JAVA

Modules

Modules

- a module
  - explicitely defines what is provided but also what is ***required***

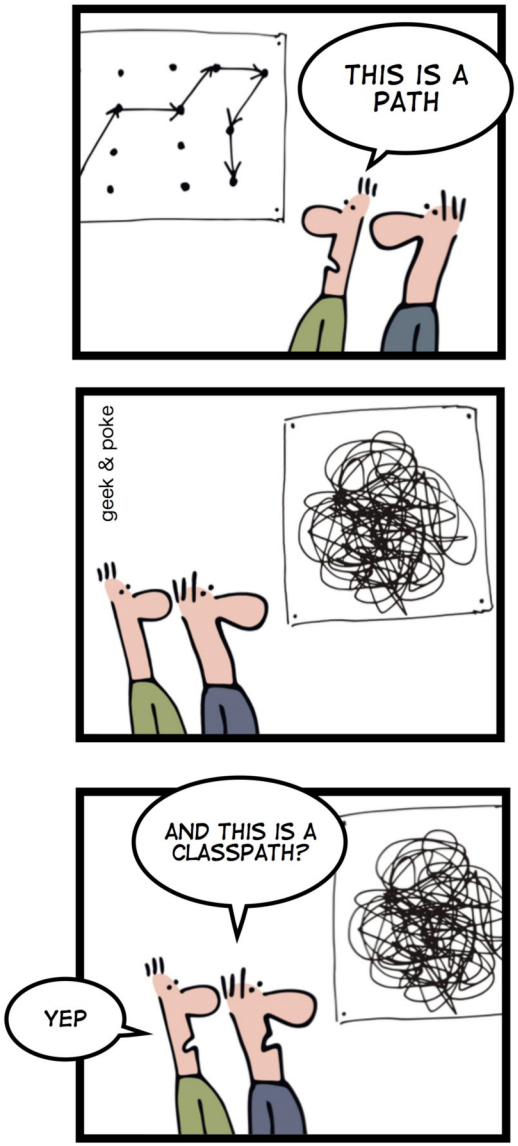
- why?
  - the *classpath* concept is “fragile”
  - no encapsulation

