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Migrating Java UI Client Apps to the Modular JDK [CON4384]

Subtitle

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Session Topics

- Quick overview of the Jigsaw/Java Platform Module System.
- Impact on JDK source tree layout
- Impact on SE and JavaFX internals.
- Impact on Java SE and non-SE JDK client APIs
- Impact on SE and JavaFX client applications.
- Creating modules for Java SE Client Service Providers
- JavaFX Application Case Studies

Quick Project Jigsaw Overview

- Multiple JEPs and parts to Project Jigsaw
- JDK source code is restructured
- JDK runtime image is restructured (no more rt.jar)
- Defines the set of JDK modules (groups of related packages)
- Requires modules list modules on which they depend (JDK dependency graph)

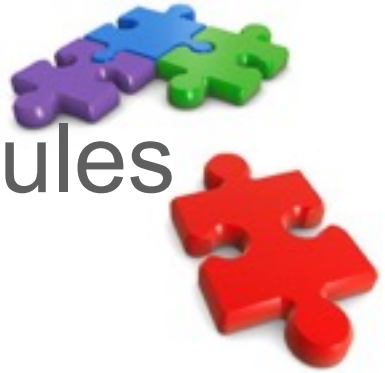
Project Jigsaw Overview (continued)

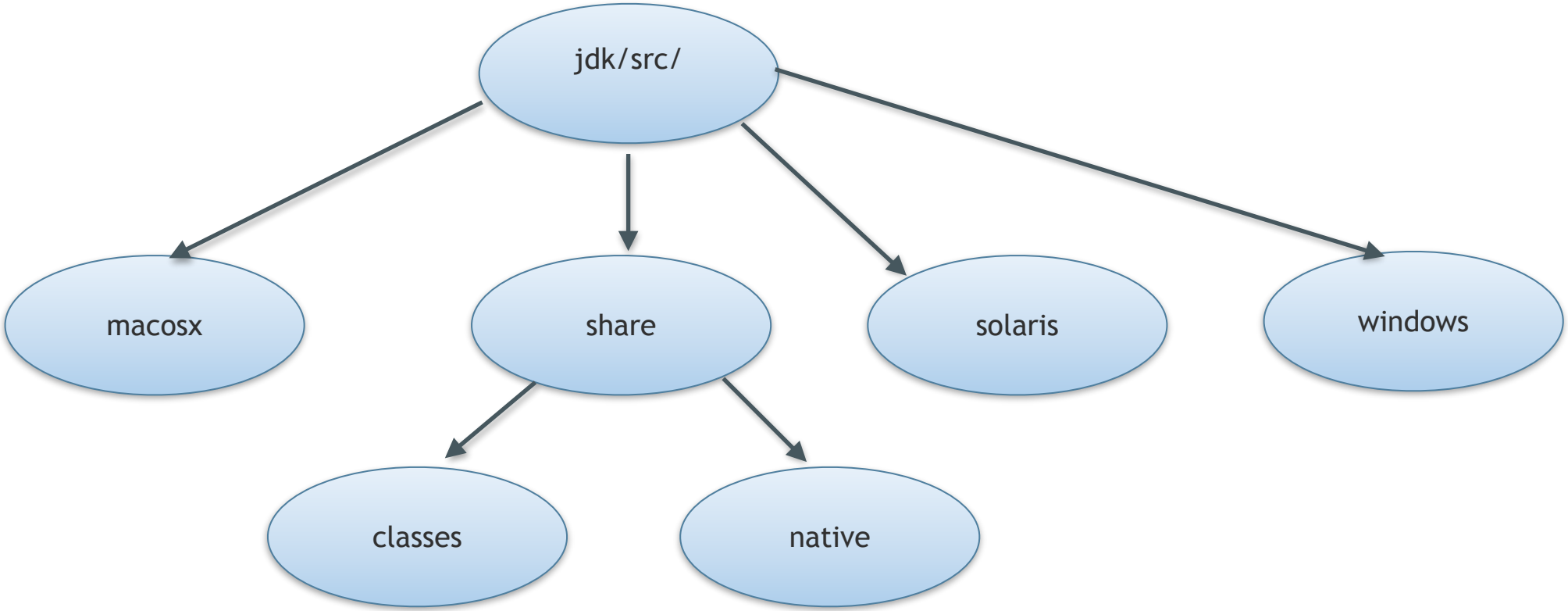
- Uses Service Providers for JDK to access code in external modules (no explicit dependency)
- Enforces encapsulation by denying access to packages not exported from a module
- Defines new language keywords and APIs for using the module system.
- Provides tools for building a modular JDK image

Some rules (consequences) of the Module System

- Internal JDK APIs are off-limits, even with no security manager
- Supportedness becomes a binary decision - no grey areas.
- SE modules cannot depend on non-SE modules - even internal ones.
- SE modules cannot export non-SE types.
- Exports are at the package level - all or nothing.
- No split packages

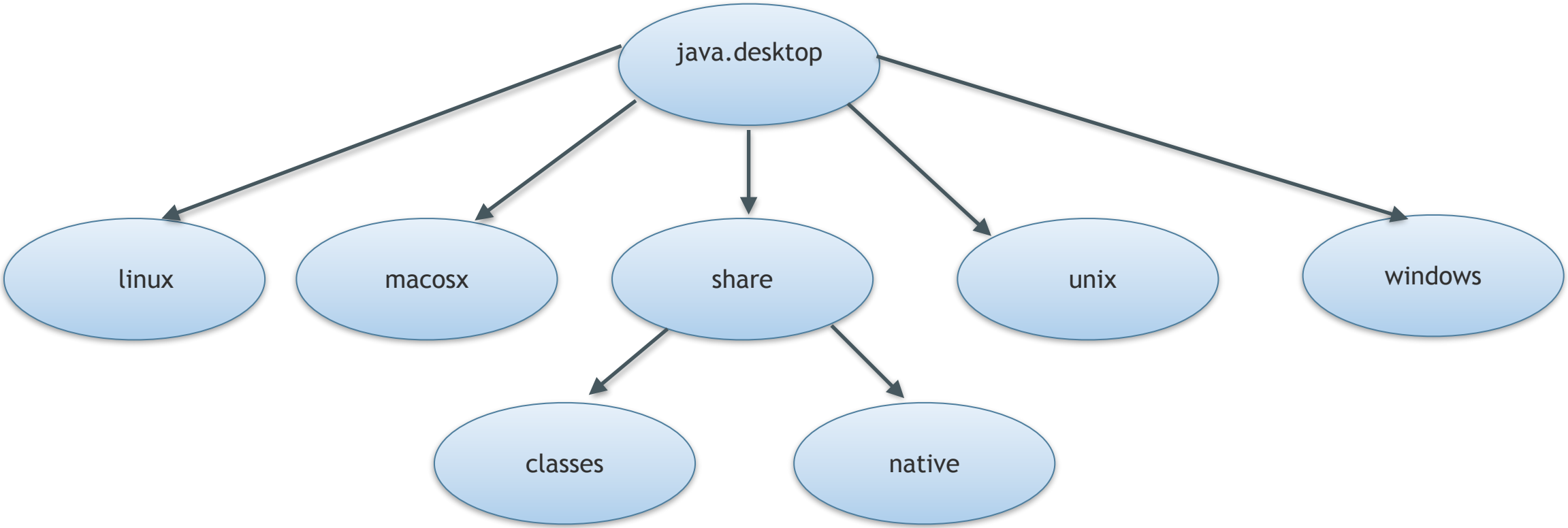
JDK Source Code restructuring and Client Modules





