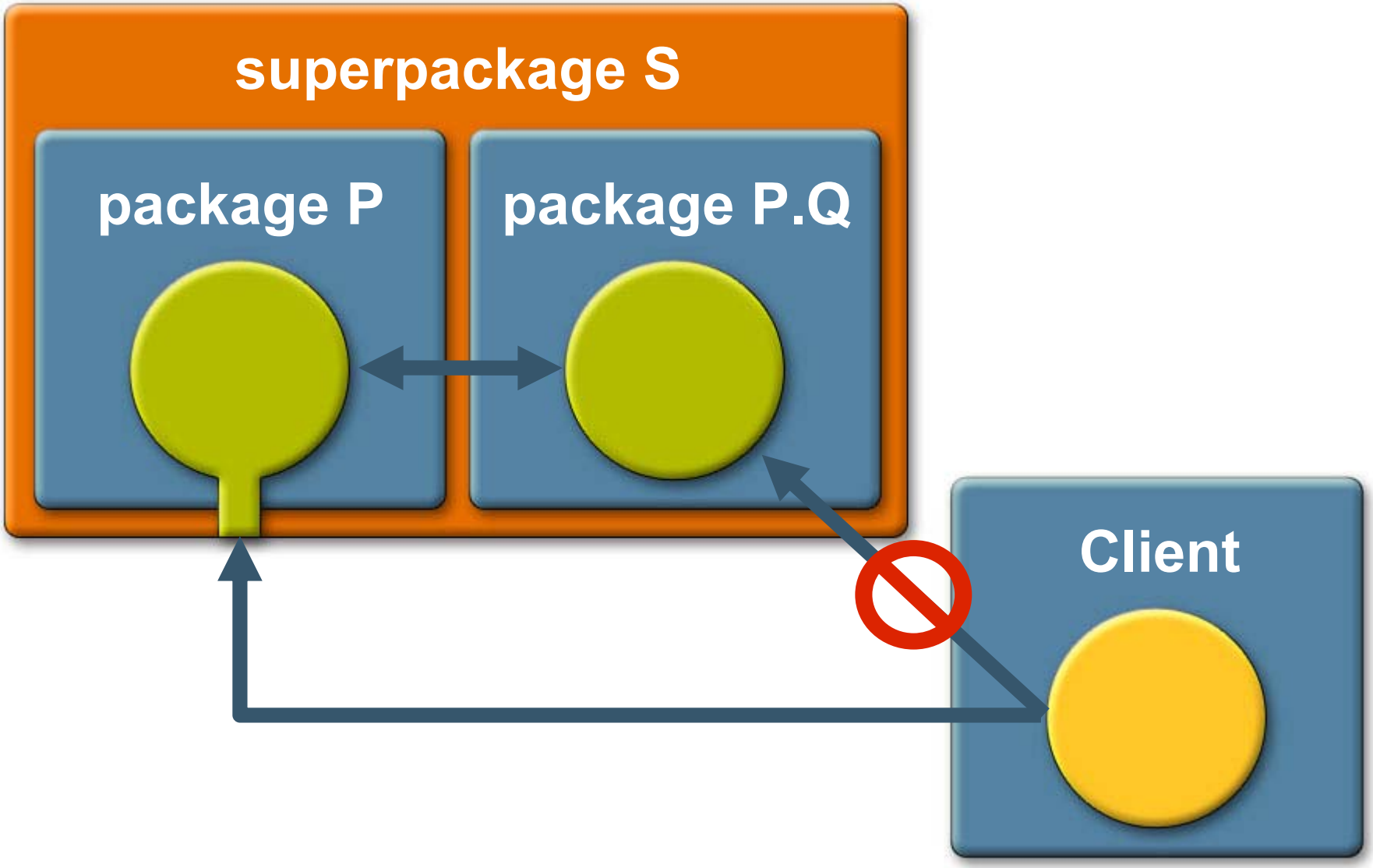
- A package(!)
- A namespace
- A type

Example

```
superpackage jdk {

  member package java.util;
  member package java.io;
  member package sun.io;    // Impl detail

  export java.util.*;       // Public API
  export java.io.*;
}
```


superpackage S
package P
package P.Q
Client

Superpackages at Compile-Time

- ***super-package.java* declares which types belong to a superpackage**
- **.java files do not** declare which superpackage they belong to

/* Run javac here */

- ***.spkg* file declares which types belong to a superpackage**
- **.class files declare which superpackage they belong to**

Superpackages at Run-Time

- **Within a superpackage, accessibility is as today**
- **Outside a superpackage, the Java Virtual Machine consults `.spkg` file to determine accessibility**
- **If member is public and exported, then accessible**
- **Access control checks are orthogonal to integrity checks performed by a module system**
  - **Can circumvent access control by hacking `.class`**

The terms “Java Virtual Machine” and “JVM” mean a Virtual Machine for the Java™ platform.

