Pivotal

Transaction Management with Spring

Transactional Proxies and @Transactional

Objectives

After completing this lesson, you should be able to

- Explain why Transactions are used
  - And how Java supports them in different ways
- Describe and use Spring Transaction Management
- Configure Transaction Propagation
- Setup Rollback rules
- Use Transactions in Tests

Agenda

- **Why use Transactions?**
- Java Transaction Management
- Spring Transaction Management
- Transaction Propagation
- Rollback rules
- Testing
- Lab
- Advanced topics

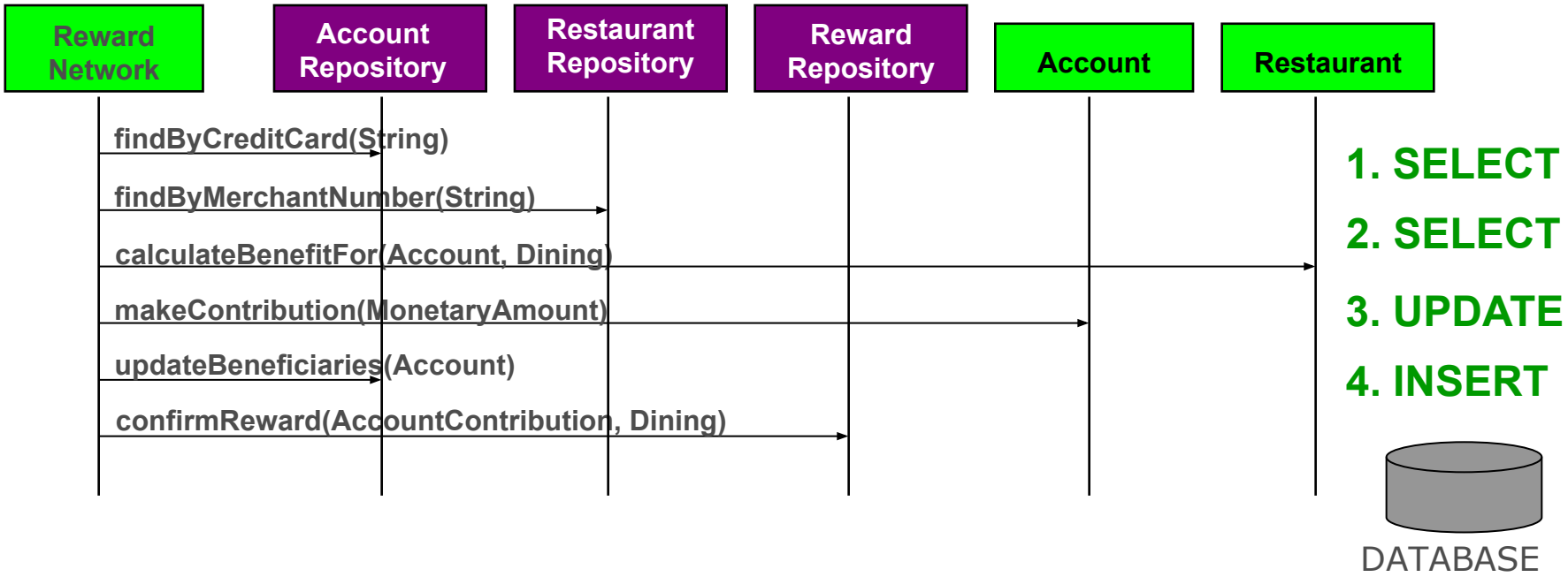
What is a Transaction?

Enable ***concurrent*** access to a ***shared*** resource

- A set of tasks which take place as a single, indivisible action
  - **A**tomic
    - Each unit of work is an all-or-nothing operation
  - **C**onsistent
    - Database integrity constraints are never violated
  - **I**solated
    - Isolating transactions from each other
  - **D**urable
    - Committed changes are permanent