Modu

- a mod
  - exp
    req

so what is

- why?
  - the
  - no e

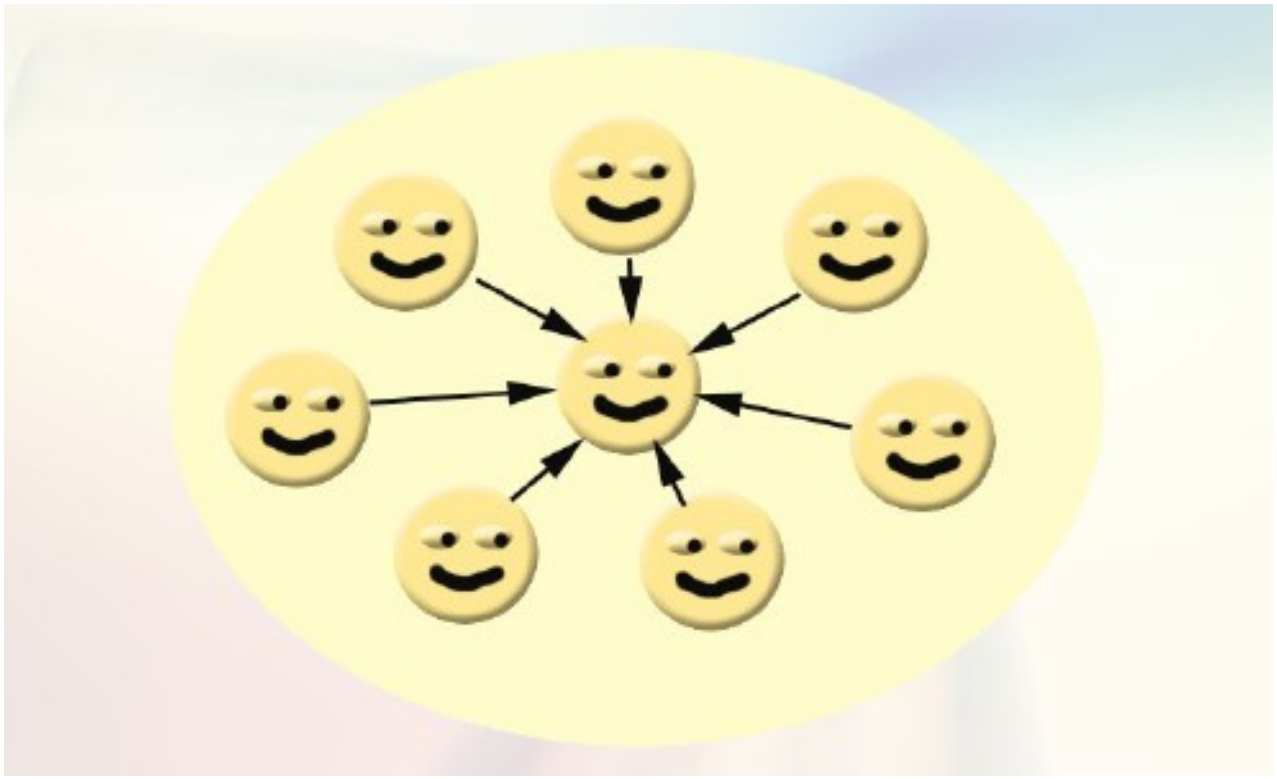


Modular apps – motivation

- why
  - applications get more complex
  - assembled from pieces
  - developed by distributed teams
  - complex dependencies
  - good architecture
    - know your dependencies
    - manage your dependencies

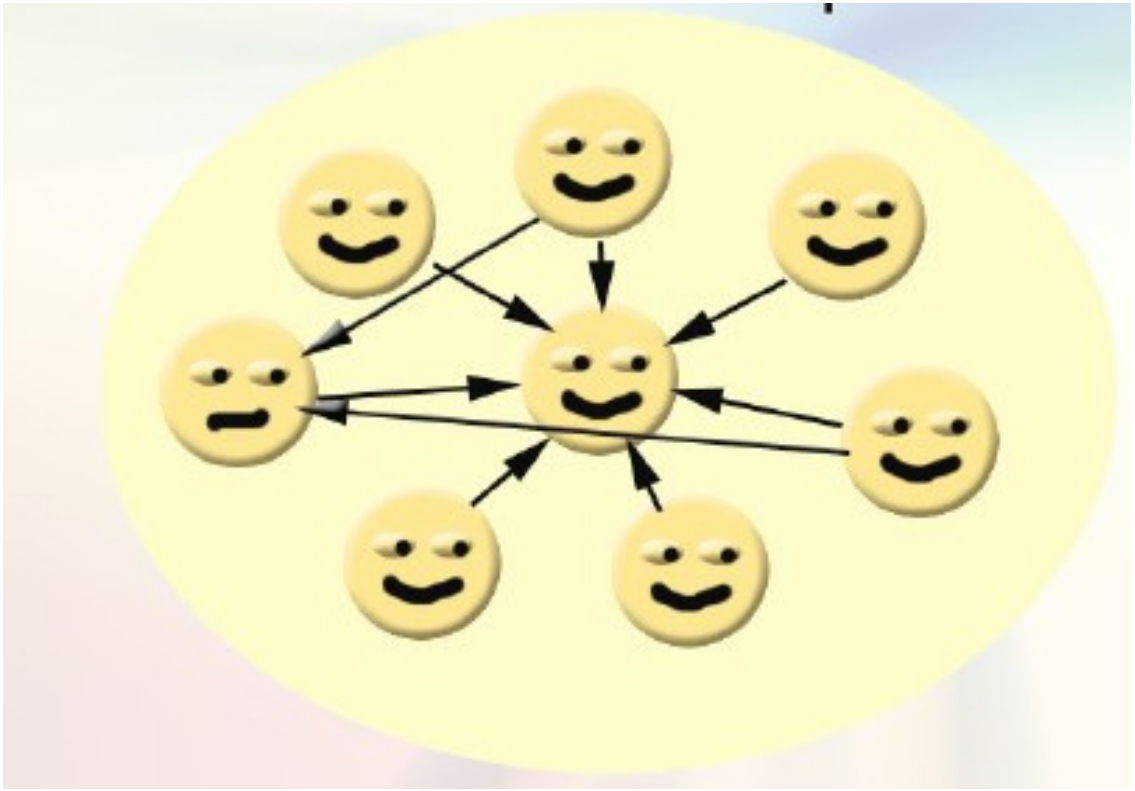
Modular apps – motivation

- Version 1.0 is cleanly designed...



