QCon NEW YORK

Migrating Speedment to Java 9

Dan Lawesson, @dan_lawesson
CSO, Speedment, Inc

Speedment

About Us

Speedment

About Us

Dan Lawesson, PhD

- AI, model-based diagnosis
- CSO with S as in Science
- 20 years of Java experience
- Previous lives: telecom and automotive IoT

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Spire

- Speedment Open Source mascot
- Lives on GitHub
- 2 years of mascot experience

Speedment

Outline

Speedment

Outline

- Speedment
- Jigsaw
- Jigsawing Speedment

Speedment

Speedment

Speedment is

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Speedment is

- a Streams API ORM

Speedment

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- a Streams API ORM
- using in-JVM memory acceleration

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- and Code Generation,

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Oracle Java Magazine May-June pages 34-40

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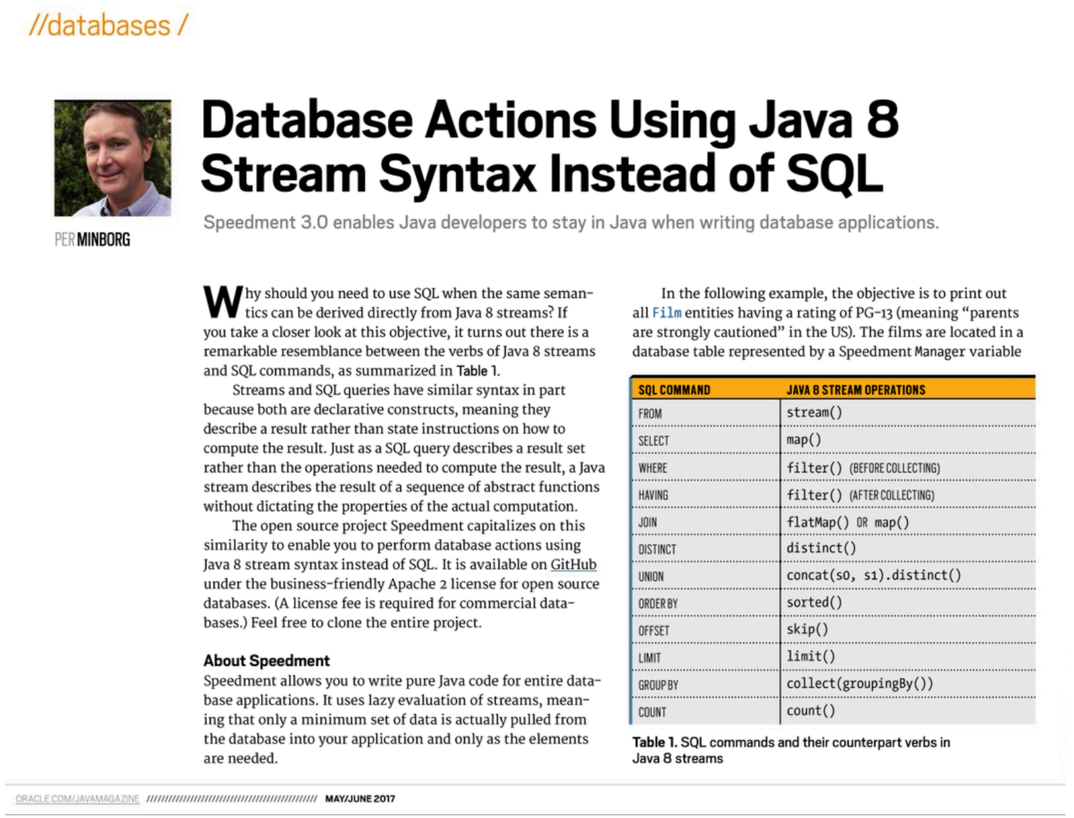

//databases /

PER MINBORG

Database Actions Using Java 8 Stream Syntax Instead of SQL

Speedment 3.0 enables Java developers to stay in Java when writing database applications.

Why should you need to use SQL when the same semantics can be derived directly from Java 8 streams? If you take a closer look at this objective, it turns out there is a remarkable resemblance between the verbs of Java 8 streams and SQL commands, as summarized in Table 1.

Streams and SQL queries have similar syntax in part because both are declarative constructs, meaning they describe a result rather than state instructions on how to compute the result. Just as a SQL query describes a result set rather than the operations needed to compute the result, a Java stream describes the result of a sequence of abstract functions without dictating the properties of the actual computation.

The open source project Speedment capitalizes on this similarity to enable you to perform database actions using Java 8 stream syntax instead of SQL. It is available on GitHub under the business-friendly Apache 2 license for open source databases. (A license fee is required for commercial databases.) Feel free to clone the entire project.

About Speedment

Speedment allows you to write pure Java code for entire database applications. It uses lazy evaluation of streams, meaning that only a minimum set of data is actually pulled from the database into your application and only as the elements are needed.

In the following example, the objective is to print out all `Film` entities having a rating of PG-13 (meaning "parents are strongly cautioned" in the US). The films are located in a database table represented by a Speedment `Manager` variable

SQL COMMAND	JAVA 8 STREAM OPERATIONS
FROM	`stream()`
SELECT	`map()`
WHERE	`filter()` (BEFORE COLLECTING)
HAVING	`filter()` (AFTER COLLECTING)
JOIN	`flatMap()` OR `map()`
DISTINCT	`distinct()`
UNION	`concat(s0, s1).distinct()`
ORDER BY	`sorted()`
OFFSET	`skip()`
LIMIT	`limit()`
GROUP BY	`collect(groupingBy())`
COUNT	`count()`

Table 1. SQL commands and their counterpart verbs in Java 8 streams

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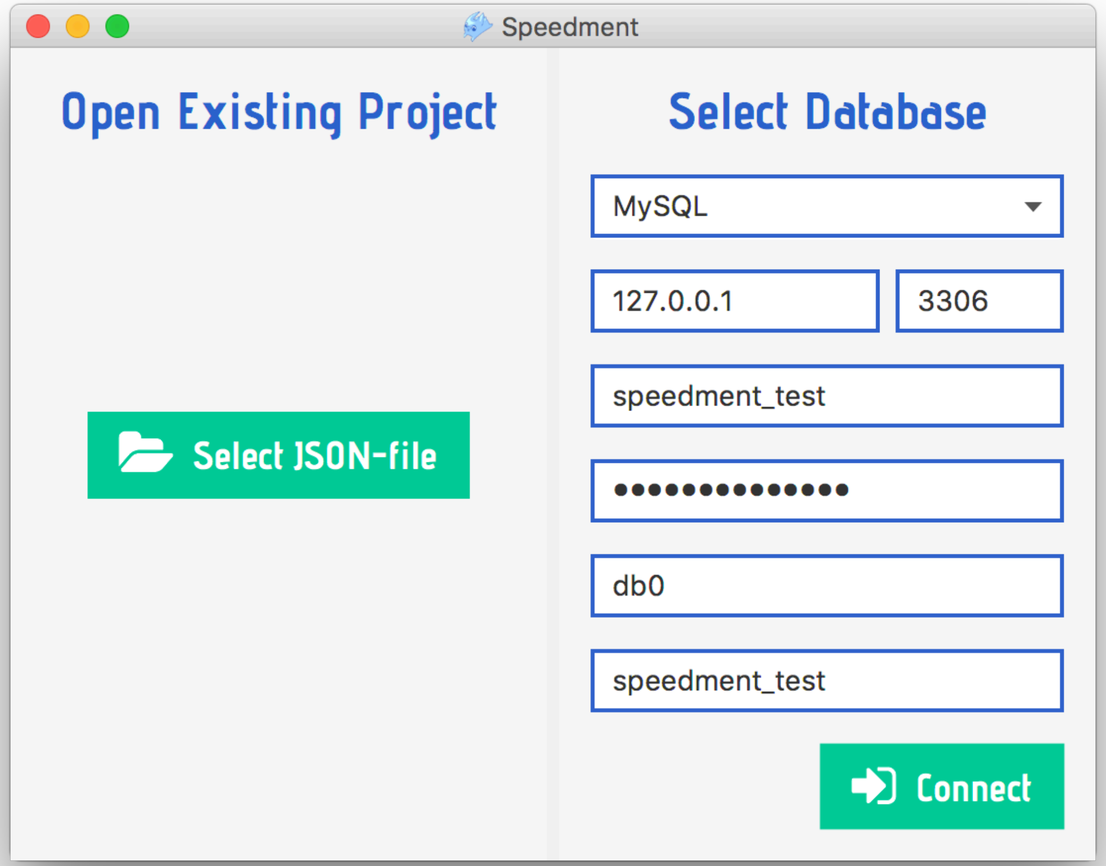
Compile-time Code Generation Tool



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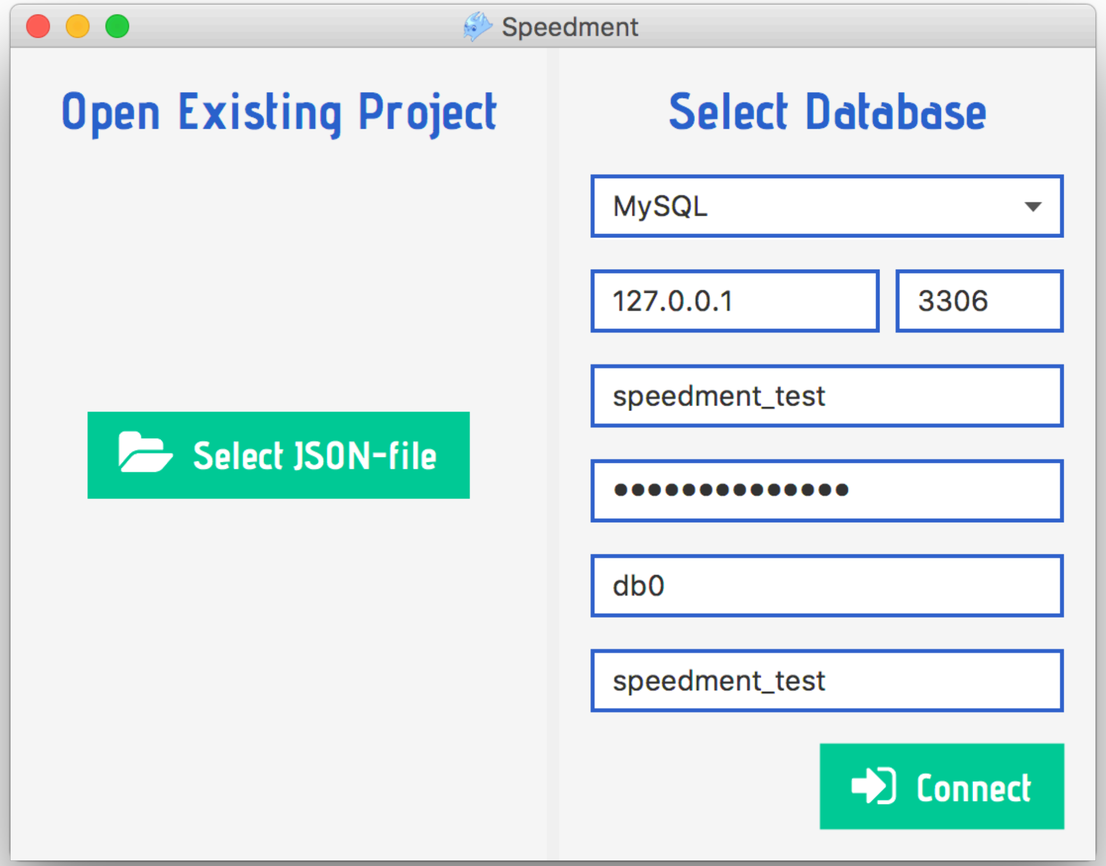