Transactions in the RewardNetwork

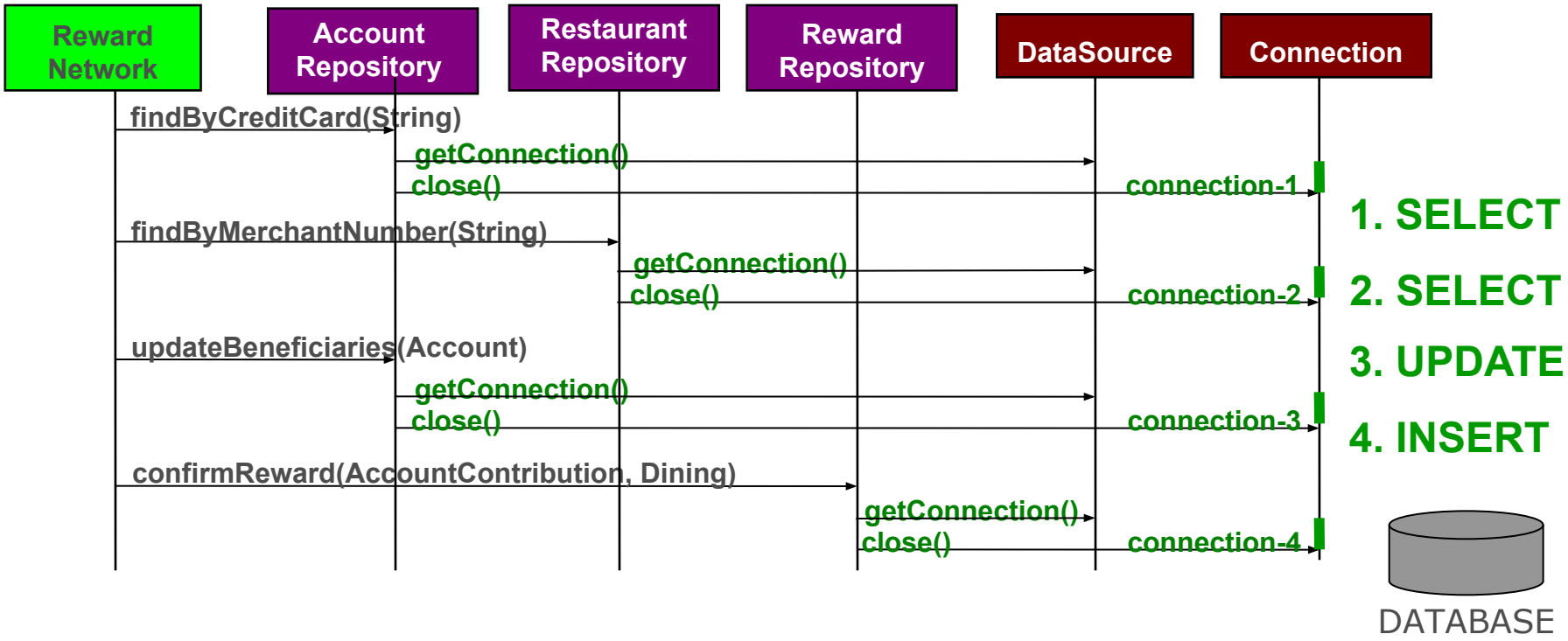
- The *rewardAccountFor(Dining)* method represents a unit-of-work that should be atomic



Naïve Approach

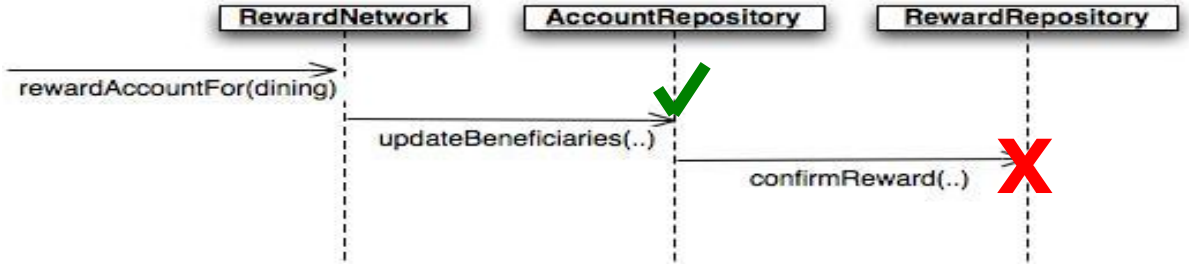
- **Connection per Data Access Operation**
  - This unit-of-work contains 4 data access operations
    - Each acquires, uses, and releases a distinct Connection
  - The unit-of-work is ***non-transactional***

Running non-Transactionally



Partial Failures (in non-Transactional operation)

