DEVOXX™

Safely Shoot Yourself in the Foot with Java 9

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Project Jigsaw: Primary Goals (Reinhold)

- Make the Java SE Platform, and the JDK, more easily scalable down to small computing devices;
- Improve the security and maintainability of Java SE Platform Implementations in general, and the JDK in particular;
- Enable improved application performance; and
- Make it easier for developers to construct and maintain libraries and large applications, for both the Java SE and EE Platforms.

So What Can We Do in Java?

- Java promised it would be 100% secure
  - In early versions JNI for CAS
- sun.misc.Unsafe added to allow JDK implementers to
  - Throw exceptions unchecked
  - Create objects without calling their constructors
  - Allocate large blocks of native memory and free it again
  - Read and write memory locations directly using CAS (peek & poke)
  - Fences
  - Release native buffer resources (Java 9)

Evolution of "Unsafe" Usage

- ConcurrentLinkedQueue.Node in Java 5 and 6

```
private static class Node<E> {
  private volatile E item;
  private volatile Node<E> next;

  private static final AtomicReferenceFieldUpdater<Node, Object> itemUpdater =
    AtomicReferenceFieldUpdater.newUpdater(Node.class, Object.class, "item");

  E getItem() { return item; }

  boolean casItem(E cmp, E val) {
    return itemUpdater.compareAndSet(this, cmp, val);
  }

  void setItem(E val) {
    itemUpdater.set(this, val);
  }
}
```

Evolution of "Unsafe" Usage

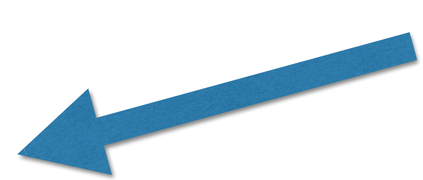
- ConcurrentLinkedQueue.Node in Java 7 and 8

```
private static class Node<E> {
  volatile E item;
  volatile Node<E> next;

  boolean casItem(E cmp, E val) {
    return UNSAFE.compareAndSwapObject(this, itemOffset, cmp, val);
  }

  void lazySetNext(Node<E> val) {
    UNSAFE.putOrderedObject(this, nextOffset, val);
  }

  boolean casNext(Node<E> cmp, Node<E> val) {
    return UNSAFE.compareAndSwapObject(this, nextOffset, cmp, val);
  }
  // but there's more ...
```



Pointer Arithmetic (try get it right ...)

```
  private static final sun.misc.Unsafe UNSAFE;
  private static final long itemOffset;
  private static final long nextOffset;

  static {
    try {
      UNSAFE = sun.misc.Unsafe.getUnsafe();
      Class k = Node.class;
      itemOffset = UNSAFE.objectFieldOffset(k.getDeclaredField("item"));
      nextOffset = UNSAFE.objectFieldOffset(k.getDeclaredField("next"));
    } catch (Exception e) {
      throw new Error(e);
    }
  }
}
```

java.util.concurrent.* Cleaned Up

- ConcurrentLinkedQueue.Node in Java 9

```
static final class Node<E> {
  volatile E item;
  volatile Node<E> next;

  boolean casItem(E cmp, E val) {
    return ITEM.compareAndSet(this, cmp, val);
  }
}
static final VarHandle ITEM;
static {
  try {
    MethodHandles.Lookup l = MethodHandles.lookup();
    ITEM = l.findVarHandle(Node.class, "item", Object.class);
  } catch (ReflectiveOperationException e) {
    throw new Error(e);
  }
}
```

Unsafe in Java 7

	Java 7
java.io.*	1
java.lang.**	7
java.math.*	1
java.net.*	3
java.nio.*	28
java.util.*	1
java.util.concurrent.**	29
java.util.zip.*	0
Total	70

Unsafe in Java 7, 8

	Java 7	Java 8
java.io.*	1	2
java.lang.**	7	5
java.math.*	1	2
java.net.*	3	3
java.nio.*	28	28
java.util.*	1	1
java.util.concurrent.**	29	36
java.util.zip.*	0	0
Total	70	77

Unsafe in Java 7, 8, 9

	Java 7	Java 8	Java 9
java.io.*	1	2	3
java.lang.**	7	5	29
java.math.*	1	2	2
java.net.*	3	3	3
java.nio.*	28	28	67
java.util.*	1	1	2
java.util.concurrent.**	29	36	8
java.util.zip.*	0	0	1
Total	70	77	114

Java 9 VarHandles

- CAS operations on non-final fields
  - Varying levels of reads and writes
    - get/setPlain (non-volatile field semantics)
    - get/setOpaque
    - getAcquire/setRelease
    - get/setVolatile (volatile field semantics)
  - Fences (Full, Acquire/Release, LoadLoad, StoreStore)
- http://gee.cs.oswego.edu/dl/html/j9mm.html

Quick Striped64 Tutorial

- Supports LongAdder and LongAccumulator
  - Creates Cell[] to hold values
    - Expands on each CAS failure
    - Maximum Cell[].length bound by Runtime.availableProcessors()
    - Cell objects are marked with @Contended, so very large
  - Threads are allocated permanently to a particular Cell
    - How?

