JVM Tool Interface (JVM TI)

Implementation in HotSpot

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JVM TI Implementation – Overview

- Implementation issues
- HotSpot implementation layers
- Implementation details
- Q & A

Implementation Issues

- Capabilities
- Early start-up
- Multiple environments
- Retransformation / Redefinition

Implementation Issues: Capabilities

- Agent requests what capabilities it wants
- Allows pay-for-what-you eat
- Allows implementation subsets
- Capabilities change VM configuration:
  - interpreter, compiler, ...
- Dynamic configuration?

```
can_tag_objects
can_generate_field_modification_events
can_get_owned_monitor_info
can_pop_frame
can_redefine_classes
```

Implementation Issues: Early start-up

- JVM TI agents start before VM initialized
- JVM TI events can be sent before main()
- VM in delicate states
- Allows VM configuration

Implementation Issues: Environments

- Each has its own JVM TI environment
- Can be multiple environments in one VM
- Each with its own capabilities, events, state, ...
- Hidden from VM Core

Implementation Issues: Redefinition

- Class redefinition allows an agent to replace the definition of an already loaded class
- Class retransformation allows an agent to transform an already loaded class
- Retransformation added in JDK6
- Used for bytecode instrumentation

Implementation: Layers

- User agent
  - JVM TI
- JVM TI View
  - jvmtiEnv.hpp
- JVM TI Implementation
  - jvmtiExport.hpp
- VM Core

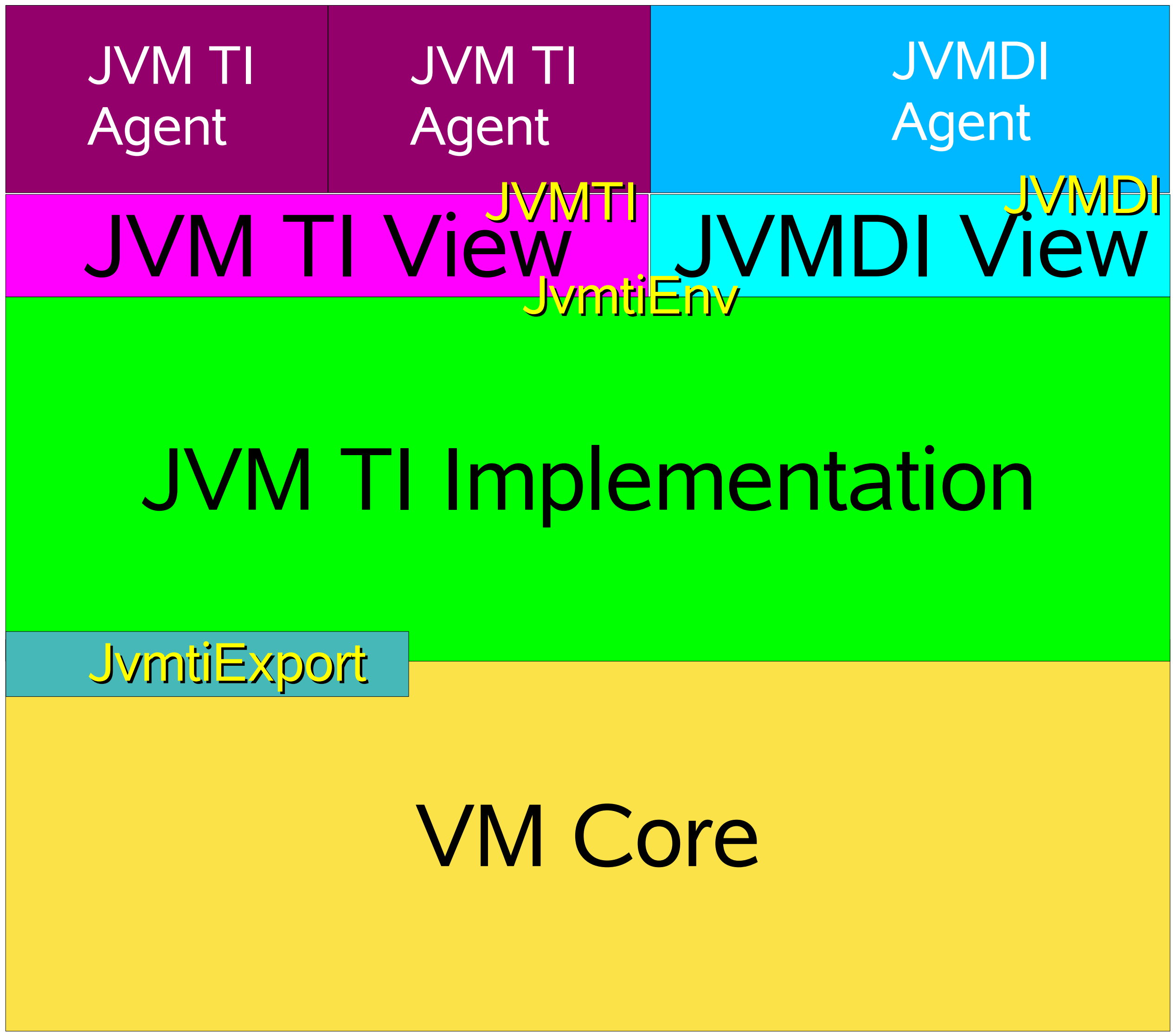
Implementation: Layers – JVM TI View

- Transitions from JVM TI (external C interface)
- To HotSpot implementation of JVM TI
  - HotSpot types
  - C++ calls
- Both interfaces and transition code generated
  - jvmti.h (JVM TI standard interface – C-interface)
  - jvmtiEnter.cpp (transition code)
  - jvmtiEnv.hpp (interface to HotSpot implementation)

