

Magdeburger Developer Days, 11.04.2018

Continuous Database Integration mit Flyway

Sandra Parsick

mail@sandra-parsick.de

@SandraParsick

Zu meiner Person

- Sandra Parsick
- Freiberuflicher Softwareentwickler und Consultant im Java-Umfeld
- Schwerpunkte:
 - Java Enterprise Anwendungen
 - Agile Methoden
 - Software Craftmanship
 - Automatisierung von Entwicklungsprozessen
- Trainings
- Workshops
- Softwerkskammer Ruhrgebiet
- Twitter: @SandraParsick
- Blog:
<http://blog.sandra-parsick.de>
- E-Mail: mail@sandra-parsick.de



Agenda

- Continuous Database Integration (CDBI)
- Flyway
- Flyway Demo
- Fallstricke

Continuous Database Integration

- Definition
- Motivation
- Aufbau

Definition

„Continuous Database Integration (CDBI) is the process of rebuilding your database and test data any time a change is applied to a project's version control repository“

(aus Continuous Integration by Paul M. Duvall, Steve Matyas und Andrew Glover)

Motivation

- Alle Entwickler teilen sich eine Testdatenbank.
- Keiner weiß, welche Datenbankskripte auf welchen Datenbankinstanzen ausgeführt worden.
- Testdatenbank unterscheidet sich von der Produktionsdatenbank.
- Datenbankmigrationsskripte verteilen sich auf Emails, Release Notes, Ticketsysteme, etc.

Aufbau

- Behandle den Datenbank-Code wie einen ganz normalen Source-Code
 - Alle Datenbank Artefakte (DDL, DML, Konfigurationen, Testdaten, Stored Procedures, Functions etc) gehören ins VCS.
 - Jede Änderung an den DB Artefakten wird getestet.
- Jeder Entwickler hat seine eigene Datenbank / Testdatenbanken ähneln den Produktionsdatenbanken.
 - Automatisiertes Aufsetzen der Datenbank.
- Änderungen an der Datenbank sind nachvollziehbar.
 - Historie der Änderungen

Flyway

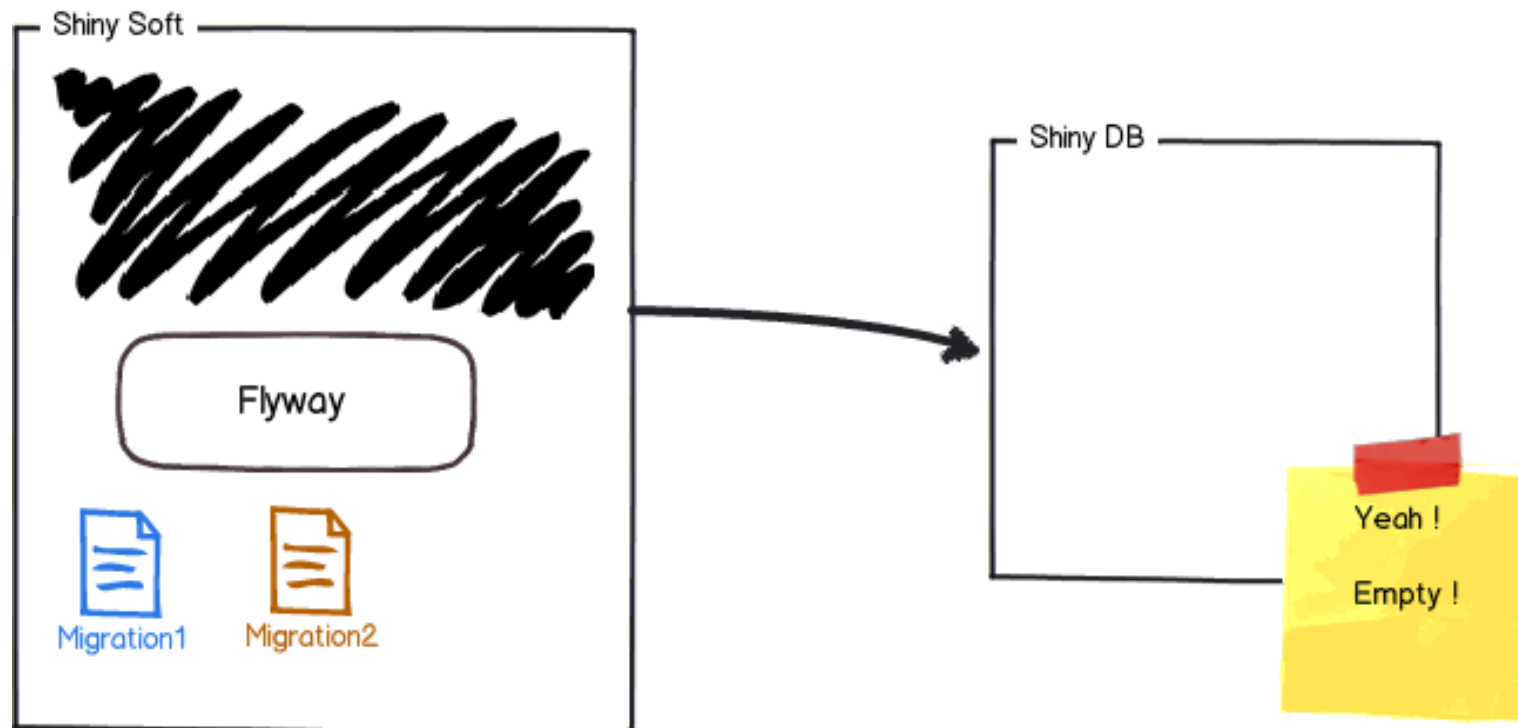
- Was ist Flyway?
- Wie funktioniert Flyway?
- Wie werden Migrationsskripte für Flyway geschrieben?
- Was kann Flyway nicht?
- Wie kann Flyway benutzt werden?

Was ist Flyway?



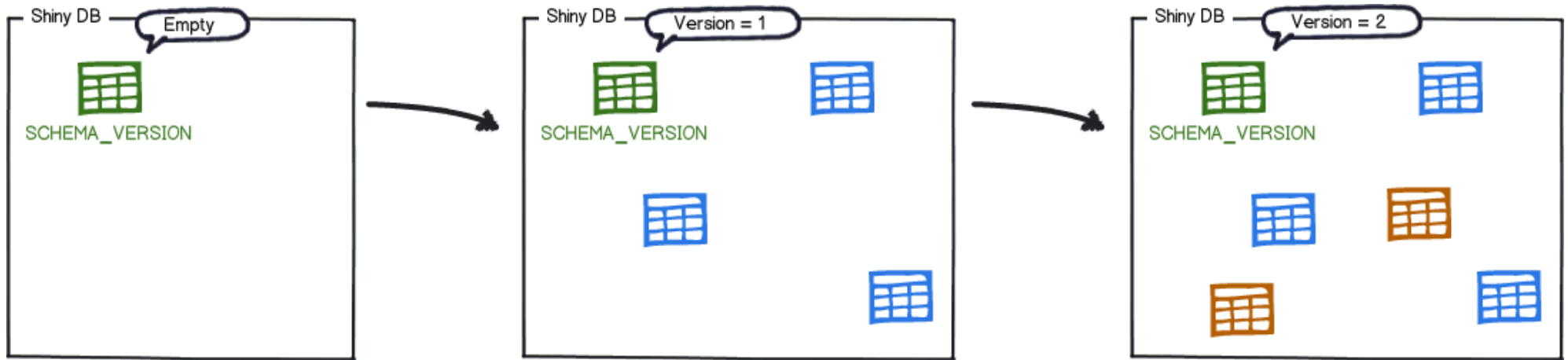
- Migration Framework für Relationale Datenbanken basierend auf Java
- Erstellt eine Datenbank „from scratch“
- Verwaltet den Stand der Datenbank
- Vier Migrationsmodi:
 - SQL-, Java-basierte Migration
 - Versionierte, wiederholbare Migration
- Aktuelle Version: 5.0.7
- Homepage: <http://flywaydb.org/>
- Twitter: @flywaydb

Wie funktioniert Flyway?



