The JDK Tools:
The Secret Weapons of the JVM

Yoel Spotts
yoel@cyspotts.net

March, 2015
DevNexus
Atlanta, GA

About Me

- 15 years experience
- Senior developer at Travel Syndication Technology (TST)
- blah, blah, blah

Acknowledgements

- Presentation by Staffan Larsen
  - http://www.slideshare.net/stalar/diagnosing-your-application-on-the-jvm
- Marcus Hirt's blog
  - http://hirt.se/blog/
- Oracle resources
  - http://docs.oracle.com/javase/8/docs/technotes/guides/troubleshoot/tooldescr.html
  - http://docs.oracle.com/javase/8/docs/technotes/tools/

Agenda

- Why
- Focus
- Connecting to the JVM
- Tools
- Demo

Why

- Helpful tools
- Deeper understanding of JVM
  - entry points
  - mechanics
- Understand UI tools

  visualvm, jconsole, JMC
- Helpful for all JVM languages

Focus

- Command line vs UI
  - Closer to bare metal
  - Sometimes, no access to UI
- Monitoring and troubleshooting
- Little to no setup

| 6

```
→  bin  ls -la
total 8072
drwxrwxr-x  46 root  wheel    1564 Dec 18 00:10 .
drwxrwxr-x  16 root  wheel     544 Dec 18 00:05 ..
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:09 appletviewer
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:09 extcheck
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 idlj
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 jar
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 jarsigner
-rwxrwxr-x   1 root  wheel   99312 Dec 18 00:10 java
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 javac
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 javadoc
-rwxrwxr-x   1 root  wheel    2293 Dec 17 17:49 javafxpackager
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 javah
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 javap
-rwxrwxr-x   1 root  wheel    2293 Dec 18 00:10 javapackager
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 jcmd
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 jconsole
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 jdb
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 jdeps
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 jhat
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 jinfo
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 jjs
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 jmap
-rwxrwxr-x   1 root  wheel     405 Dec 18 00:10 jmc
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 jps
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 jrunscript
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 jsadebugd
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 jstack
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 jstat
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 jstatd
-rwxrwxr-x   1 root  wheel    5183 Apr  7  2014 jvisualvm
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 keytool
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 native2ascii
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 orbd
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 pack200
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 policytool
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 rmic
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 rmid
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 rmiregistry
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 schemagen
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 serialver
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 servertool
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 tnameserv
-rwxrwxr-x   1 root  wheel  116544 Dec 18 00:10 unpack200
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 wsgen
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 wsimport
-rwxrwxr-x   1 root  wheel   99392 Dec 18 00:10 xjc
```
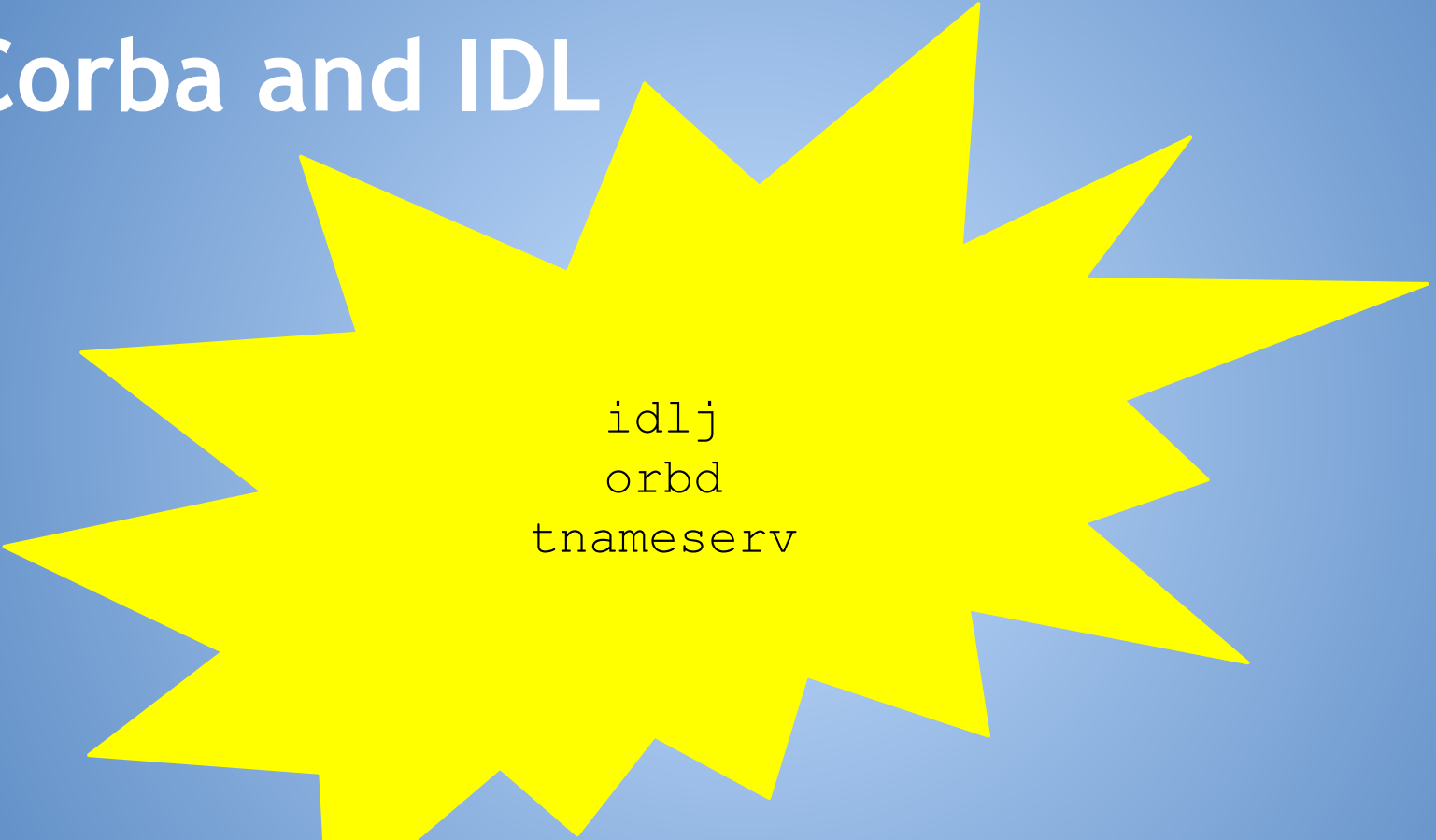
Basic Tools

```
java
javac
jar
javadoc
javah
javap
appletviewer
jdeps
extcheck
jdb
```