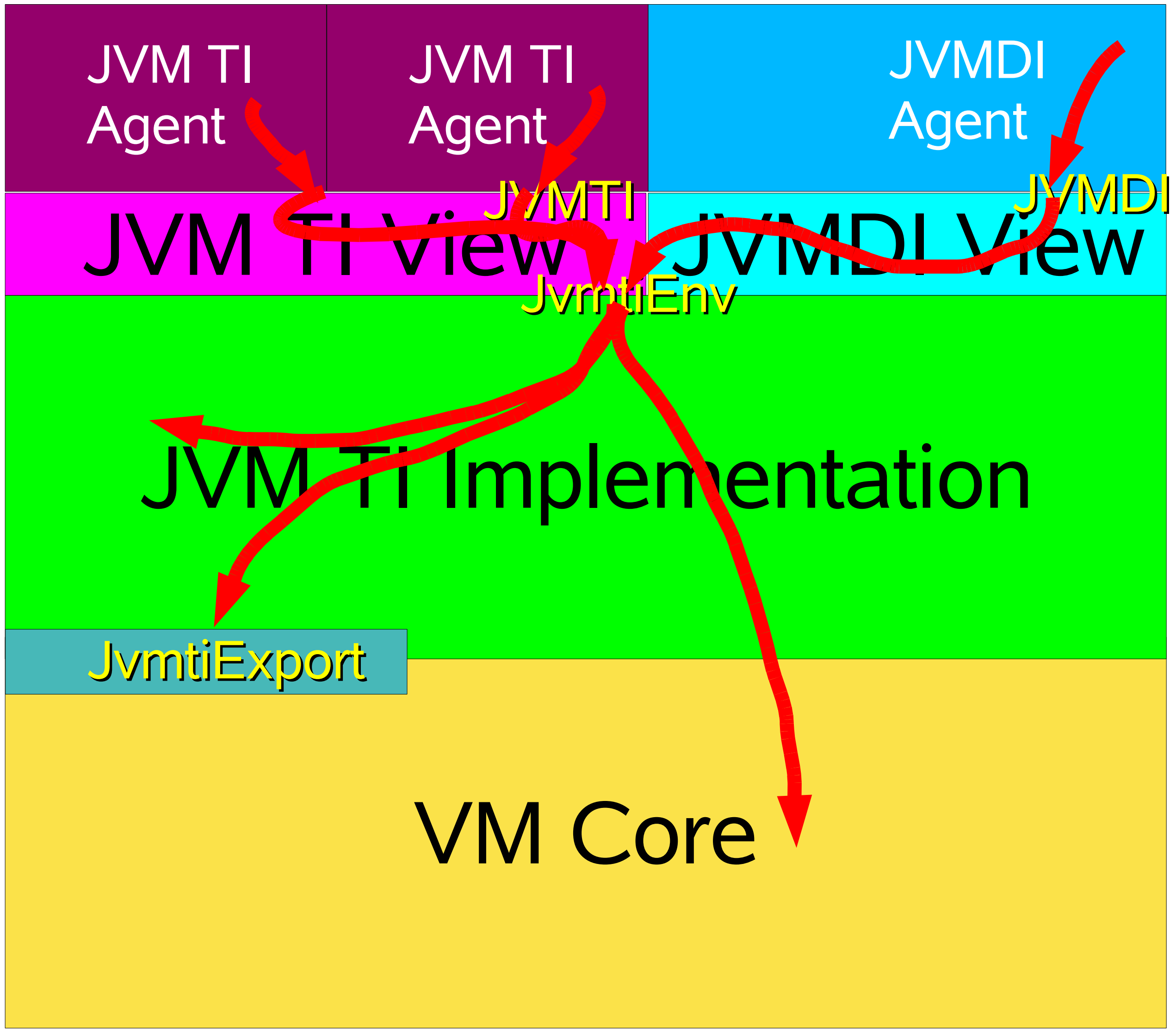
Implementation: Layers - jvmtiExport

- Communicate from JVM TI to the VM Core
  - Information that will be needed (capabilities)
    - Thus what to preserve
  - Which events to send
- Send events from the VM Core
- Shield JVM TI internals from VM Core