ThreadLocalRandom

- Introduced in Java 7 to improve on Math.random()
  - Thread-local pseudo random series
  - Very fast
  - Initially used ThreadLocal as implementation
    - Slow table lookup on every current() call
- Java 8 stores ThreadLocalRandom fields inside Thread
  - Also protected with @Contended against false sharing
    - We'll get back to @Contended later

Migration to Java 9

- Striped64 needs to get direct access to a field in Thread
  - We want to avoid Unsafe
  - VarHandles typically for fields in our class
    - includes inner classes

Changing String with VarHandles

- MethodHandles.privateLookupIn() FTW

Those Annoying Warnings

- Who likes seeing these?

```
WARNING: An illegal reflective access operation has occurred
WARNING: Illegal reflective access using Lookup on ChangeString
       to class java.lang.String
WARNING: Please consider reporting this to the maintainers of ChangeString
WARNING: Use --illegal-access=warn to enable warnings of further illegal
      reflective access operations
WARNING: All illegal access operations will be denied in a future release
```

Warnings Be Gone!

- java --add-opens java.base/java.lang=ALL-UNNAMED ...

jshell For Scripting

- A REPL to make Java more accessible to novices
- Quick Demo
- Tips:
  - Let EDITOR environment variable point to your favourite editor
  - Startup is slow, especially with
    - jshell --startup JAVASE PRINTING DEFAULT
    - All the referenced classes are compiled for scripting

Unix Style Scripting

- Start by defining a file exit.jsh that contains one line "/exit"
- First line in your file is this

```
//$JAVA_HOME/bin/jshell --execution local \
      --startup DEFAULT PRINTING $0 $@ exit.jsh; exit
```

- Notes
  - Any parameters you pass in are interpreted as script names
  - jshell normally *always* returns 0, even with System.exit(1)
    - --execution local makes System.exit(val) return val
- Thanks to Christian Stein for discussions around this

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MappedByteBuffer Unmapping

- To map a file into memory, do this:

```
RandomAccessFile raf = new RandomAccessFile(filename, "rw");
FileChannel fc = raf.getChannel();
MappedByteBuffer buf = fc.map(
  FileChannel.MapMode.READ_WRITE, offset, length);
```

- To unmap the file, wait for buf to be eligible for GC
  - A PhantomReference called Cleaner will release the native memory
- Demo of how to unmap in Java 7/8 and now in 9

JVisualVM Gone in Java 9

- We still have jcmd, jconsole, jstat, jmap, jstack
- VisualVM is available separately on Github
  - https://visualvm.github.io/download.html
- Oh, also -Xrunhprof gone
  - Although -Xprof remains for now
  - Java Flight Recorder / Java Mission Control to be open sourced soon

Making Own Fields @Contended

```
import jdk.internal.vm.annotation.Contended;

public class HighlyContended {
  private int before;
  @Contended
  private volatile int value;
  private int after;

  public int getValue() {
    return value;
  }

  public void setValue(int value) {
    this.value = value;
  }
}
```

Compiling Causes Errors

```
heinz$ javac HighlyContended.java
HighlyContended.java:1: error: package
jdk.internal.vm.annotation is not visible
import jdk.internal.vm.annotation.*;
                          ^
  (package jdk.internal.vm.annotation is declared in
module java.base, which does not export it to the
unnamed module)
1 error
```

--add-exports To The Rescue

- We compile like so

```
javac --add-exports java.base/jdk.internal.vm.annotation=ALL-UNNAMED  \
  HighlyContended.java
```

- And run with

```
java -XX:-RestrictContended HighlyContendedTest
```

--add-opens vs --add-exports

- --add-opens allows "deep reflection" on elements
- --add-exports allows access to public classes, methods and fields
  - --add-opens implies --add-exports
  - Both will be removed in a future version of Java (maybe)

Java 9 Stream Changes

- Stream.takeWhile(Predicate)

```
IntStream.generate(() -> ThreadLocalRandom.current()
    .nextInt(0, 50))
    .takeWhile(i -> i < 45)
    .forEach(System.out::println);
```

- Stream.dropWhile(Predicate)
- Stream.iterate(seed, Predicate, UnaryOperator)

```
IntStream.iterate(0, i -> i <= 30, i -> i + 2)
    .forEach(System.out::println);
```

- Don't use with parallel streams!

GC Changes

- Java 8 deprecated incremental CMS
  - Removed in Java 9
- Java 9 deprecated CMS
- Default GC is now G1GC instead of Parallel Throughput
  - G1GC is child's play to configure
    - Set maximum pause time
    - Set maximum heap
    - You're done!

Hacking BigInteger

- Let's say we want to make square() public
  - Java 8, we could patch our version in using -Xbootclasspath
  - Java 9, we need to create a patch for java.base

Hacking BigInteger

- Step 1: Compile the hacked BigInteger version

```
javac --patch-module java.base=BigMathHack/src   \
   -d BigMathHack/mypatches/java.base BigMathHack/src/java/math/BigInteger.java
```

  - (Optional) Dependency in IntelliJ to shut off compiler warnings

- Step 2: Compile our code against the patched BigInteger

```
javac --patch-module java.base=BigMathHack/mypatches/java.base   \
   -d out/production/FootShootJava9 --source-path src src/BigIntegerTest.java
```

- Step 3: Run our code against the patched BigInteger

```
java --patch-module java.base=BigMathHack/mypatches/java.base   \
  -cp out/production/FootShootJava9 BigIntegerTest
```

Questions?

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