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Modules in Nashorn

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Agenda

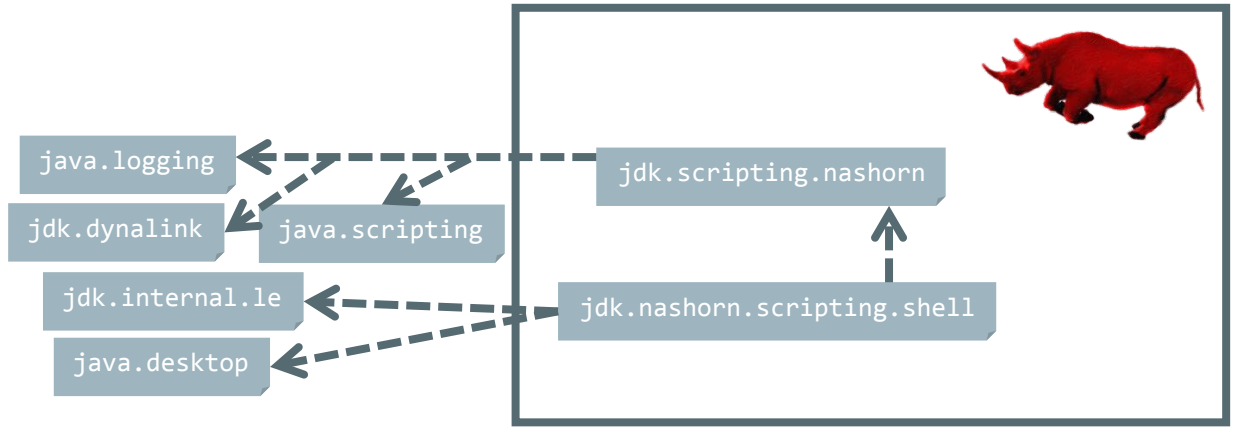
1. Nashorn Background
2. Class Loaders in Nashorn
3. Dynamic Modules in Nashorn
4. Cross-Layer Module (Qualified) Exports and Reads

What is Nashorn?

- ECMAScript 262 Edition 5.1 compliant script engine in JDK 8+
- Partial support for ECMAScript 6
  - See JEP 292 for details: http://openjdk.java.net/jeps/292
- Both programmatic access and command line `jjs` REPL
- Unix shell-like constructs as language extensions in `-scripting` mode
- Java API access from scripts
- Fine-grained security for scripts
- “compact1” compliant

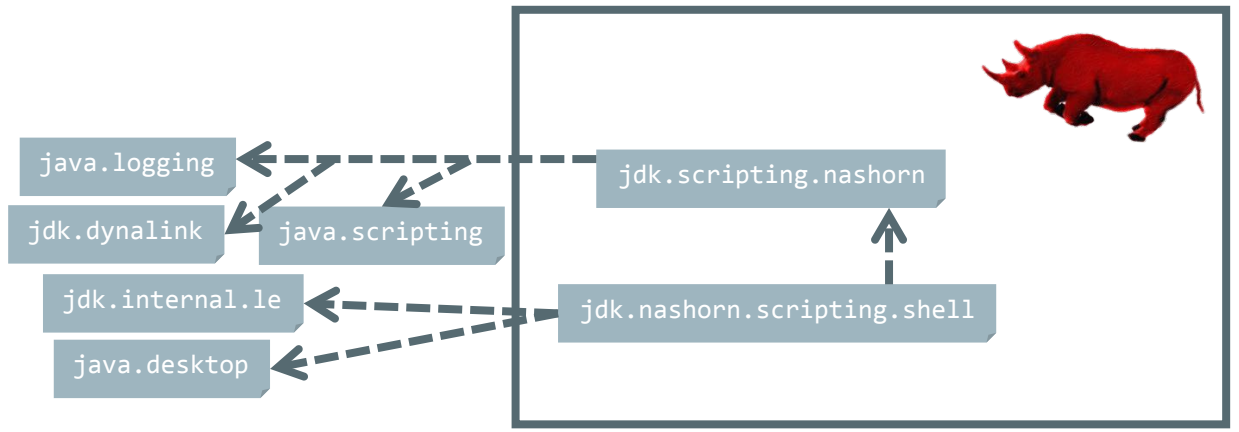
Nashorn Modules

- `jdk.scripting.nashorn`: “Nashorn module”
  - Depends only on `java.scripting`, `jdk.dynalink`, and `java.logging`
  - Provides `javax.script.ScriptEngineFactory`
  - Provides and uses Dynalink linker services
  - “compact1” compliant



Nashorn Modules

- `jdk.nashorn.scripting.shell`: "`jjs` module"
  - Nashorn `jjs` tool source code
- `jdk.dynalink`: "Dynalink module"
  - Independent module
  - Lives in Nashorn repository for historical reasons
  - Dynalink used to be an internal detail of Nashorn in JDK 8
  - Independent API in JDK 9 (JEP 276)