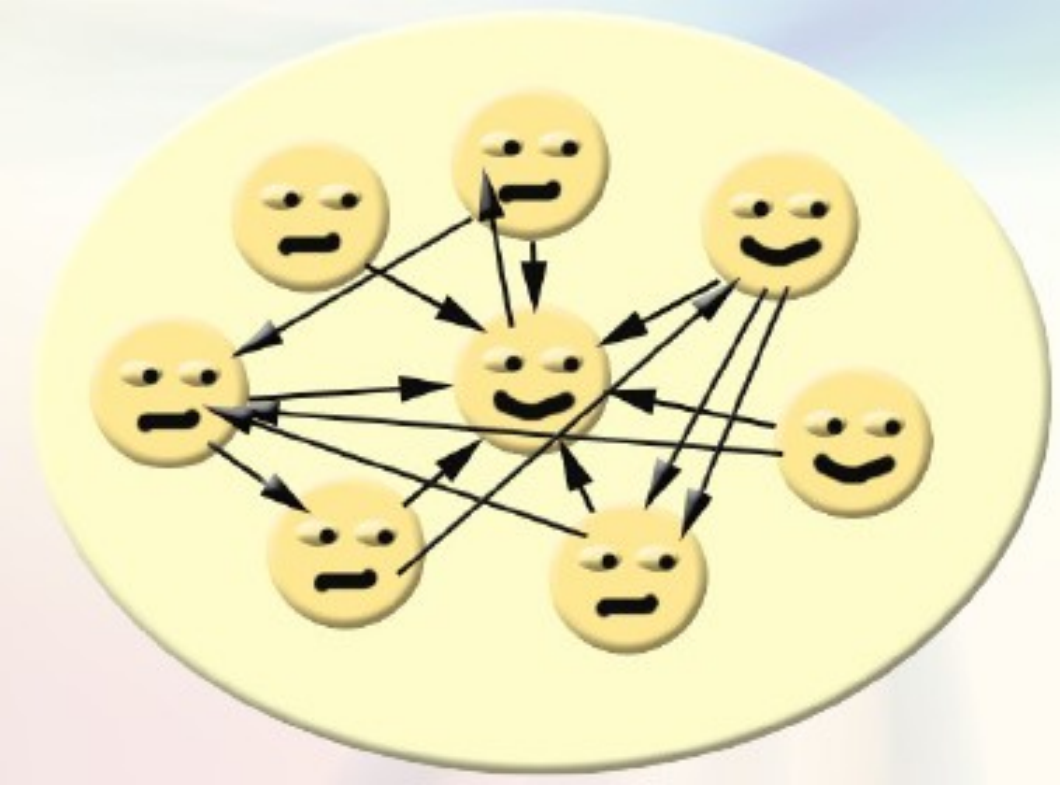
Modular apps – motivation

- Version 1.1...a few expedient hacks...we'll clean those up in 2.0



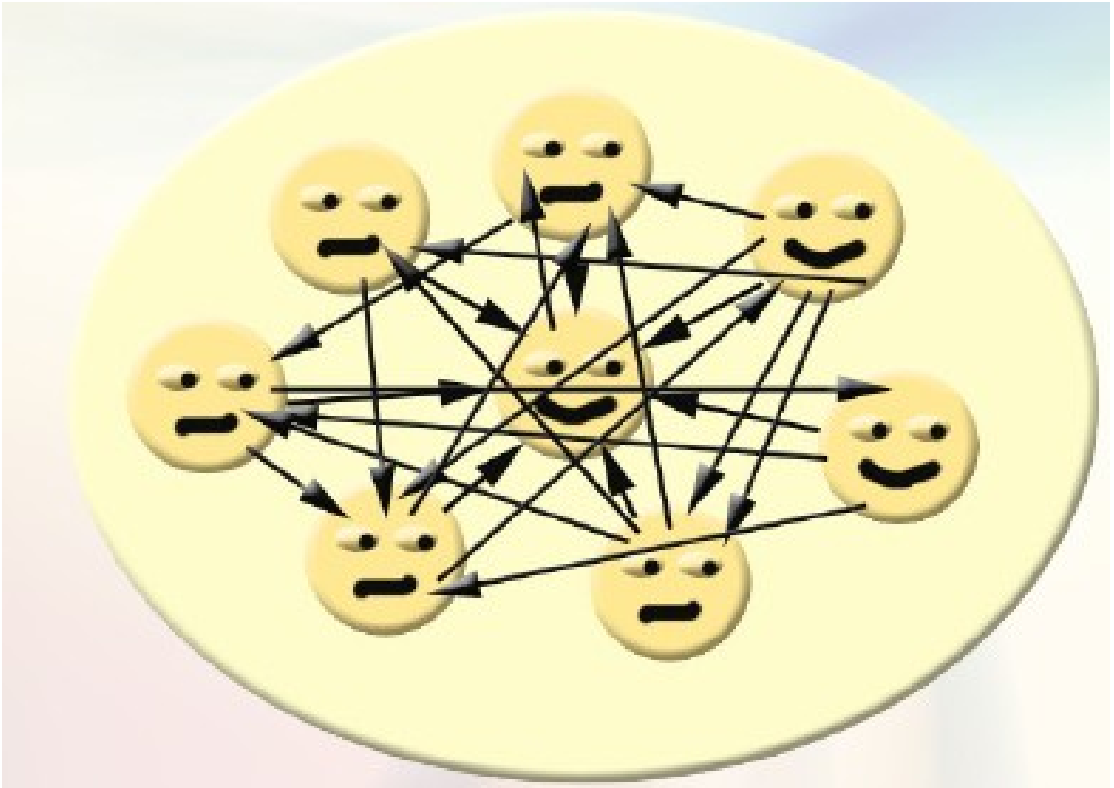
Modular apps – motivation

- Version 2.0...oops...but...it works!