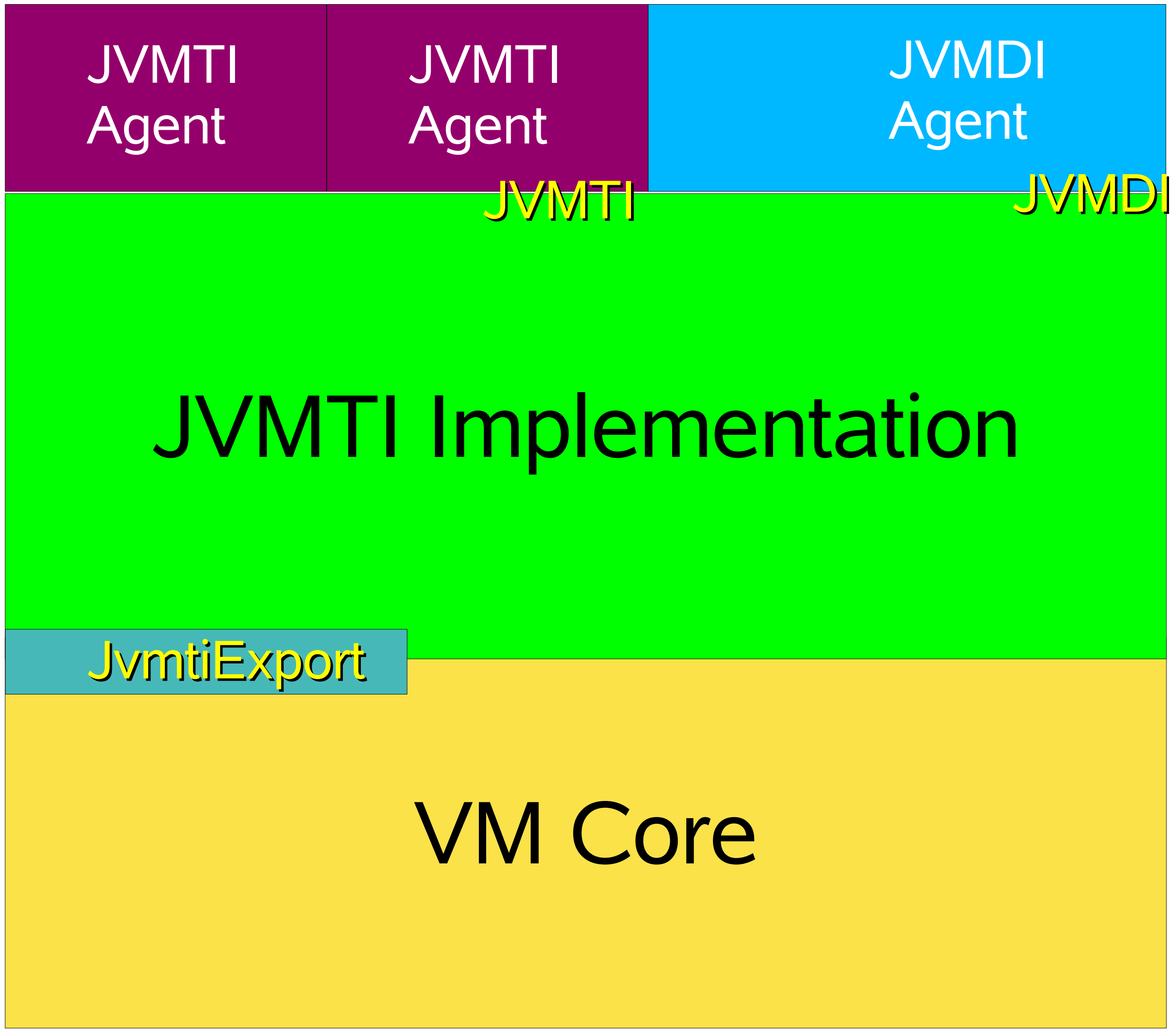
Function Architecture



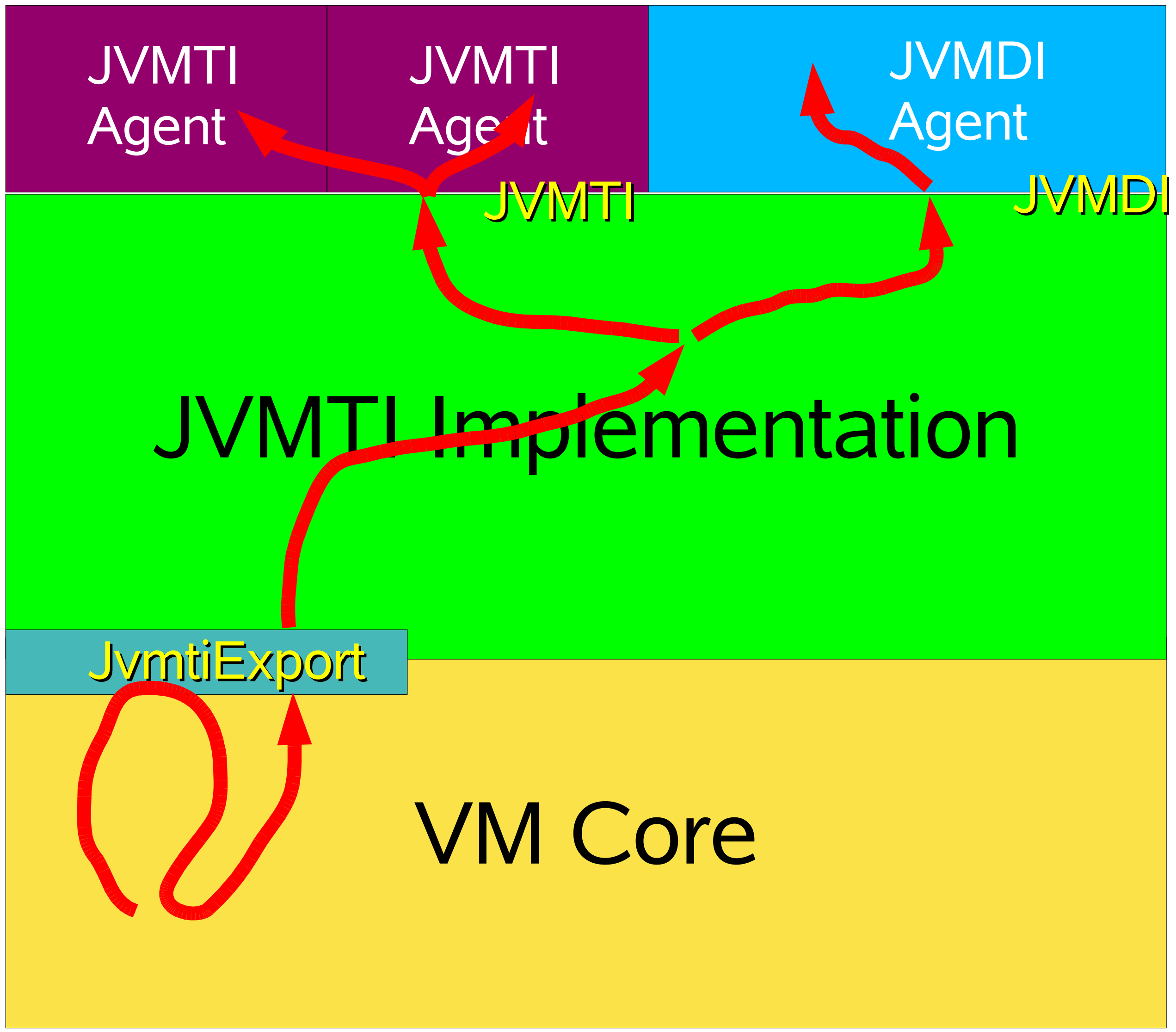
Function Flow



Event Architecture



Event Flow


JVMTI Agent
JVMTI Agent
JVMDI Agent
JVMTI
JVMDI
JVMTI Implementation
JvmtiExport
VM Core