- Suppose an Account is being rewarded



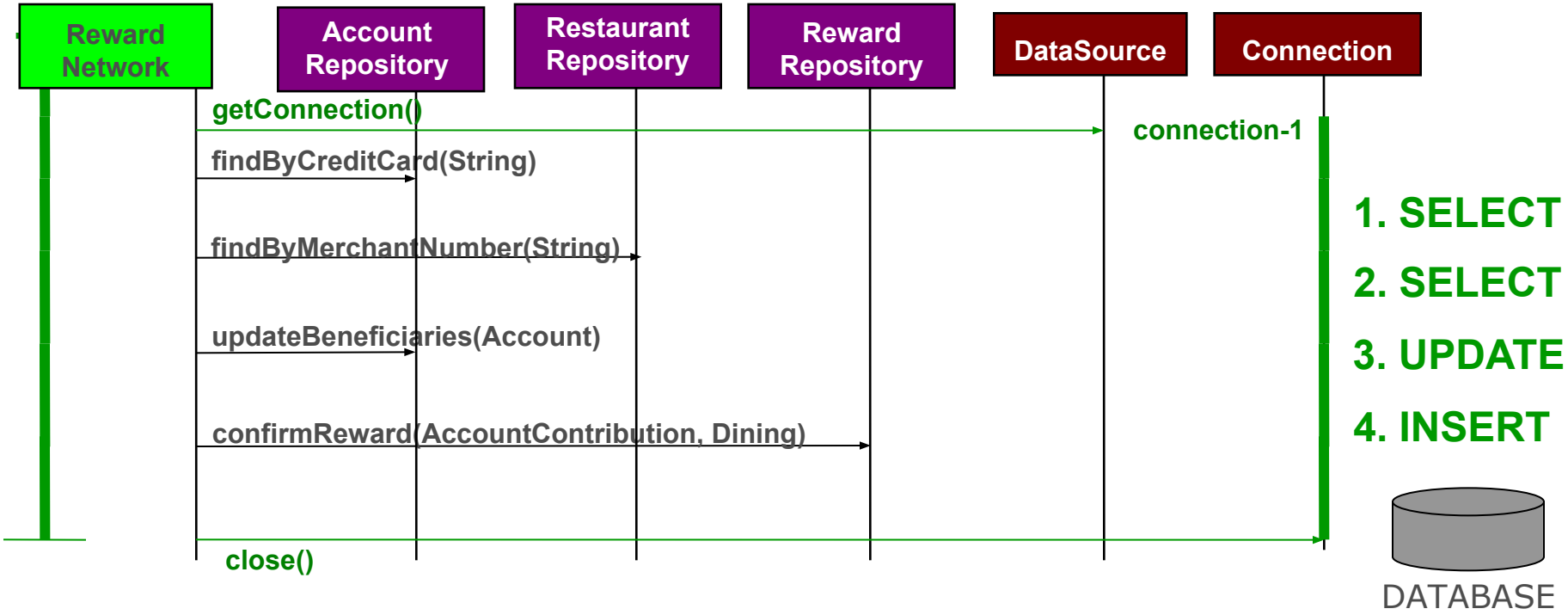
- If the beneficiaries are updated…
- But the reward confirmation fails…
- There will be no record of the reward!

The unit-of-work is **not** *atomic*

Correct Approach

- **Connection per Unit-of-Work**
  - More efficient
    - Same Connection reused for each operation
  - Operations complete as an atomic unit
    - Either all succeed or all fail
  - The unit-of-work can run in a ***transaction***

Running in a Transaction



Agenda

- Why use Transactions?
- **Java Transaction Management**
- Spring Transaction Management
- Transaction Propagation
- Rollback rules
- Testing
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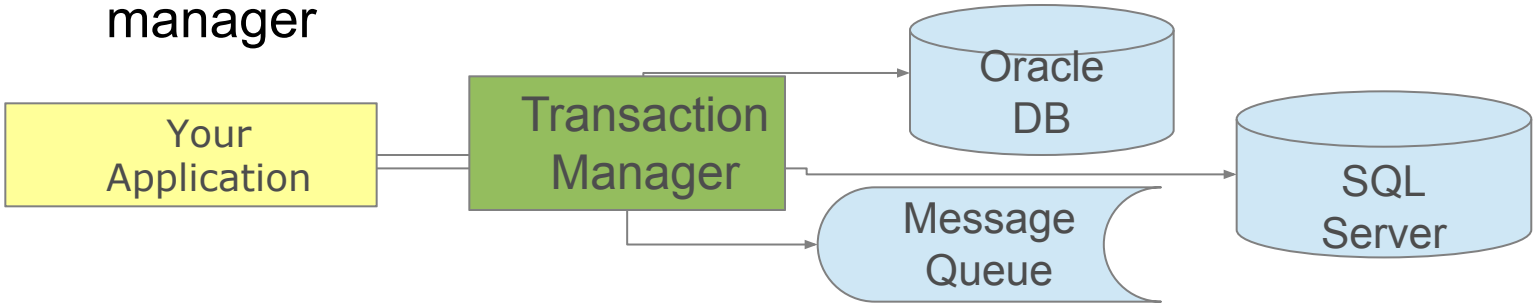
Local and Global Transaction Management