Security Tools

keytool
jarsigner
policytool
kinit
klist
ktab

Corba and IDL

```
idlj
orbd
tnameserv
```

Monitoring Tools

```
jps
jcmd
jstat
jstatd
```

Troubleshooting Tools

```
jinfo
jmap
jstack
jhat
jcmd
jsadebugd
```

| 12

Native Tools

Windows
dumpchk
msdev
windbg
HPROF

Linux
gbd
ltrace
ptrace
HPROF

Connecting to the JVM

- Attach
- JMX
- jvmstat
- jstatd (RMI)
- Serviceability Agent (SA)
- jsadebugd (RMI)
- Java Discovery Protocol (JDP)

Attach

- API provided by JDK to connect to running JVM
- Local access by same user
- Utilized by jinfo, jcmd, jstack, jmap
- Mechanics differ by platform
  - Transparent to attach client

Attach Linux/BDS/Solaris

- Linux/BDS
  - JVM creates socket $TMPDIR/.attach_pid<pid>
- Solaris
  - Door API instead of socket

Attach Windows

- Remote process injects code into running JVM
- Remote process creates thread in JVM to call code
- Reads result via pipe

JMX

- Java Management Extensions
- Used by UI clients
    - jconsole, visualvm, JMC
    - Hardly used by command line tools
- Most common to connect via RMI

jvmstat

- Lightweight performance monitoring for HotSpot
  - negligible performance hit if any
- Built in instrumentation enabled by default
  - Turn off with -XX:-UsePerfData
- $TMPDIR/hsperfdata_<username>/<pid>
  - Memory mapped file
  - Continuously updated by JVM

jstatd

- Remote interface to jvmstat
- Remote client connects over RMI
- Start one daemon per machine

SA (Serviceability Agent)

- Uses debugger interface (JPDA)
- No coordination with process
  - Suspends process in unknown state
- Considered last resort
- Allows connecting to core

SA (Serviceability Agent)