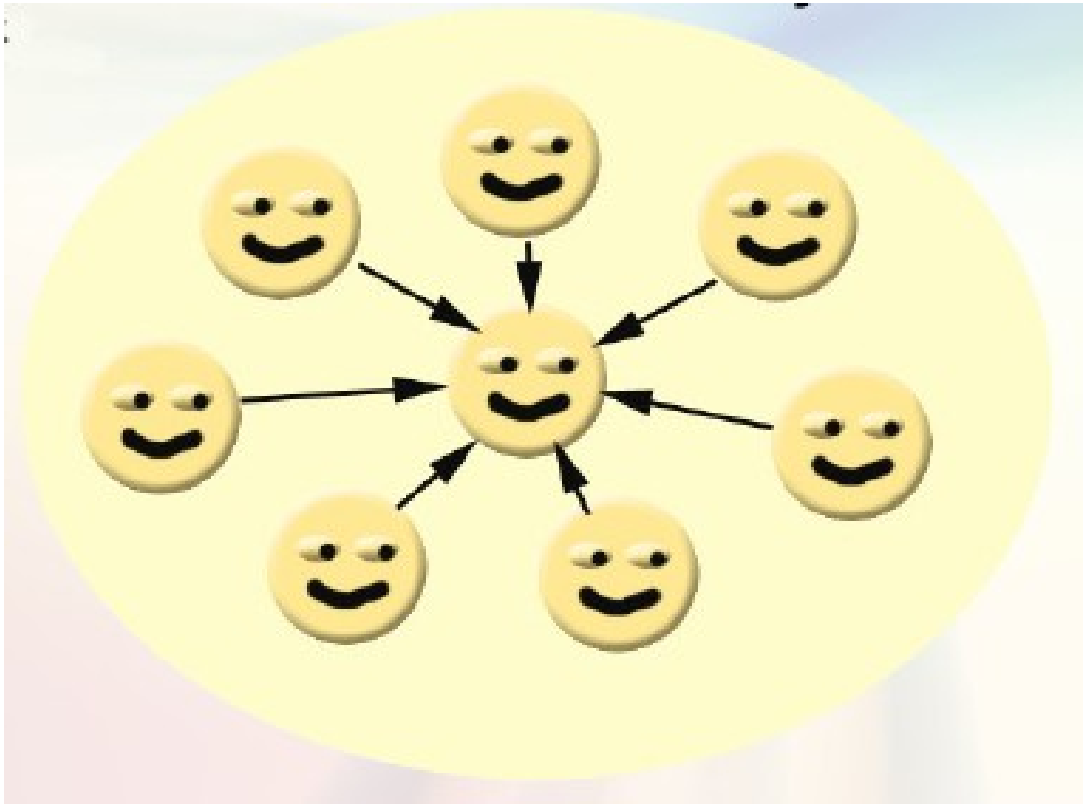
Modular apps – motivation

- Version 3.0...Help! Whenever I fix one bug, I create two more!