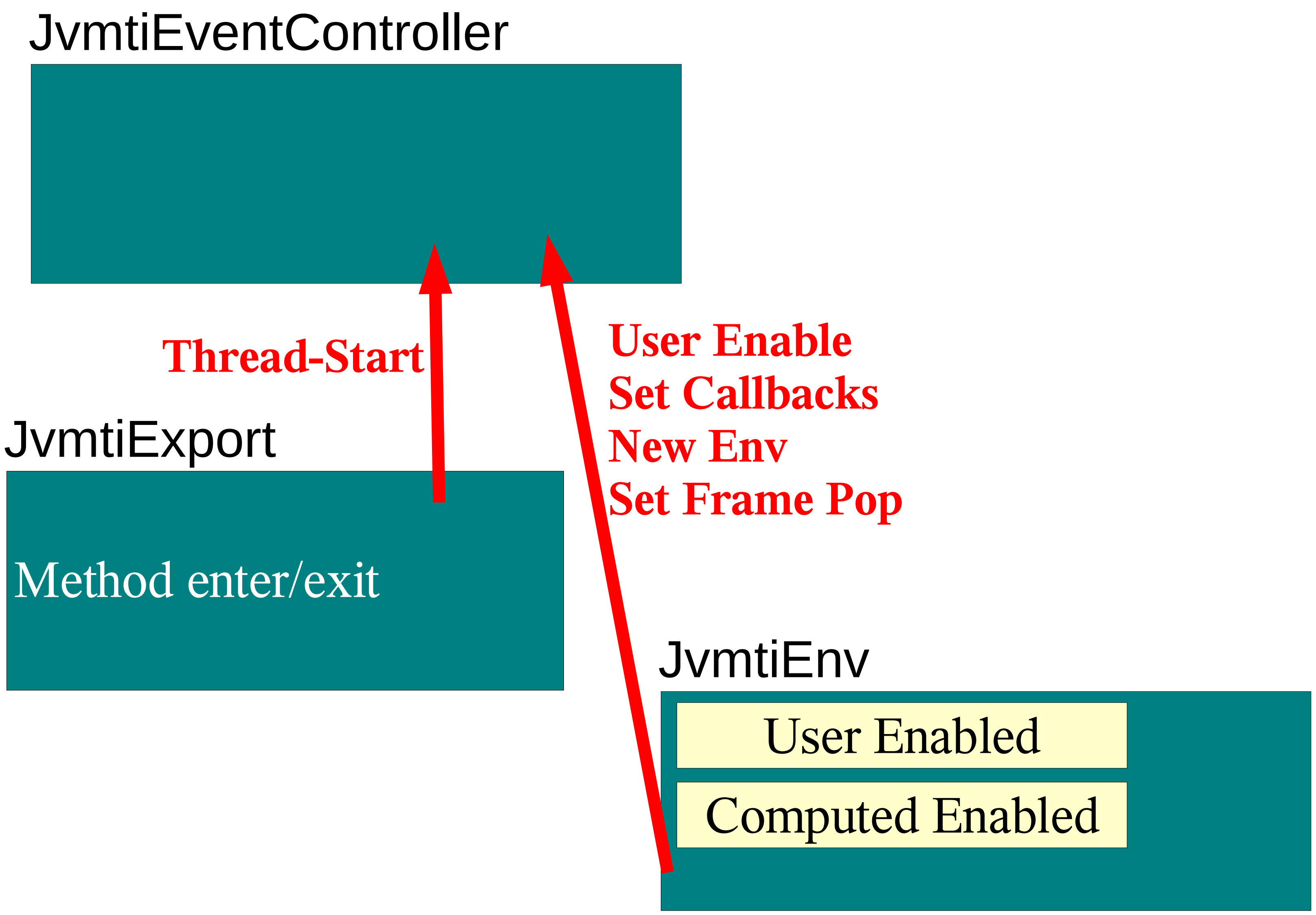
Implementation Details

- Threads and Environments
- Event Controller
- Generated Code
- Some interesting source files:
  - jvmtiRedefineClasses.cpp
  - jvmtiClassFileReconstituter.cpp
  - jvmtiTagMap.cpp

