Rubah
DSU for Java on a Stock JVM

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OOPSLA '14

Software Updates are necessary

- New features
- Fix bugs

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- New features
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NASDAQ®

- 2010 cyber-attack
- Software left outdated

Software Updates are necessary and disruptive

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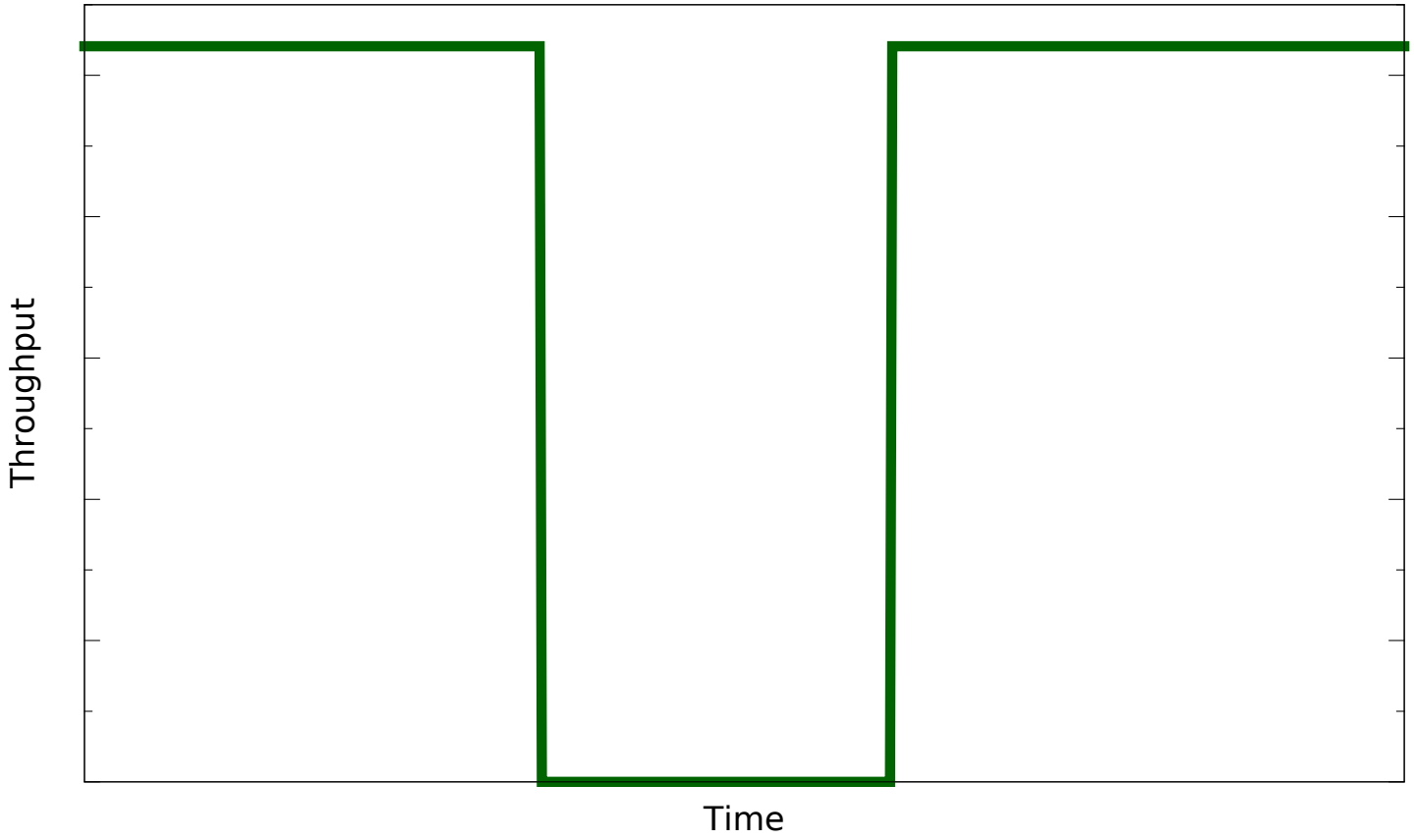
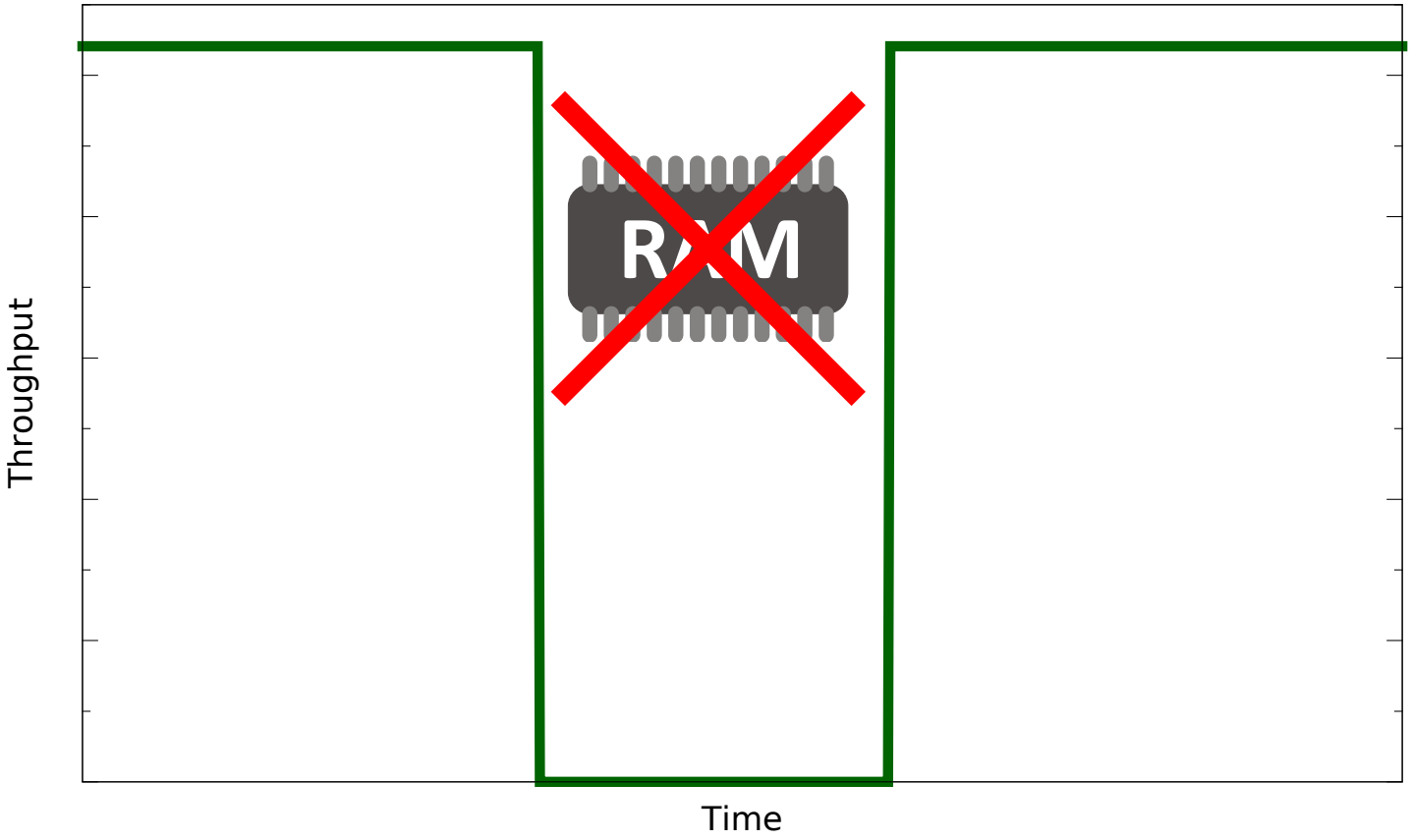


Software Updates are necessary and disruptive



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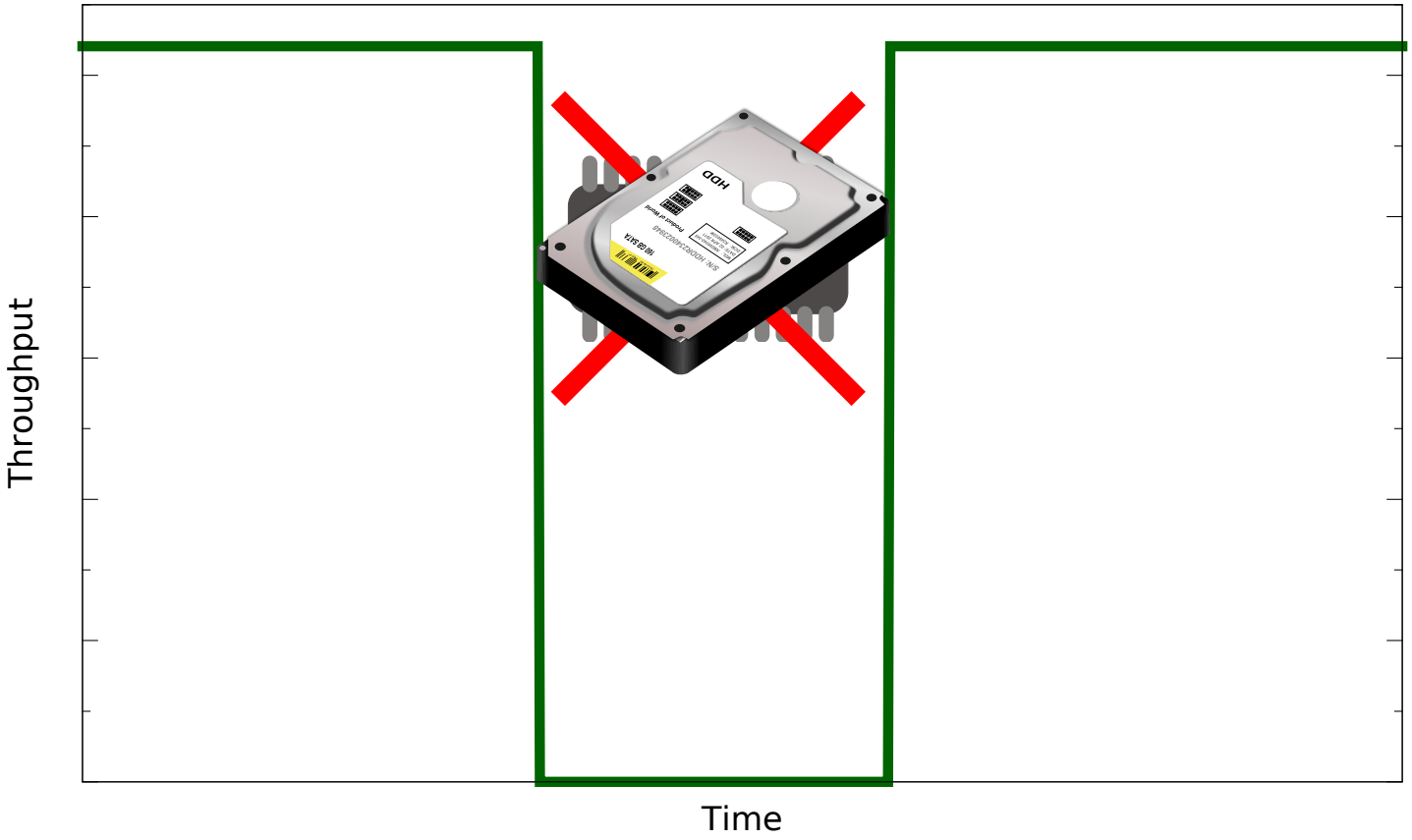

