Speculating on top of an unmodified Java VM

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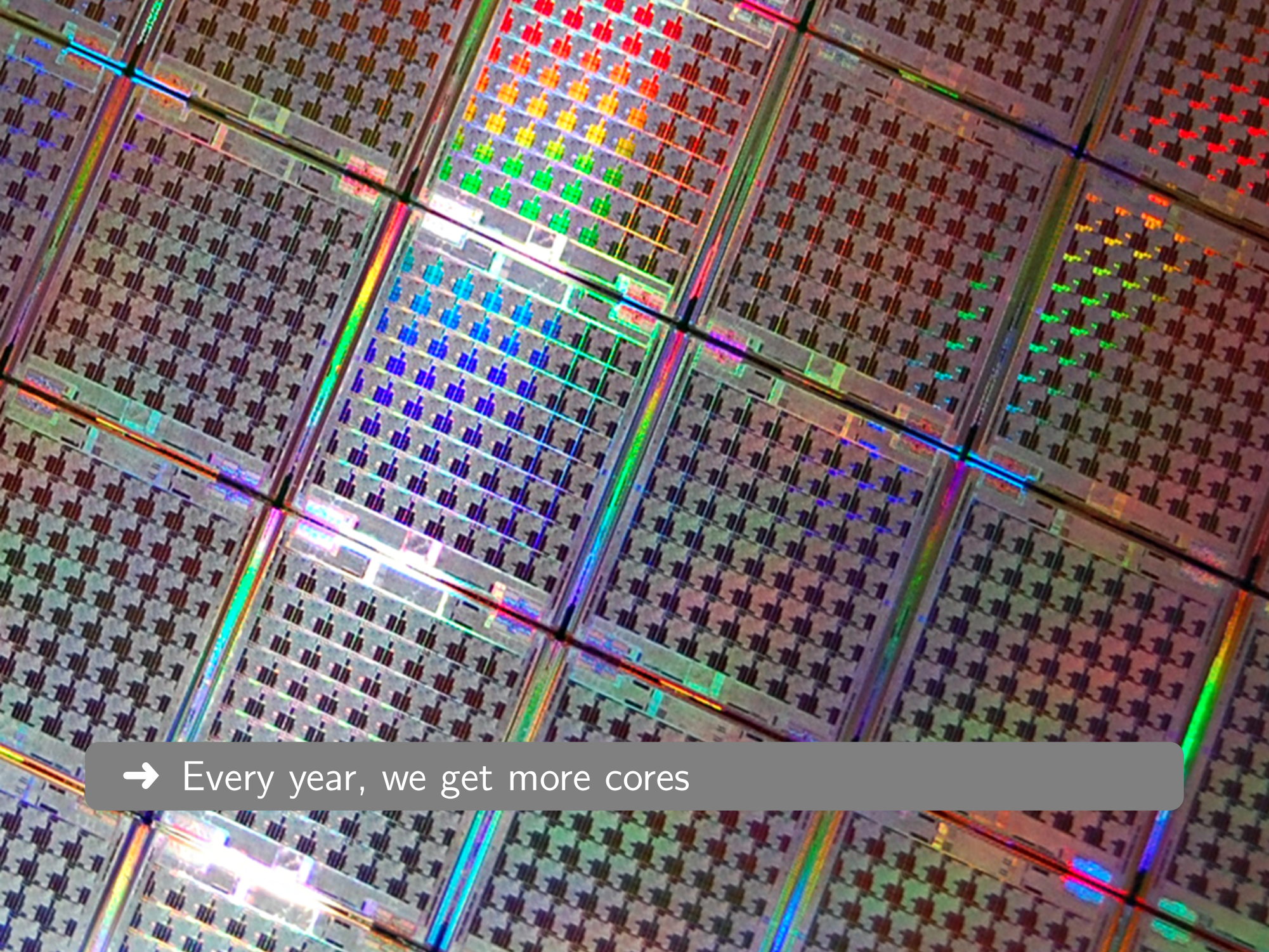
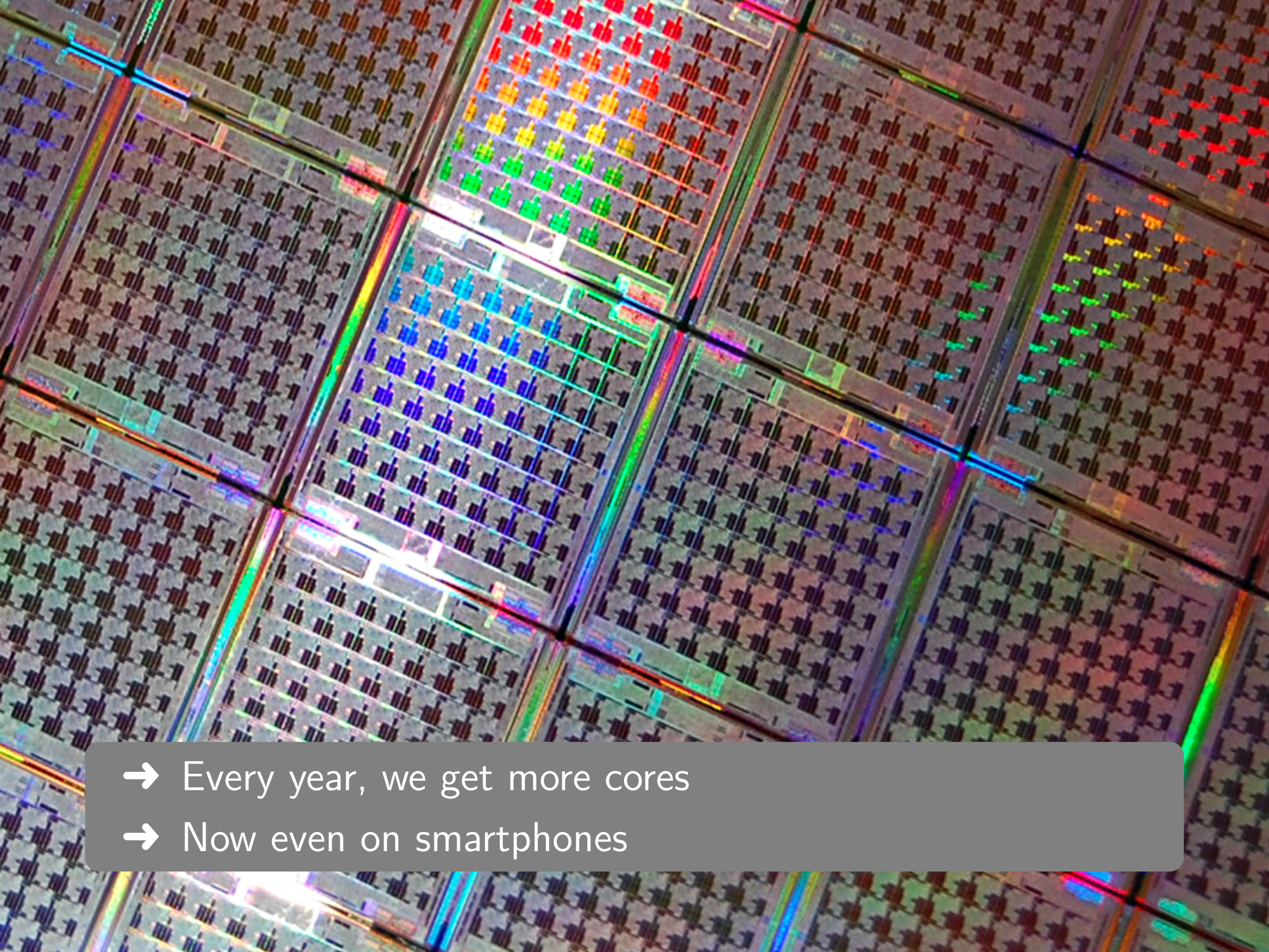