Wie funktioniert Flyway?

migrate



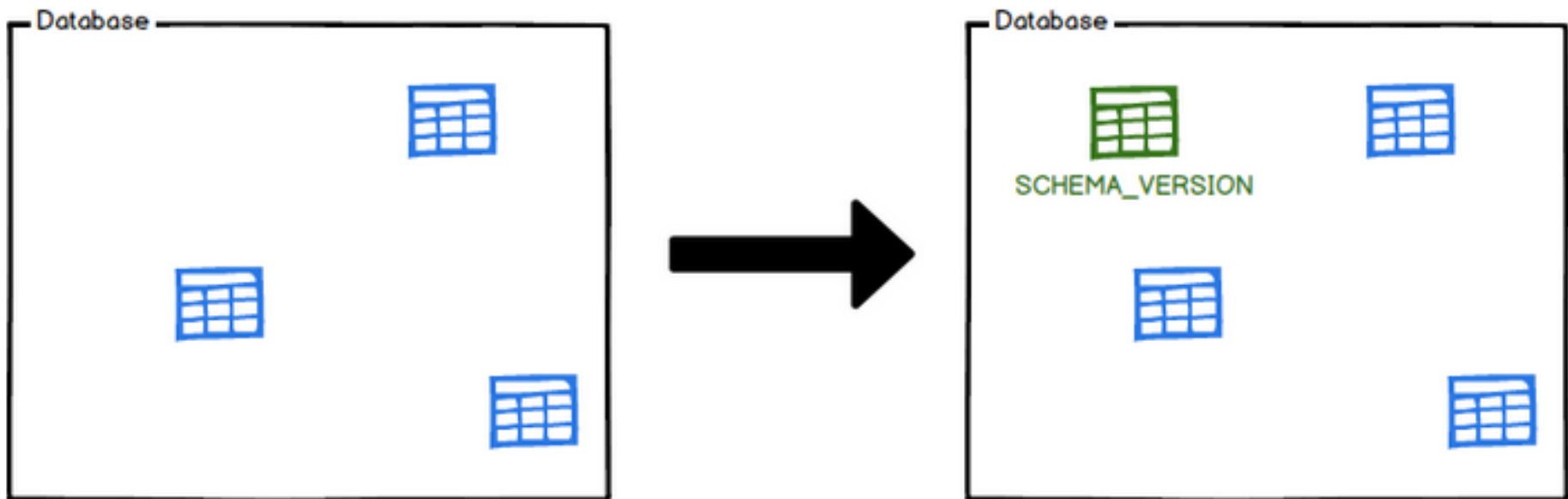
Reference: flywaydb.org

schema_version

installed_rank	version	description	type	script	checksum	installed_by	installed_on	execution_time	success
1	1	Initial Setup	SQL	V1__Initial_Setup.sql	1996767037	axel	2016-02-04 22:23:00.0	546	true
2	2	First Changes	SQL	V2__First_Changes.sql	1279644856	axel	2016-02-06 09:18:00.0	127	true

Wie funktioniert Flyway?

baseline



Migrationsskripte

- Vier Möglichkeiten

	Versioniert	Wiederholbar
SQL-basiert	✓	✓
Java-basiert	✓	✓

Versionierte Migration

- **Eigenschaften**
 - Skripte haben eine eindeutige Version
 - Werden genau einmal ausgeführt
- **Typische Anwendungsfälle**
 - DDL Änderungen (CREATE/ALTER/DROP für TABLES, INDEXES, FOREIGN KEYS,...)
 - Einfache Datenänderungen

Wiederholbare Migration

- **Eigenschaften**

- Skripte haben keine Versionsnummer
- Werden immer dann ausgeführt, wenn sich ihre Checksumme ändert
- Werden immer dann ausgeführt, nachdem alle versionierte Skripte ausgeführt wurden

- **Typische Anwendungsfälle**

- (Wieder-) Erstellung von views / procedures / functions / packages / ...
- Massenreimport von Stammdaten

SQL Migration

- **Typische Anwendungsfälle**

- DDL Änderungen (CREATE/ALTER/DROP für TABLES, VIEWS, TRIGGERS, SEQUENCES,...)
- Einfache Datenänderungen

- **Benennung der Skripte**

Prefix Description

V2_1_1_Some_description.sql

Version Seperator (two underscore)

Prefix Description

R_Some_description.sql

Seperator (two underscore)

SQL Migration

- **Syntax**

- Statement kann über mehrere Zeile gehen
- Platzhaltersupport
- Kommentare: Single (–) oder Multi-Line (/* */)
- Datenbank-spezifische SQL Syntax

- **Beispiel**

```
1      /* Create a table for person */
2
3      Create table person (
4          first_name varchar(128),
5          last_name varchar(128)
6      );
```

Unterstützte Datenbanken


 **Oracle**
(incl. Amazon RDS)

 **SQL Server**
(incl. Amazon RDS &
Azure SQL Database)

 **DB2**

 **MySQL**
(incl. Amazon RDS, Azure
Database & Google Cloud
SQL)

 **MariaDB**
(incl. Amazon RDS)

 **PostgreSQL**
(incl. Amazon RDS, Azure
Database, Google Cloud
SQL & Heroku)

 **Redshift**

 **CockroachDB**

 **SAP HANA**

 **Sybase ASE**

 **H2**

 **HSQLDB**

 **Derby**

 **SQLite**

Java Migration

- **Typische Anwendungsfälle**
 - BLOB & CLOB Änderungen
 - Fortgeschrittene Änderungen an Massendaten
(Neuberechnungen, fortgeschrittene Formatänderungen, ...)
- **Benennung der Java Klassen**

Prefix Description
V2_1_1 Some_description.java
Version Seperator (two underscore)

Prefix Description
R Some_description.java
Seperator (two underscore)

Java Migration

Beispiel

```
1 package db.migration;
2
3 import java.sql.Connection;
4 import java.sql.Statement;
5 import org.flywaydb.core.api.migration.jdbc.JdbcMigration;
6
7
8 public class V1_1_0__Insert_Data implements JdbcMigration {
9
10     @Override
11     public void migrate(Connection connection) throws Exception {
12         try (Statement statement = connection.createStatement()) {
13             statement.execute("Insert into person (first_name, last_name) Values ('Alice', 'Bob')");
14         }
15     }
16 }
17
18 }
```

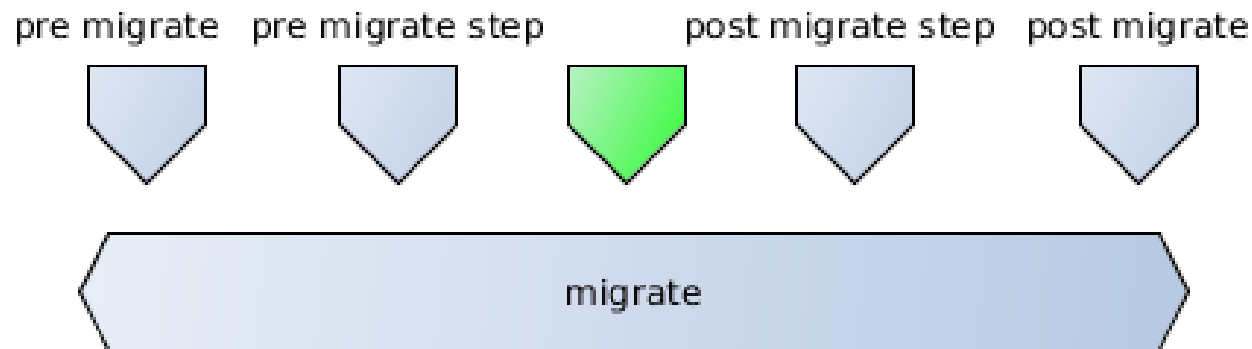
Java Migration

Beispiel Spring Support

```
1  package db.migration;
2
3  import org.flywaydb.core.api.migration.spring.SpringJdbcMigration;
4  import org.springframework.jdbc.core.JdbcTemplate;
5
6
7  public class V1_2_0__Create_Table_With_Spring_Support implements SpringJdbcMigration {
8
9      @Override
10     public void migrate(JdbcTemplate jdbcTemplate) throws Exception {
11         jdbcTemplate.execute("Create table address (street Varchar(128), place Varchar(128))");
12     }
13
14 }
15
```

Migration für Fortgeschrittene - Callbacks

- **Typische Anwendungsfälle**
 - Stored Procedure Kompilierung
 - Materialized View Update
- **Flyway Lifecycle (Beispiel migrate)**