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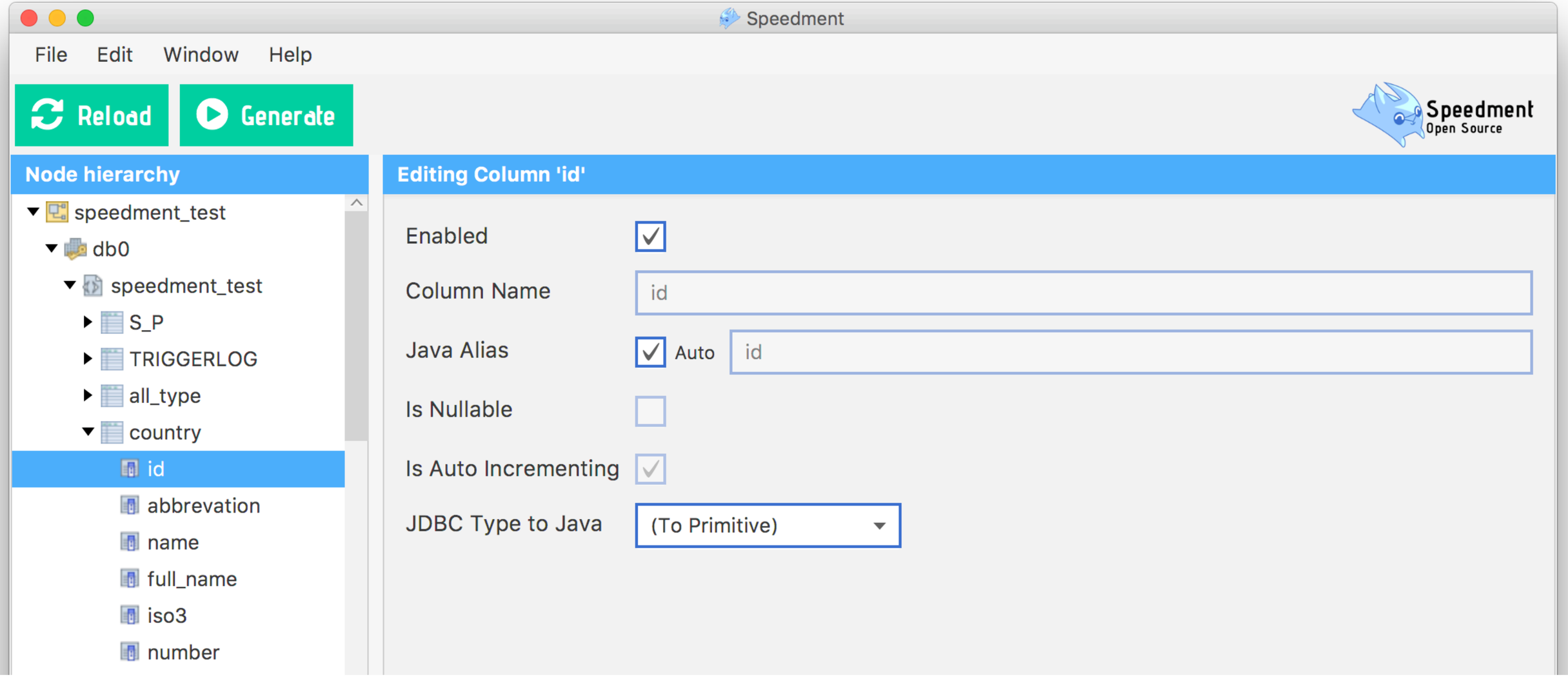
Speedment
File
Edit
Window
Help
Reload
Generate
Speedment
Open Source
Node hierarchy
speedment_test
db0
speedment_test
S_P
TRIGGERLOG
all_type
country
id
abbrevation
name
full_name
iso3
number
Editing Column 'id'
Enabled
Column Name
id
Java Alias
Auto
id
Is Nullable
Is Auto Incrementing
JDBC Type to Java
(To Primitive)

Speedment

Querying the Database using Streams

Speedment

Querying the Database using Streams

- Queries are expressed using the standard Java 8 Stream API

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Querying the Database using Streams

- Queries are expressed using the standard Java 8 Stream API
- Streams are analyzed to produce high-performance queries

Speedment

Expressing Queries as Streams

```
customers.stream()
    .filter(Customer.REGION.equal(Region.NORTH_AMERICA))
    .filter(Customer.REGISTERED.greaterOrEqual(startOfYear))
    .count();
```

Expressing Queries as Streams

Standard Stream API

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Full Type-Safety

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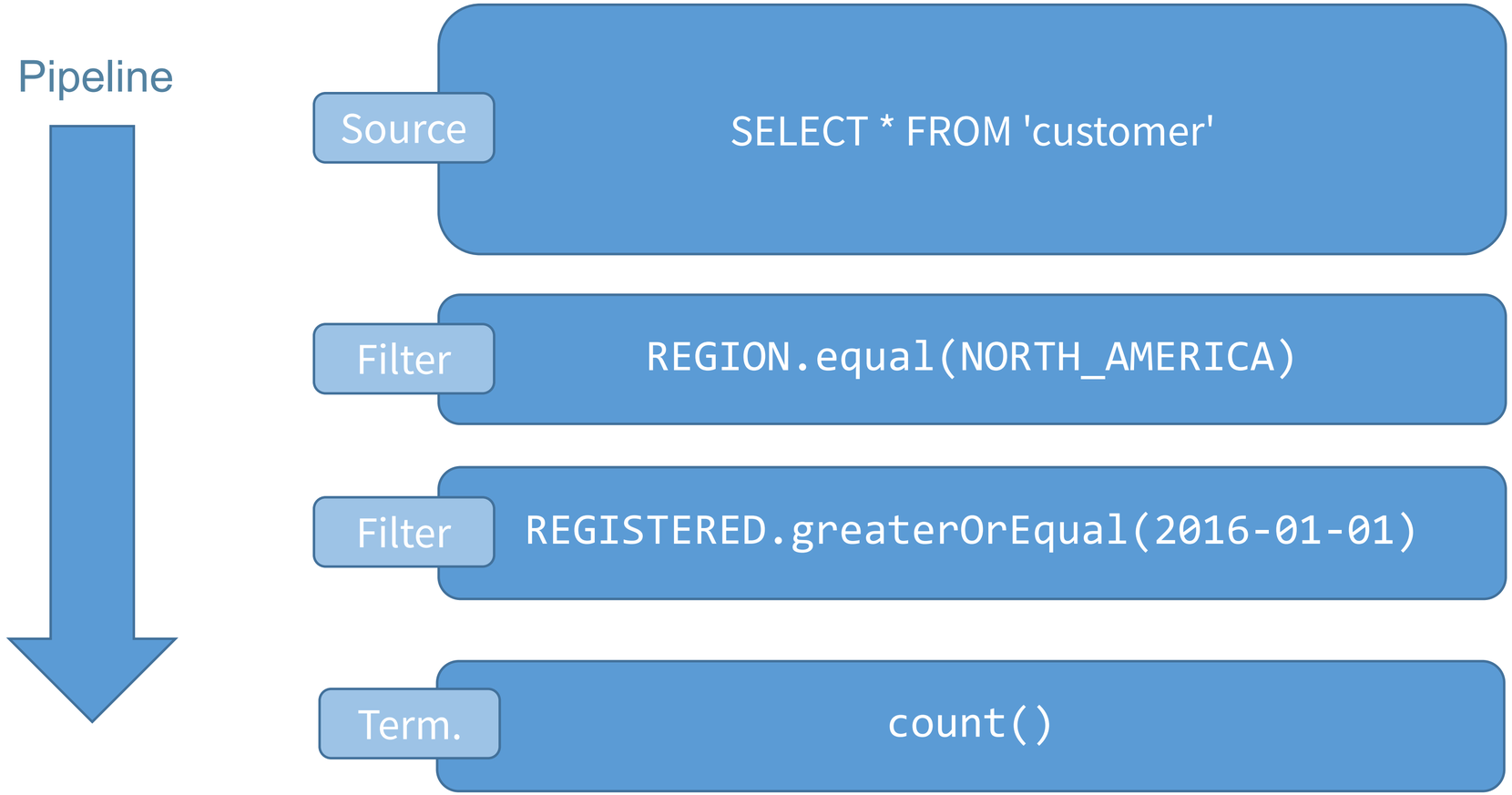
    .filter(Customer.REGISTERED.greaterOrEqual(startOfYear))
    .count();
```

Only 1 value is loaded from DB