Nashorn Background

- No interpreter, compilation to bytecode only
- Uses JDK-internal ASM for ECMAScript compilation (class files)
- Almost 100 % `INVOKEDYNAMIC` for basic operations
  - Runtime calls are statically linked (e.g., == ➔ `ScriptRuntime.EQ`)
- Dynalink for `INVOKEDYNAMIC` call site bootstrap methods

Nashorn APIs

`jdk.nashorn.api.tree` API
- Parser API
- Similar to javac tree API for ECMAScript (JEP 236)
- Full ES6 support

`jdk.nashorn.api.scripting` API
- Additional API "missing" in `javax.script`
- Script object reflection: `ScriptObjectMirror`
- `JSObject`: user-defined "script-friendly" objects implemented in Java

`jdk.nashorn.api.linker` package
- Nashorn's own Dynalink linker exported as a service for other JVM languages
- JRuby or Groovy could use Dynalink and provide tight integration with Nashorn

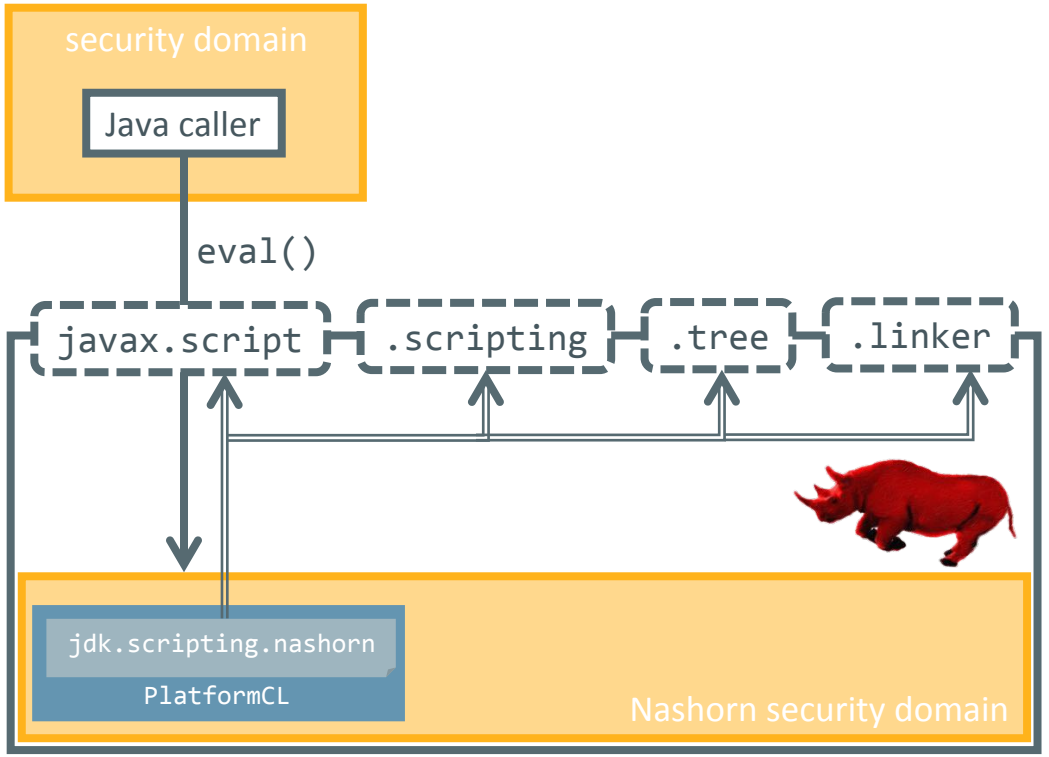
`javax.script` API (JSR 223)

Nashorn Java Integration

- Tight Java integration
  - Access to public members of public classes from JavaScript code
  - Access checks for restricted / exported packages
  - Lambdas as script functions and script functions as lambdas
- No Java reflection and `java.lang.invoke` access from scripts by default
  - Nashorn-specific reflection permission check
- `Java.extend` API to subclass Java classes and implement interfaces
  - Nashorn "adapter classes" generated for Java subclasses and interface implementations
  - Cannot use `java.lang.reflect.Proxy`, special support for `@CallerSensitive`
  - Subclassing support, `INVOKEDYNAMIC` generation for calls
  - Access to Nashorn runtime from adapters for internals

Nashorn Security

- Script sandbox
  - For scripts loaded via `ScriptEngine.eval()` methods
  - Java caller permissions not inherited by scripts
- Nashorn module
  - Assigned to platform class loader
  - Given `AllPermission`
- Fine-grained URL-based script permissions for scripts loaded via ...
  - `load`, `loadWithNewGlobal` builtins
  - `jdk.nashorn.api.scripting.URLReader`