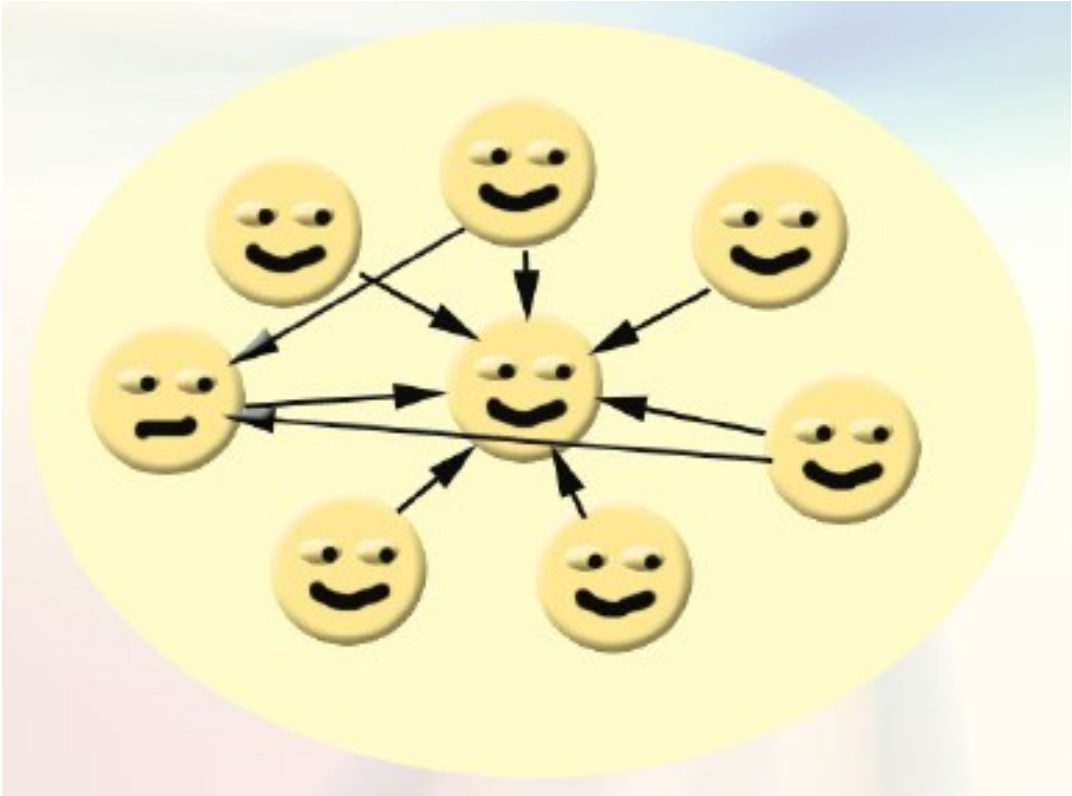
Modular apps – motivation

- Version 4.0 is cleanly designed. It's a complete rewrite. It was a year late, but it works...



Modular apps – motivation

- Version 4.1...does this look familiar?....



Module declaration

- module-info.java

```
module com.foo.bar {
    requires com.foo.baz;
    exports com.foo.bar.alpha;
    exports com.foo.bar.beta;
}
```

- modular artifact
  - modular JAR – JAR with module-info.class
  - a new format JMOD
    - a ZIP with classes, native code, configuration,...

Modules and JDK

- JDK std library modularized too
  - java.base – always „required“

```
module java.base {
    exports java.io;
    exports java.lang;
    exports java.lang.annotation;
    exports java.lang.invoke;
    exports java.lang.module;
    exports java.lang.ref;
    exports java.lang.reflect;
    exports java.math;
    exports java.net;
    ...
```

Module readability & module path

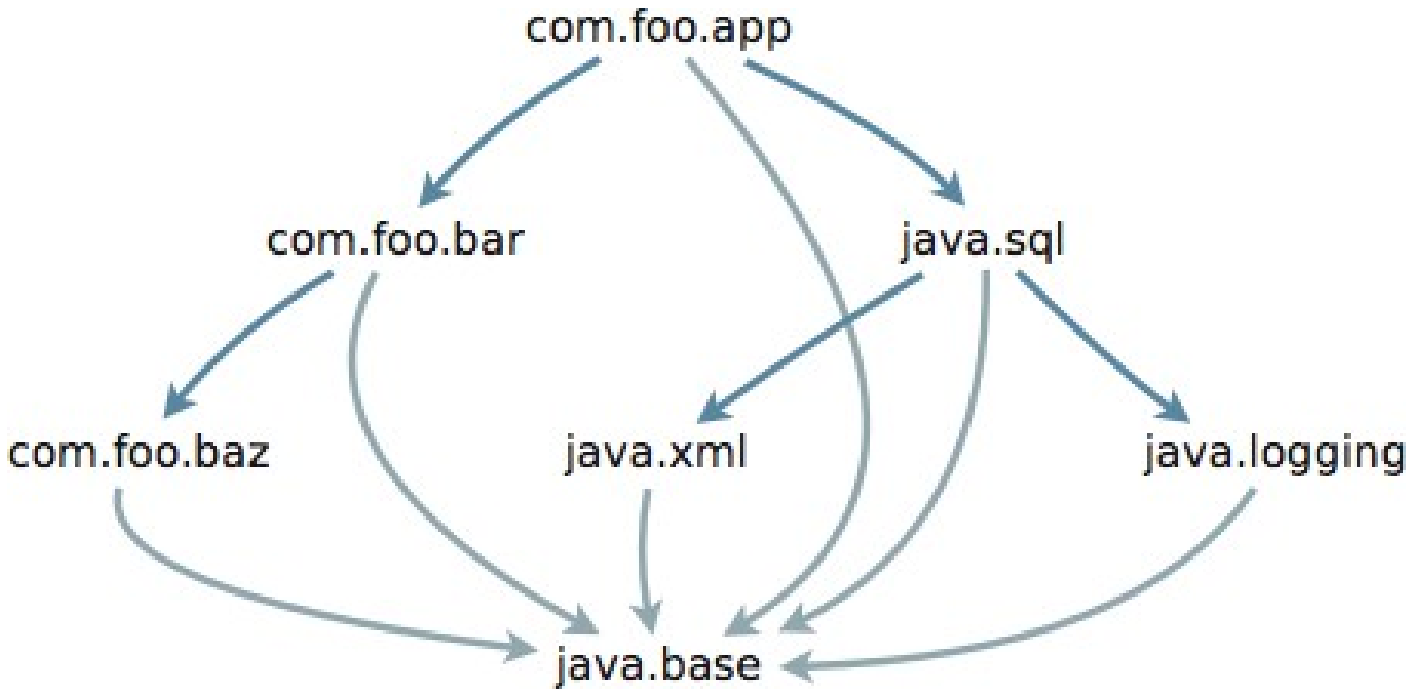
- When one module depends directly upon another