SQL Callbacks

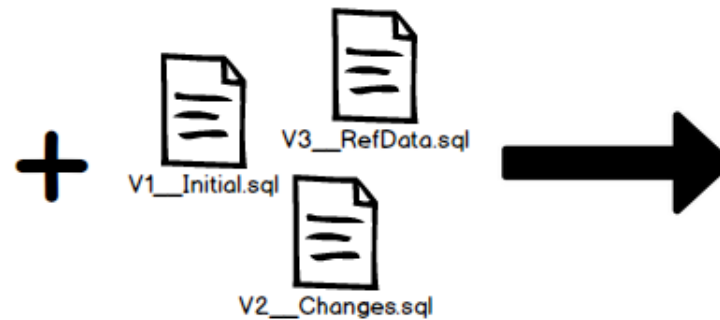
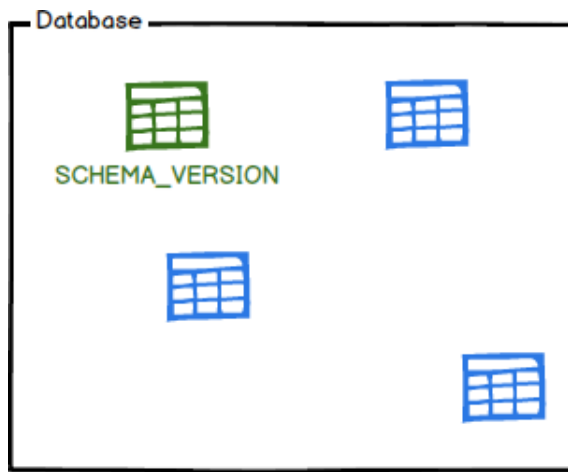
- **Beispiel migrate-Lifecycle:**
 - SQL Callback Skripte werden anhand deren Namen erkannt:
 - BeforeMigrate.sql
 - BeforeEachMigrate.sql
 - AfterEachMigrate.sql
 - AfterMigrate.sql

Java Callbacks

```
public interface FlywayCallback {  
    /**  
     * Runs before the clean task executes.  
     *  
     * @param connection A valid connection to the database.  
     */  
    void beforeClean(Connection connection);  
  
    /**  
     * Runs after the clean task executes.  
     *  
     * @param connection A valid connection to the database.  
     */  
    void afterClean(Connection connection);  
  
    /**  
     * Runs before the migrate task executes.  
     *  
     * @param connection A valid connection to the database.  
     */  
    void beforeMigrate(Connection connection);  
}
```


Weitere Flyway Befehle

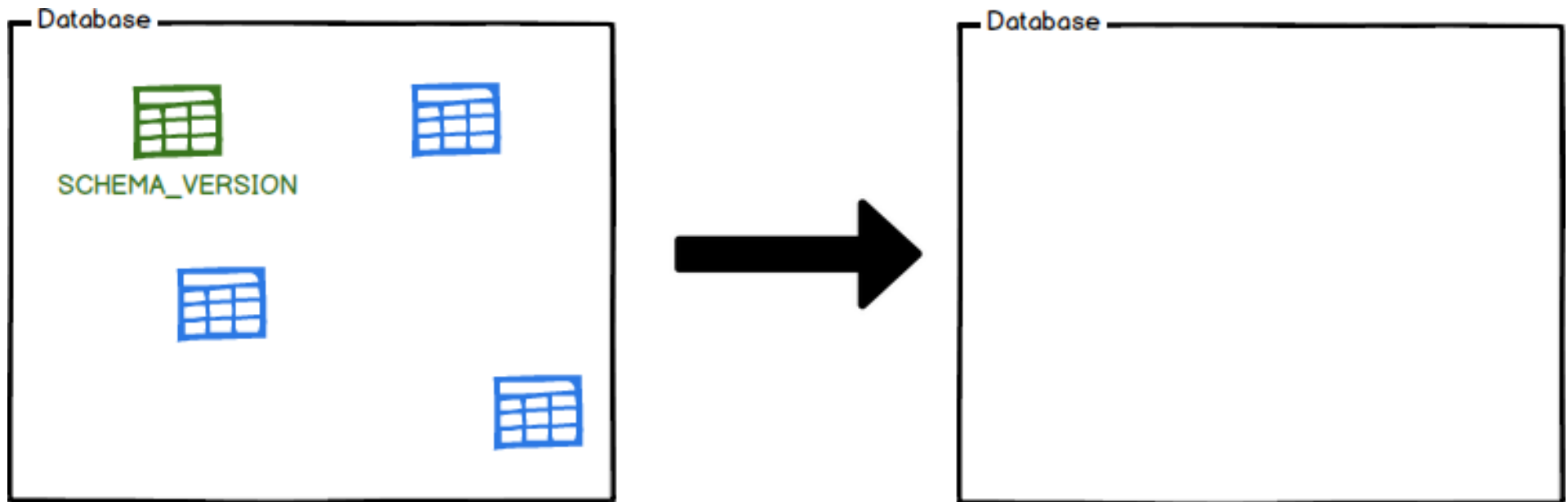
info



Version	Description	Installed on	State
1	Initial	2014-11-16 10:26:35	SUCCESS
2	Changes	2014-11-16 10:26:37	SUCCESS
3	RefData	2014-11-16 10:26:41	PENDING