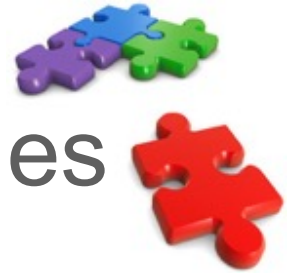
- Previously : JDK client code intermingled with all other source code.

New JDK source code organization



- Now JDK client code under its own hierarchy.

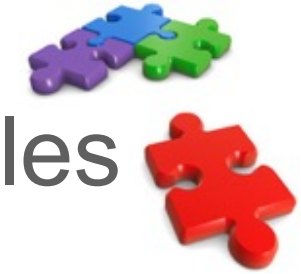
JDK Source Code restructuring and Client Modules



- New source code structure cleanly defines what is in the desktop module
- Mainly of interest to folks who use OpenJDK source
  - but eventually shows up in the runtime image.

- Maps to the "j*ava.desktop*" runtime module
  - contains all the binary code (Java classes and native, plus resources).

JDK Source Code restructuring and Client Modules



- One other very small client module : *java.datatransfer*
- Contains just the java.awt.datatransfer package
- Unbundled because non-client APIs used in embedded need it and the separation is possible (a rare case)
- java.desktop "*requires public java.datatransfer*" - so no need for apps to separately require it.
- This is the module system linkage granularity for client APIs in SE
  - Essentially all or nothing.

Impacts on JDK Client APIs and internals

- Breaks down in different ways
  - APIs retired
  - APIs adjusted / re-specified.
  - APIs made standard
  - Public replacement APIs provided for internal APIs
  - Internal changes made in the JDK in anticipation of module system constraints and rules.

Impacts on JDK Client APIs

Example 1: com.sun.image.codec.jpeg

- A non standard API from JDK 1.2 (1998)
  - Obsoleted by Image I/O in JDK 1.4 (2004)
  - Deprecated and hidden from new compilation (JDK 1.7)
  - No longer considered supported.
- Rules in effect
  - No exporting non-standard API from SE module
  - Binary choice of supportedness
- JDK action : deleted entirely
- User code action : migrate to Image I/O (javax.imageio)

Impacts on Client APIs

Example 2: java.awt.peer interfaces (this one was a toughie).

Package java.awt.peer is internal and undocumented.

But some of its types are exposed in public API

```
java.awt.Component : ComponentPeer getPeer()
java.awt.Font : FontPeer getPeer()
java.awt.Toolkit :
  ButtonPeer  createButton(Button target)
  LightweightPeer   createComponent(Component target)
java.awt.dnd.DragSource :
createDragSourceContext(java.awt.dnd.peer.DragSourceContextPeer, …)
```

Impact on Client APIs

Example 2: java.awt.peer interfaces (cont'd)

- Internal APIs in signatures of public classes very problematic
- Known to have been used historically by user code since JDK 1.0
- Rules in effect (nearly all of them)
  - No exporting non-standard API from SE module
  - Binary choice of supported-ness
  - Exports are at the package level - all or nothing.
  - No using internal JDK APIs

Impact on Client APIs

Example 2: java.awt.peer interfaces (cont'd)

- Option 1:
  - Make java.awt.peer standard
    - But these are properly internal to the desktop module
    - Needed only in ports of AWT itself (which implies a JDK port)

Impact on Client APIs

Example 2: java.awt.peer interfaces (cont'd)

- Option 2:
  - Change the documented and actual return type to Object.
    - A binary incompatibility
    - Cannot use it except as Object so not very useful.
    - JDK internal callers would need to use type-unsafe casting.

Impact on Client APIs

Example 2: java.awt.peer interfaces (cont'd)

- Option 3:
  - Stop documenting the methods: remove (only) from the spec.
  - Benefit: code that disables module boundary checking can still run
  - But too many oddities with TCK and type system.
    - Module system would still allow a call that does not try to resolve the return type to the internal type.
    - Analagous to an interface type being returned but implemented by an internal type.

Impact on Client APIs

Example 2: java.awt.peer interfaces (cont'd)

- Option 4:
  - Remove all the offending methods from the public API, making them internal to the desktop module.
    - Binary incompatible (obviously)
    - JDK code and application code will need to be updated.
  - The winner: Option 4: although it required a large set of JDK code changes and will require apps to be updated too
  - Doing nothing was not an option.

Impact on Client APIs

Replacing Application use of java.awt.peer classes.

- In practice most uses of peers we've found are one of two cases
- Usage 1: To see if a peer has been set yet

```
if (component.getPeer() != null)  { .. }
```

- Replace with JDK 1.1 API : Component.isDisplayable() :

```
public boolean isDisplayable() {
    return getPeer() != null;
}
```

Impact on Client APIs

Replacing Application use of java.awt.peer classes.