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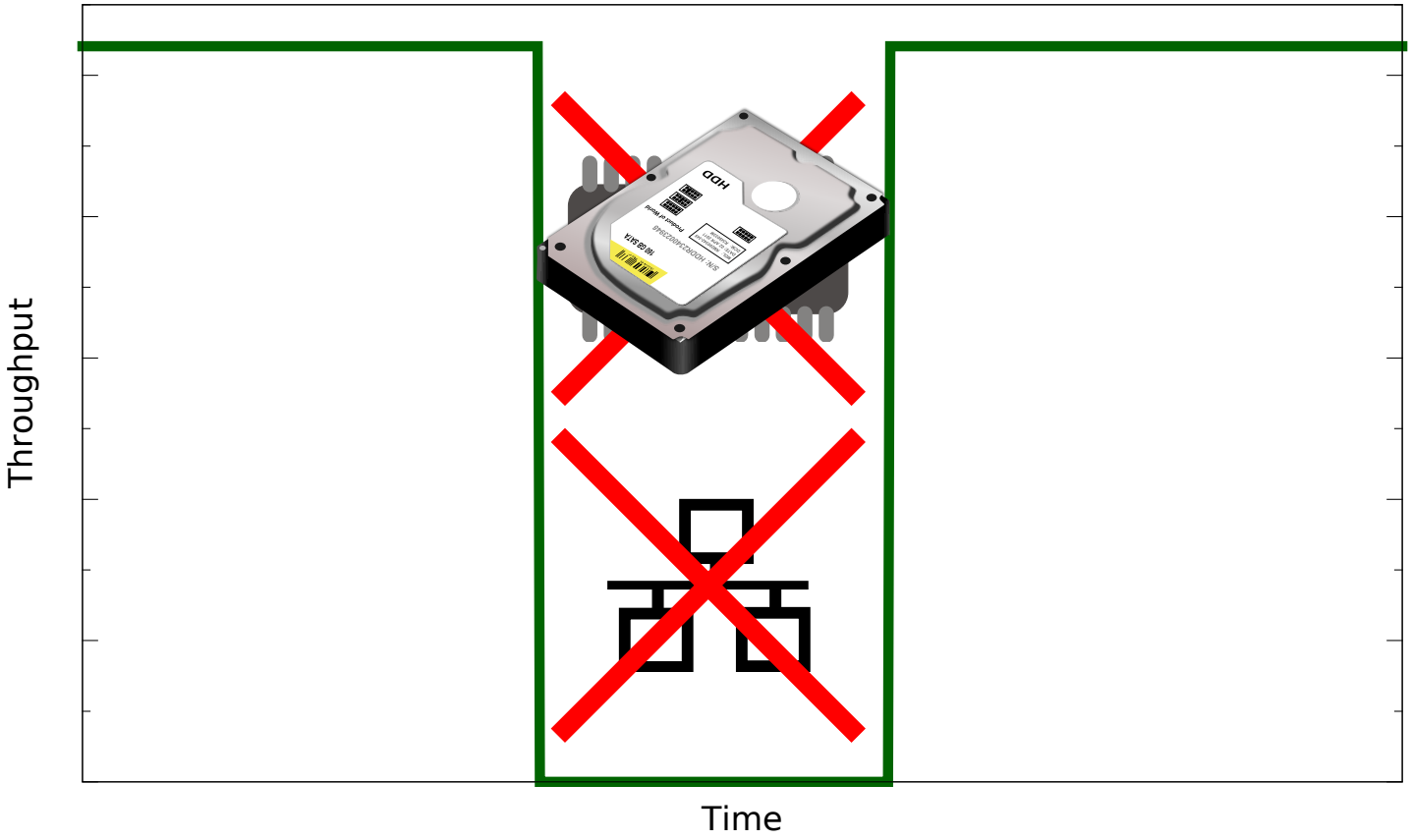

Dynamic Software Updating

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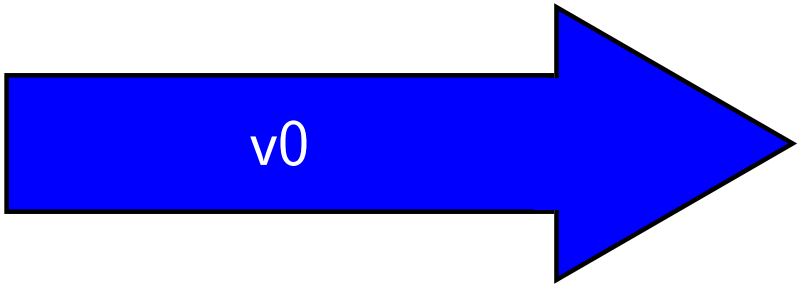

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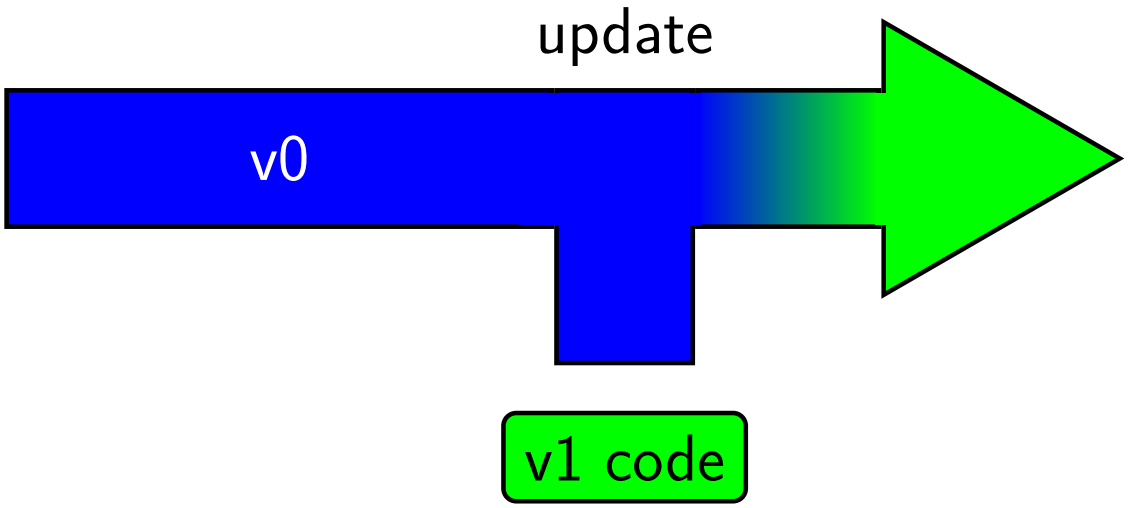

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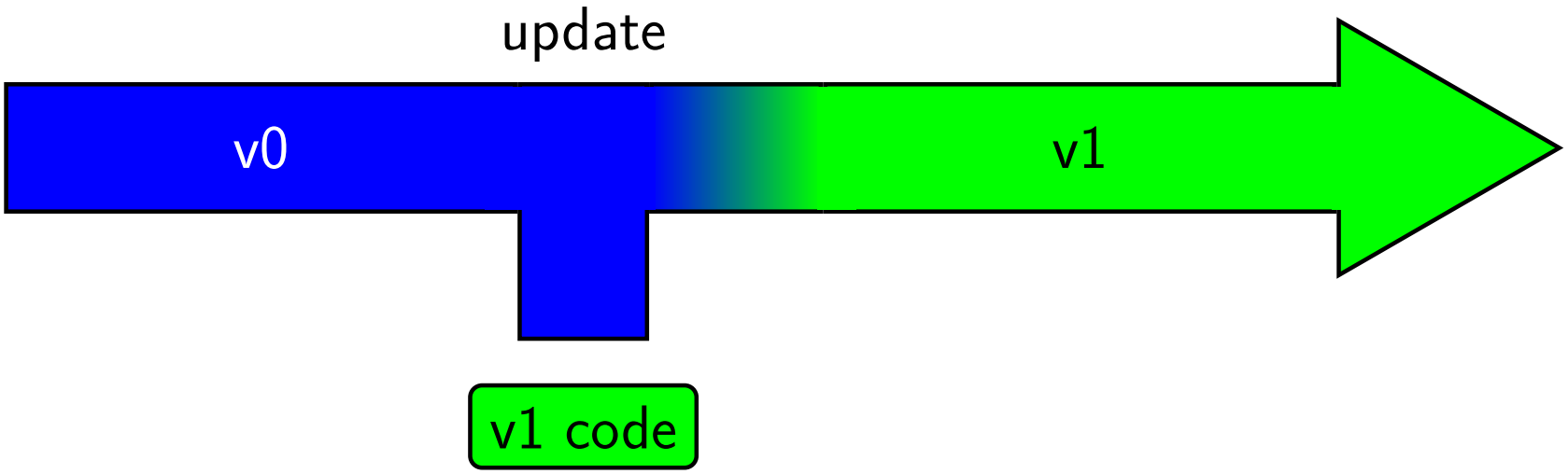

Existing DSU for Java

Efficient?	Stock JVM? No	Stock JVM? yes
No	JDrums	DUSC, DuSTM
Yes	JVolve, DCE-VM	**Rubah**

Rubah

- Efficient / Non-disruptive
- Stock JVM
- Flexible

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  - No steady-state overhead
  - Parallel/lazy algorithms
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    - Tested on Oracle HotSpot
    - Adapatable to different JVMs (OpenJDK, IBM Jikes)
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  - Optimizations rely on internals
    - Unsafe memory access, object memory layout
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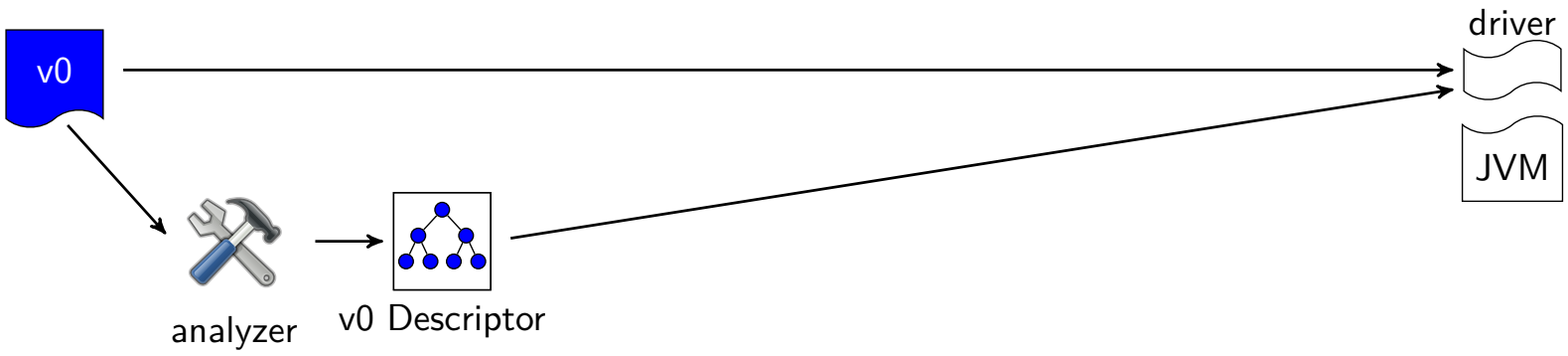
    - Adapatable to different JVMs (OpenJDK, IBM Jikes)