```
SELECT COUNT('id') FROM 'customer'
    WHERE 'customer'.'region' = ‘North America’
    AND 'customer'.'registered' >= ‘2016-01-01’;
```

Speedment

Querying the Database using Streams



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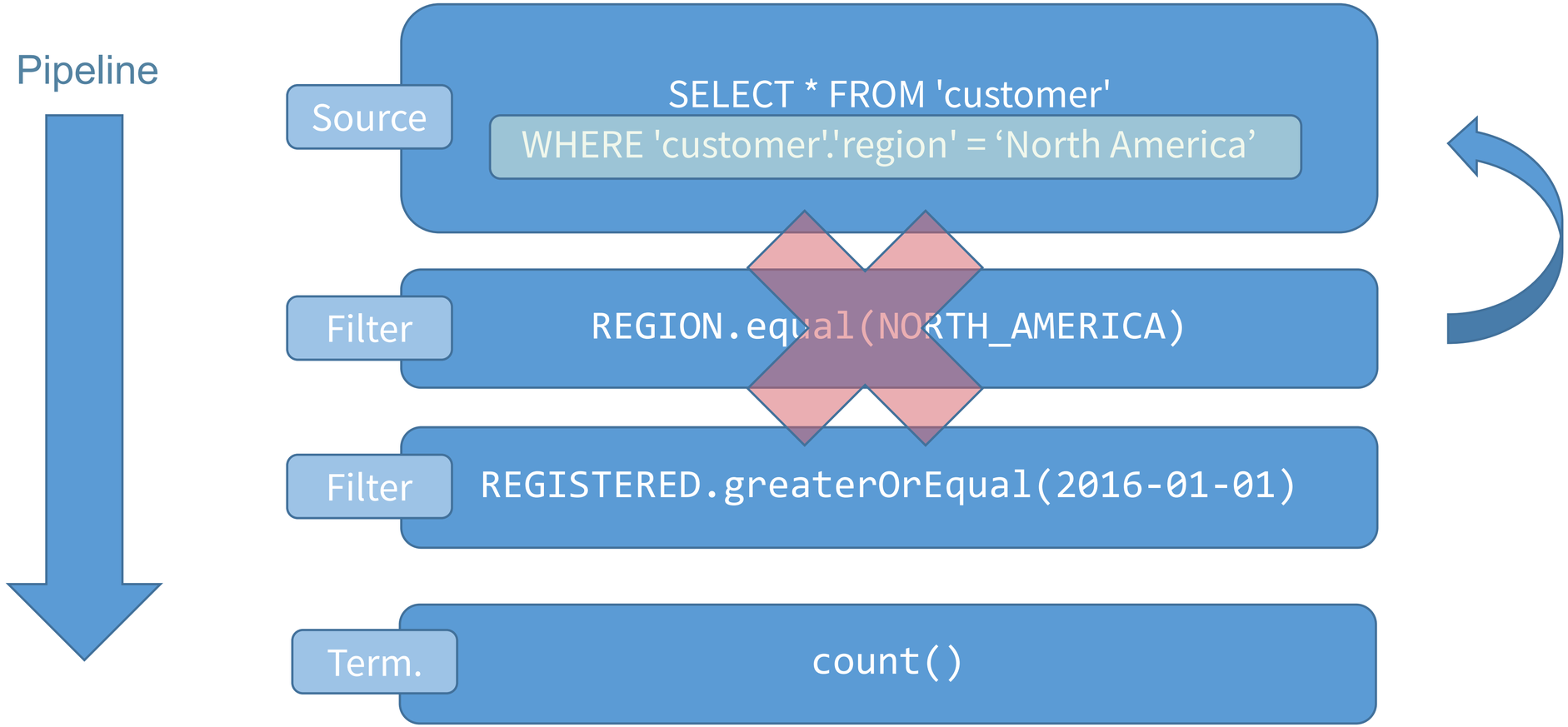

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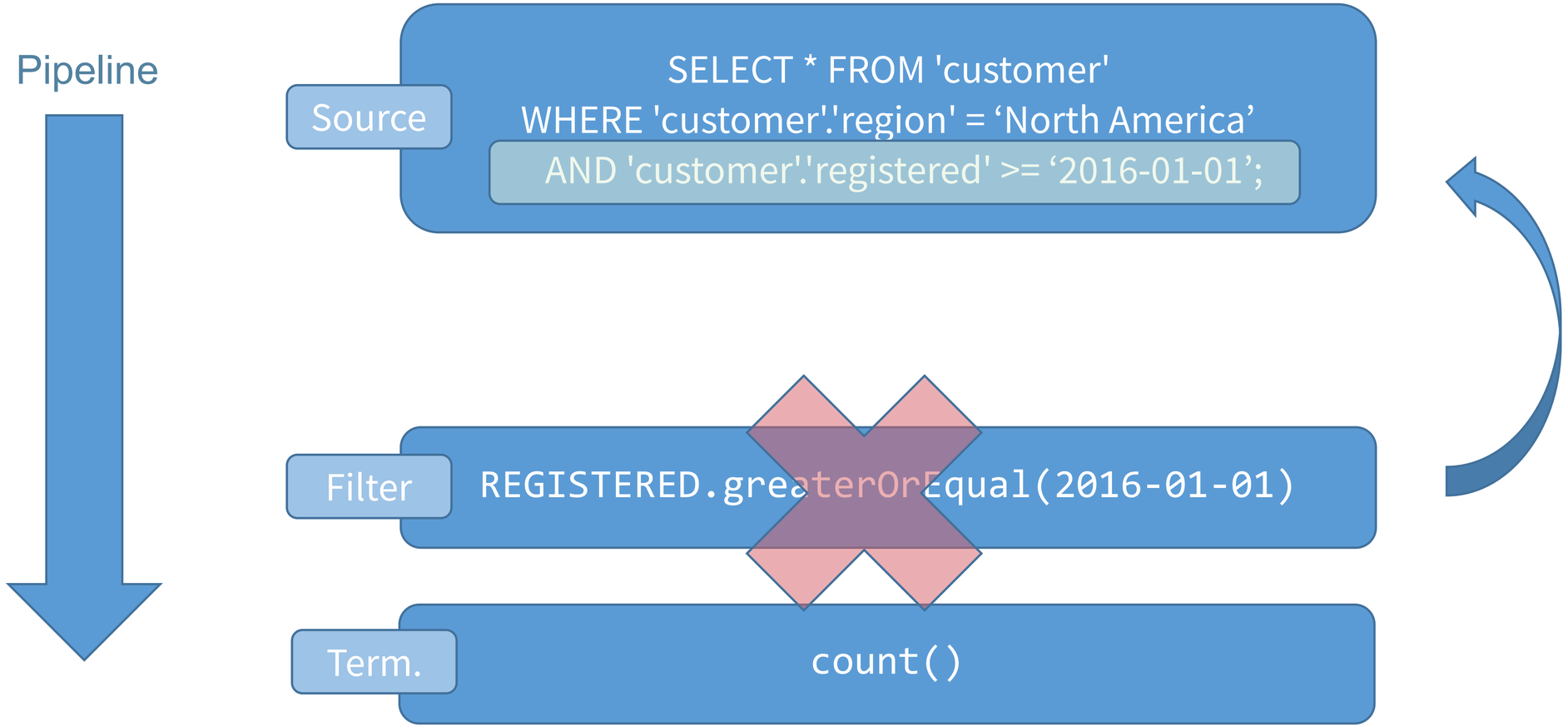

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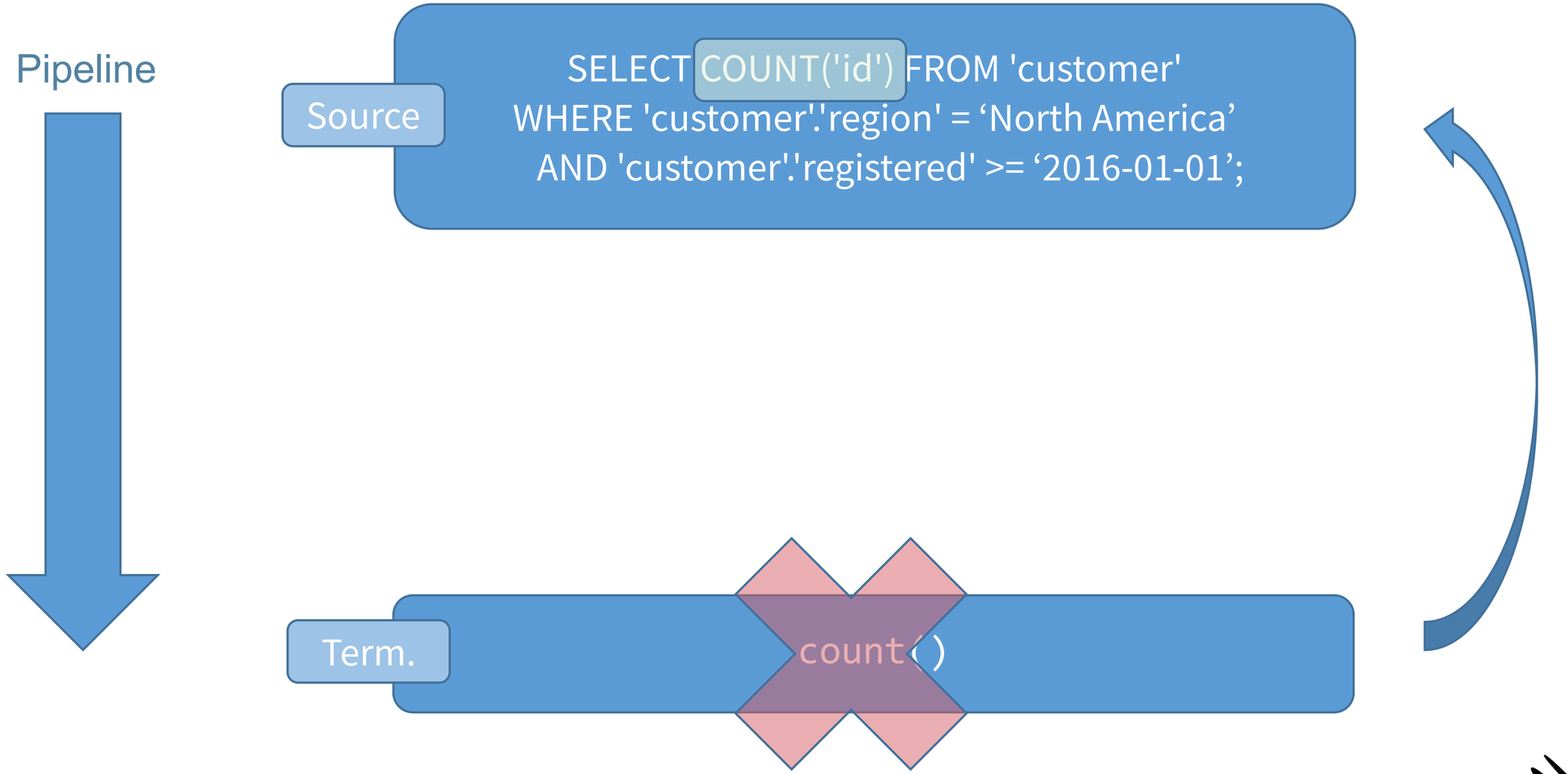

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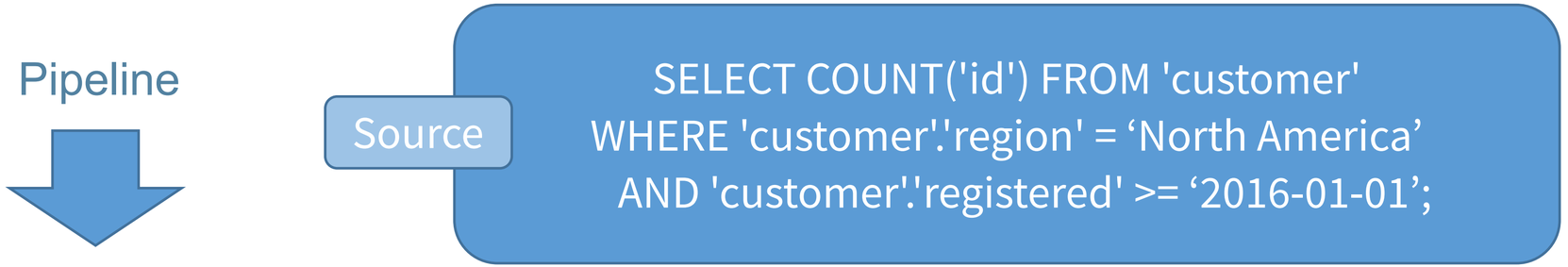

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Expressing Queries as Streams

```
// Gets the second page of customers in North America
// sorted by name in the form of a JSON array
```

Speedment

Expressing Queries as Streams

```
// Gets the second page of customers in North America
// sorted by name in the form of a JSON array

customers.stream()
    .filter(REGION.equal(Region.NORTH_AMERICA))
    .sorted(NAME.comparator())
    .skip(10)
    .limit(10)  // JVM from here…
    .collect(toJson(encode.allOf(customers)))

[
  {”id”:11, ”name”: …},
  {…},
  …
]
```

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Parallelism as Expected for a Stream

```
// Supports parallelism on custom executors
// with full control of thread work item layout
```

Speedment

Parallelism as Expected for a Stream

```
// Supports parallelism on custom executors
// with full control of thread work item layout

customers.stream()
    .parallel()
    .filter(REGION.equal(Region.NORTH_AMERICA))
    .forEach(expensiveOperatation());
```

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Querying

```
Optional<Hare> oldHare = hares.stream()
        .filter(Hare.AGE.greaterThan(5))
        .findAny();
```

Querying

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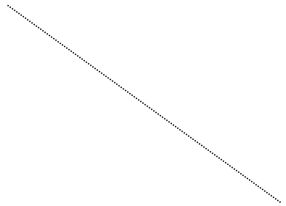

Predicate Builder

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Querying

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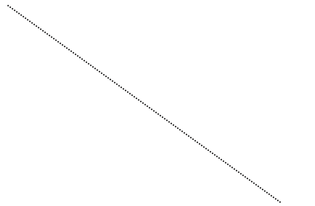

Predicate Builder

```
SELECT id, name, color, age
FROM hare
WHERE (age > 5) LIMIT 1;
```

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Entities are Linked