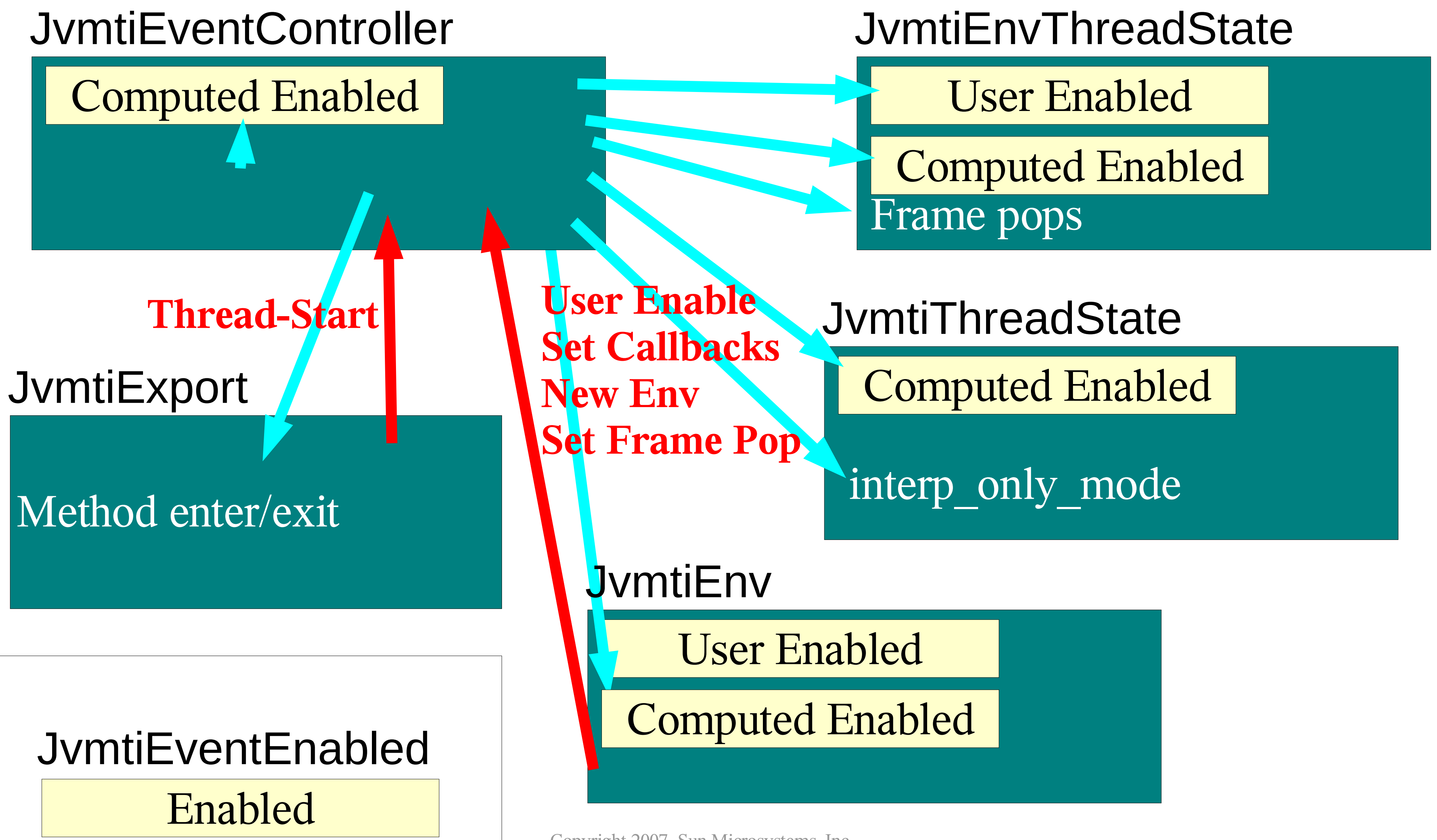
Thread / Environment Data

	Per Thread	All Threads
Per Environment	**`JvmtiEnvThreadState`** Per thread enablement Frame pop info	**`JvmtiEnv`** Global enablement Event handlers Capabilities
All Environments	**`JvmtiThreadState`** Interpret only mode Current stack depth	***All other classes/data*** *… everything else …*