➜ Every year, we get more cores



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- ➜ Now even on smartphones

- Many applications still not parallel

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- Concurrent programming still very hard

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- Concurrent programming still very hard
  - ➜ Automatic parallelization?

Thread-Level Speculation (TLS)

- Automatic

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- Optimistic

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- Automatic
- Optimistic
  - ➜ Uses some kind of memory transactions

```
void method() {
    doA();
    doB();
    doC();
}
```

Can `doA()`, `doB()` and `doC()` be executed in parallel?

TLS on the Java platform

- Modify the VM to perform TLS

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- Our idea: What if we left the VM **untouched**?

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- Our idea: What if we left the VM **untouched**?
  - Propose missing features as TLS-independent Java APIs

(Not) Diving into the VM

Take advantage of Java concurrency features

- Memory model

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- Concurrency utility classes
  - Collections
  - Atomic operations
  - Fork/Join framework

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- State-of-the-art garbage collection

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  - Oracle Java Hotspot G1 GC

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  - Do not need to be rewritten to support TLS

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- State-of-the-art garbage collection
  - Oracle Java Hotspot G1 GC
  - Azul Pauseless GC
- Take advantage of JIT Optimizations
  - Do not need to be rewritten to support TLS
- Research VM vs Production

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The big disadvantage: **overheads**!

- Spawn speculation

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- Transaction setup

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- Speculations will need to be longer-running

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The big disadvantage: **overheads**!

- Spawn speculation
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- Speculations will need to be longer-running
  - Will need to support nested speculation

Challenges

Transactification

- Need to validate speculative reads
- Need to buffer speculative writes

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- Rely on Software Transactional Memory (STM)

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- Rely on Software Transactional Memory (STM)
  - ➜ Transactify code, intercepting field/array accesses

Transactification

Can we improve on current STMs?

- Fixed commit ordering

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Can we improve on current STMs?

- Fixed commit ordering
- Relax isolation
- Concurrent nesting
- Non-conservative/dynamic transactification

Non-Transactional Operations

Operations that change state outside STM control

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Strategies

- Static identification of `native` calls

Non-Transactional Operations

Operations that change state outside STM control

Strategies

- Static identification of `native` calls
- Runtime detection and prevention

Non-Transactional Operations

Lifting restrictions

- Extend transactional system

Non-Transactional Operations

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  - Transactional IO

Non-Transactional Operations

Lifting restrictions

- Extend transactional system
  - Transactional IO
- Identify harmless `native` calls

Stack Manipulation

Saving/Reading ➜ Continuations

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- Bytecode modification

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Saving/Reading ➜ Continuations

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- OpenJDK patches

Threads & Scheduling

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  - User code can catch any exception
- Green threads would be helpful