```
// Find the owner of the orange carrot
Optional<Hare> hare = carrots.stream()
 .filter(Carrot.NAME.equal("Orange"))
 .map(hares.finderBy(Carrot.OWNER))
 .findAny();

// Find one carrot owned by Harry
// Carrot is a foreign key table
Optional<Carrot> carrot = hares.stream()
 .filter(Hare.NAME.equal("Harry"))
 .flatMap(carrots.finderBackwardsBy(Carrot.OWNER))
 .findAny();
```

Joins

```
Map<Hare, List<Carrot>> join = carrots.stream()
    .collect(
      groupingBy(hares.finderBy(Carrot.OWNER))
    );
```

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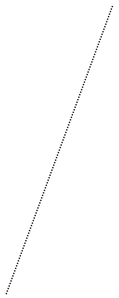

Standard Java 8

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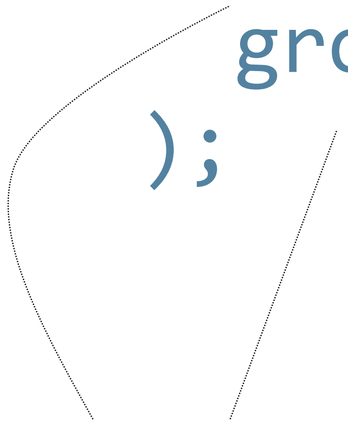

Standard Java 8

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Imperative vs Declarative

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SQL describes *what* rather than *how*

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database engine figures out the how

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Streams are also declarative - a result is described

Imperative vs Declarative

SQL describes *what* rather than *how*

database engine figures out the how

Streams are also declarative - a result is described

framework takes pipeline as input and determines the *how*

Typical ORM + Java Streams Application

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Explicit SQL + Java Stream is an *imperative* two step program:

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1. Compute Result Set `SELECT x FROM y WHERE z`

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Typical ORM + Java Streams Application

Explicit SQL + Java Stream is an *imperative* two step program:

1. Compute Result Set `SELECT x FROM y WHERE z`
2. Stream over Result Set `rs.stream().filter…`

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Speedment - Breaking the Language Barrier

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Java Stream expressing **both** database and JVM operations ->

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the program is *declarative*,

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Speedment - Breaking the Language Barrier

Java Stream expressing **both** database and JVM operations ->

the program is *declarative*,

the runtime determines the DB-JVM work split.

Speedment

Speedment - Fully Declarative DB Applications

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Fully declarative ->

Speedment

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Fully declarative ->

Speedment Enterprise: add in-memory-acceleration

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Speedment - Fully Declarative DB Applications

Fully declarative ->

Speedment Enterprise: add in-memory-acceleration

without changing anything in the stream application.

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Jigsaw

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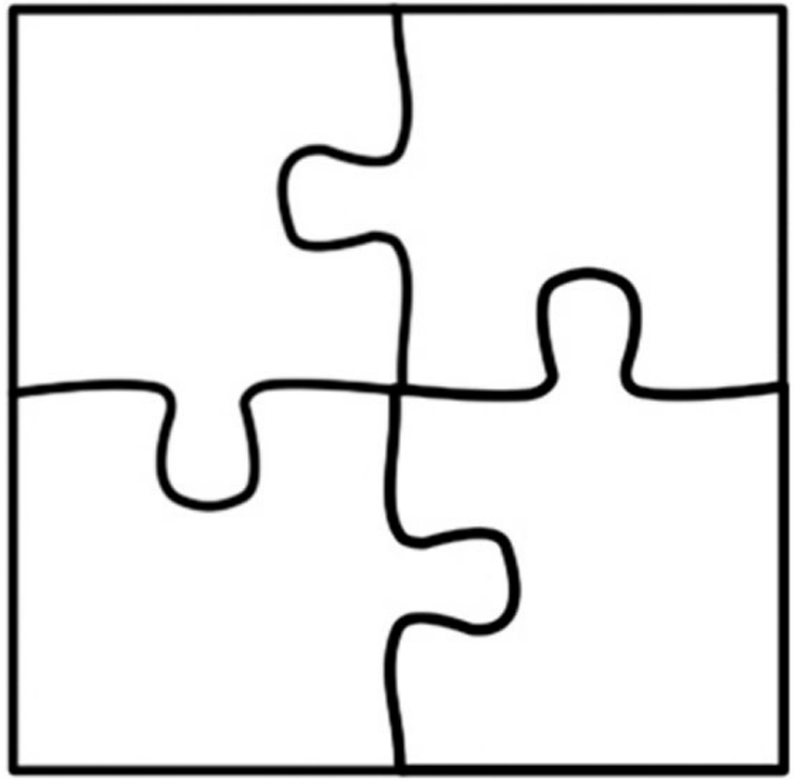
Jigsaw



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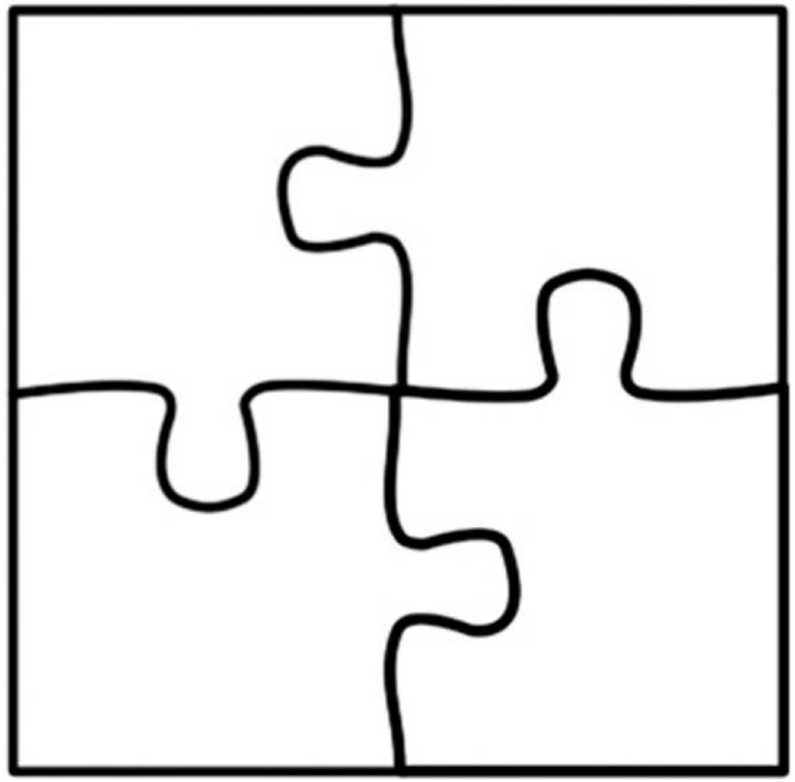
Jigsaw

- Modules - an abstraction on top of packages
  - Strong Encapsulation
  - Reliable Configuration



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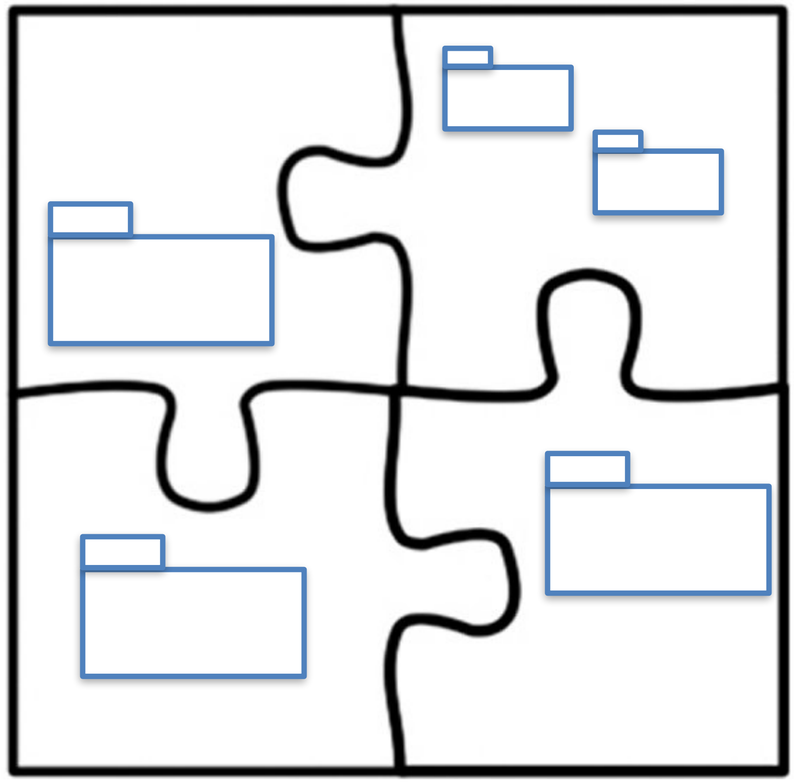

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Split Packages

Reliable configuration - a package may only belong to one module

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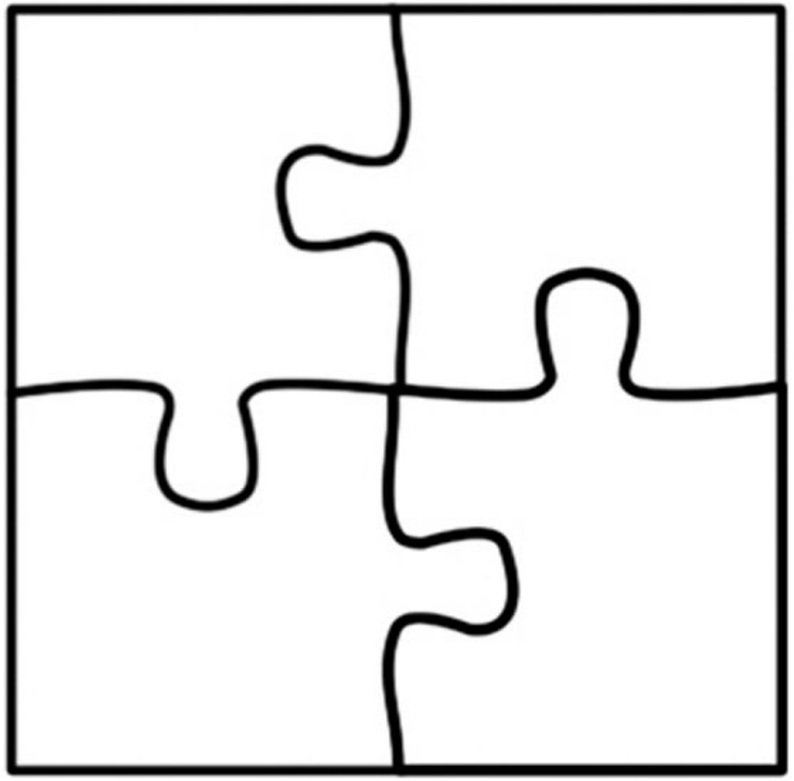

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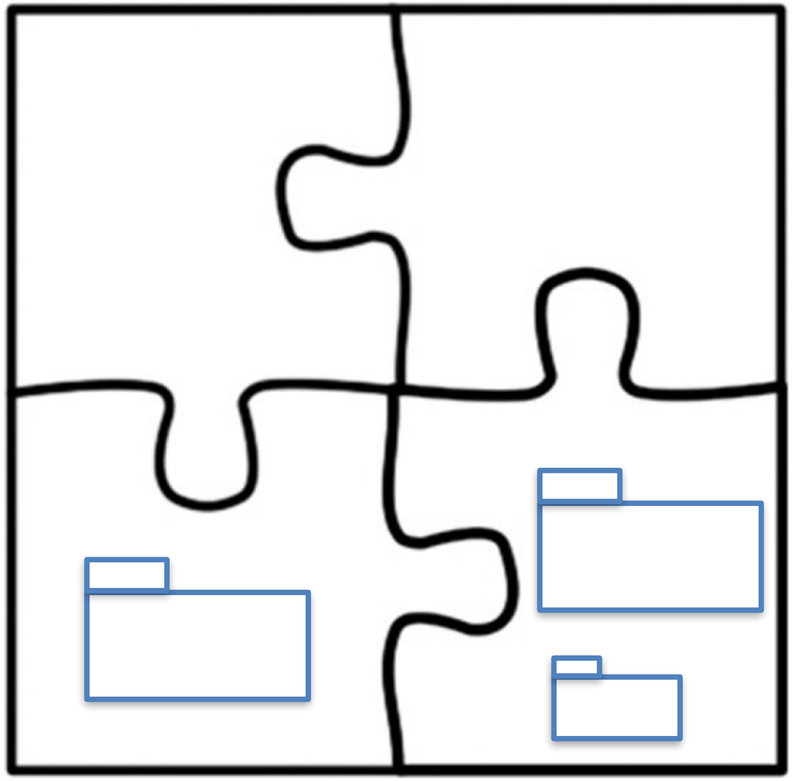

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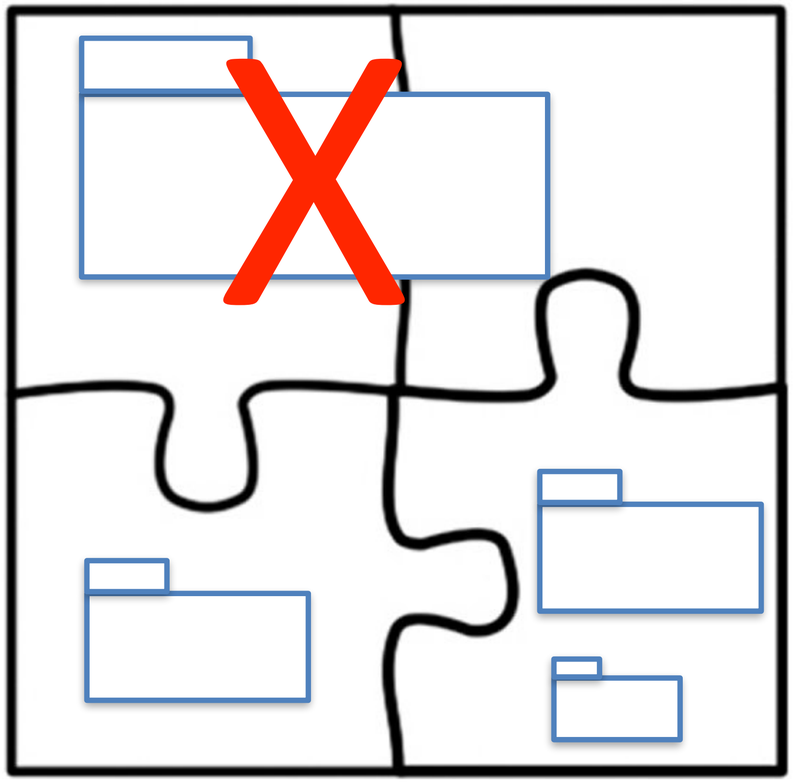

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Automatic Modules

Automatic Modules

- Smooth transition to Java 9

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- Smooth transition to Java 9
- Move the Java 8 JAR from class path to module path

Automatic Modules

- Smooth transition to Java 9
- Move the Java 8 JAR from class path to module path
- The JAR automatically becomes a module

Automatic modules vs split packages

- Maven puts dependencies on the module path

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- Java 8 to 9 portability -> automatic modules

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- Works for JDK `!=` works for applications
  - Restricts current application domain use cases

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- sun.misc.Unsafe
  - ”Should not be used” **vs** ”A key for Java real-world success”

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Some Other Jigsaw Controversies

- Works for JDK `!=` works for applications
  - Restricts current application domain use cases

- sun.misc.Unsafe
  - ”Should not be used” **vs** ”A key for Java real-world success”

- Fundamentally different compared to e.g. OSGi
  - lazy loading, dynamic package adding, split packages

Jigsawing the Java 8 Application

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Jigsawing the Java 8 Application

- Run Java 8 under Java 9 is super easy

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Jigsawing the Java 8 Application

- Run Java 8 under Java 9 is super easy