Event Controller



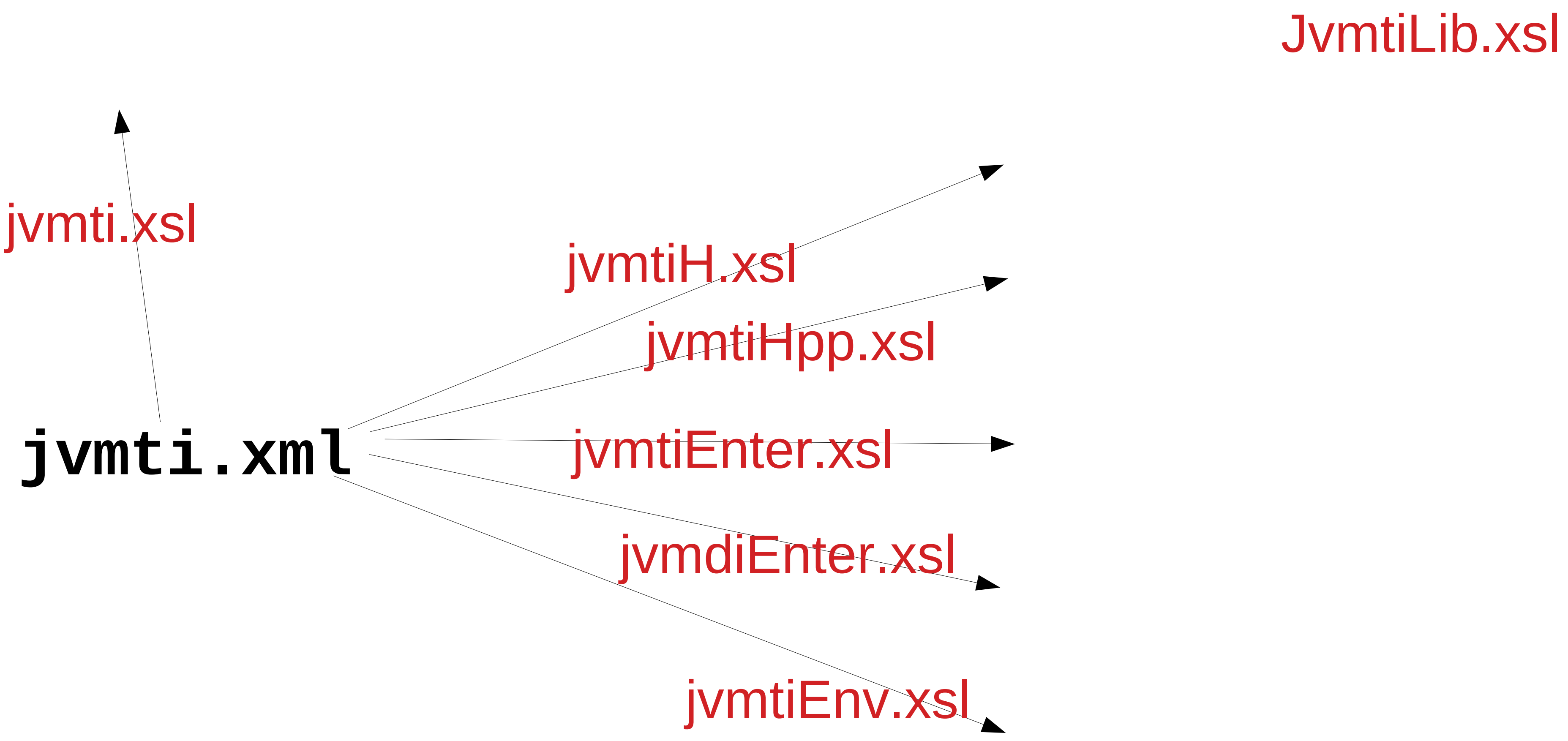
Event Controller



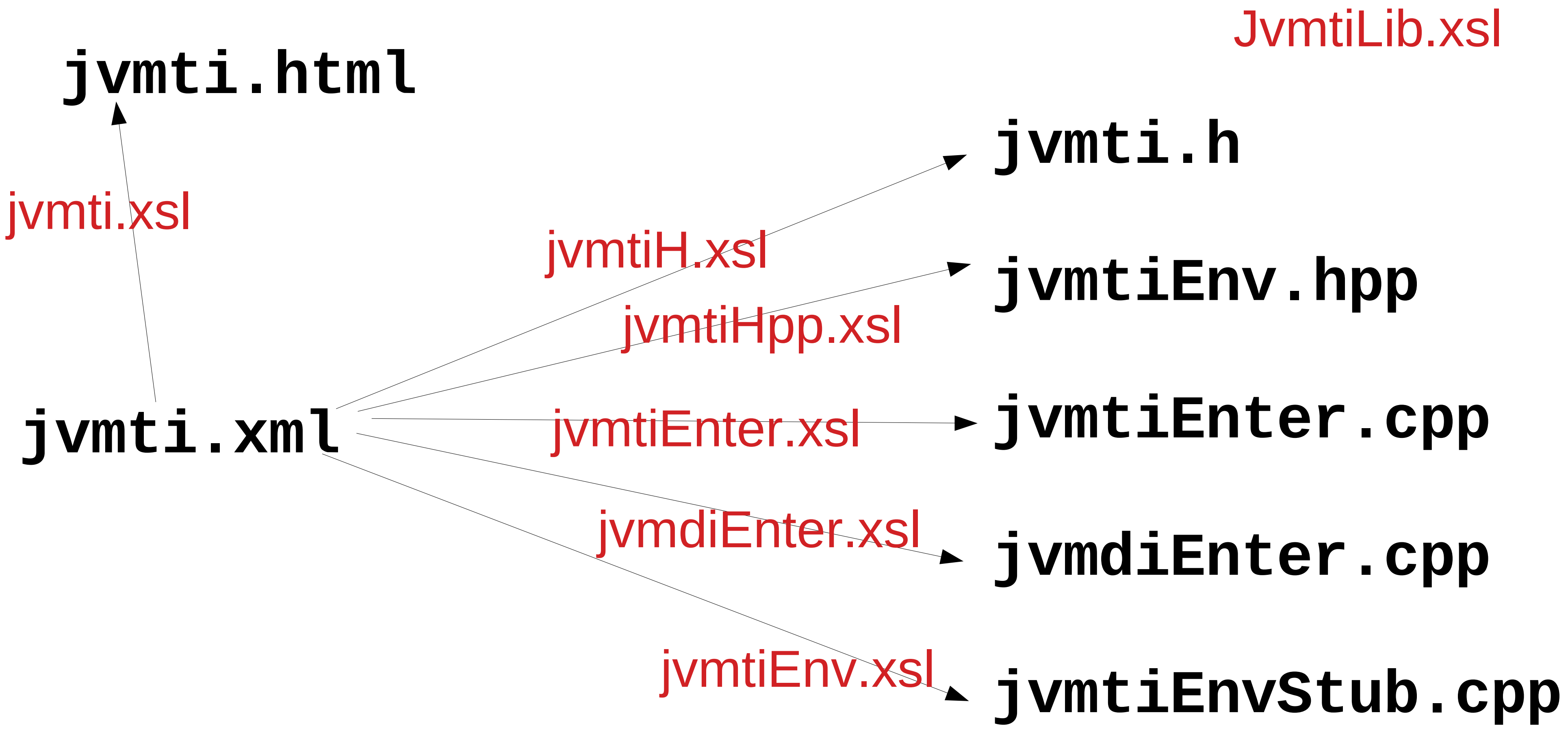
Generated Code: Originates from Spec

`jvmti.xml`

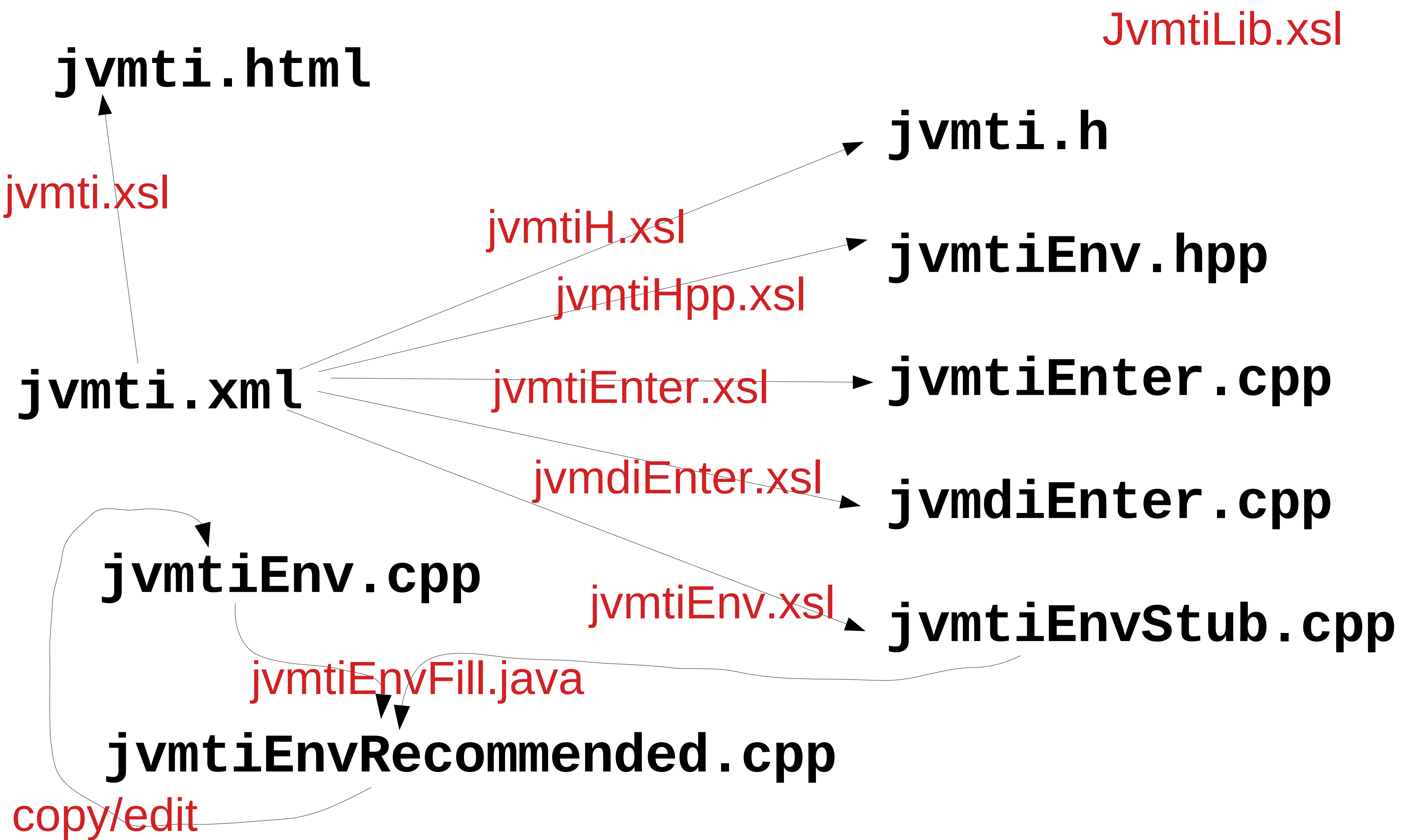
Generated Code: Generated by XSL



Generated Code: Interfaces, Code, Doc



Generated Code: Stubs filled



jvmtiRedefineClasses.cpp

- Implemented as VM_Operation
- Used by both RedefineClasses and RetransformClasses
- Dan Daugherty owns this now
- Rocket science
- See doc in jvmtiRedefineClasses.hpp

jvmtiClassFileReconstituter.cpp

- Retransformation uses the redefinition code