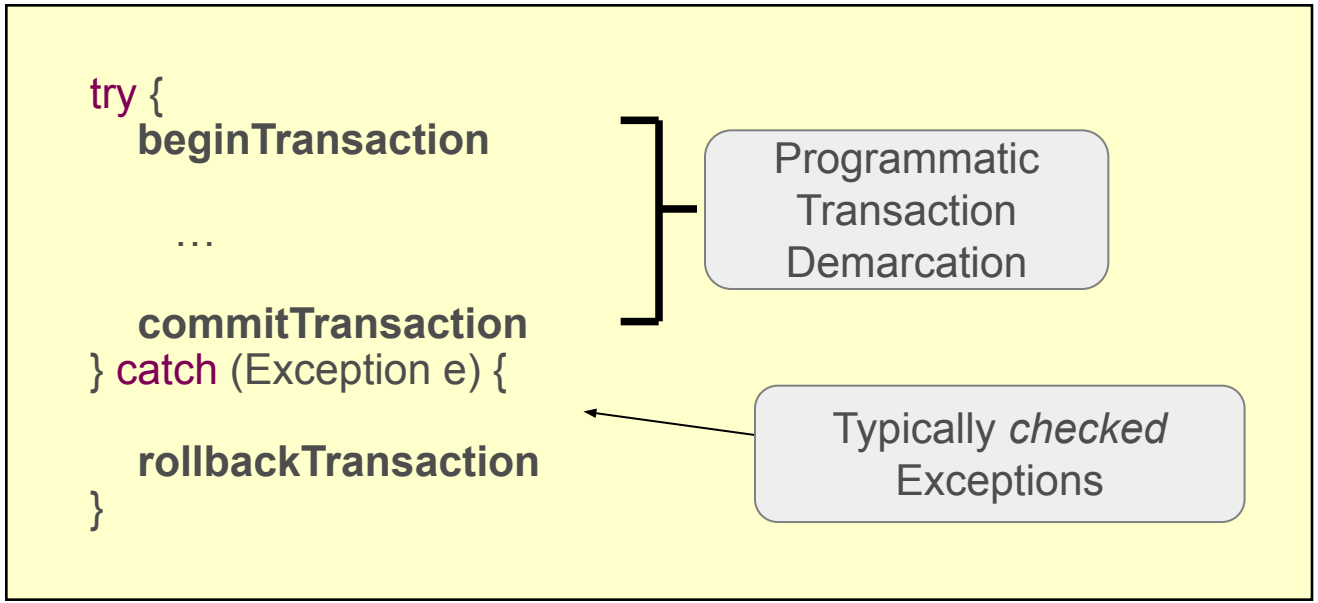
- Local Transactions – Single Resource
  - Transactions managed by underlying resource

- Global (distributed) Transactions – Multiple Resources
  - Transaction managed by separate, dedicated transaction manager



Transactional Code Pattern

- Many different APIs, but a common pattern
  - Implemented using code
  - Classic cross-cutting concern



Java API Transaction Examples

API	Begin Transaction	End Transaction
JDBC	conn = dataSource.getConnection() conn.setAutoCommit(false)	conn.commit() conn.rollback()
JMS	session = connection .createSession (true, 0)	session.commit() session.rollback()

JPA	Transaction tx =
	entityManager.getTransaction();
	tx.begin();
		tx.commit()
		tx.rollback()

Hibernate	Transaction tx = session.beginTransaction();	tx.commit() tx.rollback()

Local transactions only:

- *Code cannot 'join' a transaction already in progress*
- *Code cannot be used with global transaction*

Global Transactions in Java

Java Transaction API (JTA)

```
try {
        UserTransaction ut =
            (UserTransaction) new InitialContext()
                    .lookup("java:comp/UserTransaction");
        ut.begin();
        …

        ut.commit();
 } catch (Exception e) {
        ut.rollback();
        …
 }
```

JTA Specific API

Programmatic Transaction Demarcation

Checked Exceptions

Requires a JTA implementation:

- *"Full" application server (WebSphere, WebLogic, JBoss, etc.)*
- *Standalone implementation (Atomikos, JTOM, etc.)*

Problems with Java Transaction Management

- Multiple APIs for different local resources
- Programmatic transaction demarcation
  - Typically performed in the service layer but we don't want data-access code in the service-layer (separation of concerns)
  - Usually repeated (cross-cutting concern)
- Orthogonal concerns
  - Transaction demarcation should be independent of transaction implementation

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Spring Transaction Management – 1

- Spring separates transaction *demarcation* from transaction *implementation*
  - Demarcation expressed declaratively via AOP
    - Programmatic approach also available
  - PlatformTransactionManager abstraction hides implementation details.
    - Several implementations available
- Spring uses the same API for global vs. local.
  - Change from local to global is minor
    - Just change the transaction manager

Spring Transaction Management – 2

- There are only 2 steps
  - Declare a **`PlatformTransactionManager`** bean
  - Declare the transactional methods
    - Using Annotations, Programmatic
    - Can mix and match

PlatformTransactionManager Implementations

- Spring's **PlatformTransactionManager** is the base interface for the abstraction
- Several implementations are available
  - `DataSourceTransactionManager`
  - `JmsTransactionManager`
  - `JpaTransactionManager`
  - `JtaTransactionManager`
  - `WebLogicJtaTransactionManager`
  - `WebSphereUowTransactionManager`

Spring allows you to configure whether you use JTA or not.
It does not have *any* impact on your Java classes

Deploying the Transaction Manager

- Create the required implementation
  - Just like any other Spring bean
    - Configure it as appropriate
  - Here is the manager for a DataSource

A DataSource bean must be defined elsewhere

```
@Bean
public PlatformTransactionManager
                    transactionManager(DataSource dataSource) {
    return new DataSourceTransactionManager(dataSource);
}
```

Bean id "*transactionManager*" is recommended name. See Advanced slides (5) for detailed explanation on naming this bean.