```
java -cp <…> -jar app.jar
```

Speedment

Jigsawing the Java 8 Application

- Run Java 8 under Java 9 is super easy

```
java -cp <…> -jar app.jar
```

- The challenge is to move from cp to mp

Speedment

Inter module dependencies

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Inter module dependencies

Dependencies explicitly given in module-info.java

Speedment

Inter module dependencies

Dependencies explicitly given in module-info.java

```
module com.speedment.common {
    requires com.foo.bar;                          // a module we depend on
    exports com.speedment.common.invariant;        // a package we expose to the user
}
```

Speedment

A Straight-Forward Modularization Approach

class path

module path

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A Straight-Forward Modularization Approach

	class path	module path
1. All JARs on class path	`<all jars>`	

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A Straight-Forward Modularization Approach

	class path	module path
1. All JARs on class path	`<all jars>`	
2. App as a monolithic module	`<all deps>`	`myapp.jar`

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A Straight-Forward Modularization Approach

1. All JARs on class path
2. App as a monolithic module
3. Declare dependencies

	class path	module path
1.	`<all jars>`	
2.	`<all deps>`	`myapp.jar`
3.		

Speedment

A Straight-Forward Modularization Approach

	class path	module path
1. All JARs on class path	`<all jars>`	
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Speedment

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5. Modularize app		

Speedment

The Speedment Java 8 Modules

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Speedment pom.xml

Speedment

The Speedment Java 8 Modules

Speedment pom.xml

```
<modules>
  <module>common-parent</module>
  <module>runtime-parent</module>
  <module>generator-parent</module>
  <module>tool-parent</module>
  <module>build-parent</module>
  <module>plugin-parent</module>
  <module>connector-parent</module>
  <module>archetype-parent</module>
  <module>example-parent</module>
</modules>
```

The Modules of the Speedment common Module

Speedment

The Modules of the Speedment common Module

Speedment common/pom.xml

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```
<modules>
  <module>invariant</module>
  <module>function</module>
  <module>json</module>
  <module>tuple</module>
  <module>logger</module>
  <module>codegen</module>
  <module>codegenxml</module>
  <module>injector</module>
  <module>rest</module>
  <module>lazy</module>
  <module>mapstream</module>
  <module>mutablestream</module>
  <module>singletonstream</module>
  <module>common-all</module>
  <module>annotation</module>
  <module>benchmark</module>
  <module>combinatorics</module>
  <module>collection</module>
</modules>
```

Automatic Jigsawing Script Outline

Speedment

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- Create separate directories for the modules

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- Move source code packages to respective modules

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- Loop:
    1. Compile

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    2. Parse and fix errors

Automatic Jigsawing Script Outline

- Create separate directories for the modules
- Move source code packages to respective modules
- Add empty module-info.java
- Loop:
    1. Compile
    2. Parse and fix errors
    3. git add
    4. git commit

Speedment

Automatic Jigsawing - add requires

Speedment

Automatic Jigsawing - add requires

Missing Speedment internal dependency

```
\[ERROR\].*\(package (.*) is declared in module (.*),
but module com.speedment.(.*)\.(.*) does not read it\)
```

Fix:

```
 module com.speedment.X {
+    requires com.speedment.Y;
 }
```

Speedment

Automatic Jigsawing - add exports

Speedment

Automatic Jigsawing - add exports

Missing Speedment internal visibility

```
\[ERROR\].*\(package com.speedment.(.*)\.(.*) is declared in
module com.speedment.(.*)\.(.*), which does not export it\)
```

Fix:

```
 module com.speedment.Y {
+    exports com.speedment.X;
 }
```

Speedment

Automatic Jigsawing - patch (ab)use of JDK API

Automatic Jigsawing - patch (ab)use of JDK API

Speedment usage of non-public JDK API

```
\[ERROR\].*\(package (.*) is declared in module (.*), which does
not export it to module com.speedment.(.*)\.(.*)\)
```

Temporary workaround: add exports in the pom file

```
                <artifactId>maven-compiler-plugin</artifactId>
+                <configuration>
+                    <compilerArgs>
+                        <arg>–add-exports</arg><arg>java.base/sun.nio.ch=com.speedment.…
+                    </compilerArgs>
+                </configuration>
```

Speedment

Automatic Jigsawing - remove OSGi bundling

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Maven does not currently coexist well with OSGi bundling and Jigsaw

```
\[ERROR\].*Manifest com\.speedment\.([^:]*)\:([^:]*)\:[^:]*\:.* \: Invalid
class file module-info\.class \
(java\.lang\.ArrayIndexOutOfBoundsException\: 19\)
```

Temporary workaround: comment out the bundling

```
-    <packaging>bundle</packaging>
+    <packaging>jar</packaging>
…
         <plugins>
+            <!--
             <plugin>
                 <groupId>org.apache.felix</groupId>
…
```

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Speedment Open Source - the Easy Case

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- No usage of sun.misc.Unsafe

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No Reflection in Speedment

Speedment

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Speedment

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  - instantiate user code

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- O/R mapping -> reflection
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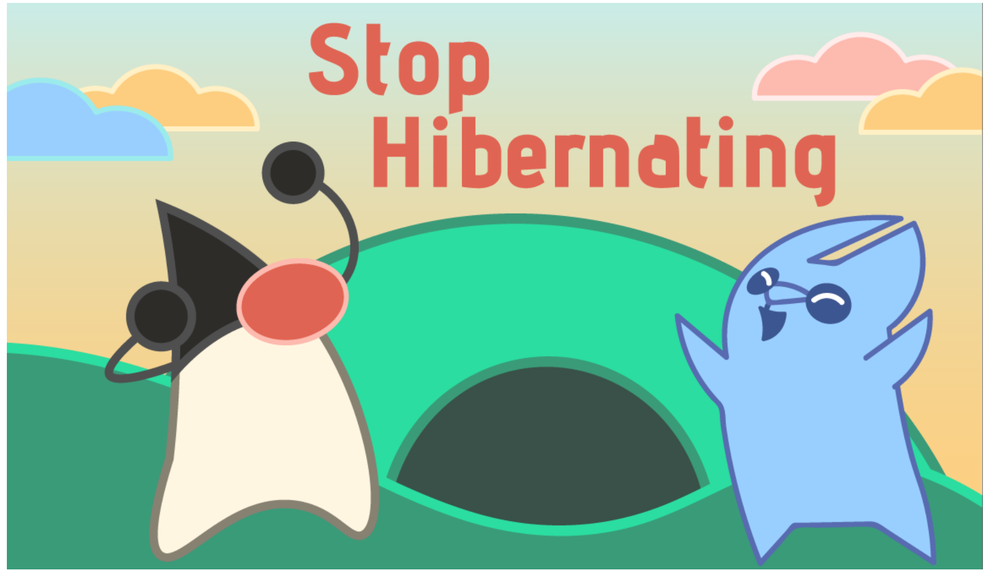
- Code Generation to the Rescue!