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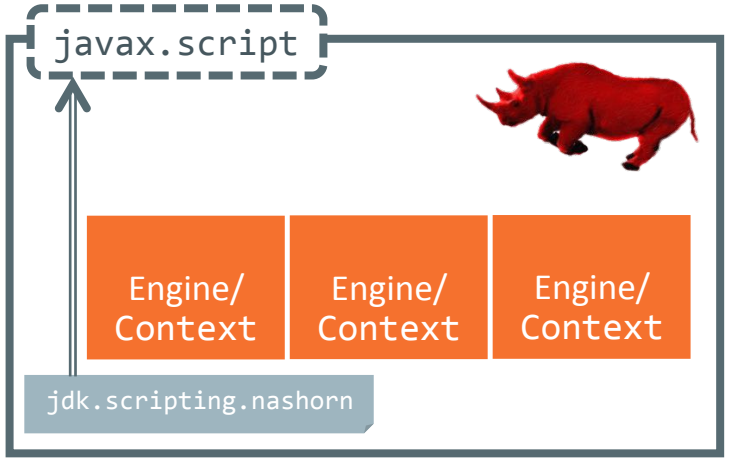
2. Class Loaders in Nashorn
3. Dynamic (Run-Time) Modules in Nashorn
4. Cross-Layer Module (Qualified) Exports and Reads

Nashorn Background

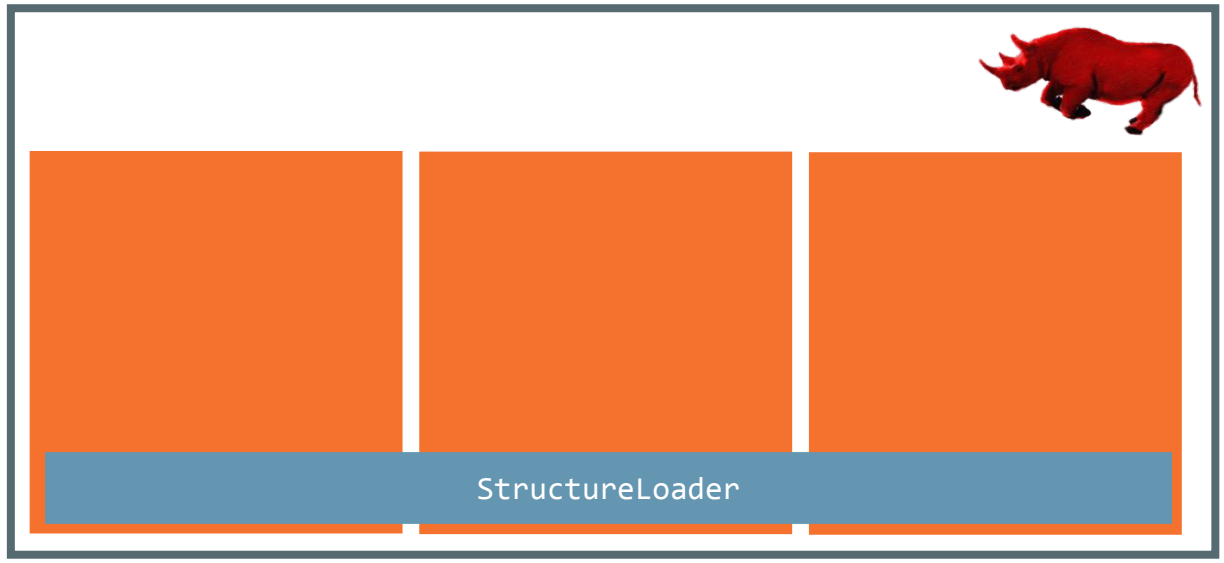
- `jdk.nashorn.internal.runtime.Context`
  - Isolation between multiple Nashorn “instances”
  - Manages configuration options, class loaders, script access to Java classes, compilation and loading of entry points
- `javax.script` API (JSR 223)
  - Supported for programmatic access
  - 1:1 correspondence between `NashornScriptEngine` and Nashorn `Context` instances



Class Loaders in Nashorn

`jdk.nashorn.internal.runtime.StructureLoader`

- Single instance per process
- Generates and loads “struct” classes
  - A bunch of `Object`/`double` fields
  - To store data for JS objects
- Shared across multiple Nashorn `Contexts`
  - Consequently, across multiple Nashorn `ScriptEngines`