- JVM has several debugging interfaces
  - Standard debugging interface (via IDE)
  - -Xdebug -Xrunjdwp:transport=dt_socket,server=y, suspend=n,address=1044
- SA does not require any arguments
- Experimental

jsadebugd

- Remote interface to SA
- Remote client connects over RMI
- Start one daemon per one process
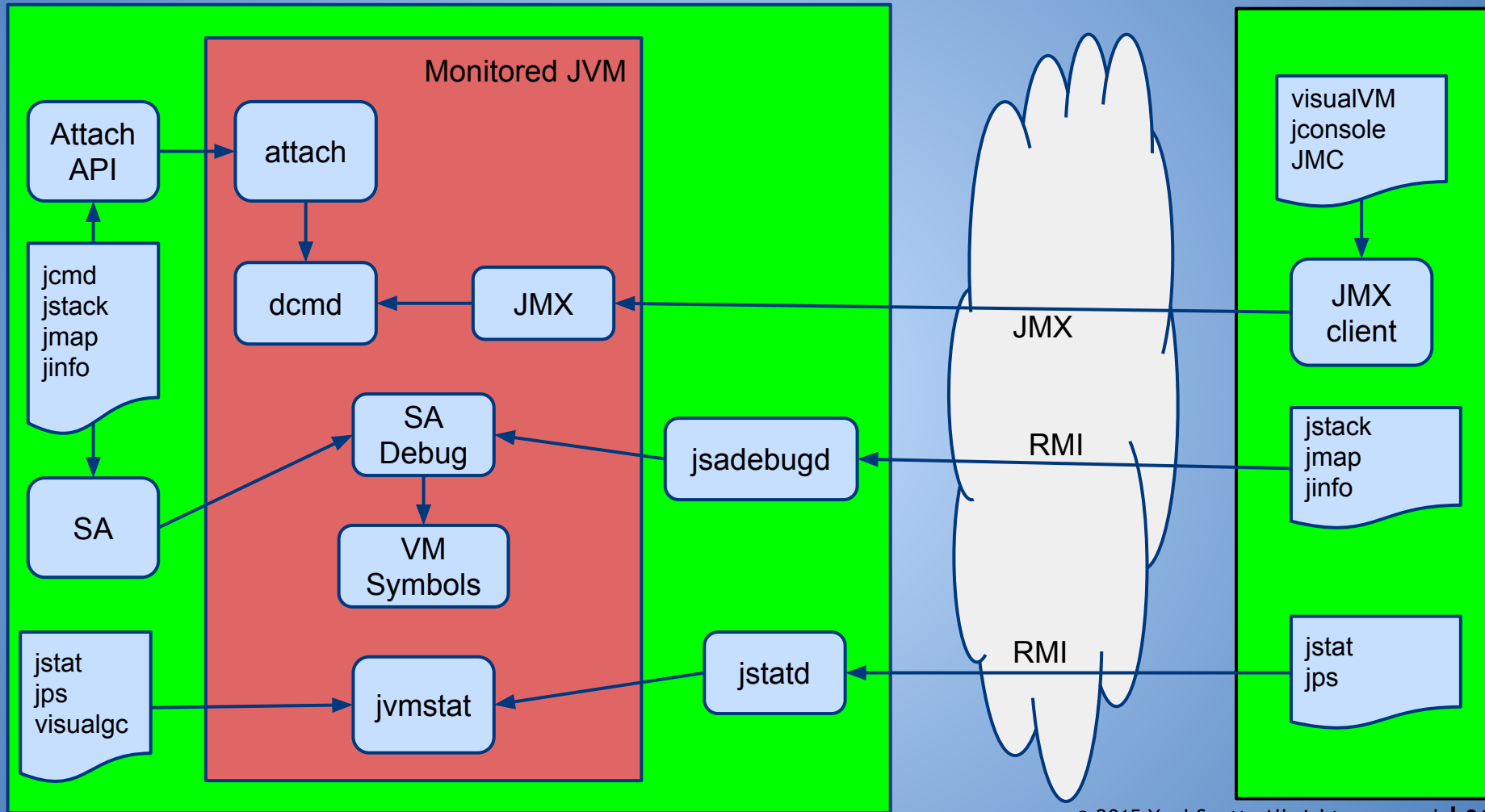
Java Discovery Protocol

- Introduced in 7u40
- Java process broadcasts presence every 5 seconds
- Must start management agent (JMX) and run process with command line options
  - http://hirt.se/blog/?p=388
- Used by Java Mission Control
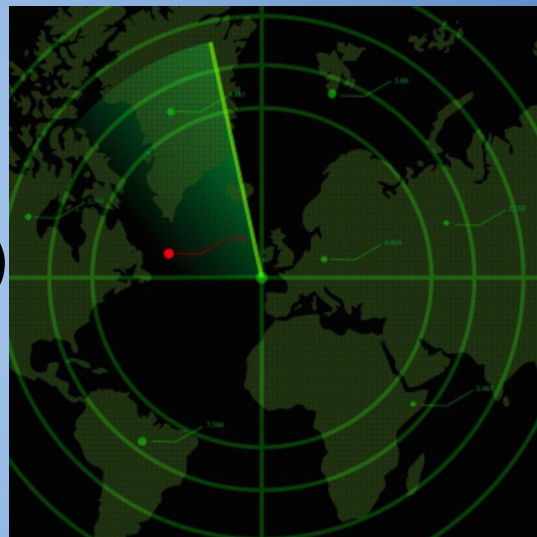
freedigitalphotos.net