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Speedment Enterprise - a Jigsaw Puzzle

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Uses sun.misc.Unsafe

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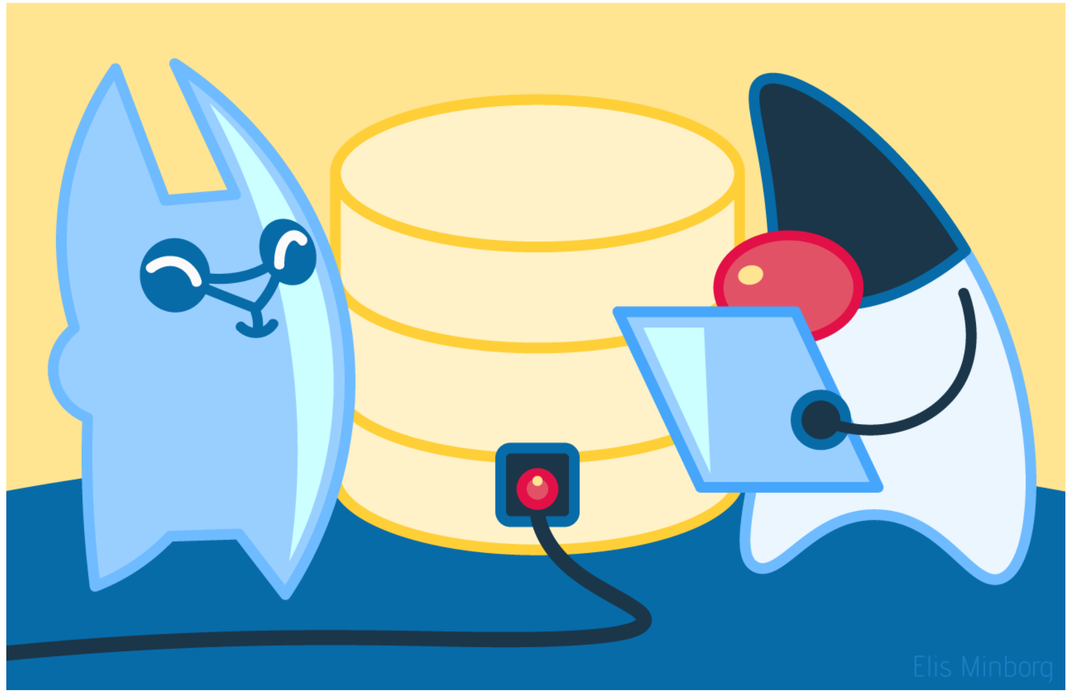
Third party dependencies

- Depends on Third Party JARs
- Automatic modules with split packages

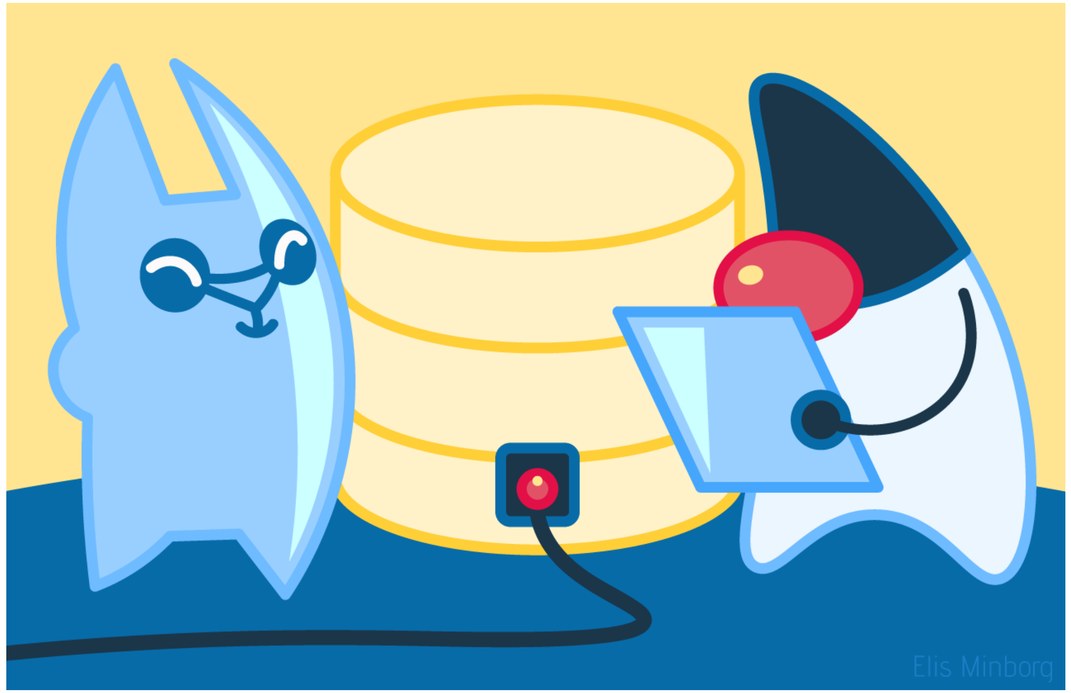
Awaiting Community Progress



Speedment

Awaiting Community Progress

- OSGi bundles



Speedment

Awaiting Community Progress

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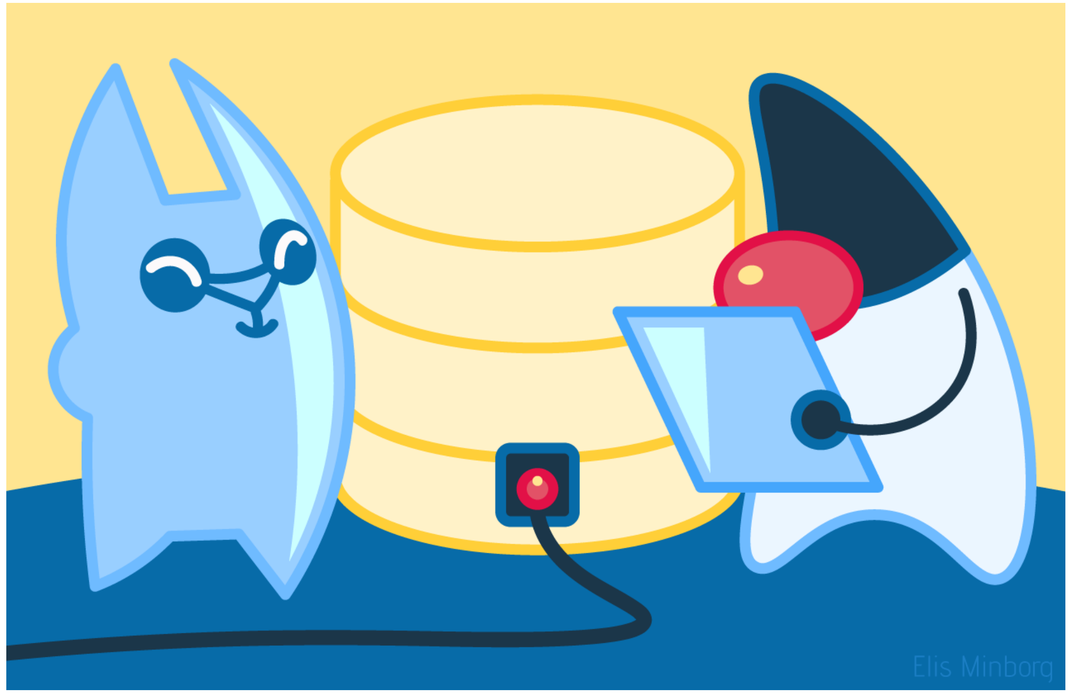

Speedment

Awaiting Community Progress

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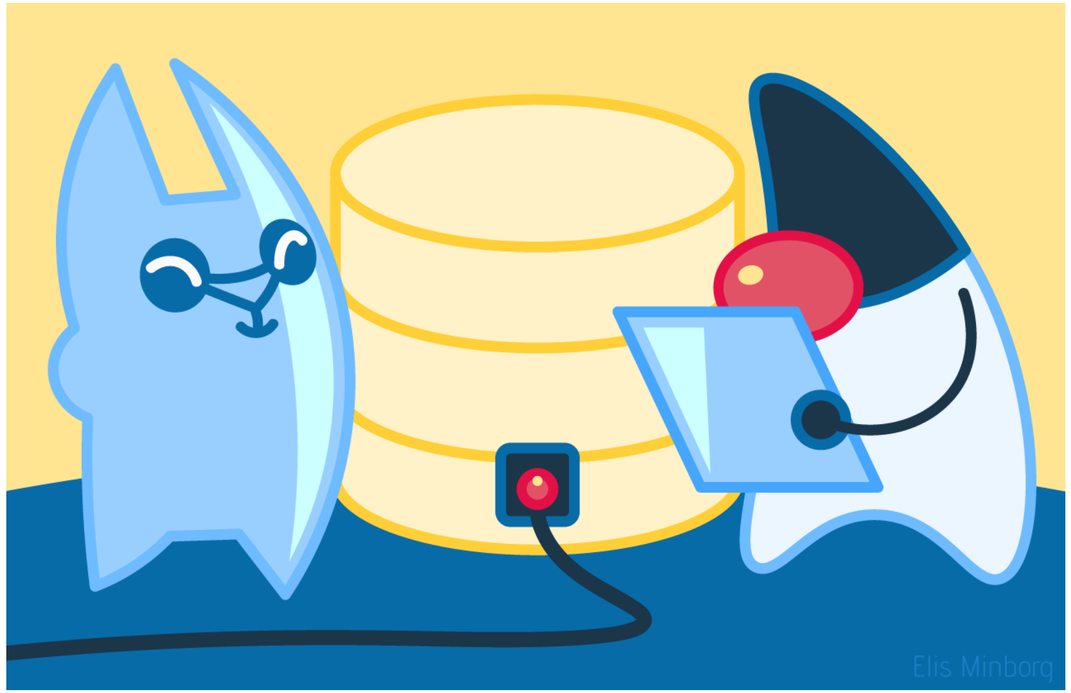
- Third Party Dependencies
  - Split packages



Speedment

Awaiting Community Progress

- OSGi bundles

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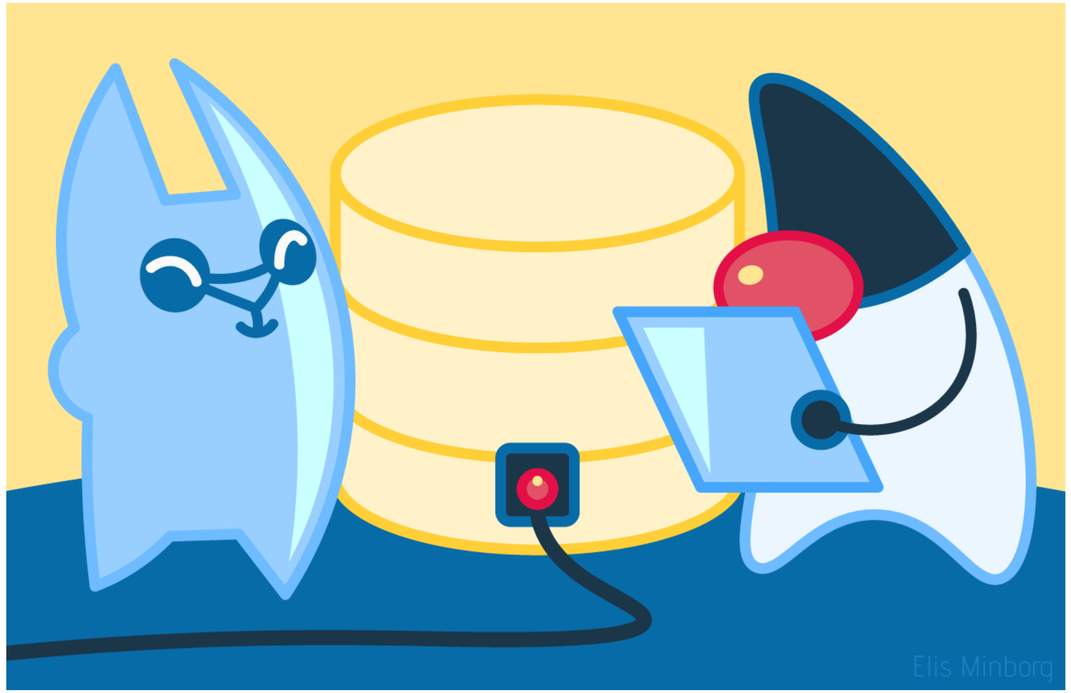
  - Concealed package conflicts