- Flexible
  - Unrestricted class updates
  - 13 versions of 5 real-world applications
    - **H2**
    - **Voldemort**
    - **CrossFTP**
    - **Jake2**
    - **Java Email Server**

Using Rubah



Rubah Driver

- Loads the program

Rubah Driver

- Loads the program

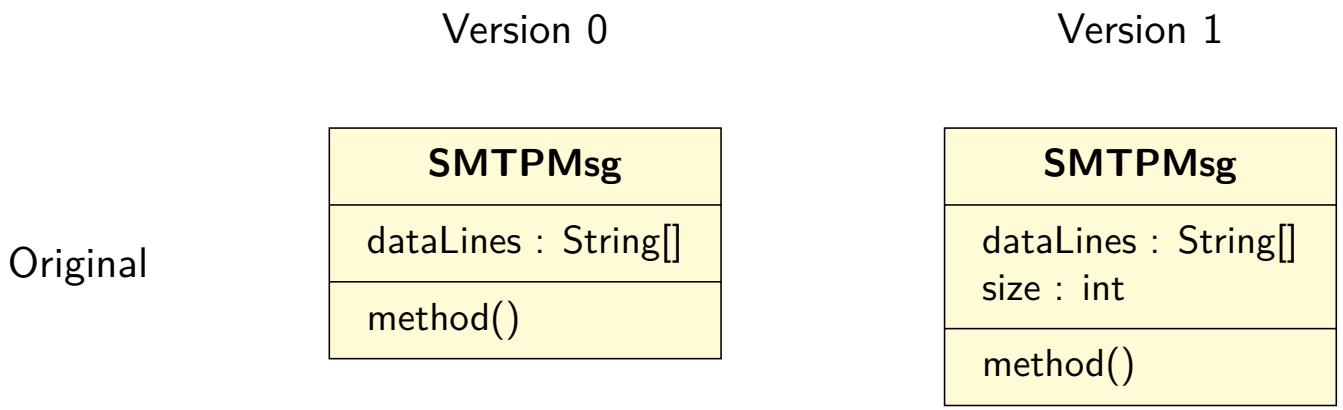
```
java <main-class> <args>
```

becomes

```
java rubah.Rubah <descriptor> <main-class> <args>
```

Rubah Driver

- Loads the program
- Rewrites bytecode



Rubah Driver

- Loads the program
- Rewrites bytecode

	Version 0	Version 1
Original	**SMTPMsg** dataLines : String[] method()	**SMTPMsg** dataLines : String[] size : int method()
Rewritten	**SMTPMsg___0** dataLines : String[] method() GETdataLines SETdataLines	**SMTPMsg___1** dataLines : String[] size : int method() GETdataLines SETdataLines GETsize SETsize

Rubah Driver

- Loads the program
- Rewrites bytecode

```
java <main-class> <args>
```

VS

```
java rubah.Rubah <descriptor> <main-class> <args>
```

Rubah Driver

- Loads the program
- Rewrites bytecode

```
java <main-class> <args>
```

VS

```
java rubah.Rubah <descriptor> <main-class> <args>
```

Overhead = [-2.5% ; 2.5%]

Rubah Driver

- Loads the program
- Rewrites bytecode
- **No extra overhead!**

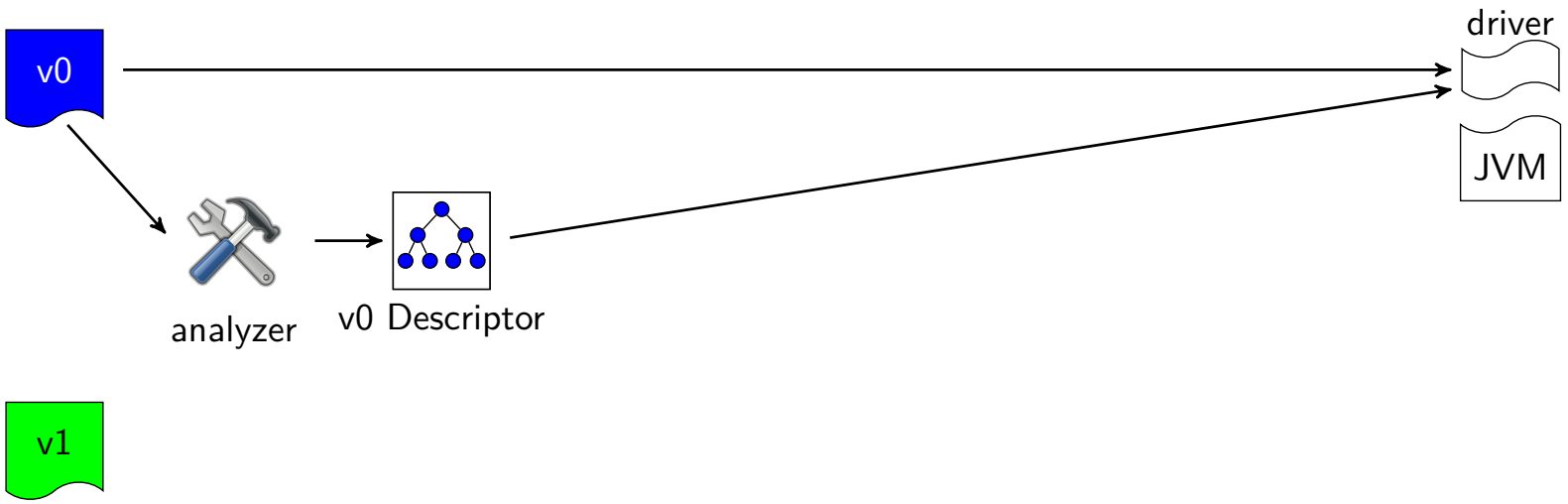
```
java <main-class> <args>
```

VS

```
java rubah.Rubah <descriptor> <main-class> <args>
```

Overhead = [-2.5% ; 2.5%]