- But first, HotSpot data structures must be converted to a class file

jvmtiTagMap.cpp

- Implements heap functionality (heap iteration and walks)
- JVM TI heap functionality identifies objects by user supplied tags
- jvmtiTagMap.cpp maps oops to JNI weak ref and tag

jvmtiManageCapabilities.cpp

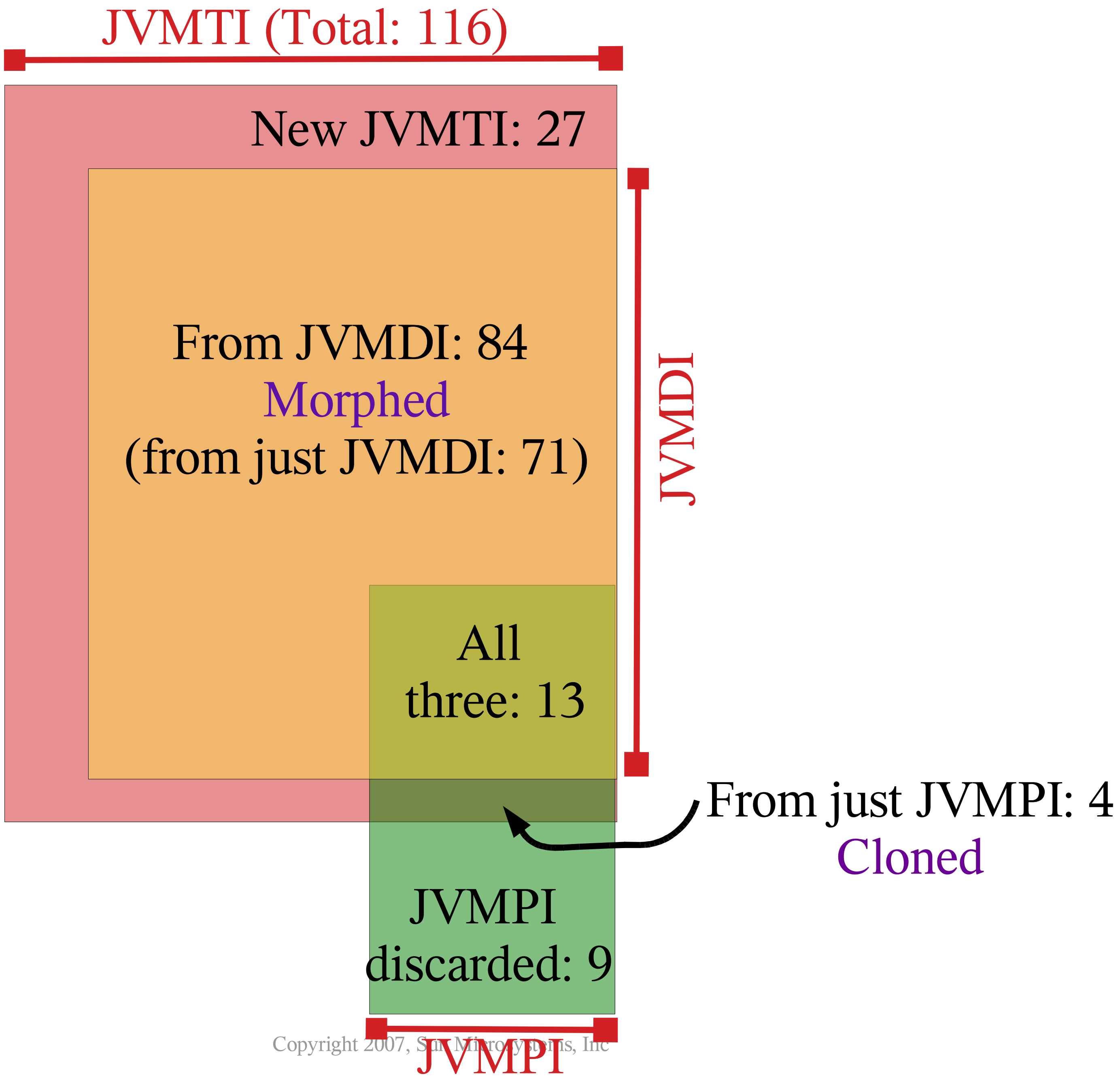
- Checks availability of requested capabilities
- Merges with other environments
- Converts capabilities to JvmtiExport flags

```
JvmtiExport::set_can_post_exceptions(
  avail.can_generate_exception_events ||
  avail.can_generate_frame_pop_events ||
  avail.can_generate_method_exit_events);
```