Communicating with the JVM

	Local Access	Remote Access	Two-way	Core files	Tools
attach	✔		✔		jcmd, jstack, jmap, jinfo
JMX		✔	✔		jconsole, visualvm, JMC
jvmstat	✔				jps, jstat, visualgc
jstatd		✔			jps, jstat, visualgc
SA	✔		☐	✔	jstack, jmap, jinfo
jsadebugd		✔	☐		jstack, jmap

Monitored JVM

Attach API → attach

jcmd
jstack
jmap
jinfo

dcmd ← JMX

SA

SA Debug ← jsadebugd

VM Symbols

jstat
jps
visualgc

jvmstat ← jstatd

JMX

RMI

RMI

visualVM
jconsole
JMC

JMX client

jstack
jmap
jinfo

jstat
jps

jps

- Queries running jvms on a system
  - "every instrumented Java HotSpot VM for the current user on the target system"
- Shows lvmid, class name
  - lvmid usually PID
  - Options to show full package name, arguments, JVM arguments
- Only shows classname for those started with java
  - but not custom launcher (e.g. JNI) - like IDE
- Will not show processes started via Windows Services
- Can call on remote machine via jstatd
- Connects via jvmstat

jstat

- Print performance and resource consumption statistics
  - especially heap sizing and gc
- Statistics gathered by JVM
  - $TMPDIR/hsperfdata_<username>/<lvmid>
- Various options for different kinds of statistics
  - class loader stats
  - HotSpot JIT compiler stats
  - gc related stats
- Options for sampling interval and constant sampling
- Can call on remote machine via jstatd
- Connects via jvmstat

jstatd

- Daemon enables attaching to jvmstat on remote machine
  - Run jps and jstat from remote machine
  - Starts RMI server
  - Connects to jvmstat on monitored machine
- Need to setup security policy on monitored machine
- Run one instance for all JVMs on remote machine
  - jstat: Specify lvmid@hostname

jstack

- Prints stack traces of all threads of a running JVM, or core file
- By default, connects via attach
- Hung process
  - Connect via SA using -F
- Info about locks and native frames
- Remote process via jsadebugd
- Superseded by jcmd

jmap

- Prints memory related statistics for a running JVM, or core file
  - heap related info
  - class specific histogram
  - permgen statistics (< jdk 8)
- Dump java heap into hprof format
- By default, connects via attach
- Hung process
  - Connect via SA using -F
- Remote process via jsadebugd
- Superseded by jcmd

jinfo

- Prints configuration information from a running Java process or crash dump
  - including system properties and command line args
- Connects via attach
- Remote process via jsadebugd
- Superseded by jcmd

jsadebud

- Daemon enables attaching to SADebug Connector on remote machine
  - jinfo, jstack, jmap
  - Starts RMI server
- Run one instance for per JVMs on remote machine
  - Start each instance with unique serverid
  - Remote commands connect to jsadebugd with given serverid

jcmd

- One of newest commands
  - Merged from JRockit
  - Supersedes earlier commands: jstack, jinfo, jmap
- Connects via attach
  - Remote via DiagnosticCommandMBean
- Self describing
  - not a set list of commands
- jcmd <pid> help
  - process itself will respond with supported commands
- jcmd <pid> help <command>
  - process itself will respond with help about specific command

jcmd

- List of running JVMs
- JVM information
  - version, properties, uptime
- Stack traces
- Heap dumps
- Native memory
  - http://hirt.se/blog/?p=401
- Start JMX management agent
- GC statistics
- JFR commands
- PermGen space stats (< jdk 8)
- PerfCounter.print
  - Raw contents of perf counter info (jstat)

jhat (Java Heap Analysis Tool)

- Can help find "unintentional object retention"
  - aka memory leaks
- Reads heap dump
  - from jmap or jcmd (or HPROF agent)
- Starts web server
  - explore object topology in browser
- Use OQL to browse object topology
  - standard queries
  - custom queries
- Answer questions
  - What is keeping an object alive
  - Where was this object allocated