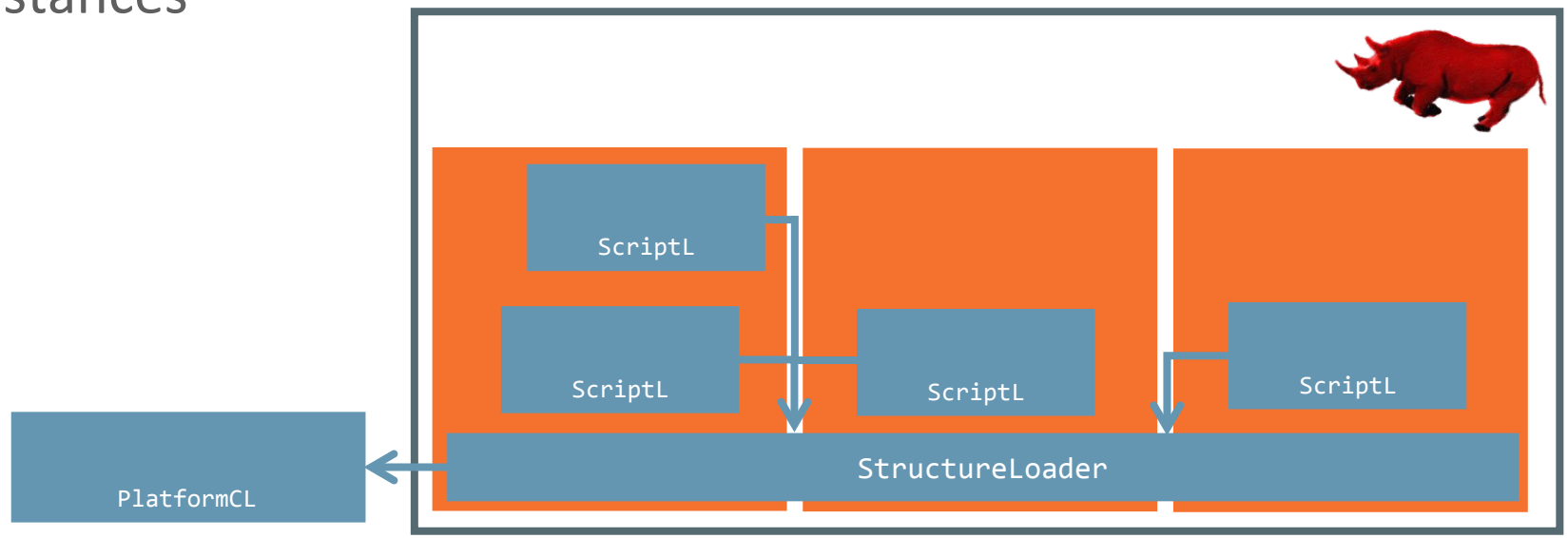


Class Loaders in Nashorn

`jdk.nashorn.runtime.internal.ScriptLoader`

- Loads one or more compiled script classes
- Fine-grained or one per Nashorn `Context`
  - Default is *fine-grained* (one per script)
  - Many `ScriptLoader` instances per `Context`
- Delegation chain
  - `ScriptLoader` → `StructureLoader` → platform loader

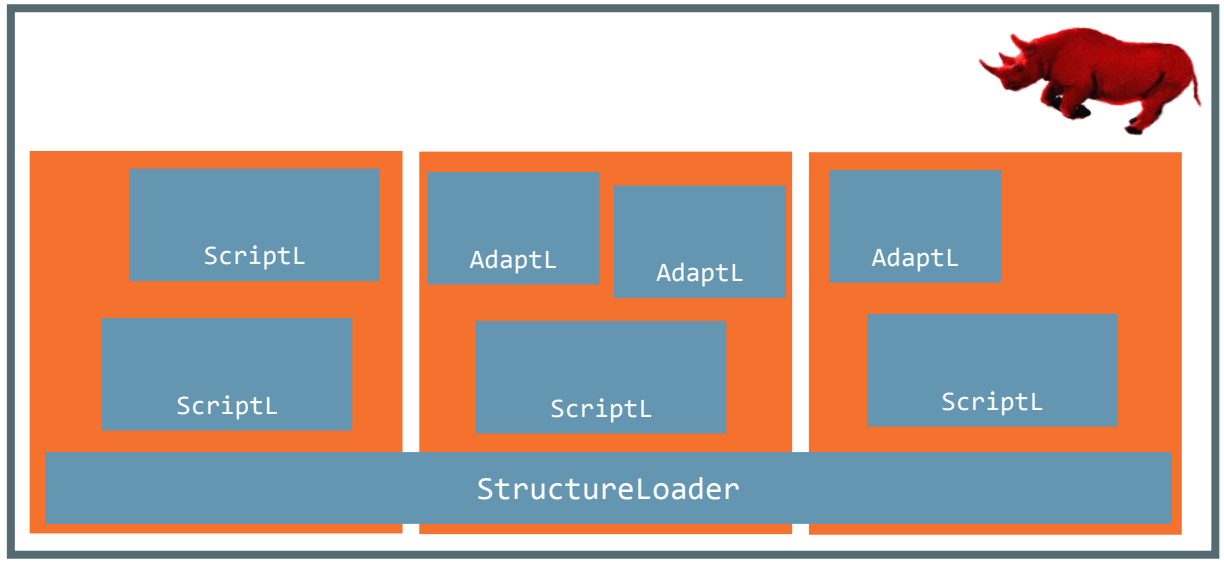
- Some script classes are loaded via `Unsafe.defineAnonymousClass()`
- A `ScriptLoader`-loaded class is used as host class
- This proves to be very effective in `eval` and/or recompilation-intensive scripts