Accessing a JTA Transaction Manager

- Use a JNDI lookup for container-managed DataSource

```
@Bean
public PlatformTransactionManager transactionManager() {
    return new JtaTransactionManager();
}

@Bean
public DataSource dataSource(@Value("${db.jndi}" String jndiName) {
    JndiDataSourceLookup lookup = new JndiDataSourceLookup();
    return lookup.getDataSource(jndiName);
}
```

  - Or use container-specific subclasses:
    - **`WebLogicJtaTransactionManager`**
    - **`WebSphereUowTransactionManager`**

@Transactional Configuration

In your code

```
public class RewardNetworkImpl implements RewardNetwork {
   @Transactional
   public RewardConfirmation rewardAccountFor(Dining d) {
      // atomic unit-of-work
   }
}
```

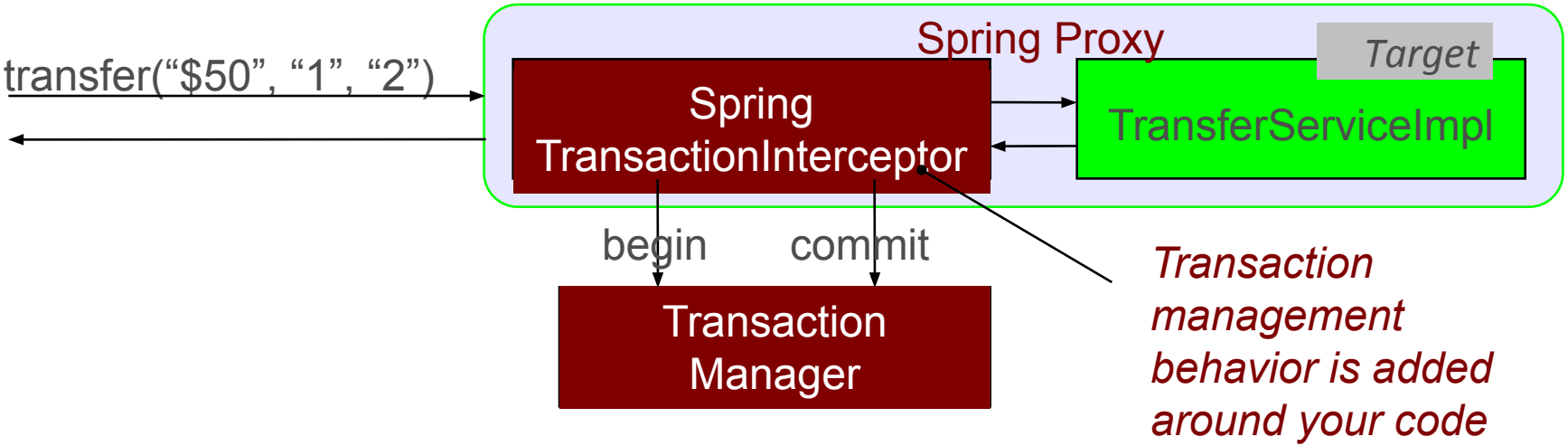
```
@Configuration
@EnableTransactionManagement
public class TxnConfig {
   @Bean
   public PlatformTransactionManager transactionManager(DataSource ds) {
      return new DataSourceTransactionManager(ds);
   }
```

Defines a Bean Post-Processor
– proxies @Transactional beans

In your Spring configuration

Declarative Transaction Management

- Target service wrapped in a proxy
  - Uses an "*around*" advice



@Transactional: What Happens Exactly?

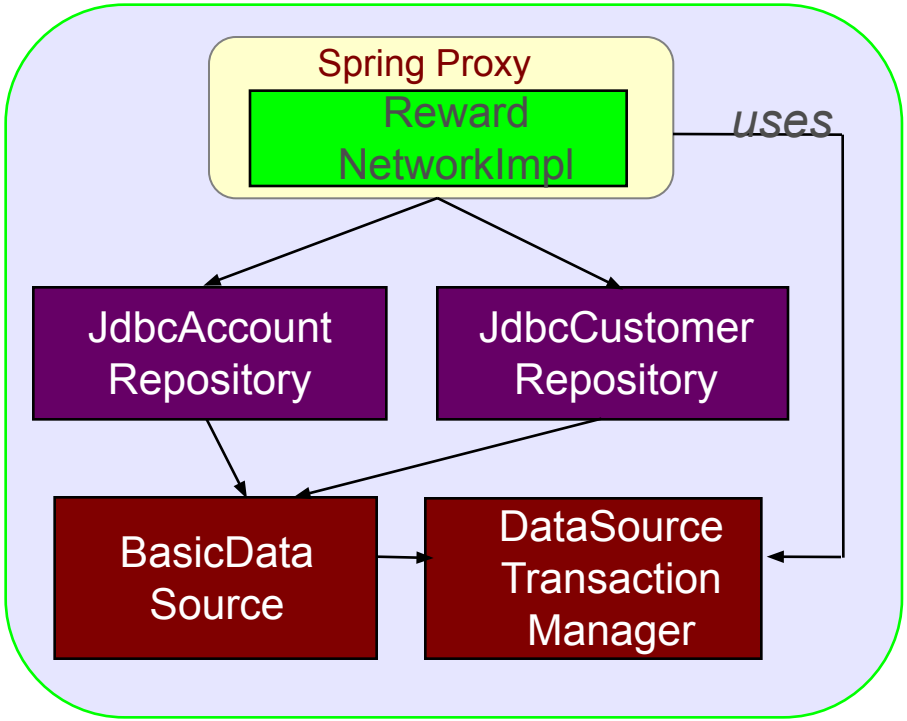
- Proxy implements the following behavior
  - Transaction started before entering the method
  - Commit at the end of the method
  - Rollback if method throws a **`RuntimeException`**
    - Default behavior
    - Can be overridden (see later)
    - Checked exceptions do not cause Rollback
- All controlled by *configuration*