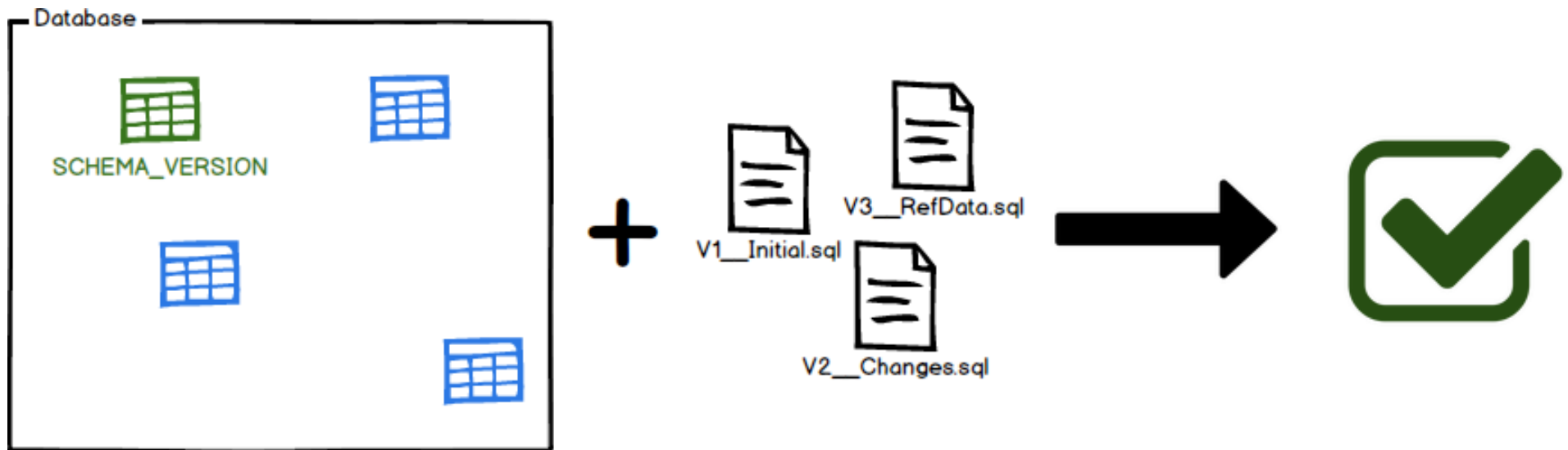
Weitere Flyway Befehle

clean



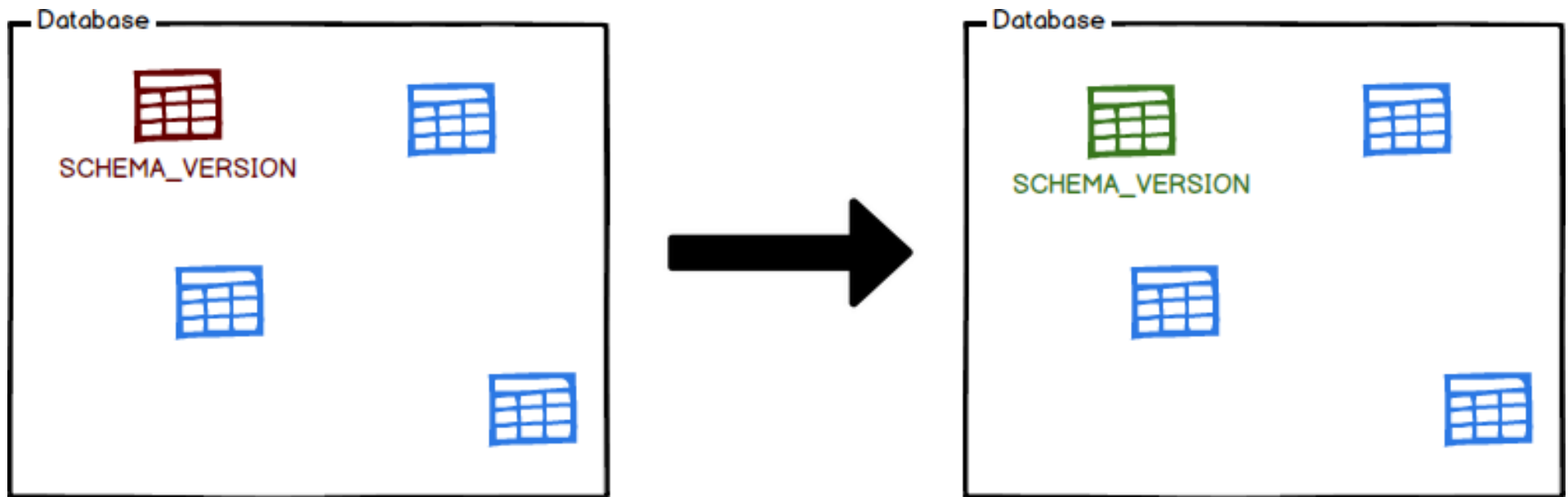
Weitere Flyway Befehle

validate



Weitere Flyway Befehle

repair



Was kann Flyway nicht?

- Rollback Skripte aufrufen (Community Edition)
- „Write once, run on many database vendors“

Neu seit Version 5

- Unterscheidung zwischen
 - Community Edition
 - Pro Edition
 - Enterprise Edition

	Community Edition	Pro Edition	Enterprise Edition
SQL-based migrations	✓	✓	✓
Java-based migrations	✓	✓	✓
Repeatable migrations	✓	✓	✓
Placeholder replacement	✓	✓	✓
Callbacks	✓	✓	✓
Custom migration resolvers/executors	✓	✓	✓
Safe for multiple nodes in parallel	✓	✓	✓
Native SQL dialect support (PL/SQL, SQLPL, T-SQL, ...)	✓	✓	✓
Latest database versions compatibility	✓	✓	✓
Java 8 / 9 compatibility	✓	✓	✓
Oracle SQL*Plus compatibility		✓	✓
Custom error handlers		✓	✓
Dry runs		✓	✓
Undo		✓	✓
Display query results		✓	✓
Older database versions compatibility			✓
Java 6 / 7 compatibility			✓
License	Apache v2	Commercial	Commercial

Wie kann Flyway benutzt werden?

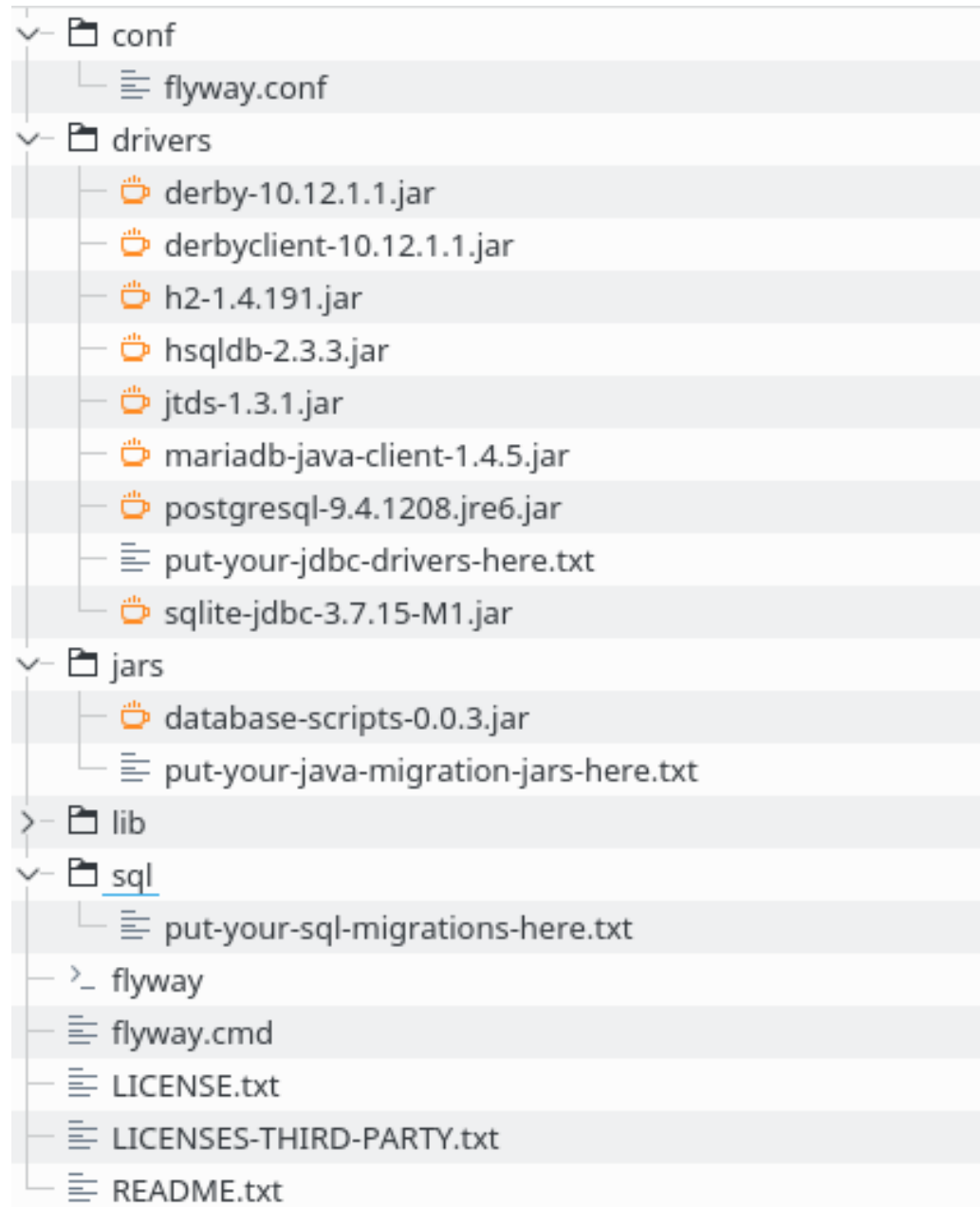
- **Flyway Clients:**

- Java API
- Maven Plugin
- Command-line Tool
- Gradle Plugin
- SBT Plugin
- Ant task

- **Third Party Plugins:**

- Spring Boot
- Grails
- Dropwizard
- Play
- Und weitere

Command-line Tool



Command-line Tool

```
flyway.url=jdbc:mysql://192.168.33.10:3306
```

```
# Fully qualified classname of the jdbc driver (autodetected by default based on flyway.url)
# flyway.driver=
```

```
# User to use to connect to the database (default: <<null>>)
flyway.user=flyway
```

flyway.conf

```
# Password to use to connect to the database (default: <<null>>)
flyway.password=flyway
```

```
# Comma-separated list of schemas managed by Flyway. These schema names are case-sensitive.
# (default: The default schema for the datasource connection)
```

```
# Consequences:
```

```
# - The first schema in the list will be automatically set as the default one during the migration.
```

```
# - The first schema in the list will also be the one containing the metadata table.
```

```
# - The schemas will be cleaned in the order of this list.
```

```
flyway.schemas=flyway_demo
```

```
# Name of Flyway's metadata table (default: schema_version)
```

```
# By default (single-schema mode) the metadata table is placed in the default schema for the connection provided by the datasource.
```

```
# When the flyway.schemas property is set (multi-schema mode), the metadata table is placed in the first schema of the list.
```

```
# flyway.table=
```

```
# Comma-separated list of locations to scan recursively for migrations. (default:
filesystem:<<INSTALL-DIR>>/sql)
```