Class Loaders in Nashorn

`jdk.nashorn.internal.runtime.linker.JavaAdapterClassLoader$...`

- Used to load Java interface implementations and Java subclasses implemented in scripts
- One class loader instance per super type combination
- Delegation chain
  - Parent loader must be able to see all types in implemented super type, and should see Nashorn runtime classes (e.g., `ScriptObject`)
  - Loader is chosen accordingly, e.g., thread context loader



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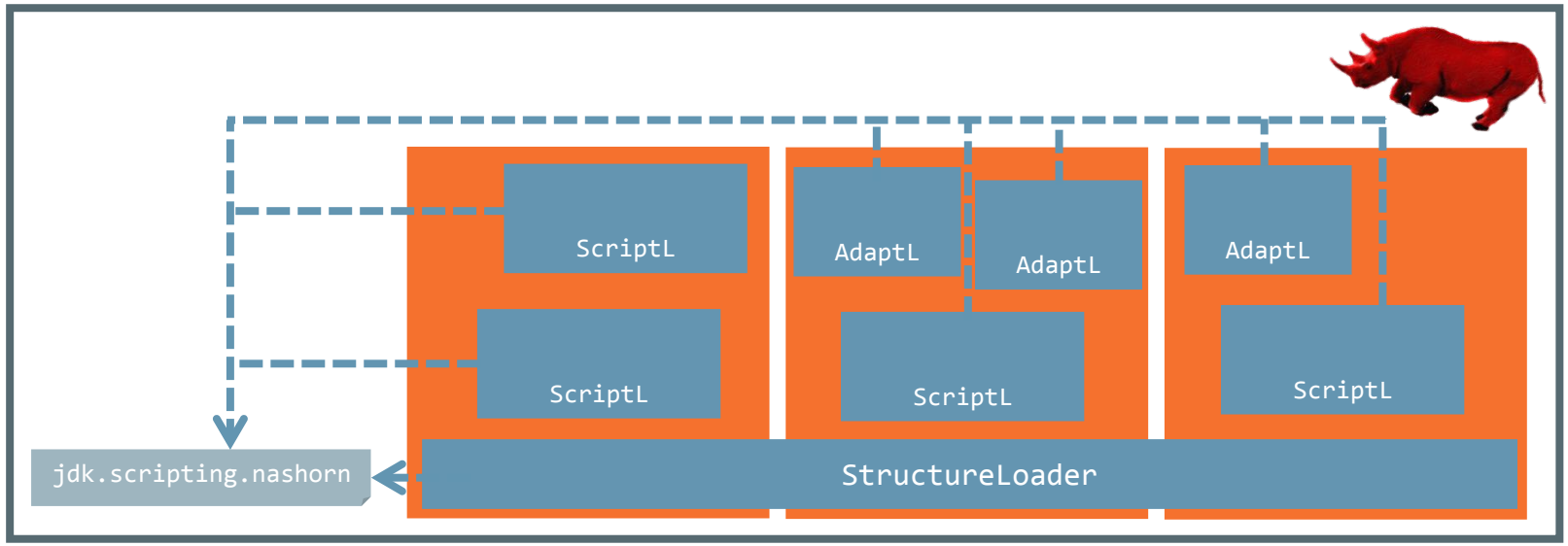
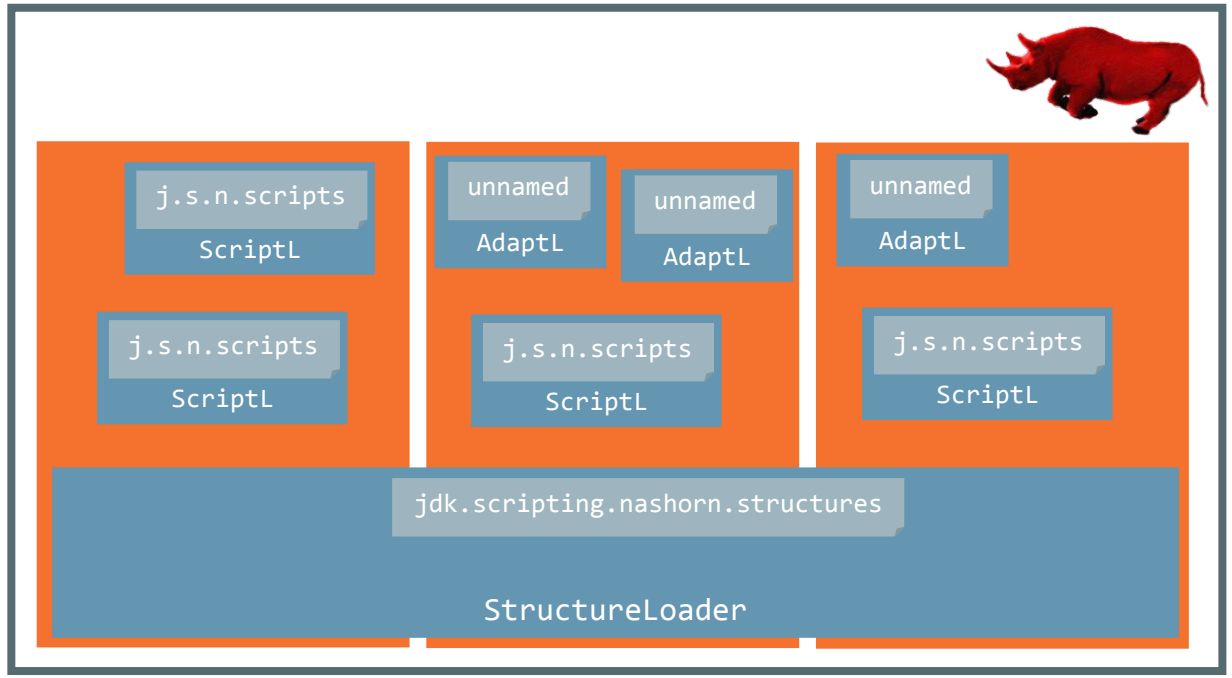
Why Dynamic Modules?