- Usage 2: To test if a component is lightweight

```
if (component.getPeer() instanceof LightweightPeer) ..
```

- Replace with JDK 1.2 API : `Component.isLightweight()` :

```
public boolean isLightweight() {
    return getPeer() instanceof LightweightPeer;
}
```

Impacts on JDK Client APIs

- **Example3: com.apple.eawt.desktop APIs**
  - Apple JDK supported these to provide access to OS X platform features
    - eg way to draw attention to app (bouncing dock icon)
    - handlers for standard system events

Impacts on JDK Client APIs

- **Example 3: com.apple.eawt.desktop APIs**
  - Rules in effect:
    - cannot export non-SE APIs
    - binary choice of supportedness
- Solution JEP 272: make standard APIs
  - extend java.awt.Desktop to provide similar functionality
  - query capability to test if platform provides a feature

Impacts on JDK Client APIs

- **Example 4: Java Access Bridge (an assistive technology)**
- Java Access Bridge (JAB) is not in the java.desktop module
  - It does not export any Java SE APIs
- java.awt.Toolkit responsible for loading JAB via reflection.
- Rules in effect:
    - SE module (ie java.desktop) cannot depend on non-SE module

Impacts on JDK Client APIs

- **Example 4: Java Access Bridge (an Assistive Technology (AT))**
- Solution: Support AT as a ServiceProvider
- AT will implement a new interface
  `javax.accessibility.AccessibilityProvider`
- JAB module will ***provide*** this service
- java.desktop will ***use*** the service.
  - java.util.ServiceLoader will take care of the loading/visibility

Impacts on JDK Client APIs

- **Example 5: Setting a Swing Look and Feel (L&F)**
- Swing provides two APIs to set the current L&F
  - `UIManager.setLookAndFeel(Class lafClass)`
  - `UIManager.setLookAndFeel(String lafName)`

Which one should you use ?

Impacts on JDK Client APIs

- **Example 5: Setting a Swing Look and Feel (L&F)**
- For built-in (JDK-provided) L&F ?
  - eg java.desktop module provides platform L&F
  - name of the class is exposed via

```
lafName = UIManager.getSystemLookAndFeelClassName()
Class lnfClass = Class.forName(lafName);
```

Impacts on JDK Client APIs

- **Example 5: Setting a Swing Look and Feel (L&F)**
- What about external / 3rd party L&F ?
- Either can work
  - If 3rd party L&F is an unnamed module (ordinary jar) you can instantiate
  - As a module it may export the class and package and you may ***require*** the module.

```
UIManager.setLookAndFeelClassName(lnfClass)
```

Using string name ?

`UIManager` will add a runtime read edge

```
UIManager.class.getModule().addReads(lnfClass.getModule())
```

Example of how JDK internals need to be updated to work with the module system

Impacts on JDK Client APIs

- **Example 6: Locating resources.**

  `javax.imageio.ImageReader.processWarning(String basename)`

  takes a resource bundle name but where should it look for the bundle ? Can client code provide additional localized resources for a standard (SE) Image I/O plugin ?

  Jigsaw expects resources in a named module to be located using the class loader which loaded the module.

Impacts on JDK Client APIs

- **Example 6: Locating resources.**
- Action:
  - Image I/O updated to restrict lookup
  - Now must come only from the same location as the plugin
  - For java.desktop provided services this is the ‘boot’ class loader.
  - For 3rd party external plugins this means they need to be provided by the plugin
- This all makes sense as you cannot localize some one else’s plugin
- Here jigsaw helped add clarity to what the code should have enforced all along.

Impact: Defining new public APIs

- Some internal APIs used by applications because there is still no public equivalent of useful functionality (but you need to tell us).
- Rule in effect
  - No using internal JDK APIs
- Solution : promote internal API to public
- Two small examples:

  sun.awt.ShellFolder (selected functionality)

  sun.awt.CausedFocusEvent
- Apps will need to change but can use reflection

Creating modules for Client Service Providers

- Several client APIs define Service Provider interfaces
  - javax.imageio (5)
  - javax.print (2)
  - javax.sound (8)
  - java.awt.im (Input Methods)
  - javax.accessibility (new in JDK 9 as discussed earlier)

Creating modules for Client Service Providers

- SPI support has been around since JDK 1.3
  - java.util.ServiceLoader can be used to load application-supplied implementation of interfaces
  - more useful than ever in JDK 9 - updated to work with module system
  - no need to know the dependent module, just the service name

Creating modules for Client Service Providers

- SE API defines the name of an interface
  - eg **`javax.imageio.spi.ImageReaderSpi`**
- Application provides a jar with a file :
  - META-INF/services/javax.imageio.ImageReaderSpi
  - Entry in that file defines the name of it's implementing class,eg **`simp.SIMPImageReader.Spi`**

Creating modules for Client Service Providers

- Creating a modular jar for a javax.imageio plugin:

  Step 1: Create module-info.java (new language syntax)

```
module simp /* name of the modular jar */ {
     requires java.desktop;
     exports simp to java.desktop; /* java package exported (see next slide) */
     provides javax.imageio.spi.ImageReaderSpi with simp.SIMPImageReaderSpi;
}
```

  Step 2: Create simp.jar as for JDK 8, but with module-info.java compiled in.

  Step 3: Add simp.jar to the ***module path :*** java -mp simp.jar …

Creating modules for Client Service Providers

- Creating a modular jar for a javax.imageio plugin:

  Why do we need “exports simp to java.desktop” ? Something of a special case in Image I/O

  - Image I/O plugin in the module provides the (String) name of its IIOMetadataFormat class
  - Core Image I/O IIOMetadata class provides a method that looks up this name and instantiates as necessary :

```
public IIOMetadataFormat getMetadataFormat(String)
```

- Unless the package is exported, it cannot be accessed. One module can add a read-edge to another module but *cannot* force the module to expose its internals.
- If designing today, it would be the plugin code that would be required to create the instance
- NB jigsaw is still evolving. This method ‘broke’ last week because it uses Class.forName(Module, String) on a potentially un-named module and the behaviour was changed in that case.

Creating modules for Client Service Providers

- Need your code to work with JDK 8 too ?
  - Not ready to require 9 and later ?
- Do nothing - Your JDK 8 “jar” is made into an “automatic module”
  - No module-info means it is a regular jar
  - Implicitly all packages are exported
  - ServiceLoader handles the dependency as for a regular module.
  - Put jar on the class path as now (not the module path)
- You do not get the encapsulation benefits, but no code changes are needed.

