OVM
lessons learned

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NSF/HDCP - Assured Software Composition for Real-Time Systems

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Darpa's Goal: Fly Boeing's UAV

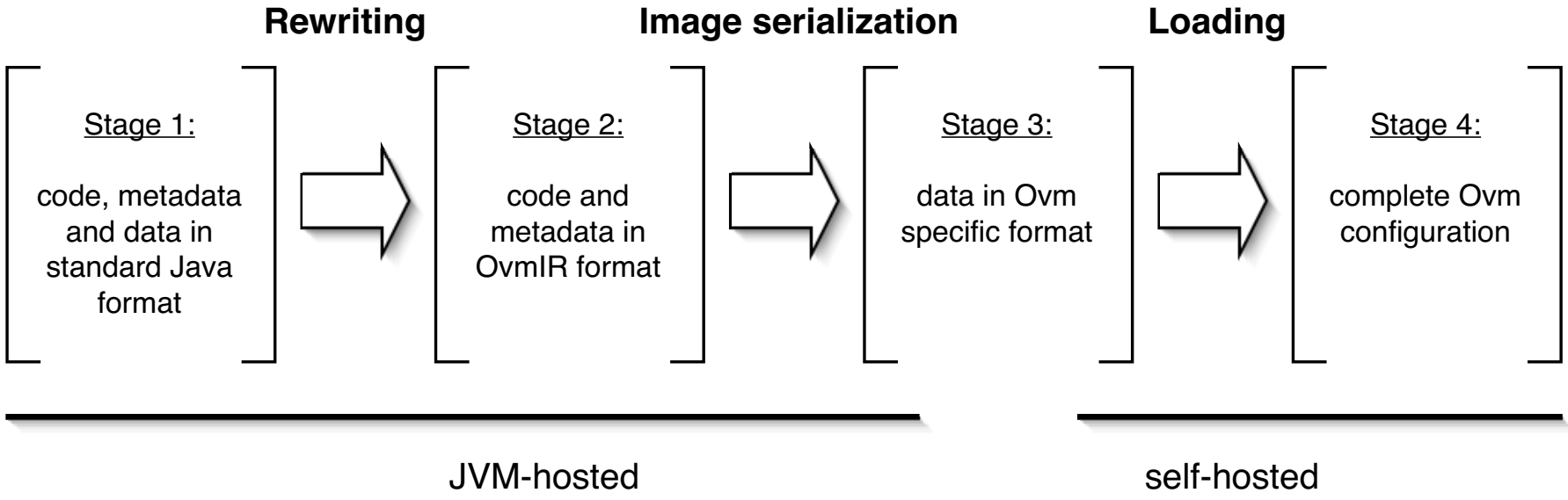
- Our mission:
  implement a Real-time Specification for Java compliant VM
- Only other RTSJVM was an interpreter & proprietary
- Target is avionics software for the Boeing/Insitu ScanEagle UAV

A Configurable Open VM

- A clean-room implementation
- *Internal project goal:*
  open source framework for language runtime systems
- A Java-in-Java VM
- 150KLoc of Java, 15Kloc of C code
- GNU classpath libraries + our own RTSJ implementation

Build Process

- Bootstrapped under Hotspot
- Configuration and partial evaluation
- Generate an executable image (data+code)
- IR-spec + interpreter generation



Lessons

- JavaInJava
  - anecdotal evidence of lower bug rates
  - same optimizing compiler for VM & user code
  - fewer cross-language calls

```
public Oop updateReference(MovingGC oop) {
  int sz = oop.getBluepqrint().getVariableSize(oop);
  if (sz >= blockSize) {
      movedBytes += sz;
      VM_Word off = VM_Address.fromObject(oop).diff(heapBase);
      int idx = off.asInt() >>> blockShift;
      block.pin(idx);
      return oop;
  } else {
      VM_Address newLoc = getHeapMem(sz, false);
      Mem.the().cpy(newLoc, VM_Address.fromObject(oop), sz);
      oop.markAsForwarded(newLoc);
      return newLoc.asOop();
  }
```

Ovm Configurations

execution engine	aot / jit / interp	
static analysis	off / CHA / RTA	
fast locks	on / off	
memcopy	fast / bounded-latency	
I/O system	SIGIOSocketsPollingOther (Profiling) / SIGIOSockectsStallingFilesPolling	SelectSocketsPollingOther SelectSocketsStallingFiles-PollingOther
threading	java / realtime / profiling	pip / time preemptive
transactions	on / off/ profile	
object/mem models	AllCopy:B-M-F-H	MostlyCopyWB:B-M-F-H
	MostlyCopySplitRegions:B-Mf-F-H	JMTk:B-M-J-H
	MostlyCopyWB:B-Mf-F-H	MostlyCopy:B-M-F-H
	MostlyCopyRegions:B-M-F-H	SimpleSemiSpace:B-M-F-H
	MostlyCopyingRegions-B_Mf_F_H	minimalMM-B_0M
	MostlyCopyingSC-B_M_F_H	minimalMM-B_M
	minimalMM-B_M_J_H	

Lessons

- Configuration mechanisms
  - ☑ Interfaces and inheritance are not sufficient (we have 3371 classes and ~450 interfaces)
  - ☑ AOP should be revisited
  - ☑ Component systems such as Jiazzi, Scala...
  - ☑ We rolled our own...

Lessons

- Configuration mechanisms, example transactions:
  - Implementing a form of transactional memory in Ovm takes about ~1200 lines code.
  - Changes to the sources of the VM, ~40 lines in 34 different places, e.g.:

```
void runThread(OVMThread t) throws PragmaNoPollcheck{
  boolean aborting =
   Transaction.the().preRunThreadHook(thisThread, t);
  setCurrentThread(t);
  Processor.getCurrentProcessor().run(t.getContext());
  ...
  Transaction.the().postRunThreadHook(aborting);
```

Lessons

```
boolean aborting =
 Transaction.the().preRunThreadHook(thisThread, t);
```

- Generated C code

```
jboolean _stack_2 =
 S3Transaction_preRunThreadHook(e.roots->vals[97]),
                                _stack_0, _stack_1);
```

- Stitcher specification

```
# Select an implementation of the transactional API described in the
# Preemptible Atomic Region paper. EmptyTransaction gives the
# default behavior. S3Transaction is the real thing.
s3.services.transactions.Transaction \
                s3.services.transactions.S3Transaction
```

Lessons

- Domains
  - Separation is necessary
  - one Executive and possibly multiple User domains
  - Each domain can have it's memory manager, scheduler, class libraries, and even object model
  - opaque types
  - cross domain accesses are reflective
  - enforced by the type system -- requires Object *not* to be builtin
  - special handling of exceptions crossing boundaries

Lessons

- GCC as a backend
  - ☑ offload low-level optimizations
  - ☑ cross-platform portability
  - ☑ using C++ exceptions is suboptimal
  - ☑ inlining can lead to bloat and long compile times
  - ☑ No precise GC ... but working on it.

Lessons

- Cooperative Scheduling
  - ☑ OS-independent
  - ☑ Priority inversion avoidance (PIP/PCE) supported in a portable fashion and optimized by the compiler
  - ☑ but, we had to implement our own non-blocking I/O

```
# 291 "./s3/util/queues/Queue.java"
static jboolean Queue_isEmpty(queues_Queue * ovm_this){
        _pc0:;
        if (CHECK_EVENTS())  signalEvent();
```