- Nashorn module only exports `jdk.nashorn.api.*` packages
- Access to Nashorn internals required by compiled script classes, generated "struct" classes, Java adapters
- Generated code should be accessible from Nashorn runtime (only) as well
- Default unnamed modules for generated classes are not enough



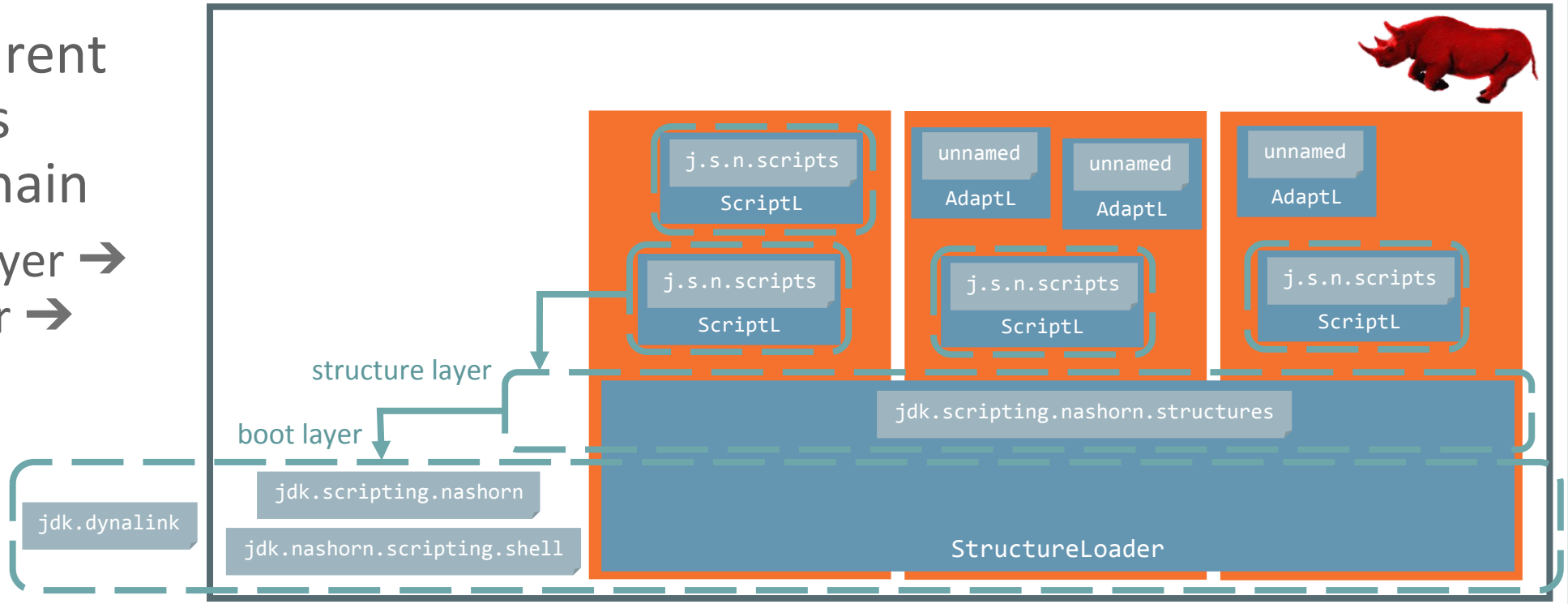
Dynamic Modules in Nashorn

- Dedicated dynamic *named* modules
  - For the `StructureLoader`: `jdk.scripting.nashorn.structures`
  - For `ScriptLoaders`: `jdk.scripting.nashorn.scripts` (per loader)
- Each adapter loader has its own dynamic *unnamed* module