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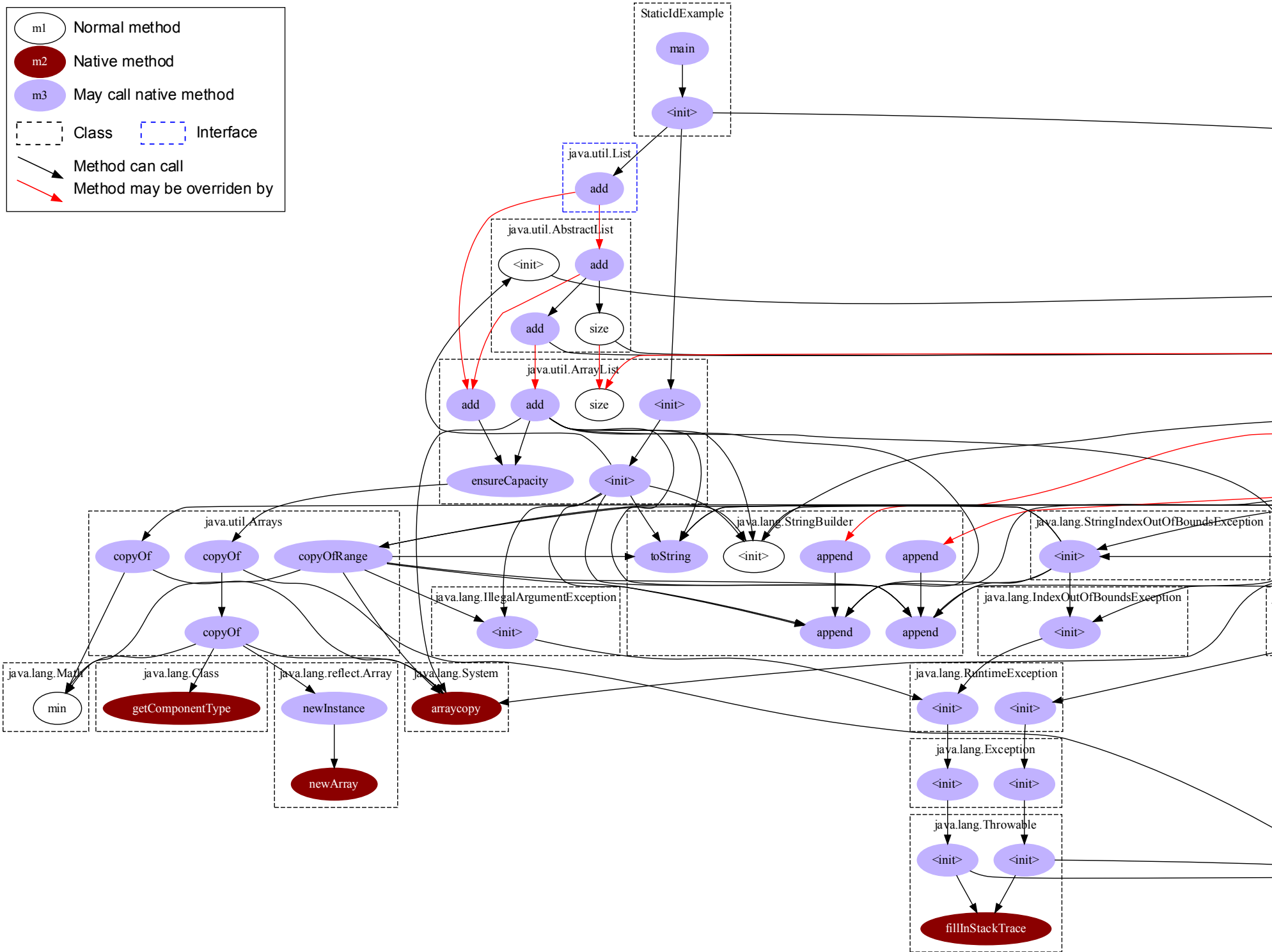
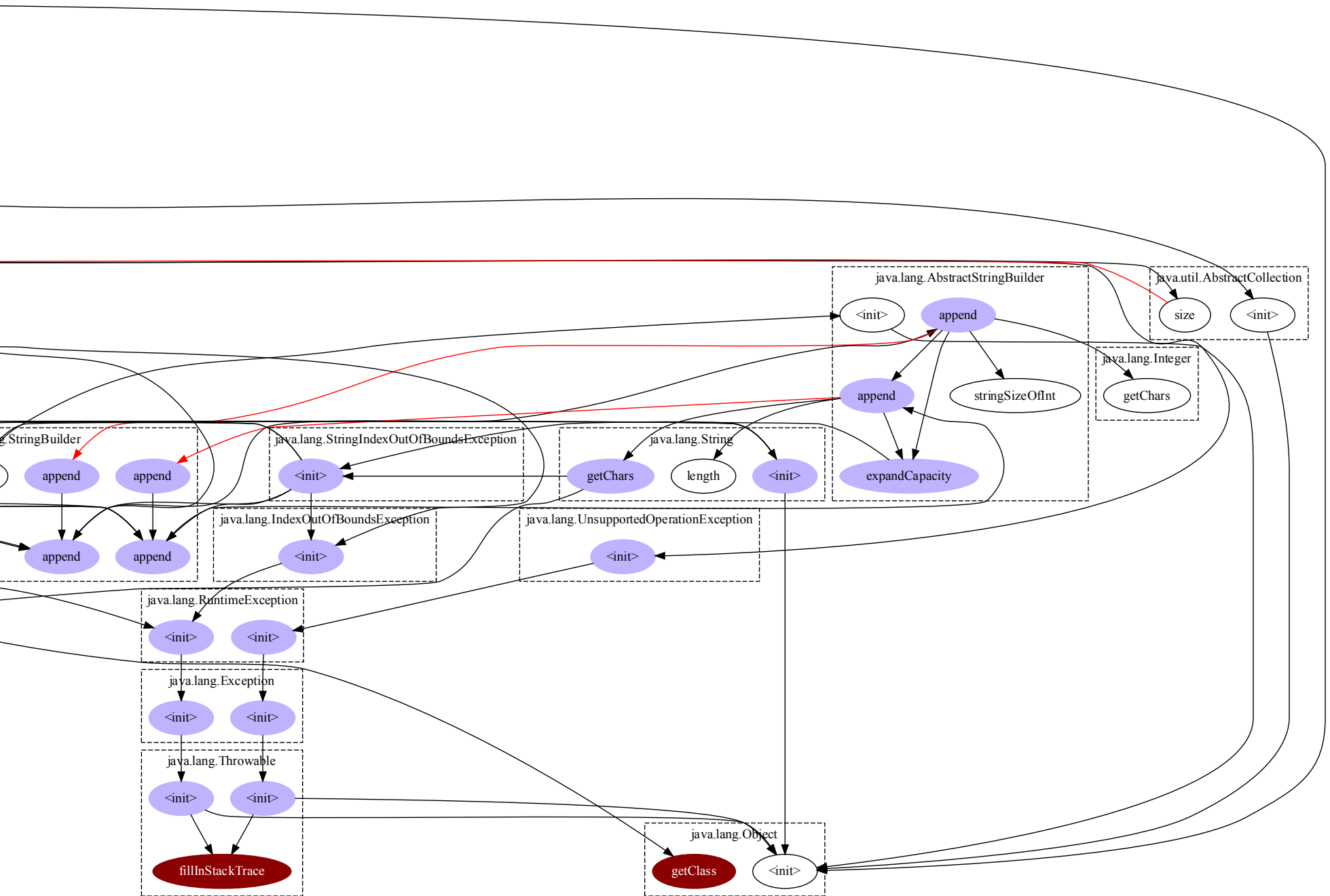
  - ➜ Continuations, more control over threads, TM support, ...