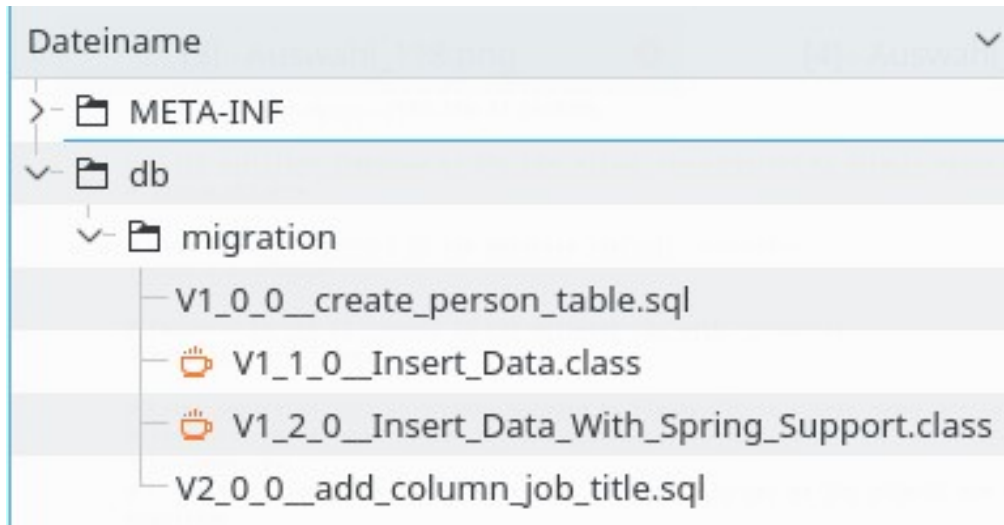
```
# The location type is determined by its prefix.
```

```
# Unprefixed locations or locations starting with classpath: point to a package on the classpath and may contain both sql and java-based migrations.
```

```
# Locations starting with filesystem: point to a directory on the filesystem and may only contain sql migrations.
```

```
flyway.locations=db/migration
```

Command-line Tool



database-scripts-0.0.3.jar

Command-line Tool



Command-line Tool

Pipeline Deployment Pipeline Demo

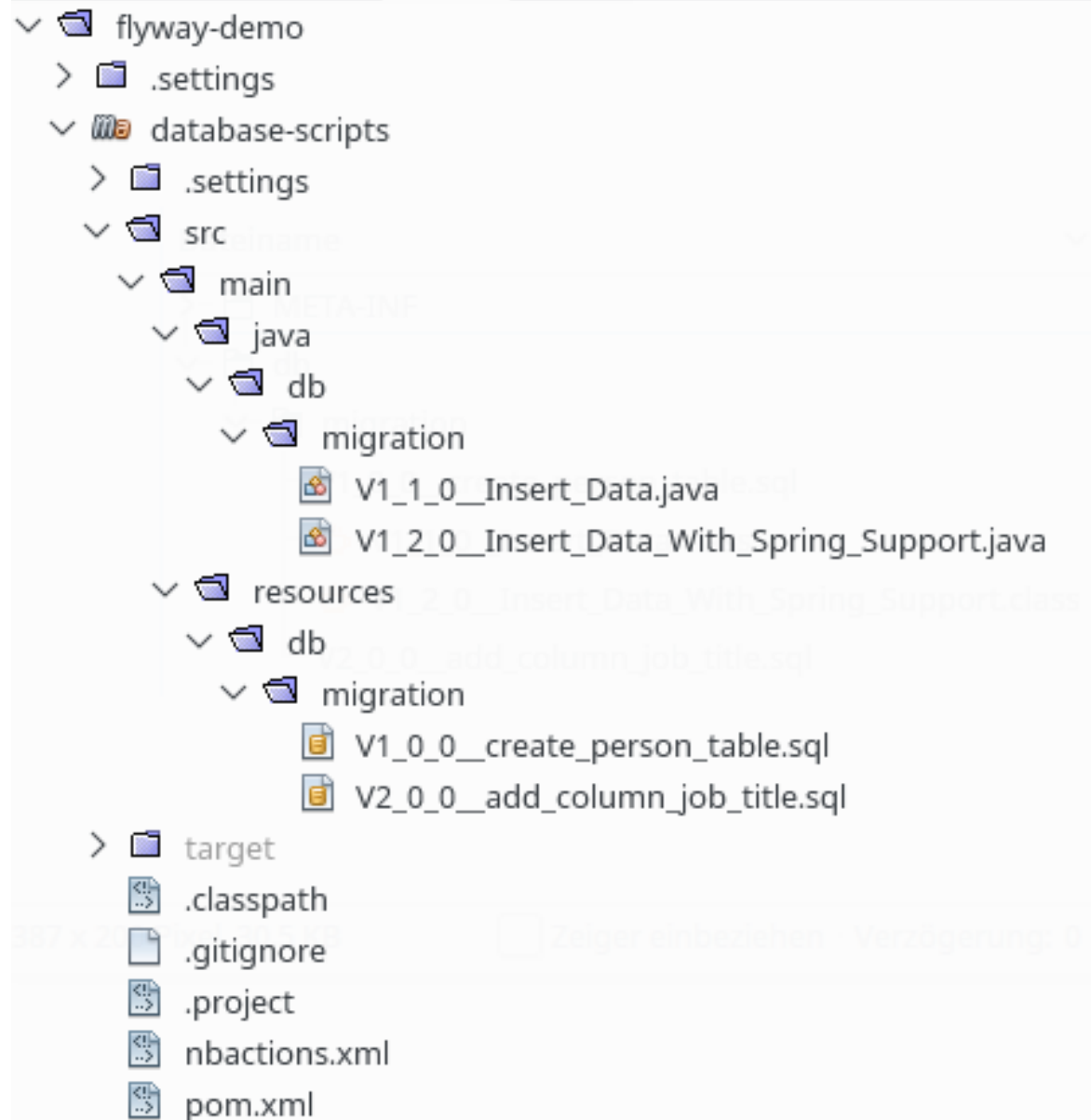


[Recent Changes](#)

Stage View

			DB Migration	Webdeployment
Average stage times: (Average <u>full</u> run time: ~7s)			6ms	7s
#20	Dec 02 10:54	No Changes	4ms	8s
#19	Dec 02 10:37	No Changes	14ms	8s failed
#18	Oct 17 17:35	No Changes	3ms	7s
#17	Oct 17 17:34	No Changes	3ms	7s

Maven Plugin



Maven Plugin

pom.xml

```
<build>
  <plugins>
    <plugin>
      <groupId>org.flywaydb</groupId>
      <artifactId>flyway-maven-plugin</artifactId>
      <version>${flyway.version}</version>
      <configuration>
        <schemas>
          <schema>flyway_demo</schema>
        </schemas>
        <user>flyway</user>
        <password>flyway</password>
        <url>jdbc:mysql://192.168.33.10:3306</url>
      </configuration>
    </plugin>
  </plugins>
</build>
```

Maven Plugin



Maven Plugin

Build

Stamm-POM

pom.xml



Goals und Optionen

deploy



Erweitert...

Post-Build-Schritte

☒ nur bei erfolgreichen Builds ☐ nur bei erfolgreichen oder instabilen Builds ☐ immer ausführen

Unter welchen Bedingungen sollen die Post-Build-Schritte ausgeführt werden?

Maven Goals aufrufen

X



Maven-Version

(Standard)

Goals

flyway:clean flyway:migrate flyway:clean



Erweitert...