Speedment

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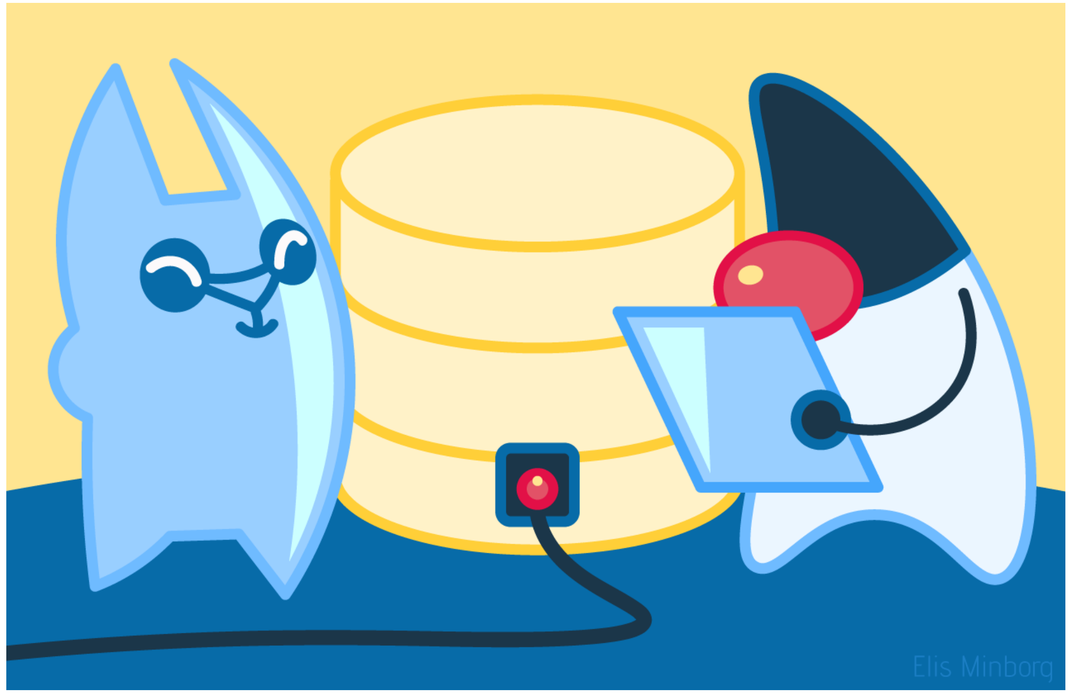

Speedment

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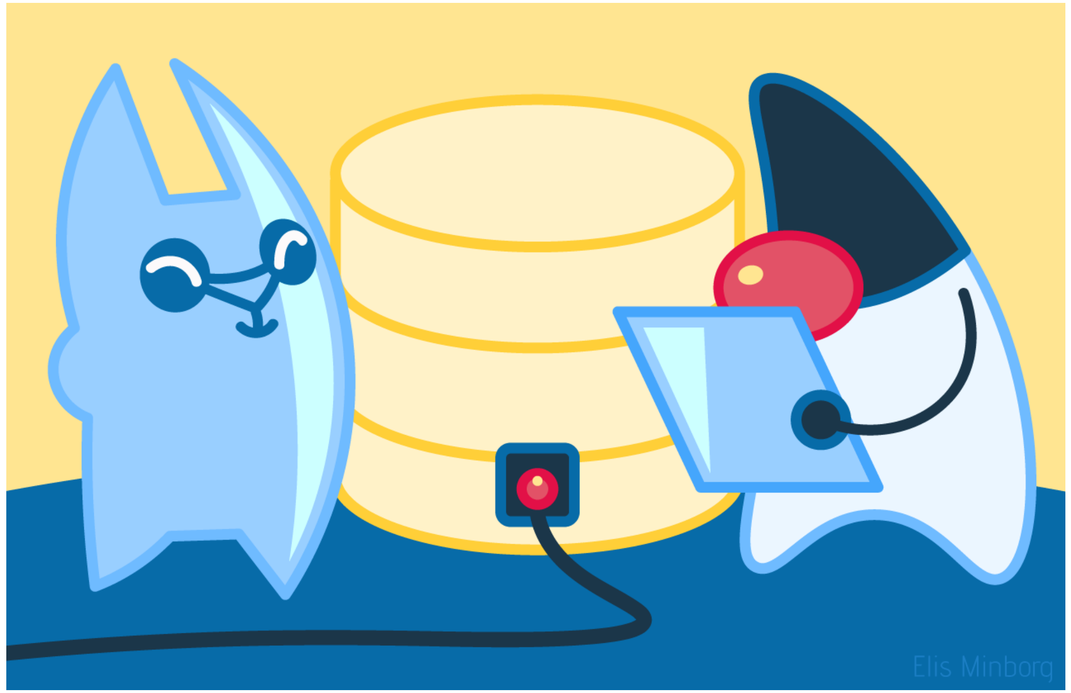

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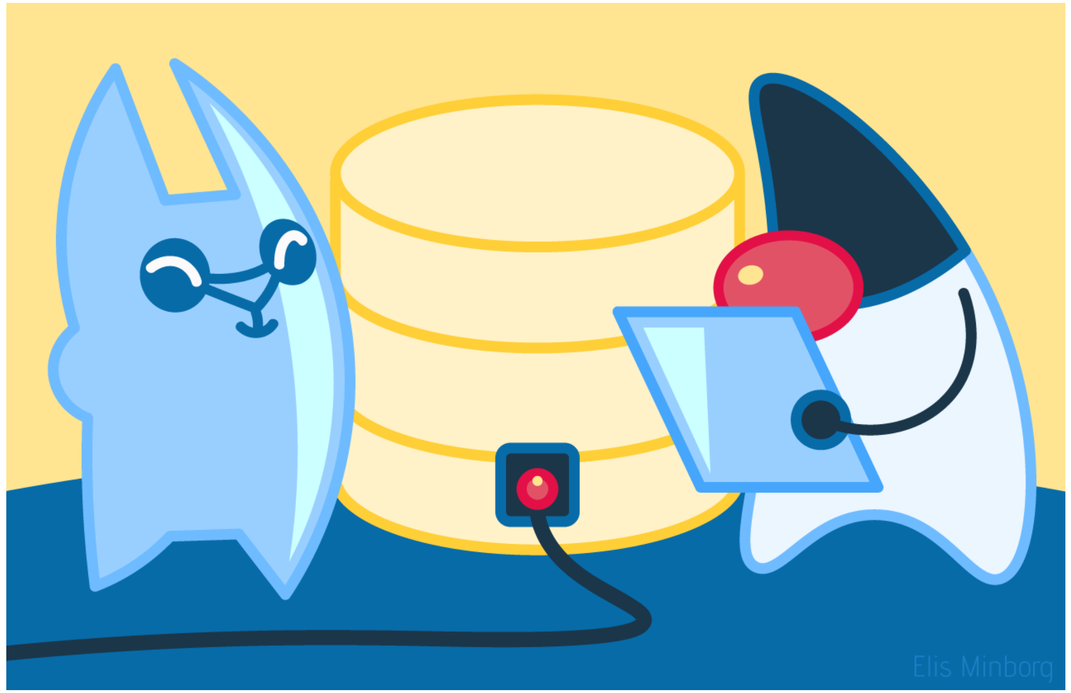
  - Duplicate package names
- Spring Integration
- Unit test frameworks



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Conclusions

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Lean Principle – "Defer Commitment" or "Decide as late as possible”

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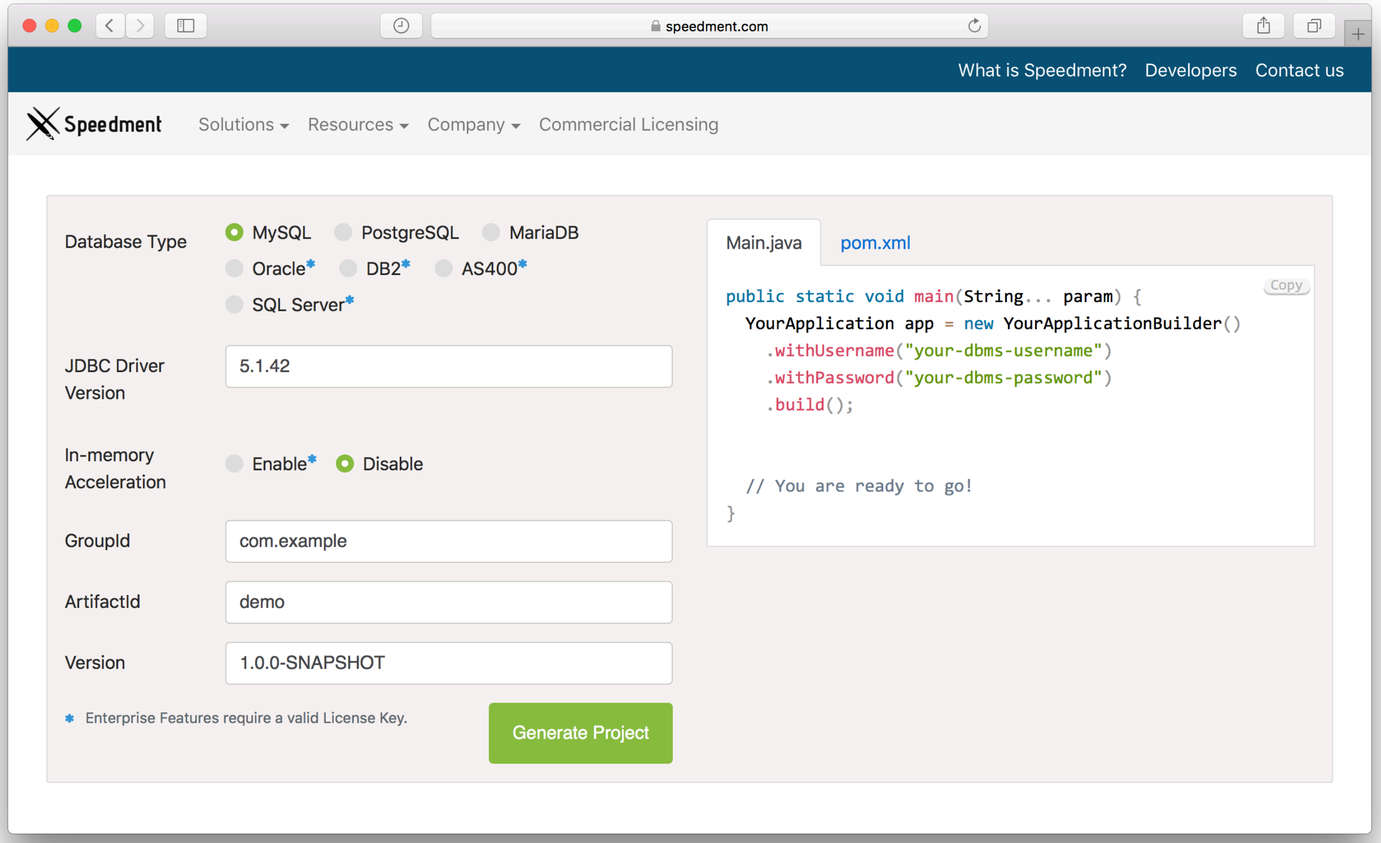
Try Speedment

github.com/speedment/speedment
www.speedment.com/initializer/



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Q&A

@speedment

@dan_lawesson

Speedment

Extra Slides for Q&A

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Many-to-Many

```
Map<Human, List<Hare>> humanFriends = friends.stream()
.collect(
  groupingBy(humans.finderBy(Friend.HUMAN), // Classifier
    mapping(
      hares.finderBy(Friend.HARE), //Friend to Hare finder
      toList() // Downstream aggregation w. List collector
    )
  )
);
```