  Module ***reads*** another module (or, equivalently, second module is ***readable*** by first)

- ***Module path*** – equivalent to classpath
  - but for modules
    - -p, --module-path
  - running application
    java -p <module_path> name_of_module/name_of_class

Module graph

```
module com.foo.app {
    requires com.foo.bar;
    requires java.sql;
}
```



Accessibility

- If two types S and T are defined in different modules, and T is public, then code in S can access T if:
  - S's module reads T's module, and
  - T's module exports T's package

Implied readability

- Readability is not transitive
  - example:

in java.sql

```
java.sql.Driver {
    java.util.Logger getParrentLogger();
    ...
```

in java.logging

```
module java.sql {
  requires public java.logging;
  requires public java.xml;
  exports java.sql;
  exports javax.sql;
  exports javax.transaction.xa;
}
```

Services & ServiceLoader

```
module com.mysql.jdbc {
  requires java.sql;
  requires org.slf4j;
  exports com.mysql.jdbc;
  provides java.sql.Driver with com.mysql.jdbc.Driver;
}
```

```
module java.sql {
  requires public java.logging;
  requires public java.xml;
  exports java.sql;
  exports javax.sql;
  exports javax.transaction.xa;
  uses java.sql.Driver;
}
```

Qualified exports

- module java.base {
  ...
  exports sun.reflect ***to***
  java.corba,
  java.logging,
  java.sql,
  java.sql.rowset,
  jdk.scripting.nashorn;
  }

- not intended for common usage

requires static

- required at compile time, but is optional at runtime

```
module com.foo.bar {
    requires static com.foo.baz;
}
```

- WARNING
  - code that uses `required static` package has to be prepared for unavailability

opens, open

- before Java 9, anything can be accessed via reflection
  - even private members
- in Java 9+, reflection follows rules of modules
- but – packages can be opened

```
module com.foo.bar {
    opens com.foo.bar.alpha;
}
```

- types in opened package are accessible at runtime

```
open module com.foo.bar { }
```

  - opens all its packages

opens to

- **opens** package **to** list-of-modules
  - opens to code in the listed modules only

Reflection

```
package java.lang.reflect;

public final class Module {
  public String getName();
  public ModuleDescriptor getDescriptor();
  public ClassLoader getClassLoader();
  public boolean canRead(Module source);
  public boolean isExported(String
                    packageName);
  ...
}
```

Layer

- layer – instantiation of module graph at runtime
- maps each module in the graph to the unique class loader

- layers can be stacked
  - a new layer can be built on top of another one
    - a layer's module graph can be considered to include, by reference, the module graphs of every layer below it
- boot layer
  - created by VM at startup

- layers intended for app. servers, IDEs,...

Compatibility with “old” Java

- Classpath still supported
  - in fact – modules are “optional”

- Unnamed module
  - artefacts outside any module
    - “old” code
  - reads every other module
  - exports all of its packages to every other module

Automatic module

- a named module that is defined implicitly
  - it does not have a module declaration

- “regular” JAR placed on the module path rather than the class path
  - JAR without module-info.java

Scripting API

Overview

- support of scripting languages directly from Java
  - integrating scripts to a Java program
  - calling scripts
  - using Java objects from a script
    - and vice-versa
  - …
- since Java 6 directly part of JDK
  - JavaScript engine is also part of JDK
    - Java 6-7 – Mozilla Rhino engine
    - Java 8 – Nashorn engine
    - an implementation of JavaScript language in Java
    - since Java 11 – Nashorn deprecated
      - will be removed without replacement
        - but the Scripting API remains
  - there are many implementations for other languages
    - used via the ServiceLoader

Why

- a unified interface for all scripting languages
  - previously, every implementation has it own interface
- easy usage of scripting languages
  - variable “without” types
  - automatic conversions
  - …
  - no need to compile programs
    - a “shell” can be used
- usage
  - complex configuration files
  - an interface for the application admin
  - extending an application (plugins)
  - scripting in an applications
    - as JS in a browser, VBScript in Office,...