Post-Build-Schritt hinzufügen ▾

Migrationstests mit JUnit und Testcontainers



Migrationstests mit JUnit und Testcontainers

```
public class DbMigrationITest {  
  
    @Rule  
    public MySQLContainer mysqlDb = new MySQLContainer();  
  
    @Test  
    public void testDbMigrationFromTheScratch(){  
        Flyway flyway = new Flyway();  
        flyway.setDataSource(mysqlDb.getJdbcUrl(), mysqlDb.getUsername(), mysqlDb.getPassword())  
  
        flyway.migrate();  
    }  
}
```

Migrationstests mit JUnit und Testcontainers

TESTS

Running db.migration.DbMigrationITest

INFO - ertyClientProviderStrategy - Found docker client settings from environment

INFO - ckerClientProviderStrategy - Found Docker environment with Environment variables, system properties and defaults. Resolved:

dockerHost=unix:///var/run/docker.sock

apiVersion='{UNKNOWN_VERSION}'

registryUrl='https://index.docker.io/v1/'

registryUsername='sparsick'

registryPassword='null'

registryEmail='null'

dockerConfig='DefaultDockerClientConfig[dockerHost=unix:///var/run/docker.sock,registryUsername=sparsick,registryPassword=<null>,registryEmail=]

INFO - DockerClientFactory - Docker host IP address is localhost

INFO - DockerClientFactory - Connected to docker:

Server Version: 17.05.0-ce

API Version: 1.29

Operating System: Linux Mint 18.2

Total Memory: 19511 MB

! Checking the system...

✓ Docker version is newer than 1.6.0

✓ Docker environment has more than 2GB free

✓ File should be mountable

✓ Exposed port is accessible

INFO - [mysql:latest] - Creating container for image: mysql:latest

INFO - [mysql:latest] - Starting container with ID: 2668be66c2631e49b5bcb4e180665d223525ec896ea78034326076d5f9063d53

INFO - [mysql:latest] - Container mysql:latest is starting: 2668be66c2631e49b5bcb4e180665d223525ec896ea78034326076d5f9063d53

INFO - [mysql:latest] - Waiting for database connection to become available at jdbc:mysql://localhost:32769/test using query 'SELECT 1'

INFO - [mysql:latest] - Obtained a connection to container (jdbc:mysql://localhost:32769/test)

INFO - [mysql:latest] - Container mysql:latest started

INFO - VersionPrinter - Flyway 4.0.3 by Boxfuse

INFO - DbSupportFactory - Database: jdbc:mysql://localhost:32769/test (MySQL 5.7)

INFO - DbValidate - Successfully validated 2 migrations (execution time 00:00.011s)

INFO - MetadataTableImpl - Creating Metadata table: `test`.`schema_version`

INFO - DbMigrate - Current version of schema `test`: << Empty Schema >>

INFO - DbMigrate - Migrating schema `test` to version 1.0.0 - create person table

INFO - DbMigrate - Migrating schema `test` to version 2.0.0 - add column job title

INFO - DbMigrate - Successfully applied 2 migrations to schema `test` (execution time 00:00.133s).

Tests run: 1, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 13.9 sec

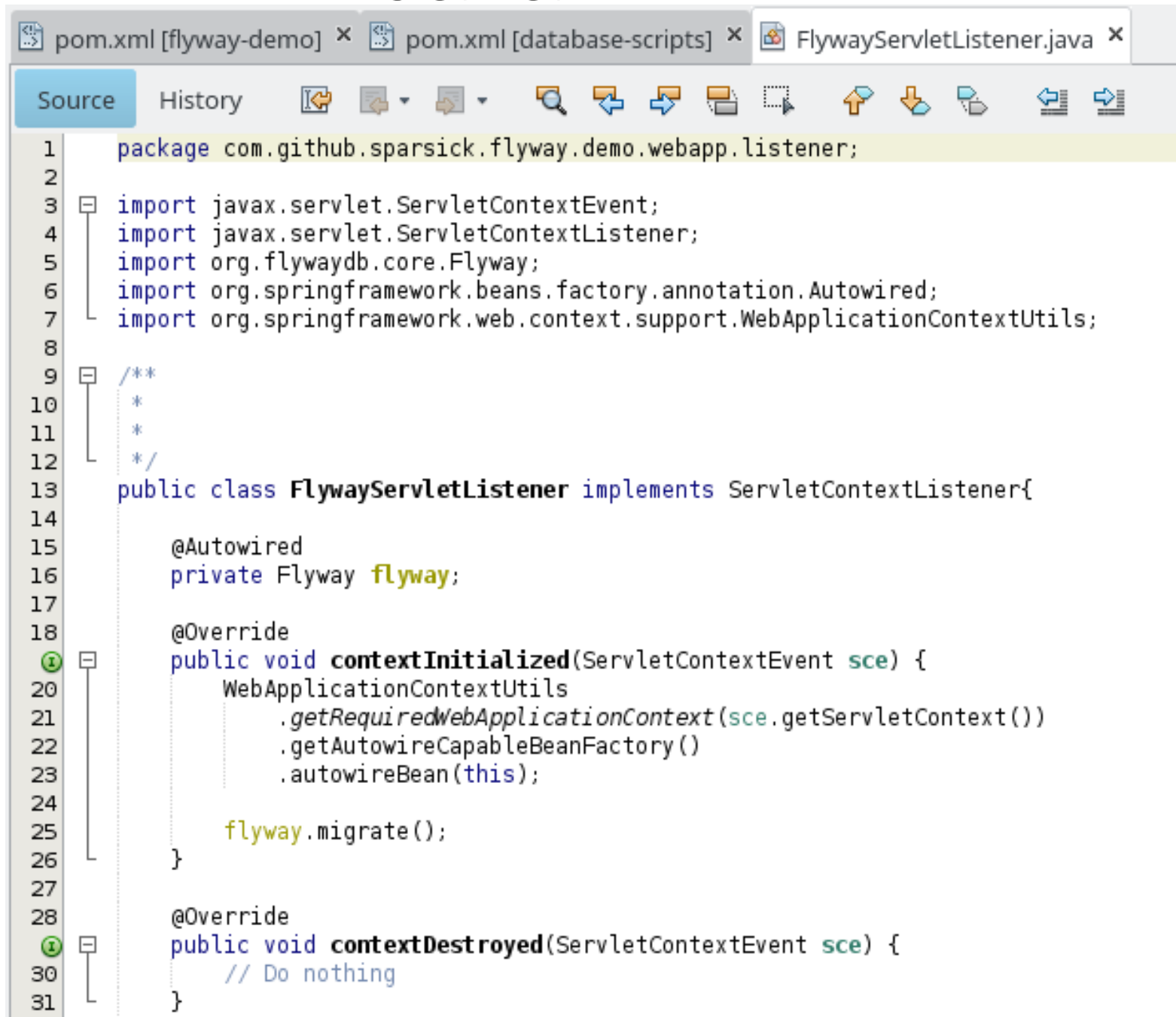
Integrationstest für die Persistenzschicht

```
public class PersonRepositoryITest {  
  
    @Rule  
    public MySQLContainer mysqlDb = new MySQLContainer();  
  
    @Test  
    public void saveAndLoadAPerson() {  
        Flyway flyway = new Flyway();  
        flyway.setDataSource(mysqlDb.getJdbcUrl(), mysqlDb.getUsername(), mysqlDb.getPassword());  
        flyway.migrate();  
  
        PersonRepository personRepositoryUnderTest = new PersonRepository(flyway.getDataSource());  
        Person person = new Person("Alice", "Bob");  
        personRepositoryUnderTest.save(person);  
  
        List<Person> persons = personRepositoryUnderTest.findAllPersons();  
  
        assertThat(persons.size(), Is.is(1));  
        assertThat(persons.get(0), Is.is(person));  
    }  
}
```

Testcontainers

- Temporary database containers - spezielle MySQL, PostgreSQL, Oracle XE und Virtuoso container
- Webdriver containers - Dockerized Chrome oder Firefox browser für Selenium/Webdriver Operationen mit automatischer Videoaufnahme
- Generic containers – irgendein Docker Container
- Docker compose – Wiederverwendung von Docker Compose YAML Datei
- Dockerfile containers – Container direkt von einem Dockerfile

Java API



```
1 package com.github.sparsick.flyway.demo.webapp.listener;
2
3 import javax.servlet.ServletContextEvent;
4 import javax.servlet.ServletContextListener;
5 import org.flywaydb.core.Flyway;
6 import org.springframework.beans.factory.annotation.Autowired;
7 import org.springframework.web.context.support.WebApplicationContextUtils;
8
9 /**
10  *
11  *
12  */
13 public class FlywayServletListener implements ServletContextListener{
14
15     @Autowired
16     private Flyway flyway;
17
18     @Override
19     public void contextInitialized(ServletContextEvent sce) {
20         WebApplicationContextUtils
21             .getRequiredWebApplicationContext(sce.getServletContext())
22             .getAutowireCapableBeanFactory()
23             .autowireBean(this);
24
25         flyway.migrate();
26     }
27
28     @Override
29     public void contextDestroyed(ServletContextEvent sce) {
30         // Do nothing
31     }
```