Dynamic Modules in Nashorn

- Nashorn source modules live in boot layer
  - Boot layer configuration cannot be modified
  - `java.lang.reflect.Layer` API is used to create single-module layers
- Layer child/parent chain matches class loader chain
  - Some script layer ➔ structure layer ➔ boot layer



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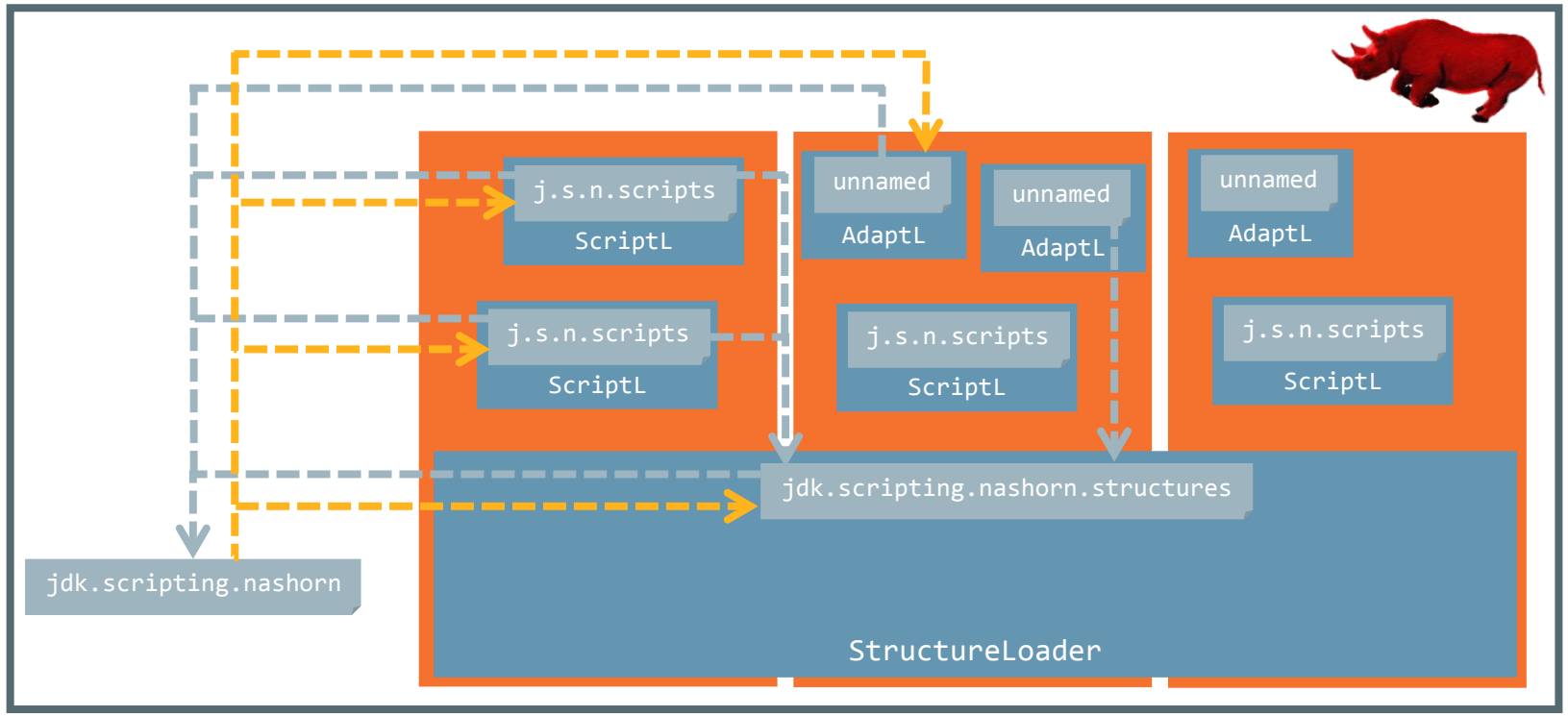
Access Control in Nashorn

- JDK 8(u)
  - Nashorn uses package access runtime permission checks to implement access restrictions
  - All Nashorn packages except `jdk.nashorn.api.*` packages are `package.access` permission checked
- In JDK 9, dynamic named modules are used to enforce internal Nashorn access to generated/compiled code and vice versa

Access Control in Nashorn

- Characteristics
  - Each Java adapter loader has its own dynamic *unnamed* module
  - Script loaders and structure loader have their own dynamic *named* modules
- Rules
  - Nashorn runtime needs access to scripts/structs/ adapters and vice versa
  - Scripts and adapters need access to structs
  - No access between different script modules