Usage

- package javax.scripting
- ScriptEngineManager
  - a core class
  - obtaining an instance of a script engine
- basic usage
  - an instance of ScriptEngineManager
  - obtaining a particular engine
  - running a script using the eval() method

Hello world

```
public class Hello {
  public static void main(String[] args) {
    ScriptEngineManager manager =
                                        new ScriptEngineManager();
    ScriptEngine engine =
                      manager.getEngineByName("JavaScript");
    //ScriptEngine engine =
                         manager.getEngineByExtension("js");
    //ScriptEngine engine =
    manager.getEngineByMimeType("application/javascript");
    try {
      engine.eval("println( \"Hello World!\");" );
      System.out.println(
                     engine.eval( " 'Hello World again!' "));
    } catch(ScriptException e) { ... }
  }
}
```

Overview

- script
  - a String or char stream (a reader)
  - evaluation via ScriptEngine.eval()
- interface Compilable
  - its implementation is optional
    - has to be tested – instanceof Compilable
  - a compilation of a script into byte-code
- interface Invocable
  - its implementation is optional
    - has to be tested – instanceof Invocable
  - calling methods and functions of a script
- Bindings, ScriptContext
  - environment for script execution
    - mapping variables shared between Java and a script

Obtaining an engine (1)

- ScriptEngineManager.getEngineFactories()
  - a list of all ScriptEngineFactory

```
for (ScriptEngineFactory factory :
                                engineManager.getEngineFactories()) {
  System.out.println("Engine name: " + factory.getEngineName());
  System.out.println("Engine version: " +
                                       factory.getEngineVersion());
  System.out.println("Language name: " +
                                        factory.getLanguageName());
  System.out.println("Language version: " +
                                      factory.getLanguageVersion());
  System.out.println("Engine names:");
  for (String name : factory.getNames()) {
    System.out.println("   " + name);
  }
  System.out.println("Engine MIME-types:");
  for (String mime : factory.getMimeTypes()) {
    System.out.println("   " + mime);
  }
}
```

Obtaining an engine (2)

- ScriptEngineFactory.getEngine()

- or directly

- ScriptEngineManager.getEngineByName()
- ScriptEngineManager.getEngineByExtension()
- ScriptEngineManager.getEngineByMimeType()

Scripts

- evaluating a script
  - Object ScriptEngine.eval(String s, ...
  - Object ScriptEngine.eval(Reader r, …
- passing variables (a basic variant)
  - void ScriptEngine.put(String name, Object value)
  - Object ScriptEngine.get(String name)
  - WARNING: be aware of type conversions

Passing variables

- interface Bindings
  - extends Map<String,Object>
  - a basic implementation – SimpleBindings
- interface ScriptContext
  - an environment, in which scripts run
  - a basic implementation – SimpleScriptContext
  - contains scopes
    - scope = Binding
  - special scopes
    - ENGINE_SCOPE – local for ScriptEngine
    - GLOBAL_SCOPE – global forEngineManager
  - getAttribute(..) / setAttribute(..) corresponds to getBindings(..).get / put
  - std Reader and Writer (input/output) for a script can be set