Using Rubah



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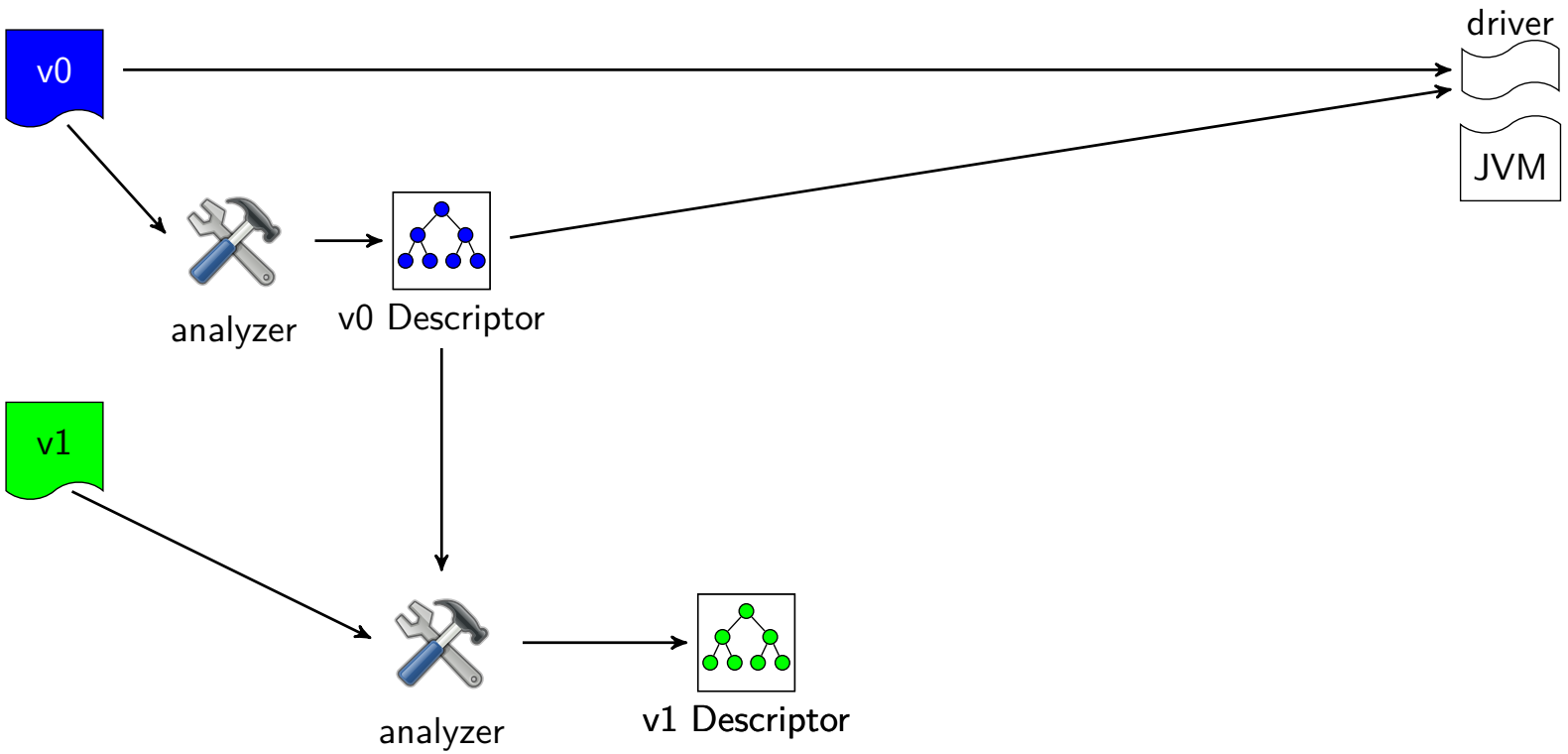
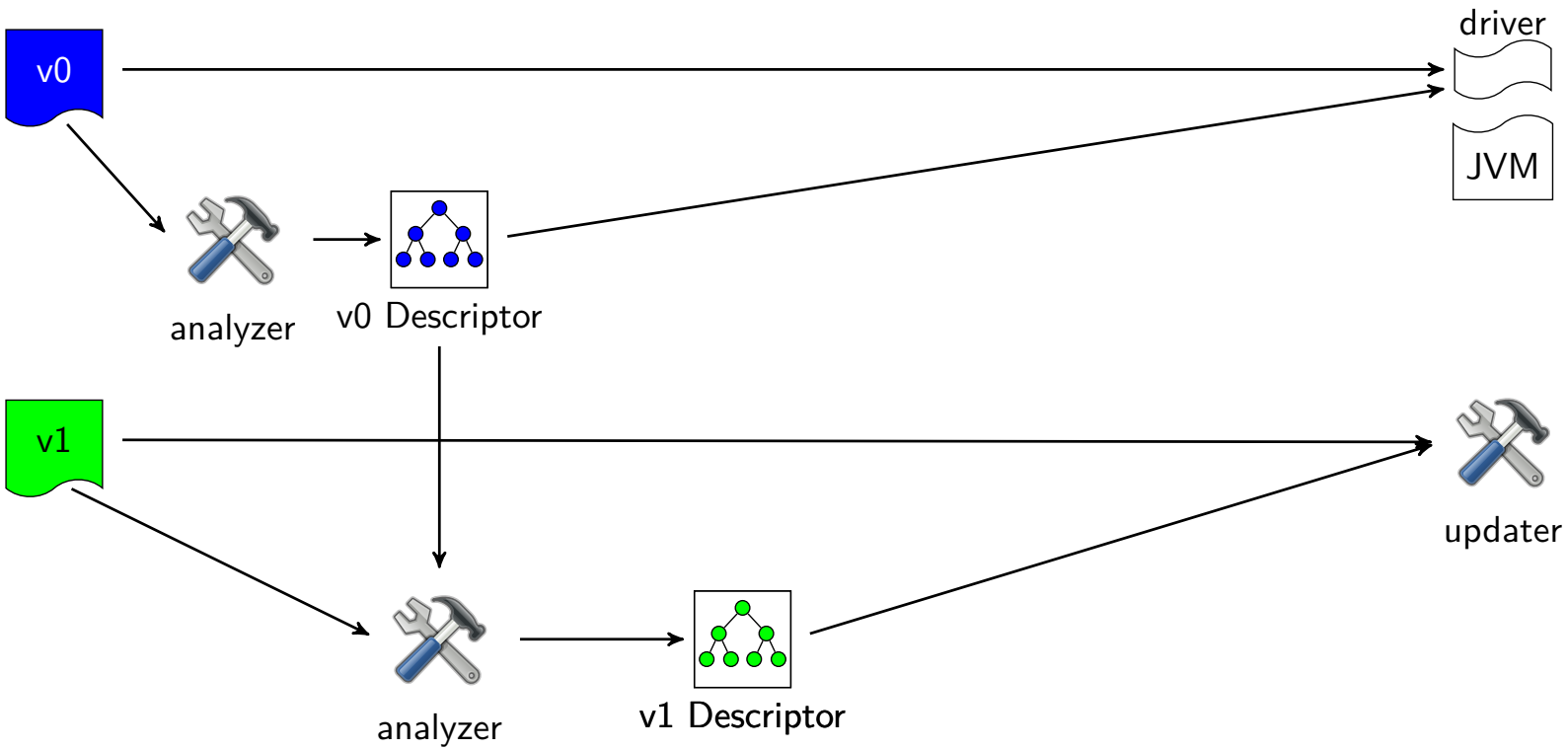
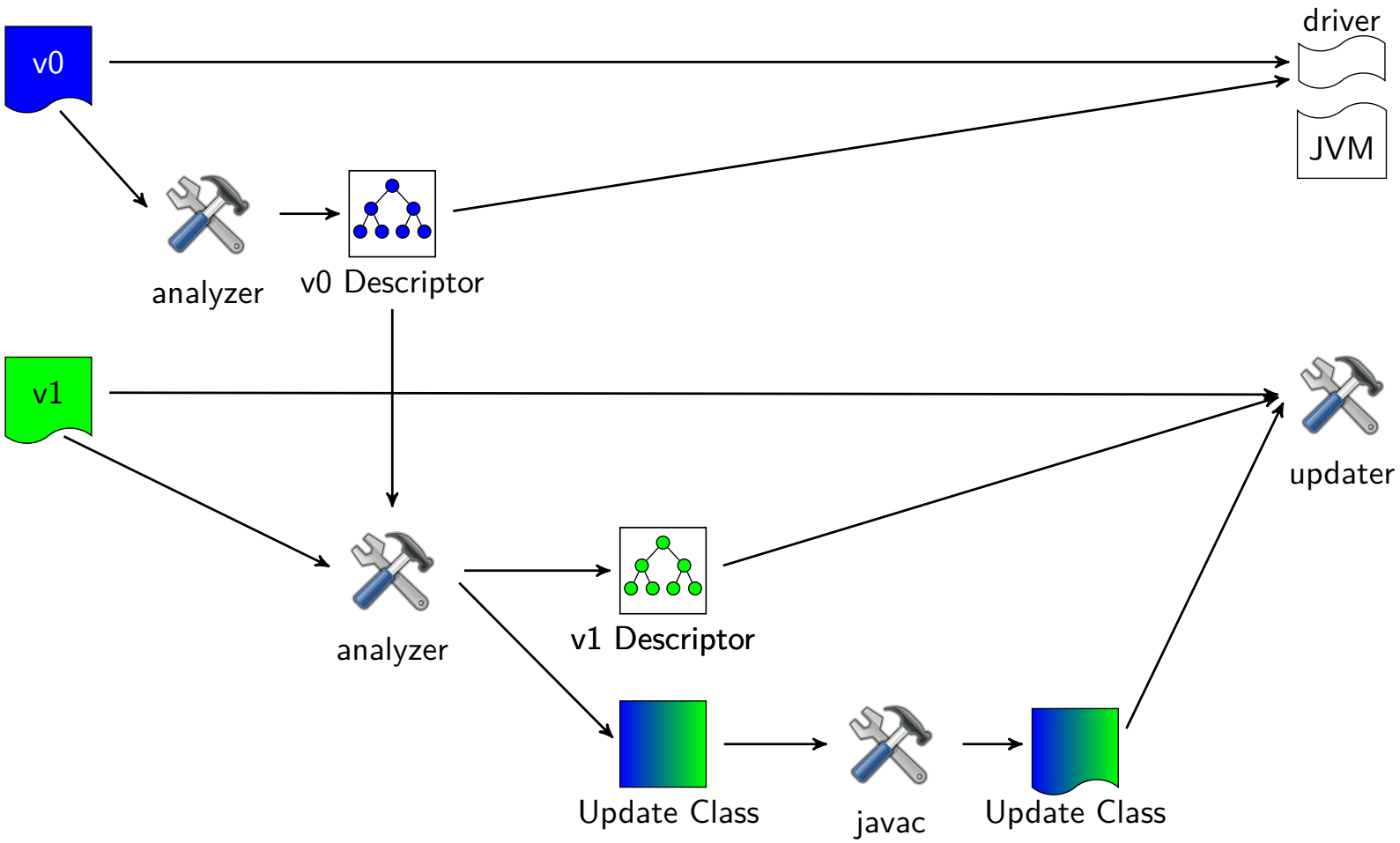

v0
driver
JVM
analyzer
v0 Descriptor
v1
analyzer
v1 Descriptor

Using Rubah


v0
driver
JVM
analyzer
v0 Descriptor
v1
updater
analyzer
v1 Descriptor

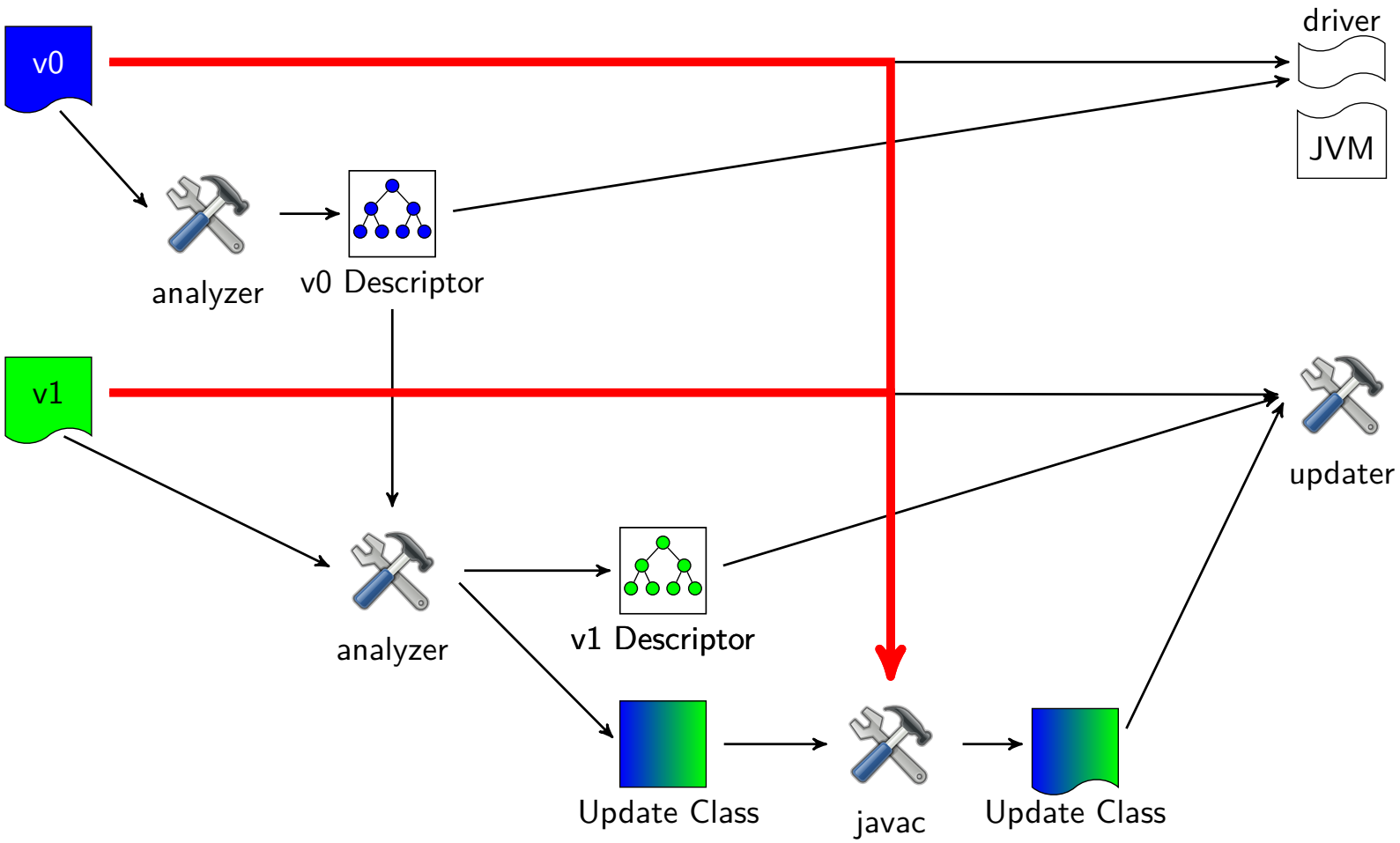
Using Rubah


v0
driver
JVM
analyzer
v0 Descriptor
v1
updater
analyzer
v1 Descriptor
Update Class
javac
Update Class