Speedment

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```

Standard Java 8

Speedment

Update

```
hares.stream()
   .filter(Hare.ID.equal(42)) // All Hares with ID = 42 (just one)
   .map(Hare.AGE.setTo(10))   // Applies a setter
   .forEach(hares.updater()); // Applies the updater function
```

Speedment

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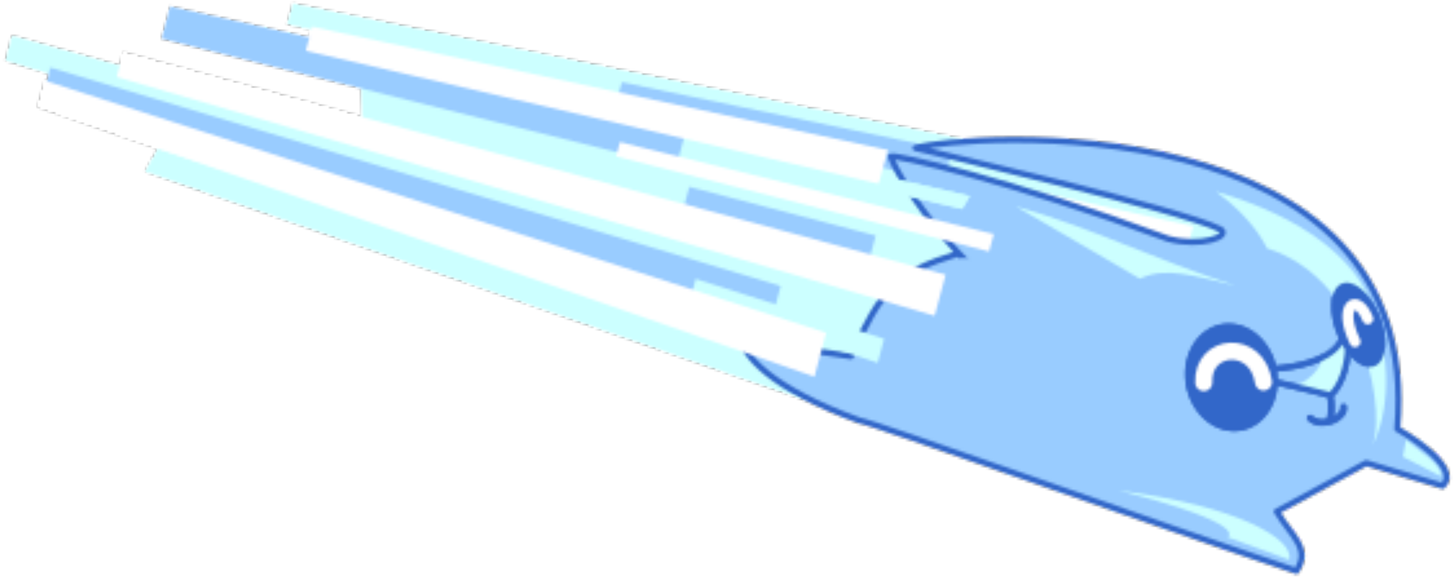
Database Connectors

Speedment

Beyond Open-Source

- Speedment Enterprise
- Run your database queries orders of magnitude faster!
  - 10x, 100x, 1 000x, 10 000x, …
- Use the same Stream API



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How is This Possible?

- No changes to user-written code
- Alternative stream source
- Data is stored in-memory
- Generates optimized serializers for off-heap storage

Speedment

In-JVM-Memory, JMH Benchmarks(*)

Benchmark	Mode	Cnt	Score	Error	Units
SpeedmentBenchmark.findStartsWith	avgt	200	≈ 10^{-5}		s/op
SpeedmentBenchmark.findStartsWithSql	avgt	200	≈ 10^{-4}		s/op
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SpeedmentBenchmark.scrollSorted	avgt	200	≈ 10^{-5}		s/op
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(*) Preliminary results, Mac Book Pro, 2.2 GHz i7, 16GB, MySQL 5.7.16 standard with indexes on all relevant columns.

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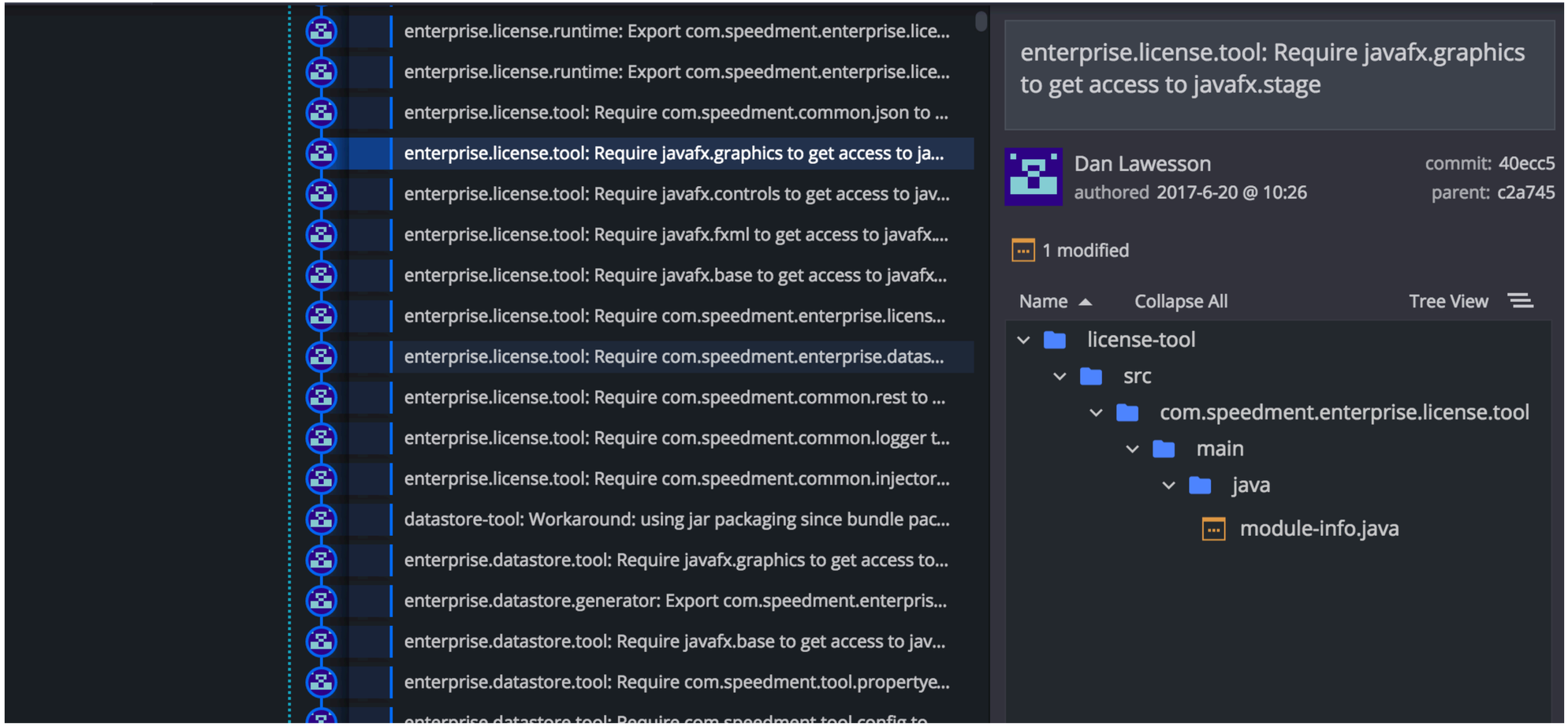
Speedment

Gitkraken view of Jigsawing Script Commits



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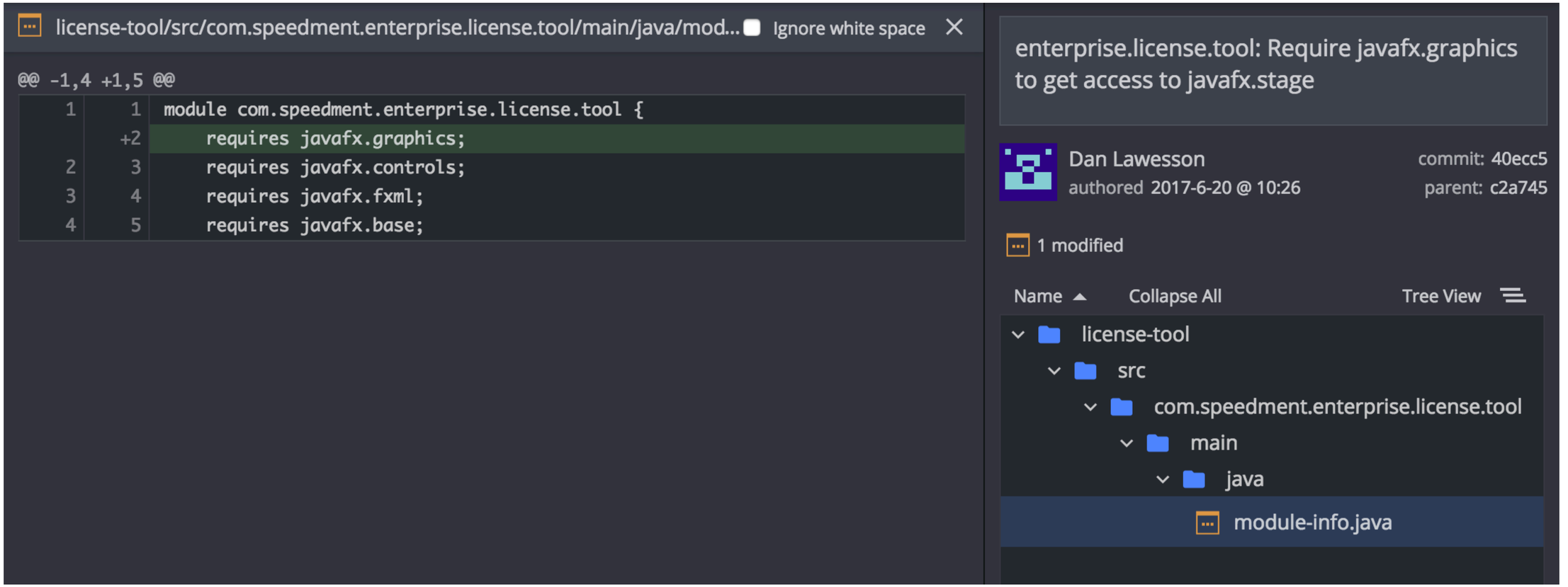

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