Nested Superpackages

- Superpackages can contain superpackages
- Useful in large projects
  - Information hiding between internal components
- A nested superpackage can be exported
  - Its exported types are accessible outside the enclosing superpackage
  - Types from non-exported superpackages are only accessible within the enclosing superpackage
- Multiple levels of nesting possible

Example

```
superpackage foo {
  member superpackage foo.xml, foo.net;
  export superpackage foo.xml;
}


superpackage foo.xml member foo {
  member package foo.xml.dom,
                 foo.xml.dom.utils;
  export foo.xml.dom.Factory;
}
```

Impact of Superpackages

- New classfile attribute
  - Must work with serialization
- Reification of superpackages in java.lang.reflect
  - Must perform access control checks
- javax.lang.model
  - JSR 269 Pluggable Annotation Processing
- Documentation and instrumentation
  - javadoc and javap
- **`com.sun.source.tree`**
  - Sun's compiler Tree API

Miscellenia

- Name/location of `super-package.java`
- Text or binary format of `.spkg` file
- Context-sensitive “keywords”
  - `member/export/superpackage`
- Annotations allowed in superpackage declaration
- A class belongs to at most one superpackage
- Superpackage namespace is distinct from (and is not obscured by) type and package namespaces

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Package Interfaces

- A class can have an interface, but a package cannot
- Javadoc™ says which classes to use in a package
- Superpackages restrict public types, but types are still fundamentally organized as packages
- A package interface makes intentions clear

Separate Compilation Is Not Very Separate

- It is impossible to avoid referencing a class *somewhere in a Java platform program*
  - *To use* **`new`**
  - *To invoke a static factory method*
- *Compilation requires class definitions*
- *Class definitions may not always be available*
- *Dummy classes with empty methods are dull*
- *A package interface provides the type information needed for separate compilation*

Example

```
package interface P;
import Z.*;

class C implements I {
  public C(int i);
  protected Object f;
  String m()
    throws Exc;
}
```

```
package A;
import P.*;

class Client {
  C c = new C(5);
  ... c.f ...
  try { c.m(); }
  catch (Exc e) {..}
}
```

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JSR 294

- “Improved Modularity Support in the Java Programming Language”
- Expert group discussion started in March 2007
  - General agreement on superpackage direction
  - Mailing list is publicly readable
- Membership ensures coherence with JSR 277 (Java Module System) and JSR 291 (OSGi)
- Scheduled for inclusion in Java Platform, Standard Edition 7 (Java SE 7)
  - Early access implementation later this year
  - Open source via OpenJDK

JSR 294 Expert Group Membership

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Deployment Aspects

- Superpackages work just fine with existing deployment mechanisms
  - Java Archive (JAR) file, WAR, EAR files; Applets, JNLP/WebStart, etc.
- Even more interesting when combined with support for deployment modules
- Deployment modules defined by JSR 277
  - Superpackage forms basis of deployment module
  - Uses members, exports, metadata information
- Other deployment technologies also expected to take advantage of superpackages

Summary

- Superpackages are an effective mechanism for information hiding in the Java programming language
- Extension of the familiar access control model
- Superpackages support the Java Module System
- Scheduled to arrive in Java SE 7

For More Information

- TS-2318
  - “JSR 277: Java Module System”
- BOF-2400
  - “JSR 277 and JSR 294”
- JSR main page
  - http://jcp.org/en/jsr/detail?id=294
- Expert group mailing list archive and observer list
  - http://cs.oswego.edu/mailman/listinfo/jsr294-modularity-observer
- Blogs
  - http://blogs.sun.com/abuckley/
  - http://blogs.sun.com/andreas/

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