Convert method

```
01
02
03      void convert( ???  o0, ???  o1) {
04
05
06
07
08      }
09
```

Using Rubah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Convert method

```
01
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03      void convert( SMTPMsg  o0, SMTPMsg  o1) {
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```
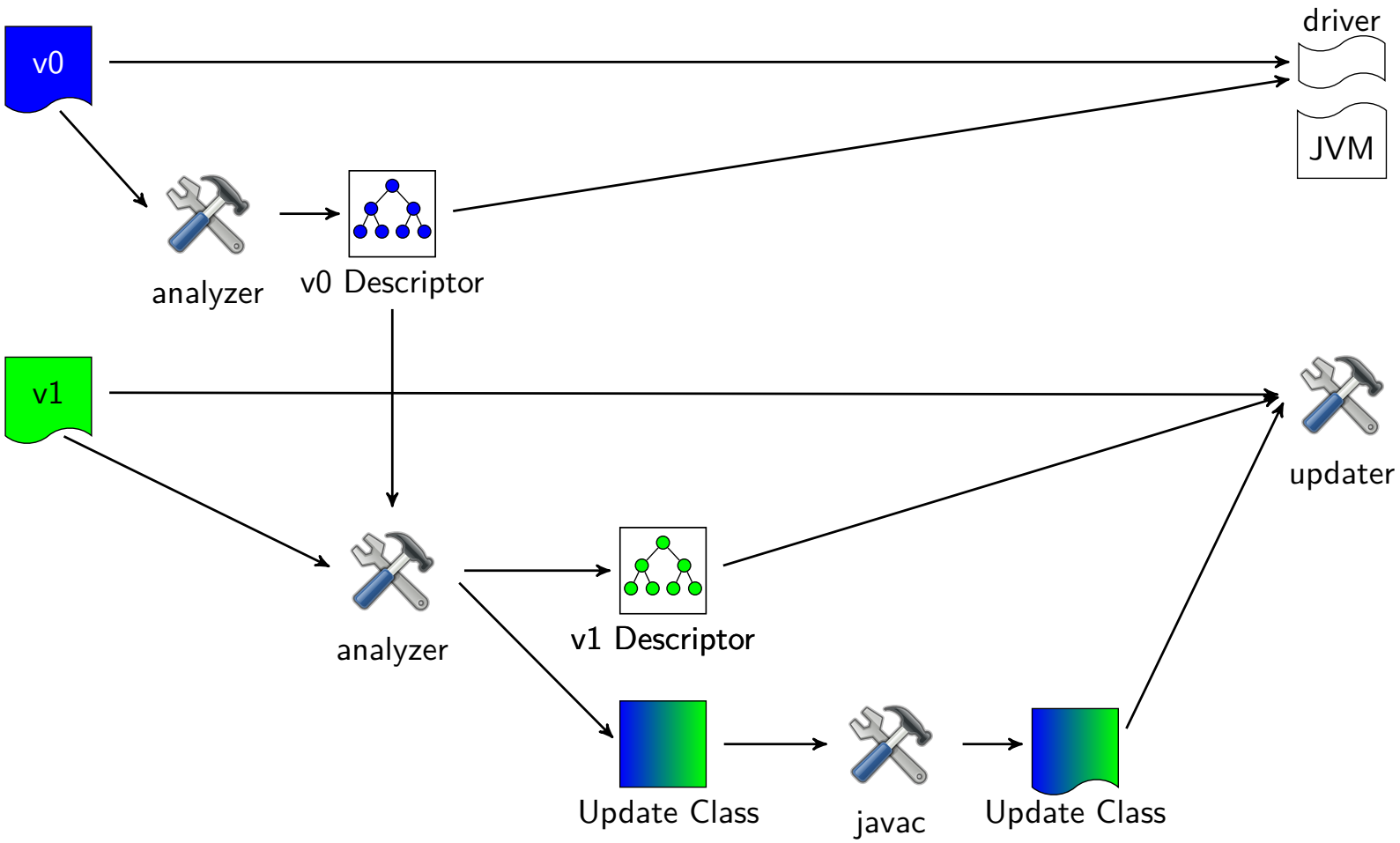

Using Rubah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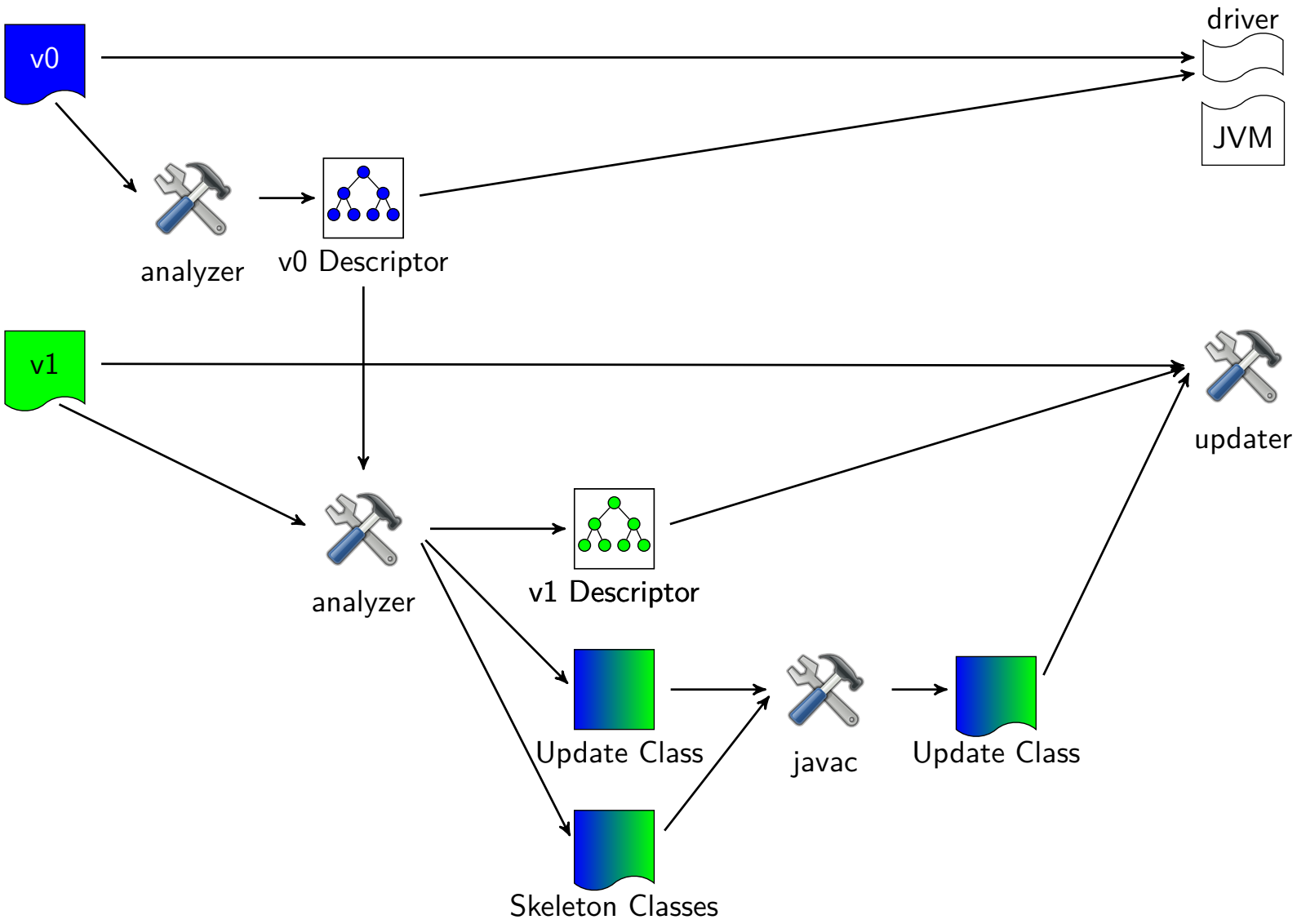
v0
driver
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analyzer
v0 Descriptor
v1
updater
analyzer
v1 Descriptor
Update Class
javac
Update Class
Skeleton Classes

Convert method

```
01
02
03      void convert( v0. SMTPMsg o0, v1. SMTPMsg o1) {
04
05
06
07
08      }
09
```

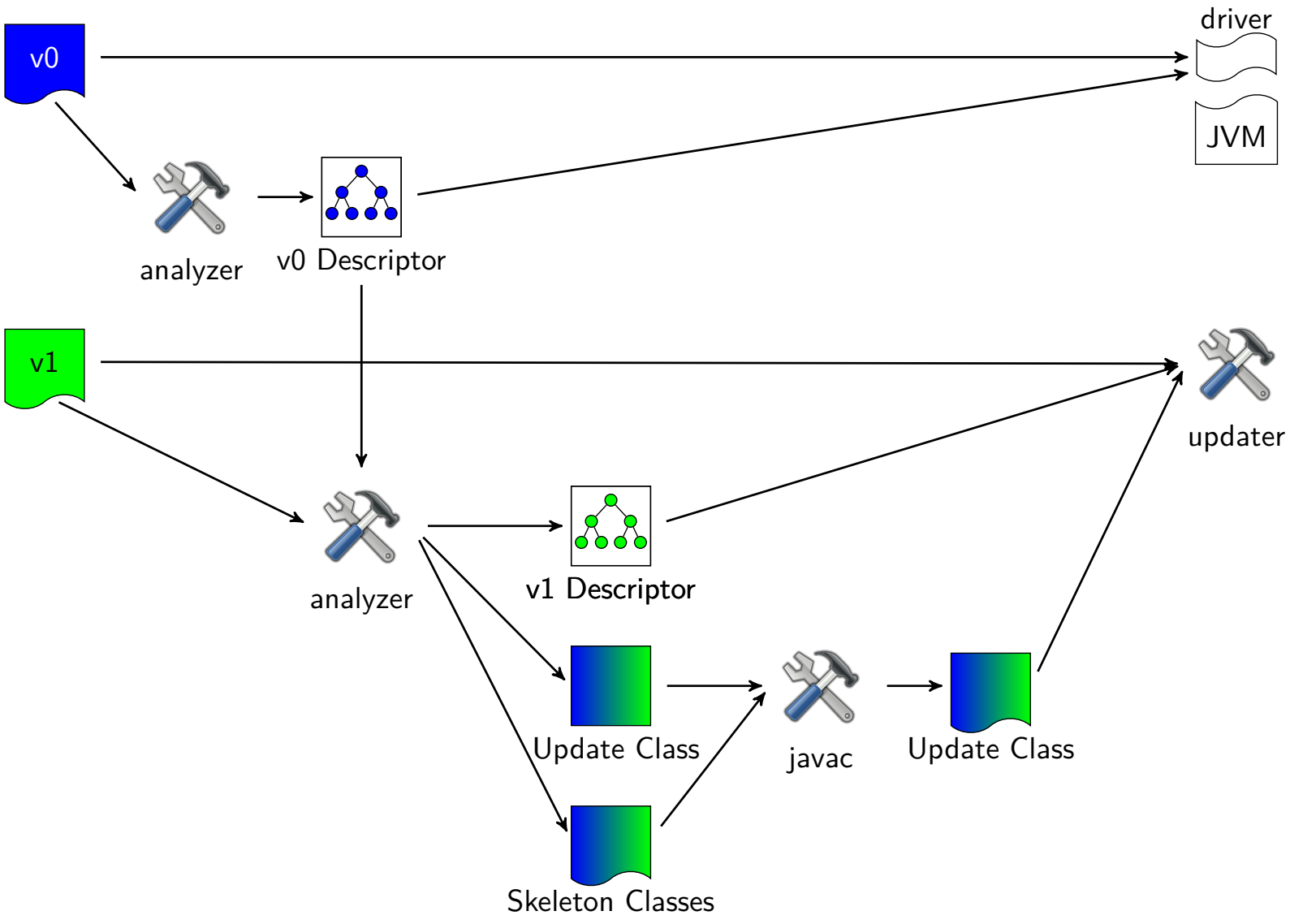
Convert method