Passing variables

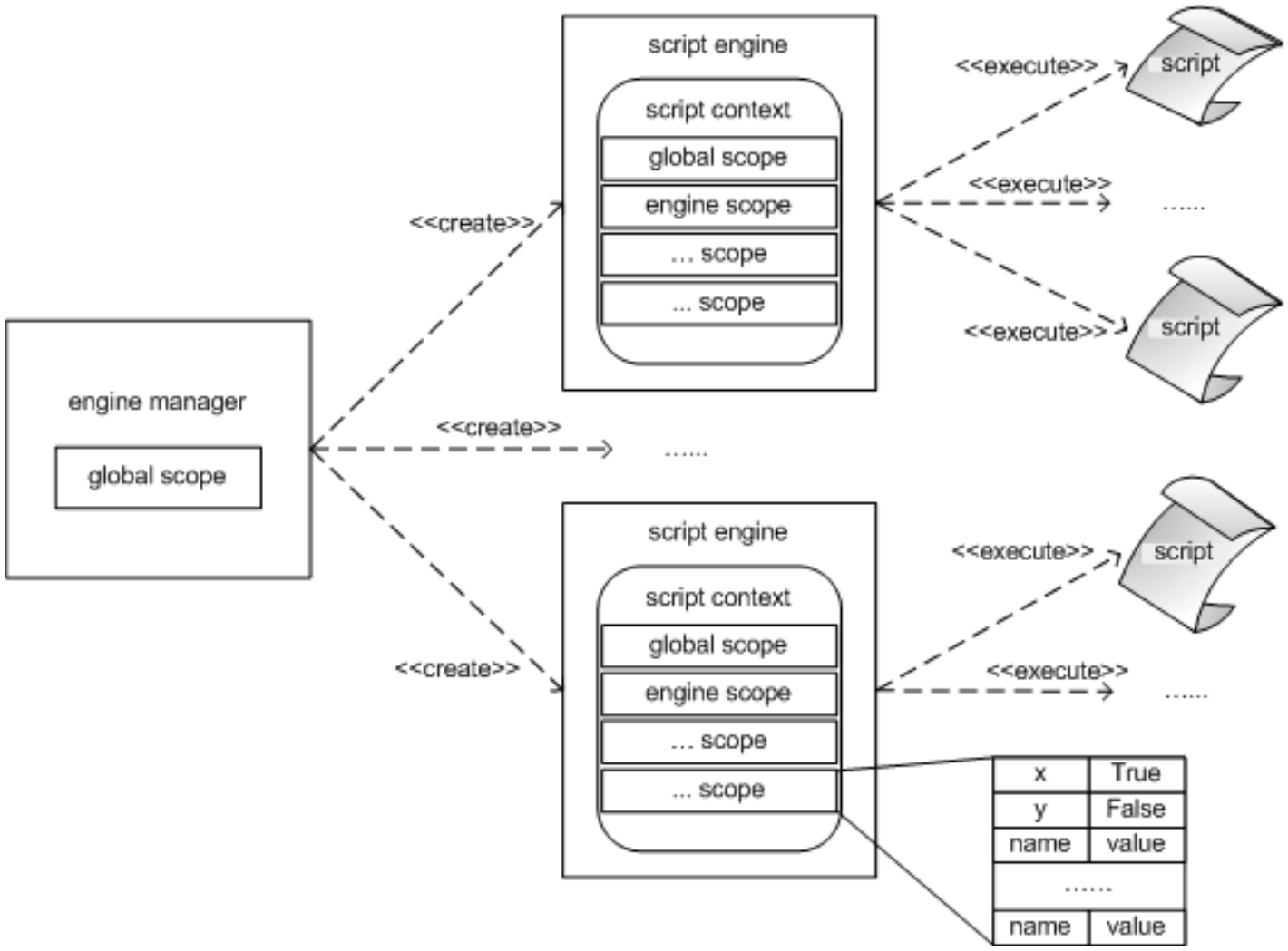


image source: http://www.javaworld.com/javaworld/jw-04-2006/jw-0424-scripting.html

Calling functions/methods

- interface Invocable
  - optional, has to be tested (instanceof)
  - offers
    - calling script functions from Java code
    - calling script objects' methods from Java code (in a case of object oriented script)
    - implementing a Java interface by functions (methods) of a script

```
ScriptEngine engine = manager.getEngineByName("javascript");
Invocable inv = (Invocable) engine;

engine.eval("function run() { println( 'function run'); };");
Runnable r = inv.getInterface(Runnable.class);
(new Thread(r)).start();

engine.eval("var runobj = { run: function()
                                { println('method run'); } };");
o = engine.get("runobj");
r = inv.getInterface(o, Runnable.class);
(new Thread(r)).start();
```

JavaScript engine in JDK (1)

- some functions removed (or substituted)
  - mostly from security reasons
- integrated functions for import of Java packages
  - importPackage(), importClass()
    - packages accessible via Packages.PackageName, shortcuts (variables) defined for the most used packages: java (equivalent to Packages.java), org, com,...
    - java.lang is not imported automatically (possible conflicts of objects Object, Math,...)
    - since Java 8 it is necessary to first use **`load("nashorn:mozilla_compat.js");`**
  - JavaImporter object
    - for “hiding” imported elements to variables (to avoid conflicts)

```
var imp = new JavaImporter( java.lang, java.io);
```

JavaScript engine in JDK (2)

- Java objects in js
  - creating as in Java
  - var obj = new Clazz(...)
- Java arrays in js
  - created via Java reflection
  - var arr = java.lang.reflect.Array.newInstance(..)
  - then used commonly: arr[i], arr.length,...

```
var a = java.lang.reflect.Array.newInstance( java.lang.String, 5);
a[0] = "Hello"
```

- anonymous classes
  - anonymous implementation of a Java interface

```
var r  = new java.lang.Runnable() {
    run: function()
    {
        println( "running...");
    }
};
var th = null;
th = new java.lang.Thread( r);
th.start();
```

JavaScript engine in JDK (3)

- anonymous classes (cont.)
  - auto-conversion of a function to an interface with a single method

```
function func() {
     print("I am func!");
};
th = new java.lang.Thread( func);
th.start();
```

JavaScript engine in JDK (4)

- overloaded Java methods
  - reminder
    overloading “resolved” at compile time (javac)
  - when JavaScript variables passed to Java methods, the script engine selects the right variant
  - selection can be influenced
    - object[“method_name(parameter_types)”](parameters)
    - warning! string without spaces!

Other engines

- many existing engines
  - awk, Haskell, Python, Scheme, XPath, XSLT, PHP,...
- creating own engine
  - implementing API
    - at least necessary to implement
      - ScriptEngineFactory
      - ScriptEngine
  - declaring implementation of the javax.script.ScriptEngineFactory
    - for the ServiceLoader