Impact: Re-specifying Java SE APIs

- A few cases where existing standard APIs do not play well with the module system
  - Cannot be fixed up ‘internally’. Case in point:
    - `javax.imageio.spi.ServiceRegistry.lookupProviders(Class)`
    - Is a wrapper around `ServiceLoader.load()`
      - pre-dates that as public API
      - lookups up an arbitrary Service Provider Interface
    - What is the catch ?

Impact: Re-specifying Java SE APIs

- To use a service a module must declare in its module-info.java

```
uses org.duke.SomeService
```

- ServiceLoader looks at its immediate caller which is java.desktop
- A long list of these in the module-info for java.desktop for standard SPIs but it does not include SomeService and consequently lookup will fail.
- JDK resolution: no need for this API since ServiceLoader is standard
  - As of JDK 1.9 it will load only the Image I/O specified service provider interfaces. Applications using it otherwise will break.

JDK Summary and Take Aways

- Examples provided are not by any means exhaustive
  - Image I/O examples could as easily have occurred elsewhere
- Other areas in client use core reflection
- Notably java.beans, javax.sound
- Tests that access internals needed to be updated

JDK Summary and Take Aways

- Uses of core reflection in the JDK code almost always need to add a runtime read edge - any time user code is delivered via a class name is problematic
- Service Providers are the preferred solution where possible
- Application code should test itself against the regular JDK 9 to see if affected by deleted or re-specified APIs
- Application code can test against the modular JDK 9 to see if affected by usage of internals (NB jdeps tool in JDK8u bin)
- Applications can benefit from encapsulation by adopting code delivery using modules.

JavaFX and Jigsaw

- JavaFX Modules
- Impact of Jigsaw on JavaFX Applications
- Impact of Jigsaw on JavaFX Internals
- JavaFX Sample Applications

JavaFX Modules

- JavaFX source code already organized as modules (as of JDK 8)

```
modules/
    base/
    controls/
    graphics/
    ...
```

JavaFX Modules

- In general, modules are named “javafx.nnnnn”
  - where “nnnnn” is the directory name under the modules directory

```
modules/
    base/          // javafx.base module
    controls/      // javafx.controls module
    graphics/      // javafx.graphics module
    ...
```

JavaFX Modules

- JavaFX classes and resources will be linked into the JDK
  - No more jfxrt.jar
- SWT interop will still be delivered separately:
  - jfxswt.jar file delivered with the JDK
  - Cannot be linked into runtime image because it depends on third-party swt.jar
  - jfxswt.jar will be an “automatic” module (meaning no module-info.class)
  - Implementation classes will go into a named javafx.internal.swt module

JavaFX Modules

JRE Modules

Public

```
javafx.base
javafx.controls
javafx.fxml
javafx.graphics
javafx.media
javafx.swing
javafx.web
```