```
01 class UpdateClass {
02
03     void convert(v0.SMTPMsg o0,v1.SMTPMsg o1) {
04         //o1.dataLines = o0.dataLines;
05         o1.size = 0;
06
07
08     }
09 }
```

Convert method

```
01 class UpdateClass {
02
03     void convert(v0.SMTPMsg o0,v1.SMTPMsg o1) {
04         //o1.dataLines = o0.dataLines;
05         o1.size = 0;
06         for (String s : o0.dataLines)
07           o1.size += s.length();
08     }
09 }
```

Using Rubah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Update Class
javac
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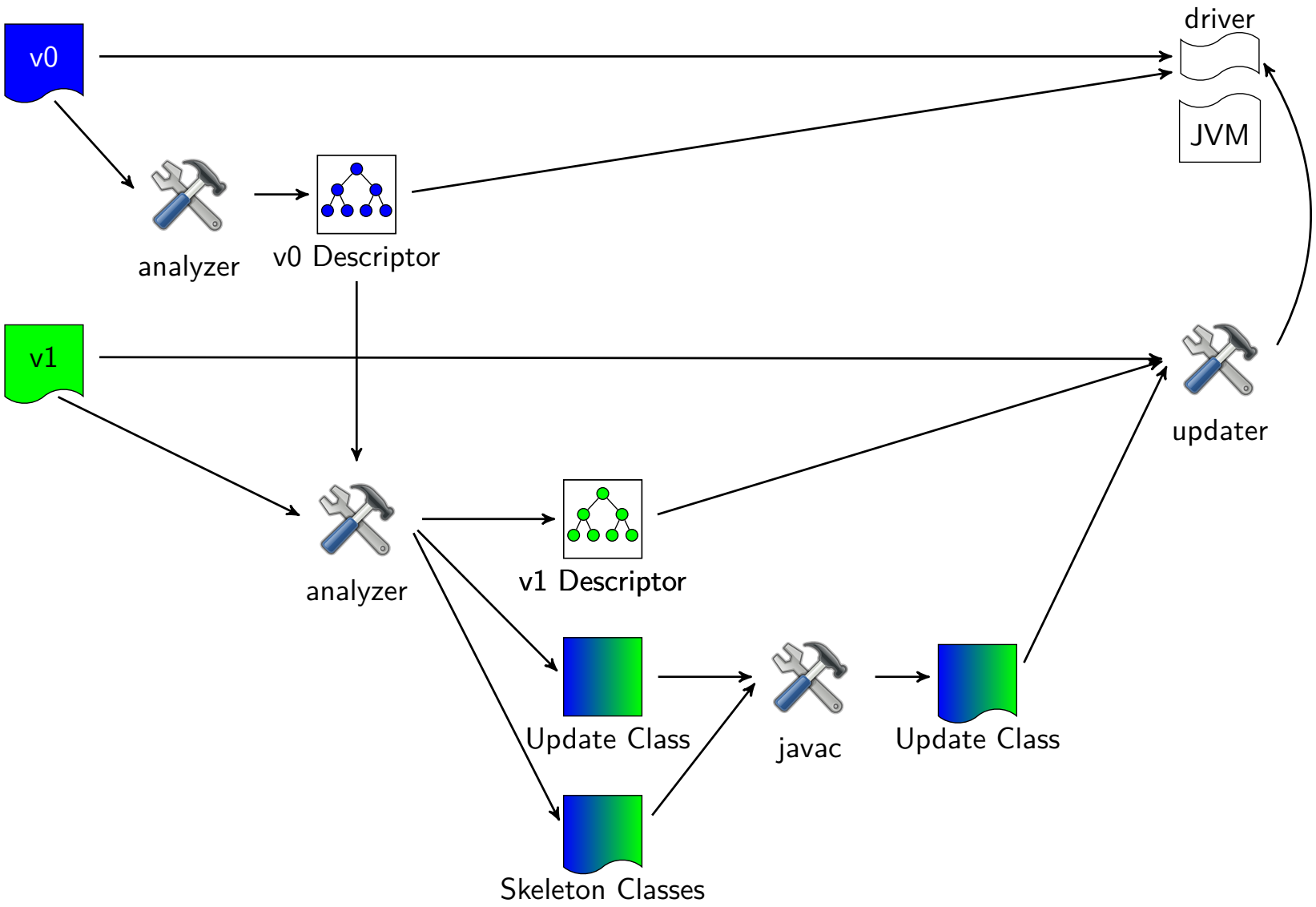
v0
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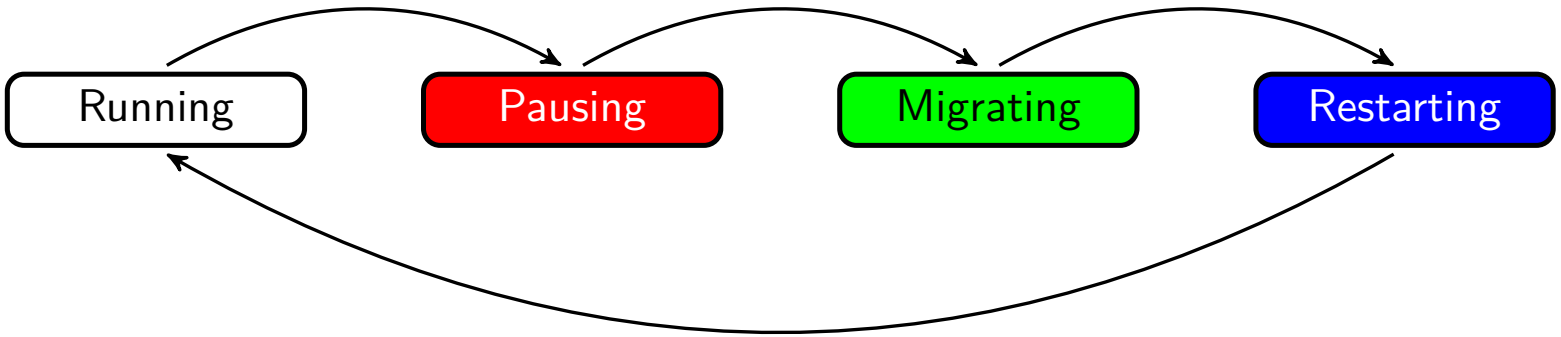
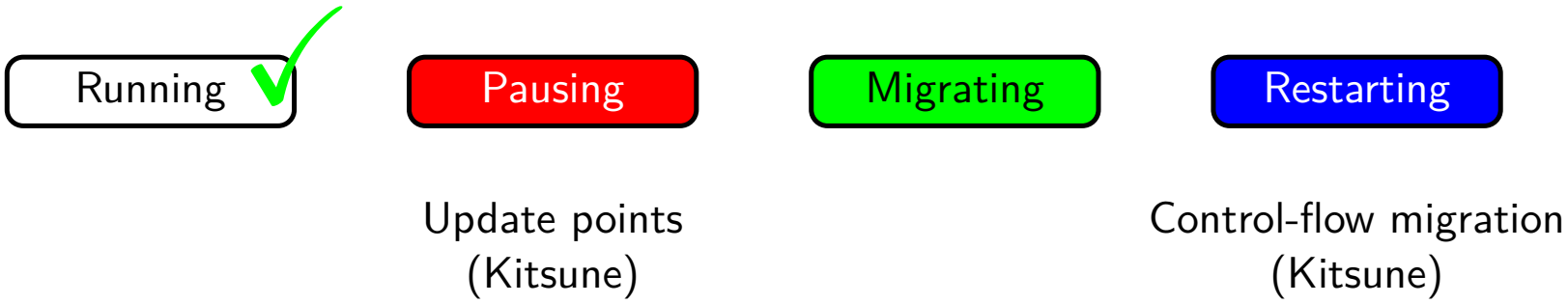
Installing an update