Transaction Bound to Current Thread

- Transaction context bound to current thread
  - Holds the underlying JDBC connection
  - Hibernate sessions, JTA (Java EE) work similarly
- **`JdbcTemplate`** used in an **`@Transactional`** method
  - Uses that connection automatically
- You can access it manually

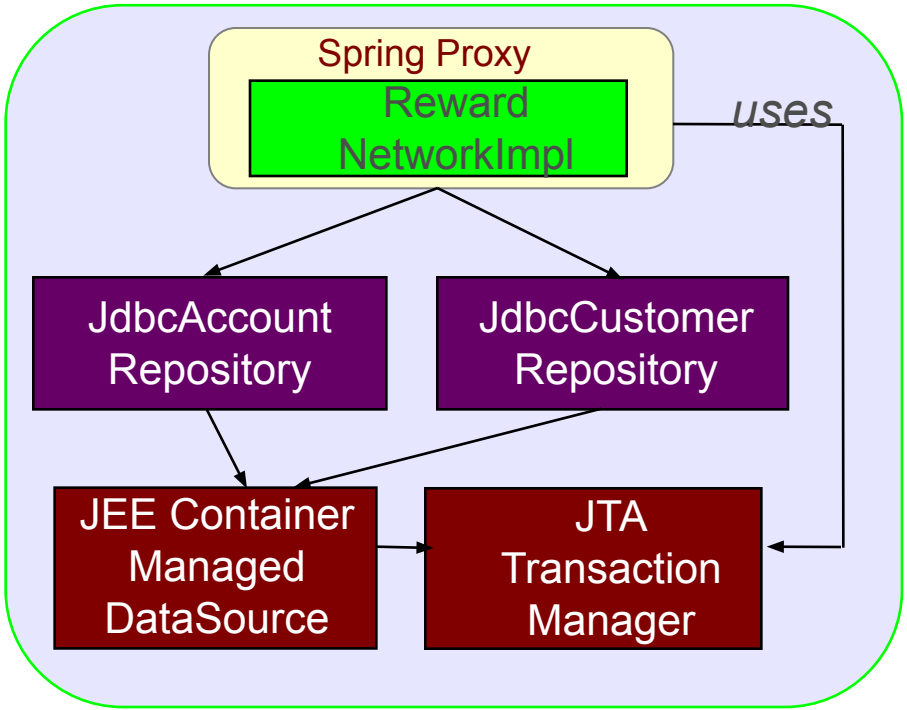
```
DataSourceUtils.getConnection(dataSource)
```

Local JDBC Configuration



- How?
  - Define and use local data source
  - Use DataSource Transaction Manager
- Purpose
  - Integration testing and/or Production
  - Deploy to Tomcat or other servlet container

JDBC Java EE Configuration



No code changes
Just configuration

- How?
  - Use container-managed datasource (JNDI)
  - Use JTA Transaction Manager
- Purpose
  - Deploy to Java EE container

@Transactional – Class Level

- Applies to all methods declared by the interface(s)

```
@Transactional
public class RewardNetworkImpl implements RewardNetwork {

   public RewardConfirmation rewardAccountFor(Dining d) {
      // atomic unit-of-work
   }

   public RewardConfirmation updateConfirmation(RewardConfirmantion rc) {
      // atomic unit-of-work
   }
}
```

Alternatively *@Transactional* can be declared on the interface instead – since Spring Framework 5.0

@Transactional – Class *and* method levels

- Combining class and method levels

```
@Transactional(timeout=60)
public class RewardNetworkImpl implements RewardNetwork {

   public RewardConfirmation rewardAccountFor(Dining d) {
      // atomic unit-of-work
   }
   @Transactional(timeout=45)
   public RewardConfirmation updateConfirmation(RewardConfirmantion rc) {
      // atomic unit-of-work
   }
}
```

default settings

override attributes at method level

Java's @Transactional

- Java also has an annotation
  - **`javax.transaction.Transactional`**
- Also supported by Spring
  - Fewer options
  - Not used in these examples
  - Be careful when doing the lab
    - Use Spring's **`@Transactional`**

Agenda

- Why use Transactions?
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- **Transaction Propagation**
- Rollback rules
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Understanding Transaction Propagation

- What should happen if **`ClientServiceImpl`** calls **`AccountServiceImpl`**?
  - Single transaction?
  - Two separate transactions?