Internal

```
javafx.deploy  [closed]
javafx.internal.swt
```

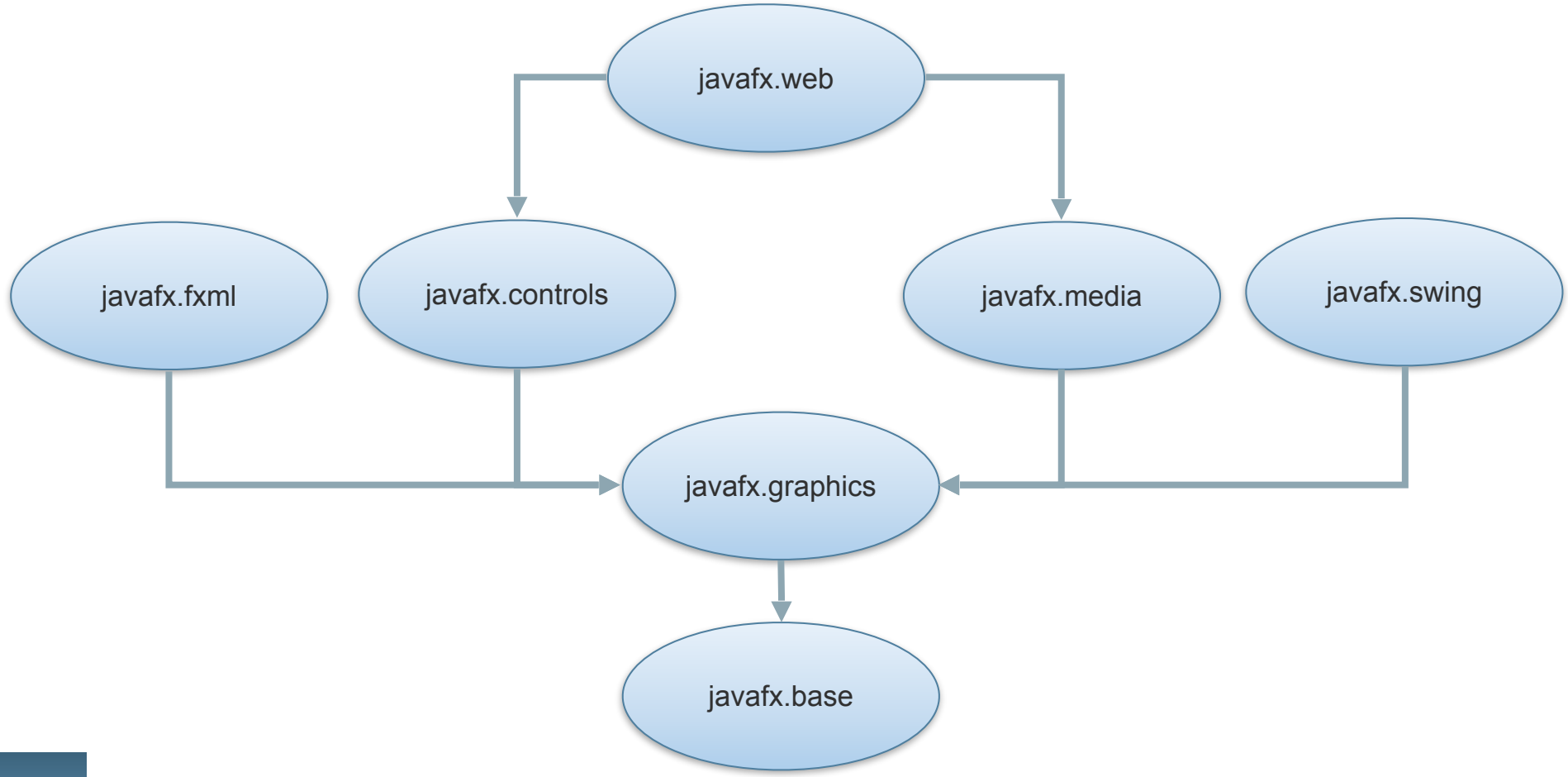
JDK Modules

Public

```
javafx.jmx
jdk.packager
jdk.packager.services
```

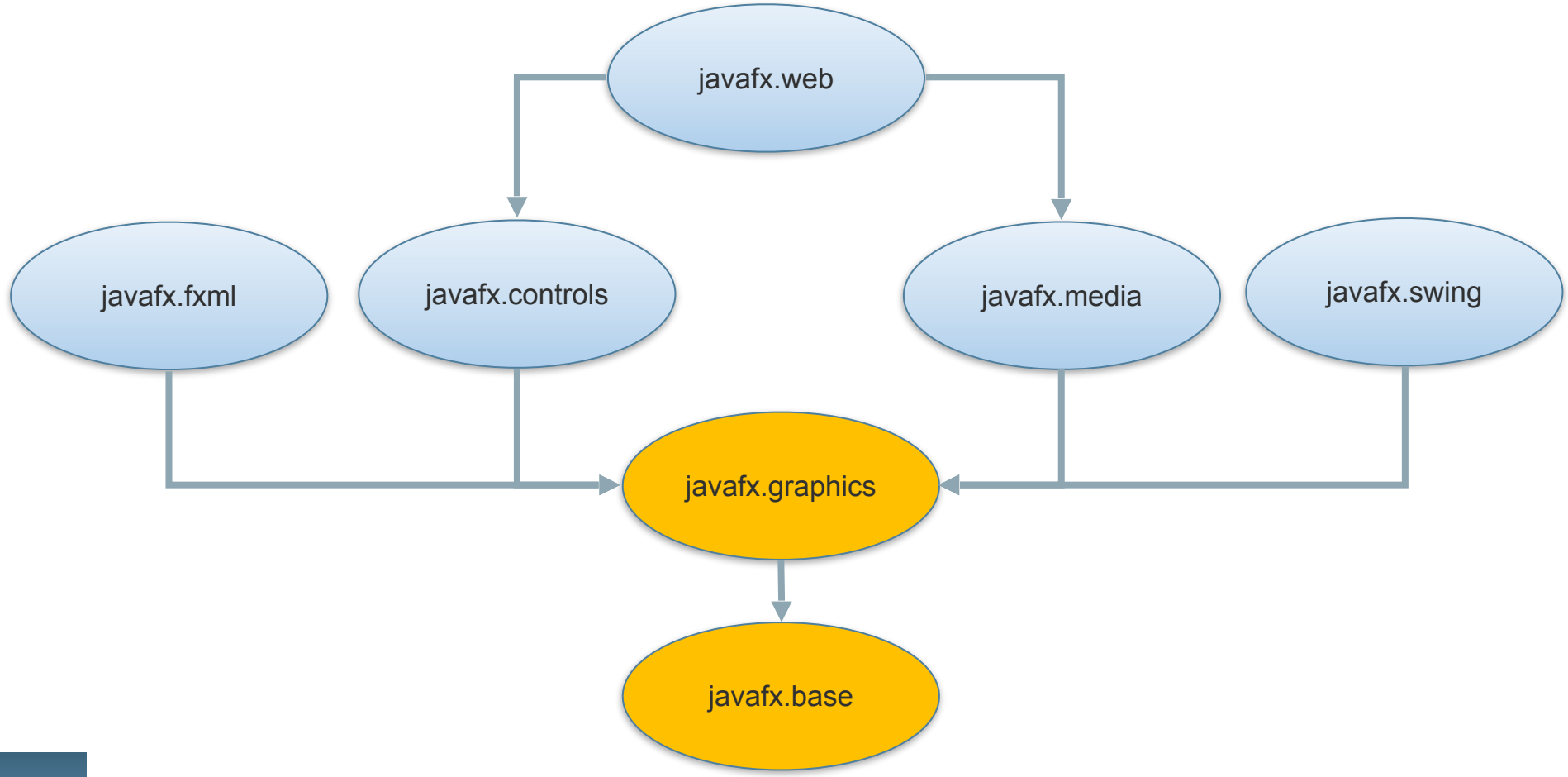
JavaFX Modules

- JavaFX module graph for runtime (JRE) modules: transitive reduction



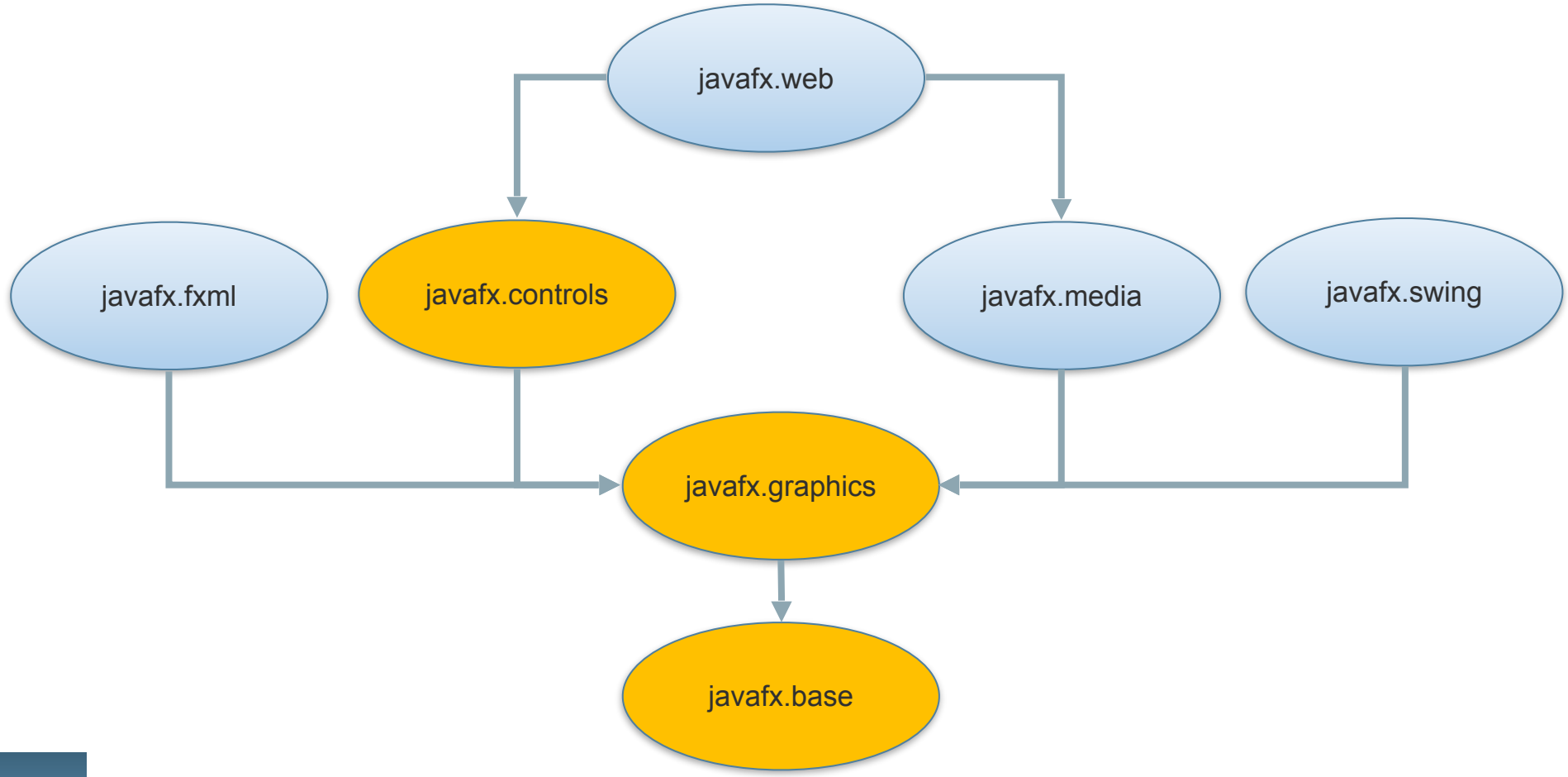
JavaFX Modules

- All JavaFX applications require javafx.graphics



JavaFX Modules

- All JavaFX UI applications require javafx.controls

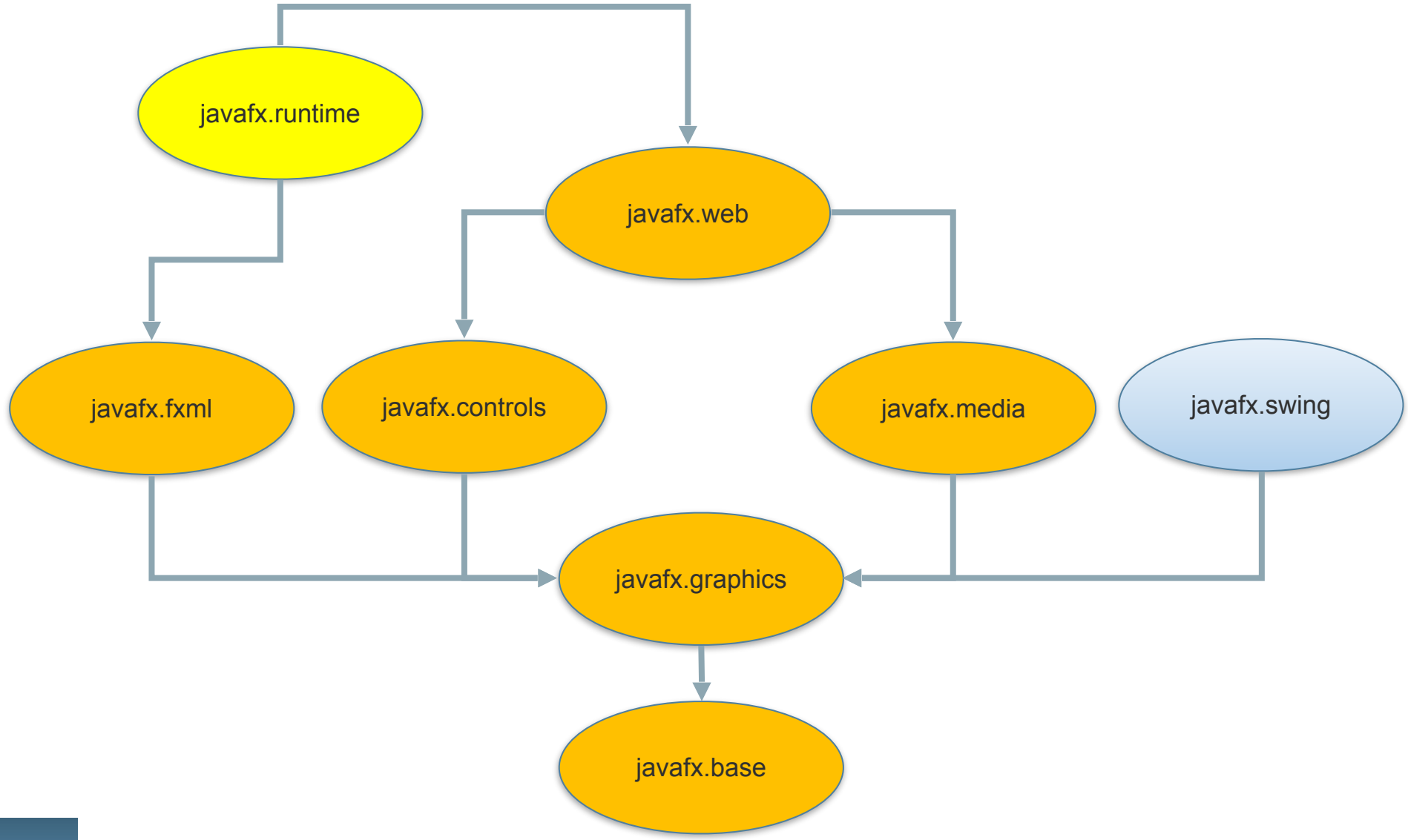


JavaFX Modules

- We will also provide an “aggregating” javafx.runtime module
  - Includes all the public javafx runtime modules except javafx.swing
  - Contains no classes or other artifacts
- A “pure” JavaFX application (no Swing interop) can just say:
  - **`requires javafx.runtime;`**

```
module javafx.runtime {
    requires public javafx.base;
    requires public javafx.graphics;
    requires public javafx.controls;
    requires public javafx.fxml;
    requires public javafx.media;
    requires public javafx.web;
}
```