Installing an update



Retrofitting

Changes

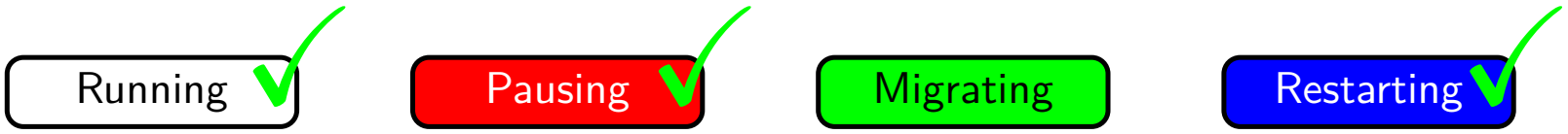
- Update points
  - Top of long running loops
  - Stops thread when update available
- Control-flow migration
  - Transfer control between update points in different versions
- Blocking I/O
  - Use non-blocking I/O or pooling
  - Rubah API

Retrofitting

Effort

Benchmark	Original LOC	Modified	
		LOC	*%*
H2	40119	267	0.67
Voldemort	87516	175	0.19
Jake2	85408	29	0.03
CrossFTP	18221	224	1.23
Java Email Server	2368	183	7.72

Installing an update



Update class
Parallel/lazy migration

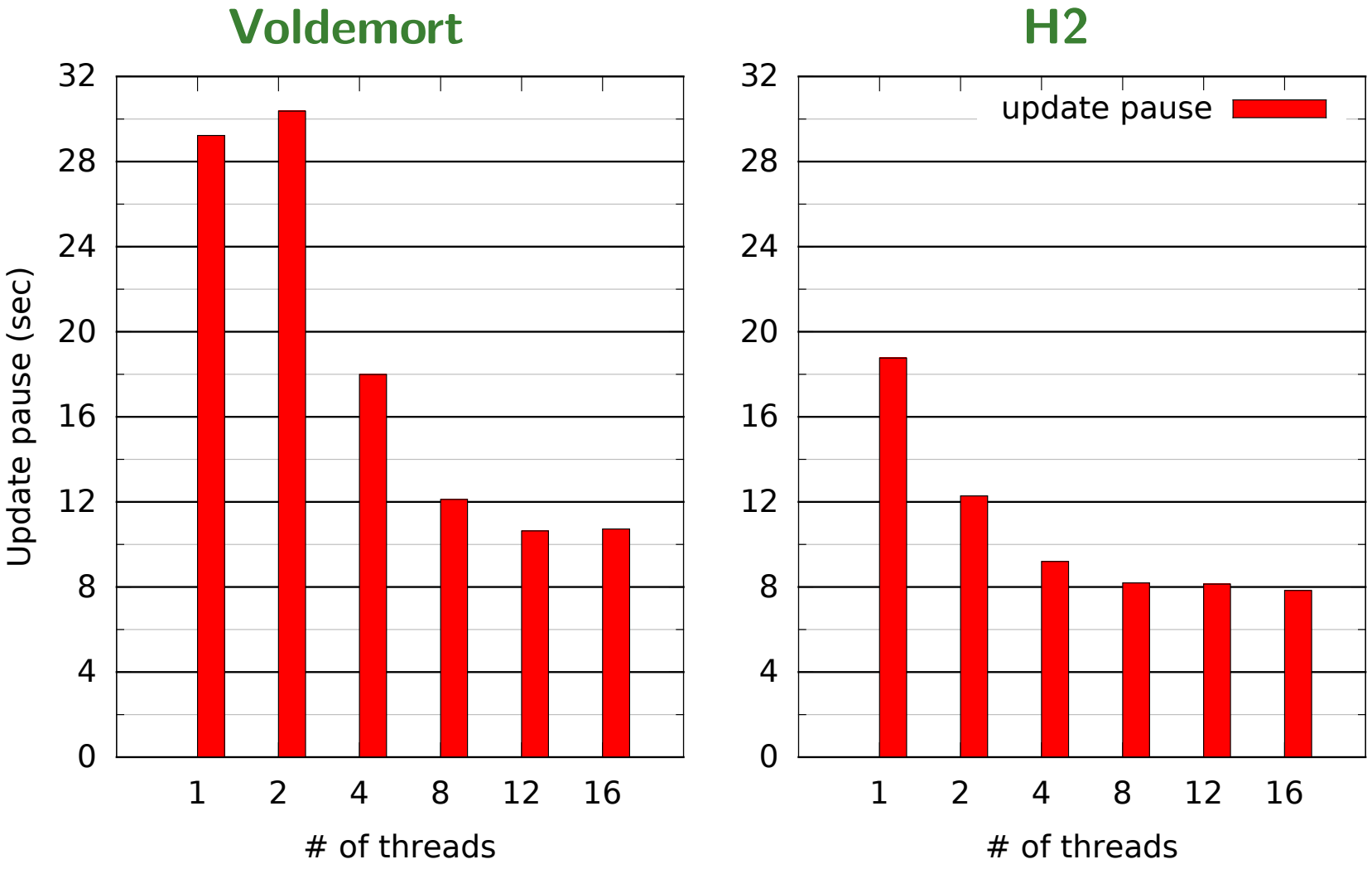
Migrating the state

Parallel migration

- Traverse heap with multiple threads
- Share work with task queue

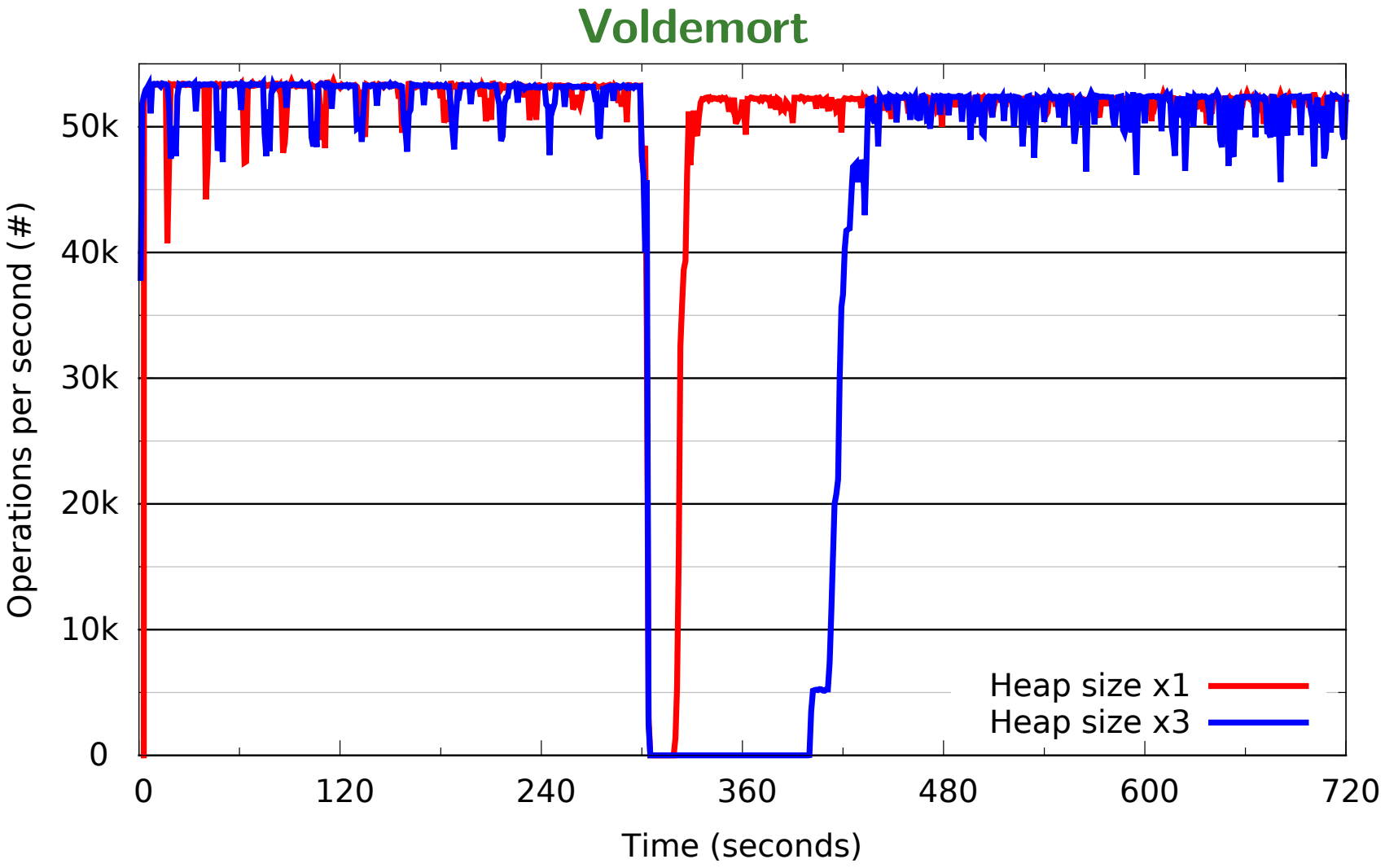
