

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 was supposed to be 100% secure**
- **In early versions we often had to code JNI**
- **sun.misc.Unsafe introduced to allow JDK implementers to**
 - **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**
 - **Throw exceptions unchecked**
 - **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);  Huh?  
    }  
  
    boolean casNext(Node<E> cmp, Node<E> val) {  
        return UNSAFE.compareAndSwapObject(this, nextOffset, cmp, val);  
    }  
    // but there's more ...  
}
```

Pointer Arithmetic Into Memory Location

```
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

Demo of Changing String with VarHandles

- **MethodHandles.privateLookupIn() FTW**

Turning Off 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 ...**

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- **<http://tinyurl.com/j-fall-2017>**



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**
 - **But we will have Java Flight Recorder / Java Mission Control soon**
 - **Plan for this to be open sourced as soon as possible**

Making Our 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!**

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, as all the referenced classes are compiled for scripting. Once it's warmed up, execution is Java speed**

Hacking jshell For 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` *always* returns 0, even with `System.exit(1)`
 - `--execution local` makes `System.exit(val)` return `val`
- **Thanks to Christian Stein for discussions around this**

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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