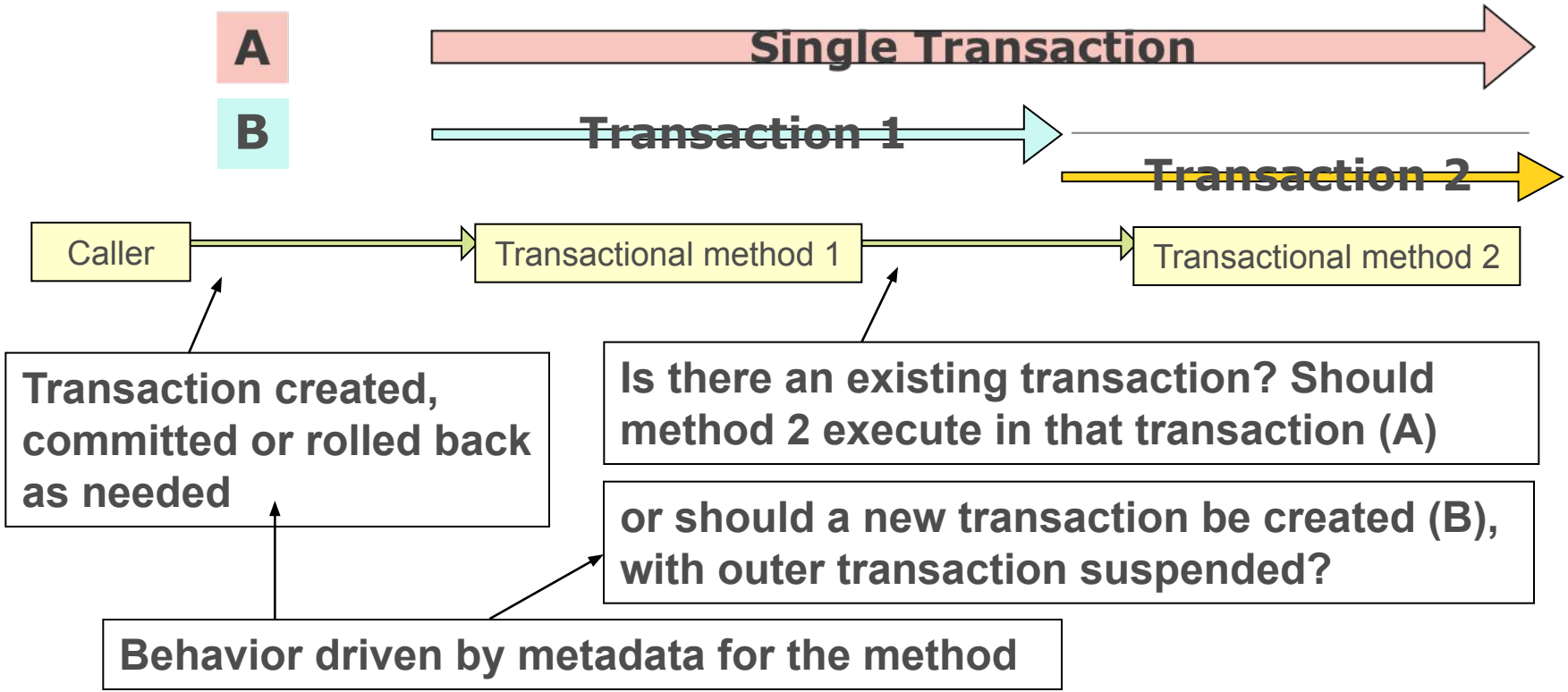
```
public class ClientServiceImpl
             implements ClientService {
  @Autowired
  private AccountService accountService;

  @Transactional
  public void updateClient(Client c) {
    // …
    this.accountService.update(c.getAccounts());
  }
}
```

```
public class AccountServiceImpl
             implements AccountService {

  @Transactional
  public void update(List <Account> accs)
   { // … }
}
```

Understanding Transaction Propagation



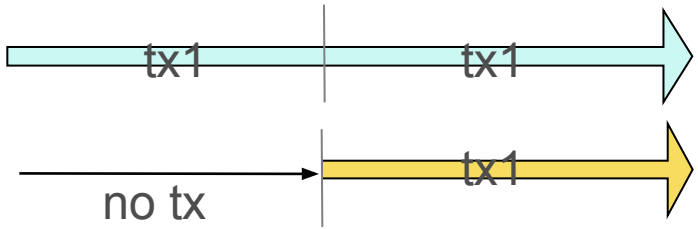
Transaction Propagation with Spring

- 7 levels of propagation
- The following examples show *REQUIRED* and *REQUIRES_NEW*
  - *Check the documentation for other levels*
- Can be used as follows:

```
@Transactional( propagation=Propagation.REQUIRES_NEW )
```