Migrating the state

Parallel migration



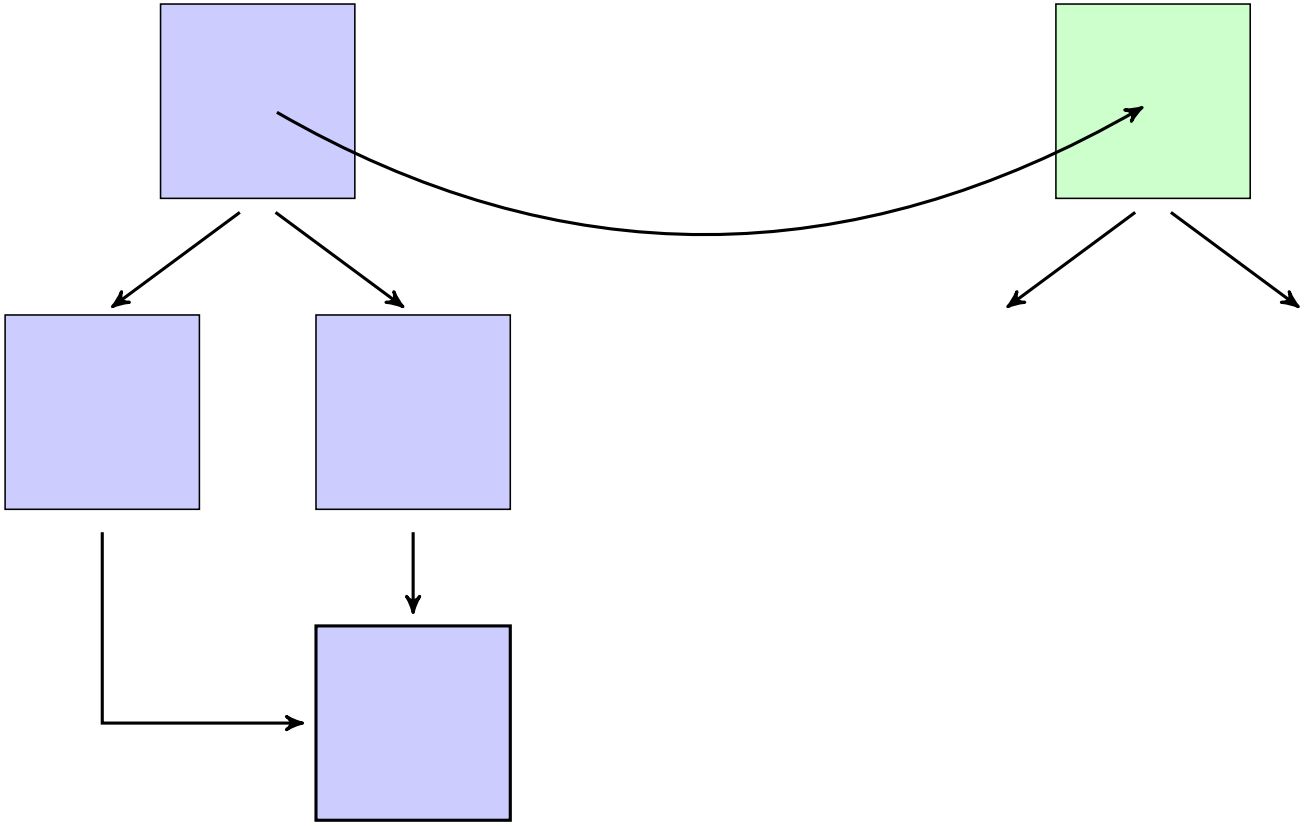
Migrating the state

Parallel migration



Migrating the state

Lazy migration



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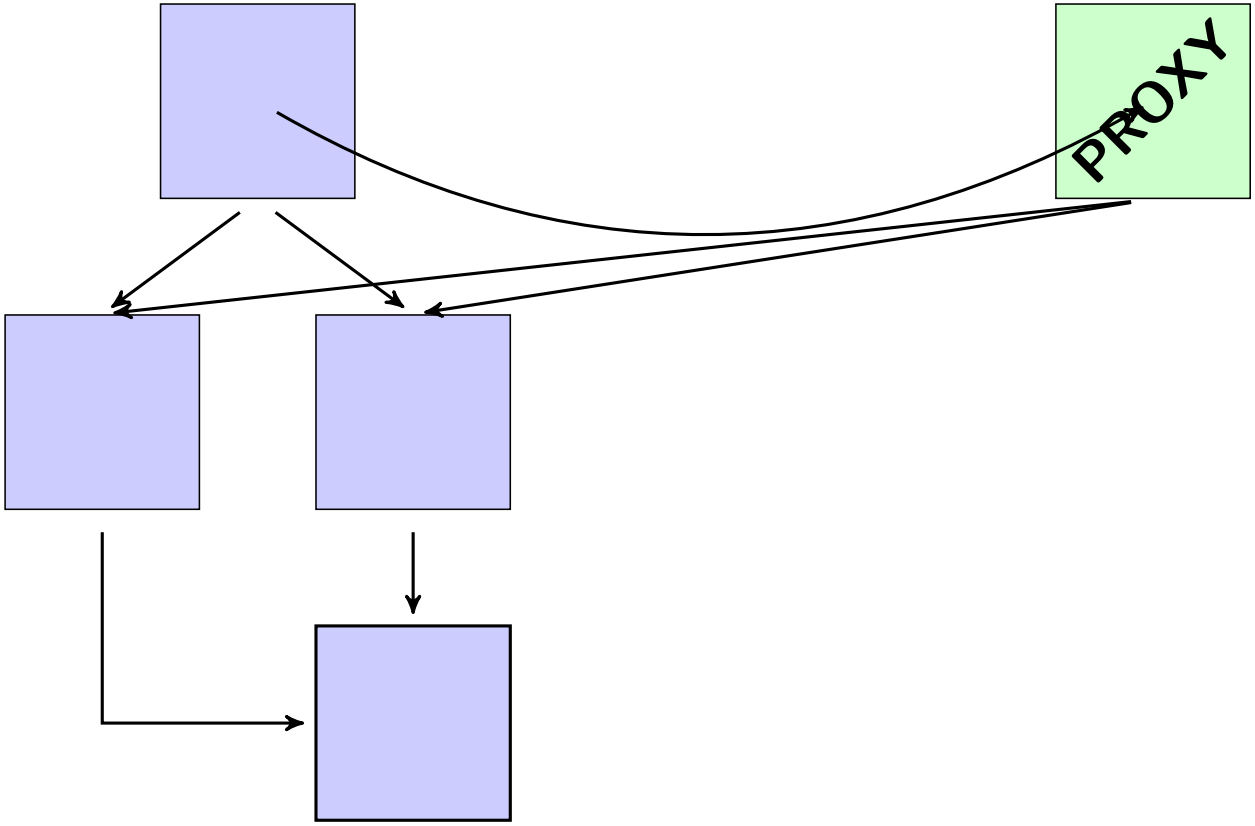

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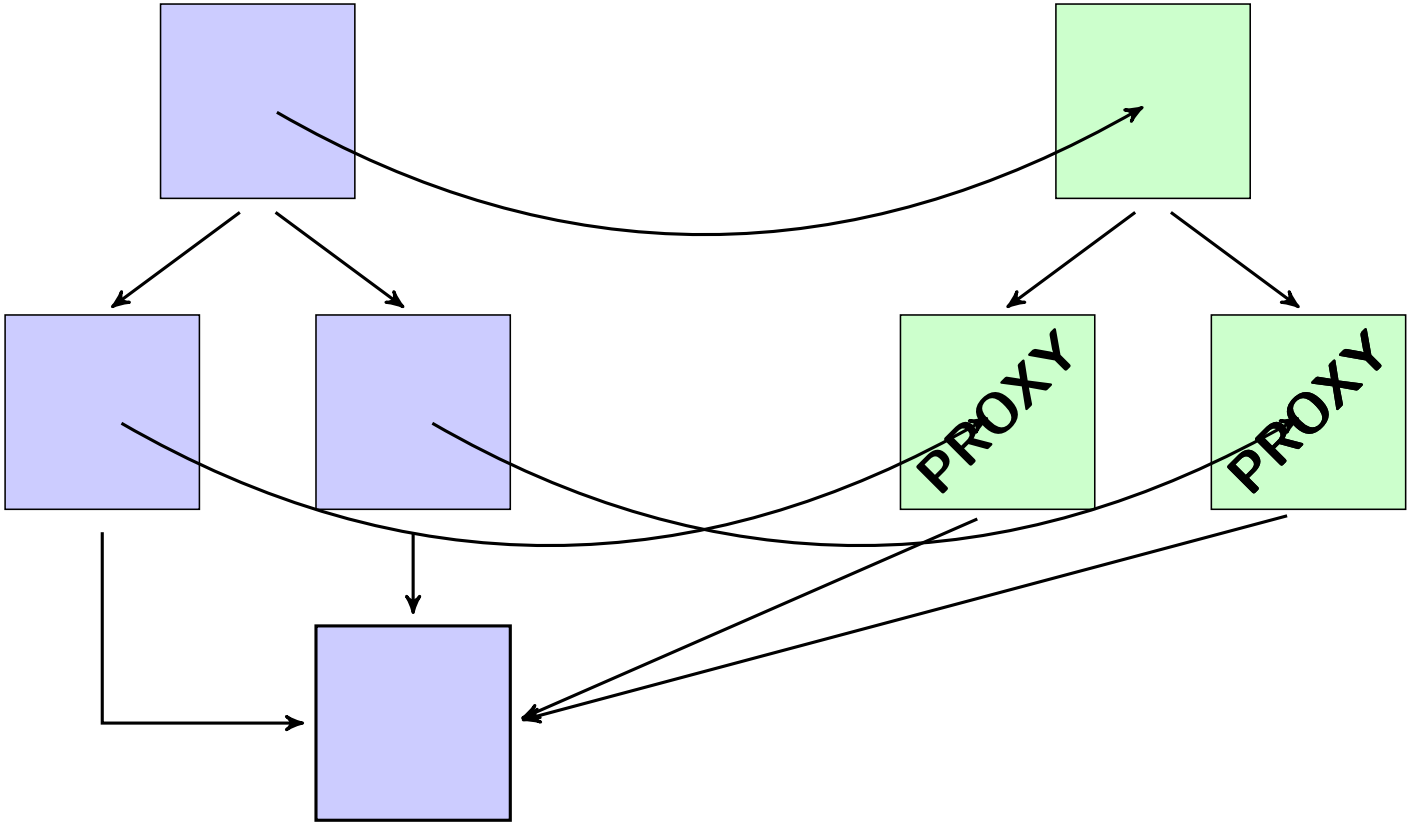

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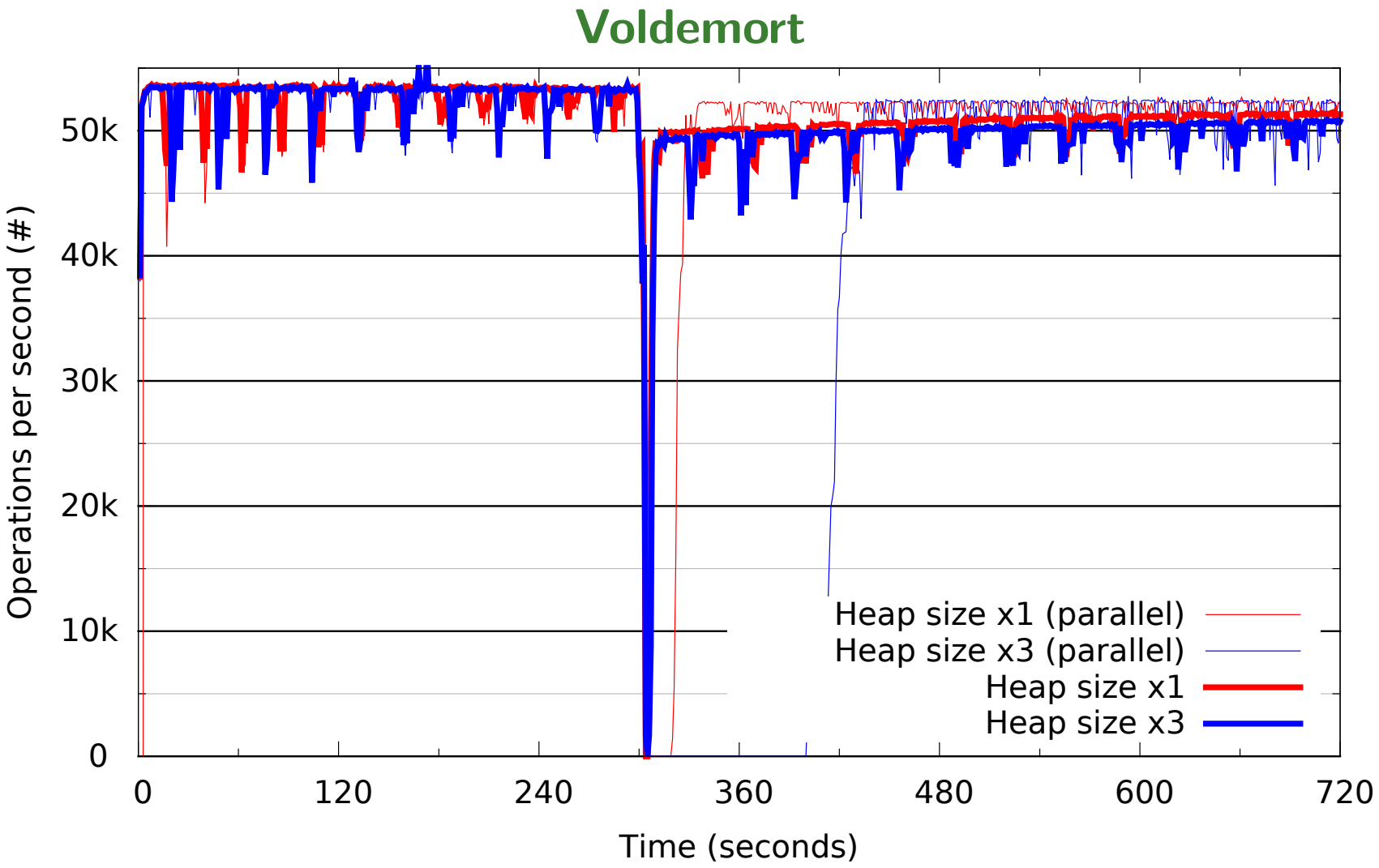

Migrating the state

Update Pause

Benchmark	Heap Size	Pause (sec)	
		Parallel	*Lazy*
Voldemort	x1	10.7	2.2
	x2	19.1	2.2
	x3	107.4	2.4
H2	x1	9.0	3.1
	x2	15.3	3.7
	x4	30.9	3.7

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Thank You!

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