JVM TI – Implementation in HotSpot

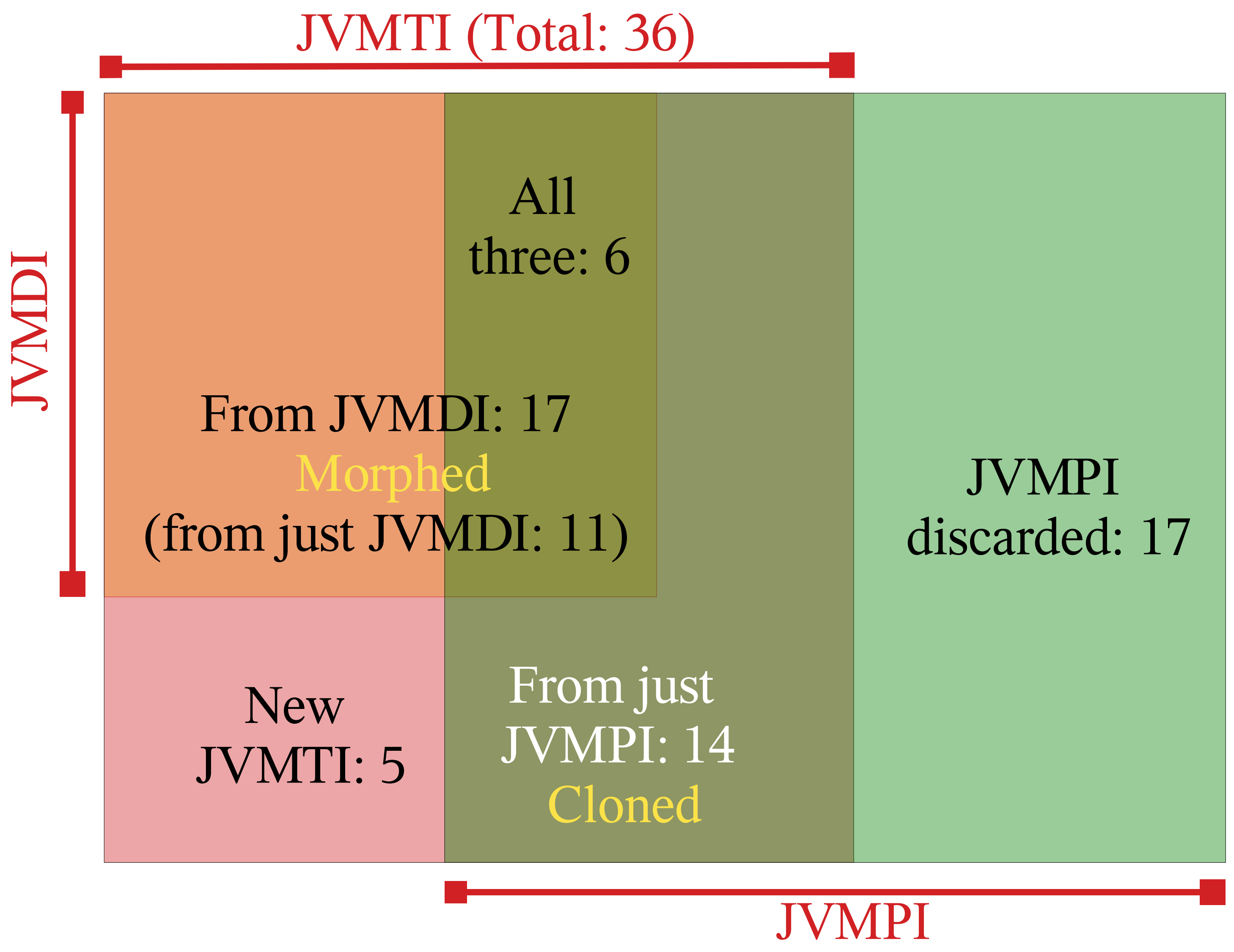
Q & A

Function Origins



To Scale

Event Origins



To Scale