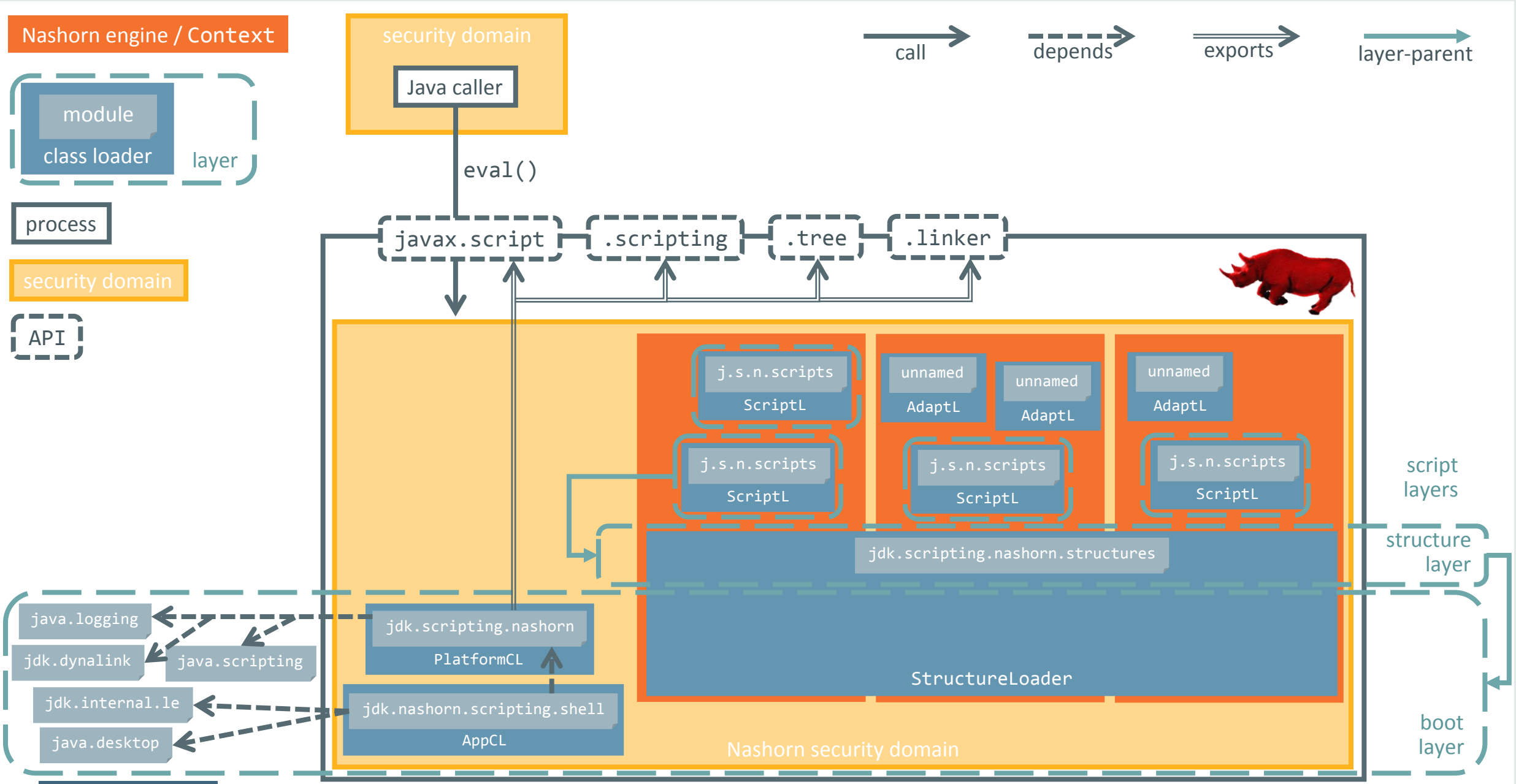


Managing Read/Export Edges

- Enabling access
  - While core reflection can ignore the module graph, method handles cannot
  - As Dynalink uses method handles, we have to enable the desired access patterns by adding the required read/exports edges in the module graph.
- `java.lang.reflect.Module.addReads/addExports`
  - To manage module graph edges between modules
  - Both `StructureLoader` and `ScriptLoader`(s) load `ModuleGraphManipulator` whose `<clinit>` code (qualified) exports package to Nashorn module
- Nashorn module
  - (Qualified) exports select `jdk.nashorn.internal.*` packages to generated code via `Module.addExports()`
  - Adds read links to generated modules to be able to create method handles

Managing Read/Export Edges

- Java adapter loaders need no explicit read/export edges
  - Unnamed modules implicitly read all other modules / export all public types
  - There is only one package with a public class in an adapter loader
- Qualified exports to unnamed modules
  - `namedModule.addExports("com.acme.internal", unnamedModule)`: qualified exports from Nashorn module to unnamed adapter module
  - Avoids having to add "read" links from adapter module to other referenced modules



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