Java API

```
<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:context="http://www.springframework.org/
  xsi:schemaLocation="http://www.springframework.org/schema/beans http://www.springframework.org
    http://www.springframework.org/schema/context
    http://www.springframework.org/schema/context/spring-context.xsd">
  <context:annotation-config/>
  <context:component-scan base-package="com.github.sparsick.flyway.demo.webapp"/>

  <bean id="wicketApplication" class="com.github.sparsick.flyway.demo.webapp.WicketApplication"/>

  <bean id="dataSource" class="org.apache.commons.dbcp.BasicDataSource"
    destroy-method="close">
    <property name="url" value="jdbc:mysql://192.168.33.10:3306/flyway_demo" />
    <property name="username" value="flyway" />
    <property name="password" value="flyway" />
  </bean>

  <bean id="flyway" class="org.flywaydb.core.Flyway">
    <property name="dataSource">
      <bean class="org.apache.commons.dbcp.BasicDataSource" parent="dataSource">
        <property name="url" value="jdbc:mysql://192.168.33.10:3306" />
      </bean>
    </property>
    <property name="schemas">
      <list>
        <value>flyway_demo</value>
      </list>
    </property>
  </bean>
</beans>
```

Spring Context

Java API

```
<context-param>
```

```
  <param-name>contextConfigLocation</param-name>
```

```
  <param-value>classpath:META-INF/spring/*.xml</param-value>
```

```
</context-param>
```

```
<listener>
```

```
  <listener-class>org.springframework.web.context.ContextLoaderListener</listener-class>
```

```
  <listener-class>com.github.sparsick.flyway.demo.webapp.listener.FlywayServletListener</listener-class>
```





```
</listener>
```

web.xml

Java API



Aufbau CDBI

- Behandle den Datenbank-Code wie einen ganz normalen Source-Code
 - Alle Datenbank Artefakte (DDL, DML, Konfigurationen, Testdaten, Stored Procedures, Functions etc) gehören ins VCS. 
 - Jede Änderung an den DB Artefakten wird getestet. 
- Jeder Entwickler hat seine eigene Datenbank / Testdatenbanken ähneln den Produktionsdatenbanken.
 - Automatisiertes Aufsetzen der Datenbank. 
- Änderungen an der Datenbank sind nachvollziehbar.
 - Historie der Änderungen 

Fallstricke

Keine Instanz-spezifischen Daten

Beispiel

```
1  
2 GRANT SELECT, INSERT ON usermgm.* TO  
3 `technical-user`@'192.168.33.10' IDENTIFIED BY 'pA$$w0rt';  
4
```

Keine Instanz-spezifischen Daten

Möglicher Lösungsansatz:

```
1  
2 GRANT SELECT, INSERT ON usermgm.* TO  
3 `technical-user`@'*' IDENTIFIED BY 'pA$$w0rt';  
4
```

- Zugriffskontrolle über eine Firewalls (iptables)

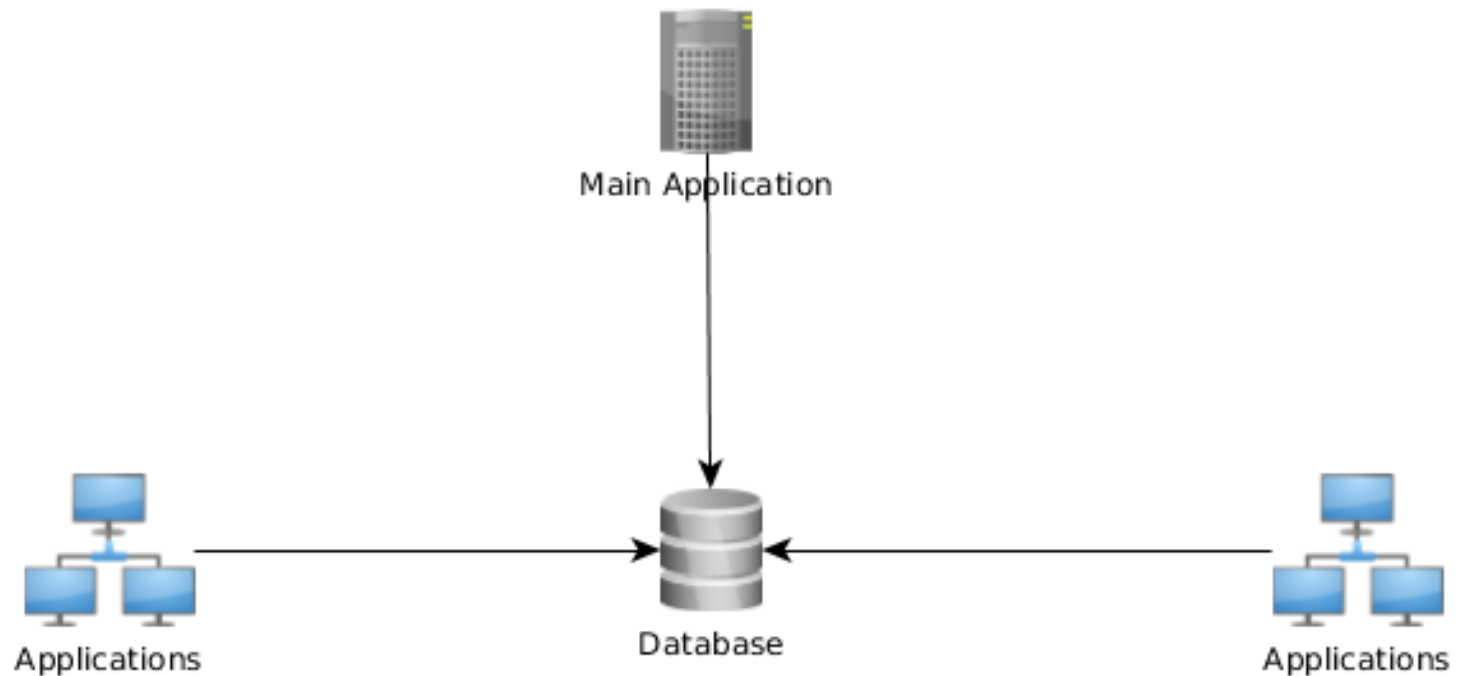
Keine Instanz-spezifischen Daten

Möglicher Lösungsansatz:

```
1 GRANT SELECT, INSERT ON usermgnt.* TO  
2 'technical-user' @ '${address}' By '${password}';  
3  
4
```