Thank you!


m1
Normal method
m2
Native method
m3
May call native method
Class
Interface
Method can call
Method may be overriden by
StaticIdExample
main
<init>
java.util.List
add
java.util.AbstractList
<init>
add
add
size
java.util.ArrayList
add
add
size
<init>
ensureCapacity
<init>
java.util.Arrays
copyOf
copyOf
copyOfRange
copyOf
java.lang.StringBuilder
toString
<init>
append
append
append
append
java.lang.StringIndexOutOfBoundsException
<init>
java.lang.IllegalArgumentException
<init>
java.lang.IndexOutOfBoundsException
<init>
java.lang.Math
min
java.lang.Class
getComponentType
java.lang.reflect.Array
newInstance
newArray
java.lang.System
arraycopy
java.lang.RuntimeException
<init>
<init>
java.lang.Exception
<init>
<init>
java.lang.Throwable
<init>
<init>
fillInStackTrace


java.lang.AbstractStringBuilder
<init>
append
append
stringSizeOfInt
expandCapacity
java.util.AbstractCollection
size
<init>
java.lang.Integer
getChars
.StringBuilder
append
append
append
append
java.lang.StringIndexOutOfBoundsException
<init>
java.lang.String
getChars
length
<init>
java.lang.IndexOutOfBoundsException
<init>
java.lang.UnsupportedOperationException
<init>
java.lang.RuntimeException
<init>
<init>
java.lang.Exception
<init>
<init>
java.lang.Throwable
<init>
<init>
fillInStackTrace
java.lang.Object
getClass
<init>