JavaFX Modules



JavaFX Modules: Packages

- Only publicly documented packages are exported
  - All are in the "javafx.*" namespace

```
javafx.base module
    package javafx.beans;
    package javafx.beans.binding;
    package javafx.beans.property;
    package javafx.beans.property.adapter;
    package javafx.beans.value;
    package javafx.collections;
    package javafx.collections.transformation;
    package javafx.event;
    package javafx.util;
    package javafx.util.converter;
```

```
javafx.controls module
    package javafx.scene.chart;
    package javafx.scene.control;
    package javafx.scene.control.cell;
    package javafx.scene.control.skin;
```

```
javafx.fxml module
    package javafx.fxml;
```

JavaFX Modules: Packages

```
javafx.graphics module
    package javafx.animation;
    package javafx.application;
    package javafx.concurrent;
    package javafx.css;
    package javafx.css.converter;
    package javafx.geometry;
    package javafx.print;
    package javafx.scene;
    package javafx.scene.canvas;
    package javafx.scene.effect;
    package javafx.scene.image;
    package javafx.scene.input;
    package javafx.scene.layout;
    package javafx.scene.paint;
    package javafx.scene.shape;
    package javafx.scene.text;
    package javafx.scene.transform;
    package javafx.stage;
```

```
javafx.media module
    package javafx.scene.media;
```

```
javafx.swing module
    package javafx.embed.swing;
```

```
javafx.web module
    package javafx.scene.web;
```

JavaFX Modularity: Application Impact

- No access to internal “com.sun.*” JavaFX packages
  - Only explicitly exported packages are visible – javafx.*
  - Accessing a non-exported package will result in a compilation or runtime error
    - And no, you can’t simply use reflection to call **`setAccessible`**
    - It can be overridden with “**`-XaddExports`**” command line switch in extreme need

JavaFX Modularity: Application Impact

- Classes in non-modular applications are in the “unnamed” module
  - By default, unnamed module reads (requires) all named modules in system
  - Can access all publicly exported packages of all modules with no app changes
- Modular applications list their dependencies in module-info.java
  - Only public types of required modules are accessible
  - Here is a minimal module-info.java for an application that uses javafx.controls, .graphics, and .base modules (controls re-exports graphics and base)

```
module my.app {
  requires javafx.controls;
}
```

JavaFX Modularity: Impact on Internals

- Modules need to list dependencies and exports
  - Qualified exports can be used to allow other modules to access internals
  - Specified in module-info.java as follows:

```
module javafx.graphics {
    requires public javafx.base;                          ← uses / re-exports
    ...
    exports javafx.scene;                                 ← public API
    ...
    exports com.sun.glass.ui to javafx.media, javafx.web; ← qualified export
    ...
}
```

JavaFX Modularity: Impact on Internals

- No conditional dependencies
  - Use Module.addReads to access a new module at runtime
    - Used by frameworks or loaders to dynamically load classes
    - Example: FXML, Beans, Application launcher
  - Use Module.addExports to export a package to another module at runtime
    - JavaFX modules don't currently do this
    - We use qualified exports in module-info.java for all such cases
      - We will probably need this to export packages from javafx.internal.swt to jfxswt.jar
    - Usage:

```
Module thisModule = MyClass.getModule();
thisModule.addExports("my.pkg", otherClass.getModule());
```

JavaFX Internals: addReads

- JavaFX Beans

ReadOnlyPropertyDescriptor.java

```
 public ReadOnlyPropertyDescriptor(... Class<?> beanClass, ...) {
     ReflectUtil.checkPackageAccess(beanClass);
+    Module thisModule = this.getClass().getModule();
+    thisModule.addReads(beanClass.getModule();
```

- JavaFX Launcher

LauncherImpl.java

```
Module thisModule = LauncherImpl.class.getModule();
Module targetModule = appClass.getModule();
thisModule.addReads(targetModule);
```

JavaFX Internals: MethodUtil

- MethodUtil.invoke will not work for resources in module
  - Used by FXML both for internal and application methods

```
BeanAdapter.java (and a few other places)

-     value = MethodUtil.invoke(getterMethod, bean, (Object[]) null);
+     value = ModuleHelper.invoke(getterMethod, bean, (Object[]) null);

ModuleHelper.invoke(...) {
    Module thisModule = ModuleHelper.class.getModule();
    Module methodModule = m.getDeclaringClass().getModule();
    if (methodModule != thisModule) {
        return MethodUtil.invoke(m, obj, params);
    } else {
        return m.invoke(obj, params);
    }
}
```

JavaFX Modularity: Impact on Internals

- Reflection issues in FX media

Locator.java

```
 private static long getContentLengthLong(URLConnection connection) {
 ...
          try {
-             return connection.getClass().getMethod("getContentLengthLong");
+             return URLConnection.class.getMethod("getContentLengthLong");
          } catch (NoSuchMethodException ex) {
              return null;
          }
```

- If “connection” class is in another module, we get IllegalAccessError
  - The method we need is in URLConnection itself, so use that directly

JavaFX Modularity: Impact on Internals

These affect JavaFX applications, too

- Resource encapsulation changes:
  - ClassLoader.getResource() will not find resources in module
    - A modular app cannot simply use "/some/path/myresource.css" as stylesheet URL
  - Class.getResource() will find resources in modules -- but **only** in your own module
    - No more “dipping into” the internals to load another module's resource
  - This affected both JavaFX internals and (at least) two sample apps