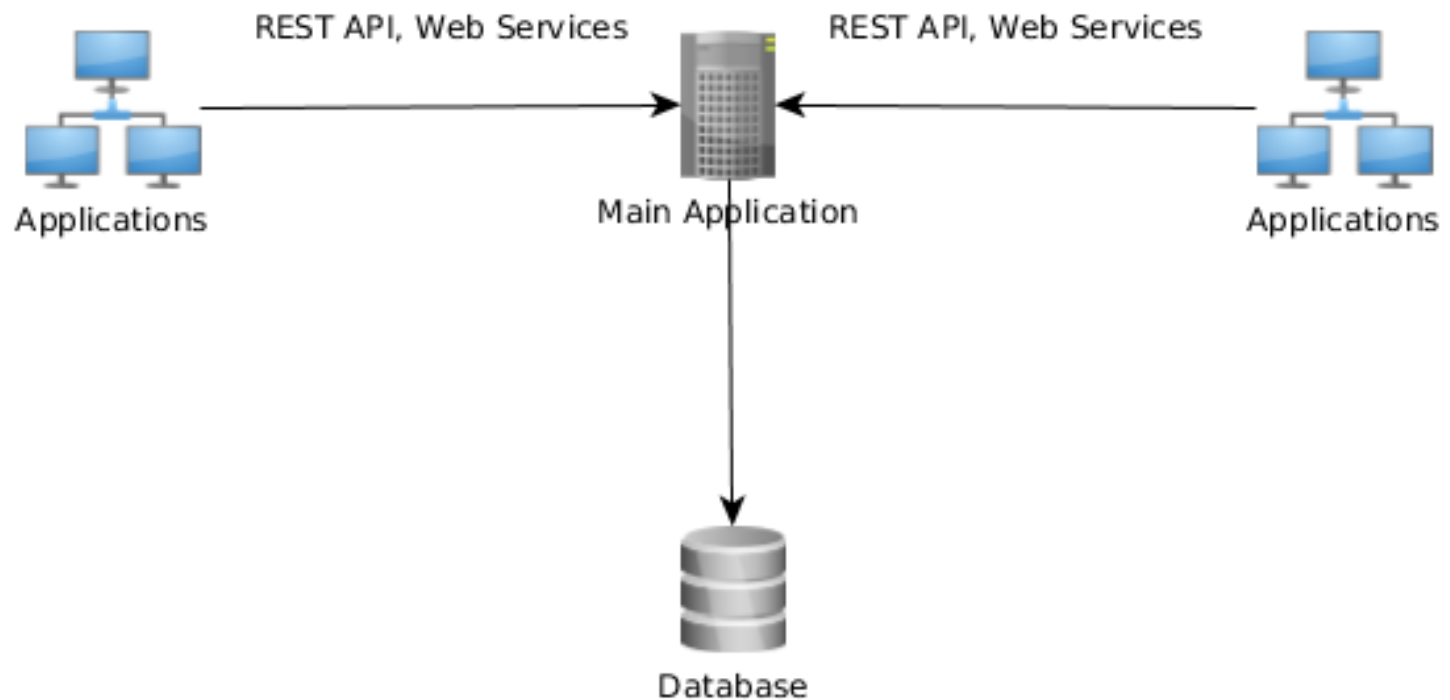
Datenbank wird von mehreren Applikationen benutzt

Ausgangslage :



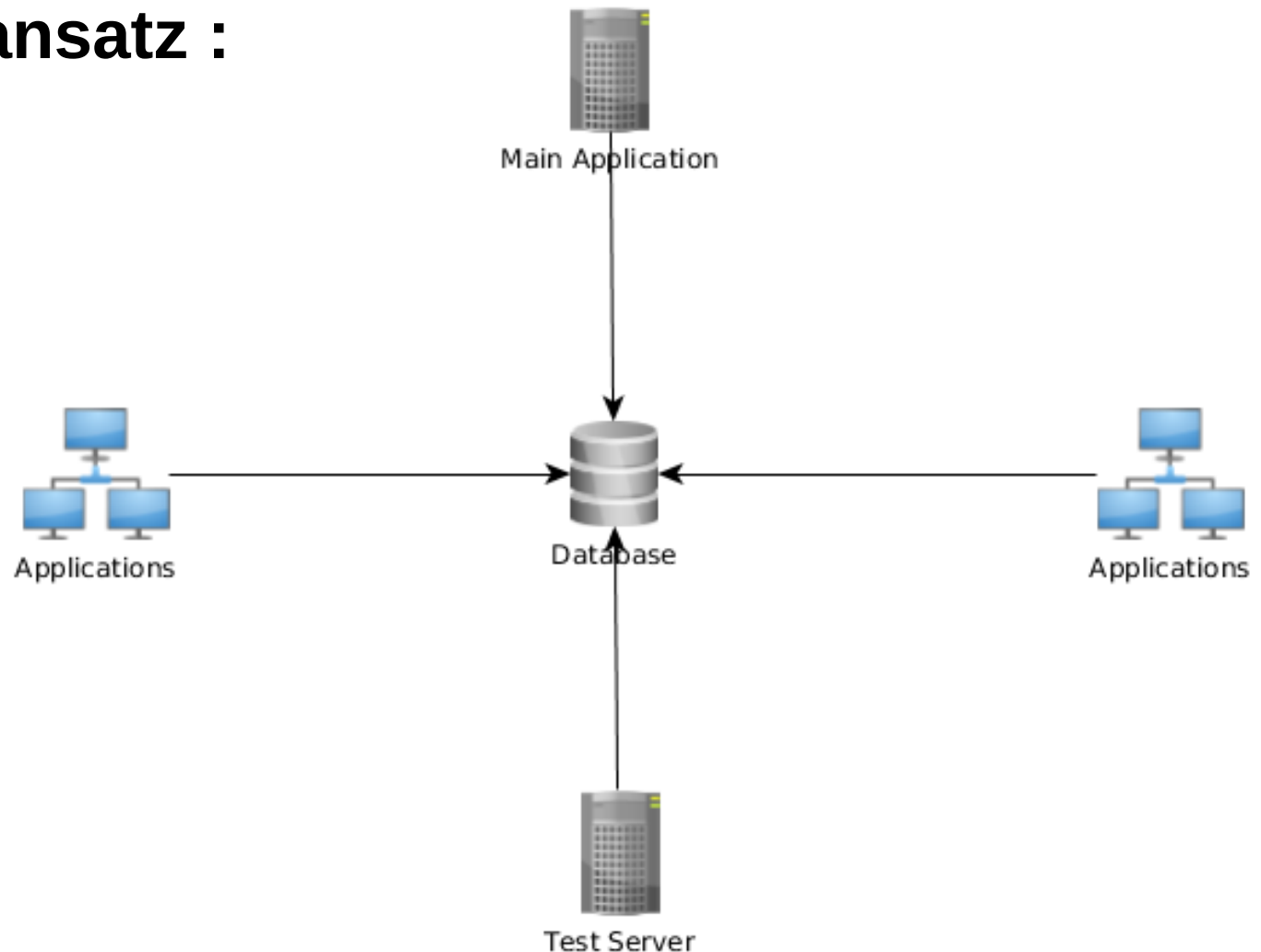
Datenbank wird von mehreren Applikationen benutzt

Lösungsansatz :

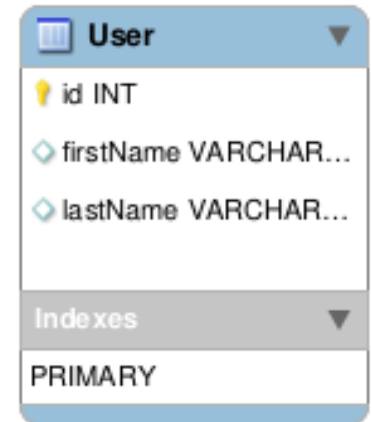
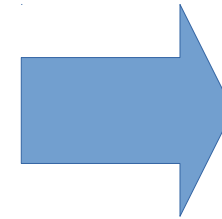
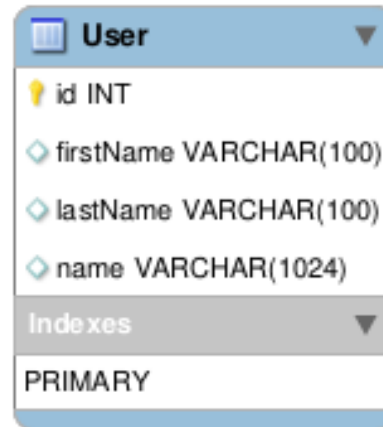
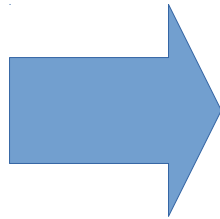
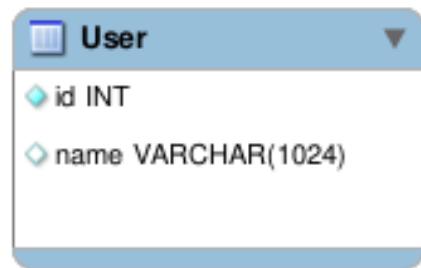


Datenbank wird von mehreren Applikationen benutzt

Lösungsansatz :



Datenbank wird von mehreren Applikationen benutzt



Weitere Fallstricke (Auszug)

- Datenänderung dauern zu lange
- Datenlöschung
- Faktor Mensch
- ...

Weitere Informationen

- Continuous Integration von Paul M. Duvall, Steve Matyas und Andrew Glover
- Refactoring Databases: Evolutionary Database Design von Scott J. Ambler und Pramodkumar J. Sadalage
- Flyway Documentation
<http://flywaydb.org/documentation/migration/>
<http://flywaydb.org/getstarted/>
- Source code:
<https://github.com/sparsick/flyway-talk>

Fragen?

<https://github.com/sparsick/flyway-talk>
mail@sandra-parsick.de
@SandraParsick