JavaFX Modularity: Impact on Internals

These affect JavaFX applications, too

- JavaFX has several APIs that take a URL (or url String)
  - CSS Stylesheets
  - FXMLLoader
  - Image & Media
  - WebEngine
- A non-modular app can continue to use ClassLoader-relative URLs
- JavaFX internals, and modular applications cannot
  - Use Class.getResource() instead

JavaFX Internals: CSS Processing

- CSS processing: loading internal CSS files (e.g., modena.css)
- Two bad assumptions:
  - Internal JavaFX resources can be loaded using absolute path
    - Relying on classpath or lookup of jfxrt.jar
  - javafx.graphics module can load resources from javafx.controls module
  - Neither will work
- Solution:
  - Create a getResource() utility method in an internal controls package
    - Package is exported to javafx.graphics via qualified exports
    - The controls module gets its own resources and passes them to graphics

JavaFX Internals: JSObject

- JDK 8 has duplicate copy of `netscape.javascript.JSObject`
  - One in plugin.jar and one in jfxrt.jar
  - Used as the return type of HostServices.getWebContext()
- We must unify them in JDK 9
- JSObject has legacy method that takes an instance of AWT Applet
  - A bad thing to have done, but we are stuck with it
  - Changing it would break too many legacy applets
  - We do not want a hard API dependency from javafx.graphics on java.desktop

JavaFX Internals: JSObject

- Solution:
  - We are making an incompatible API change to getWebContext

```
HostServices.java:
  -     public final JSObject getWebContext();
  +     public final Object getWebContext();
```

- Applications that use getWebContext() will need to cast:

```
JSObject jsWin = (JSobject)getHostServices().getWebContext();
```

JavaFX Modularity: Unit Tests

- Work in progress
- Challenges:
  - Unit tests often need to access internal (implementation) packages
  - Some "white-box" tests need to access package-private data
  - JavaFX unit tests were not organized well
    - Many were in the same package as the core module, without need
  - Named modules cannot directly access types from unnamed modules
    - Using addReads is a runtime solution, but has to be done at runtime
  - Gradle does not work with the modular JDK
    - Their unit test harness makes assumptions about JDK class loader internals

JavaFX Modularity: Unit Tests

- Progress thus far:
  - Refactored tests to put actual unit tests in separate packages
  - Use "shim" classes to access package private data
    - These live in an existing package of the module they are testing
    - Appended to the module when tests are run using -Xpatch
  - Use @argfiles to specify the list of -XaddExports and -Xpatch
  - Tests for javafx.base, graphics, and controls are now running (standalone)
- Next steps:
  - Integrate this into gradle
  - Need custom test runner to be able to run this on JDK 9 + Jigsaw

JavaFX Modularity: Impact on Internals

- JavaFX Builders violated split package rule
  - In the same package as the classes they build, but in a different module
  - Already deprecated in 8 for unrelated reasons (unable to maintain compatibility when core classes evolve)
  - We removed them in JDK 9
- AWT peer change affected FX internals
  - Swing interop depends on java.awt.dnd.peer for Drag and Drop
  - One of the public interfaces FX uses has changed in JDK 9
  - FX will need to adapt to this before we switch to using JDK 9 as boot JDK

JavaFX Sample Applications: SceneBuilder

- SceneBuilder in FX 8 uses several internal packages
  - Most were due to Skins and CSS APIs not being public
    - JEP 253 fixes that
    - SceneBuilder helped inform public CSS API
      - (e.g., ParsedValueImpl, converter classes, error handling)
  - A few miscellaneous places had no equivalent public API
    - Internal picking code -- wrote a 10 line replacement function using public API
    - Window system toolkit listeners -- mainly used for native Apple menu handling
      - no replacement, but not critical functionality
- SceneBuilder in FX 9 now uses only public API
  - Runs on Jigsaw EA build without error

JavaFX Sample Applications: Ensemble8

- Eliminated use of deprecated builders
- No other changes needed to run as non-modular app
  - Runs in the unnamed module

- One change needed to allow it to run as a module:

```
// OLD
scene.getStylesheets().setAll("/ensemble/EnsembleStylesCommon.css");

//NEW
URL url = EnsembleApp.class.getResource("EnsembleStylesCommon.css")
scene.getStylesheets().setAll(url.toExternalForm());
```

JavaFX Sample Applications: Modena

- Eliminated deprecated builders
- Eliminated access to internal stylesheets:
  - Prior to 8u60, used internal skin class
    - com.sun.javafx.scene.control.skin.ButtonSkin.class.getResource("…")
    - This fails on attempt to access internal class (which has since moved anyway)
  - Currently in 9-dev, locates the "root" of jfxrt.jar from public class
    - Control.class.getResource("Control.class").toExternalForm()
    - Strips off "javafx/scene/control/Control.class"
    - Appends the internal path to modena.css
    - This fails because of resource encapsulation

JavaFX Sample Applications: Modena

- As mentioned earlier, application can no longer get at internals
  - This is a good thing: it stops apps depending on implementation details

- Problem: Reads internal css to test different color themes
- Solution: Use public API to load the unmodified css files
  - No longer need to read the contents of the css files

JavaFX Sample Applications: 3DViewer

- Eliminated deprecated builders

- Removed use of internal APIs
  - Used com.sun.geometry.* for some geometric computation
  - Necessary geometry utility classes now imported into application
  - Removed use of performance tracker

JavaFX Modularity: Impact on Applications

- All applications need to check and avoid:
  - Use of any JavaFX com.sun.* package
    - Many already have a public replacement
  - Access to any JavaFX resources (e.g., modena.css)
  - Use of deprecated builders (already gone in JDK 9)
- If you want to modularize your application, you also need to avoid:
  - Using ClassLoader.getResource (use Class.getResource instead)
  - Passing a “classpath-relative” URL string for resources in your module into CSS, FXML, WebView, etc.
    - Don’t do this: scene.getStyleSheets().add("/path/to/my/resource/resource.css");

Modular JDK with JavaFX: Availability

- Download early access builds from java.net
  - https://jdk9.java.net/jigsaw/
  - Includes JavaFX modules

- Source code for JDK Jigsaw prototype is here:
  - http://hg.openjdk.java.net/jigsaw/jake
- Source code for JavaFX Jigsaw protype is here:
  - http://hg.openjdk.java.net/openjfx/sandbox-9-jake/rt

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