REQUIRED

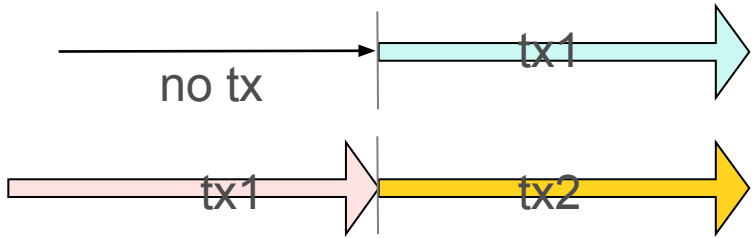
- Default value
- Execute within a current transaction, create a new one if none exists




```
@Transactional(propagation=Propagation.REQUIRED)
```

REQUIRES_NEW

- Create a new transaction, suspending the current transaction if one exists




```
@Transactional(propagation=Propagation.REQUIRES_NEW)
```

Propagation Rules Are Enforced by a Proxy

- In the example below, the 2nd propagation rule does not get applied because the call does not go through a proxy

```
public class ClientServiceImpl implements ClientService {
        @Transactional(propagation=Propagation.REQUIRED)
        public void update1() {
            update2();
        }
        @Transactional(propagation=Propagation.REQUIRES_NEW)
        public void update2() {
        }
    }
}
```

Does not get applied because the call is internal

Agenda

- Why use Transactions?
- Java Transaction Management
- Spring Transaction Management
- Transaction Propagation
- **Rollback Rules**
- Testing
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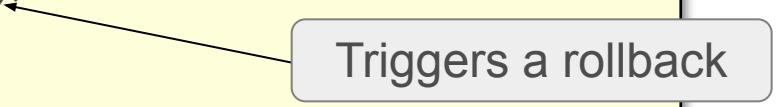
Default Behavior

- By default, a transaction is rolled back only if a *RuntimeException* has been thrown
  - Could be any kind of *RuntimeException*: *DataAccessException*, *HibernateException* etc.

```
public class RewardNetworkImpl implements RewardNetwork {
   @Transactional
   public RewardConfirmation rewardAccountFor(Dining d) {
      // ...
      throw new RuntimeException();

   }
}
```



rollbackFor and noRollbackFor

- Default settings can be overridden with *rollbackFor* and/or *noRollbackFor* attributes

```
public class RewardNetworkImpl implements RewardNetwork {

   @Transactional(rollbackFor=MyCheckedException.class,
                  noRollbackFor={JmxException.class, MailException.class})
   public RewardConfirmation rewardAccountFor(Dining d) throws Exception {
          // ...
   }

}
```

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- Why use Transactions?
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- **Testing**
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@Transactional within Integration Test

- Annotate test method (or class) with @Transactional
  - Runs test methods in a transaction
  - Transaction will be *rolled back* afterwards
    - No need to clean up your database after testing!

```
@SpringJUnitConfig(RewardsConfig.class)
public class RewardNetworkTest {
    @Test @Transactional
    public void testRewardAccountFor() {
        ...
    }
}
```

This test is now transactional

Controlling Transactional Tests

```
@SpringJUnitConfig(RewardsConfig.class)
@Transactional
public class RewardNetworkTest {

    @Test
    @Commit
    public void testRewardAccountFor() {
        ...    // Whatever happens here will be committed
    }
}
```

Make *all* tests transactional

Commit transaction at end of test

Lab: Managing Transactions Declaratively using Spring Annotations

Lab project
28-transactions

Anticipated Lab time:
20 Minutes

Optional Topics: Programmatic transactions, read-only and multiple transactions, global transactions, propagation options

Agenda

Advanced Topics

(1) Programmatic Transactions
(2) Read-only Transactions
(3) More on Transactional Tests
(4) Multiple and Global Transactions
(5) Transaction Manager bean name
(6) Global Transactions
(7) Propagation Options

1. Programmatic Transactions with Spring

- Declarative transaction management is highly recommended
  - Clean code
  - Flexible configuration
- Spring does enable programmatic transaction
  - Works with local or JTA transaction manager
  - **`TransactionTemplate`** plus callback

Can be useful inside a technical framework that would not rely on external configuration

Programmatic Transactions: example

```
public RewardConfirmation rewardAccountFor(Dining dining) {
   ...
   return  new TransactionTemplate(txManager).execute( (status) -> {
         try {
            ...
            accountRepository.updateBeneficiaries(account);
            confirmation = rewardRepository.confirmReward(contribution, dining);
         }
         catch (RewardException e) {
            status.setRollbackOnly();
            confirmation = new RewardFailure();
         }
         return confirmation;
      }
   );
}
```

Method *not* @Transactional

Lambda syntax

Method no longer throws exception, using status to perform *manual* rollback

```
public interface TransactionCallback<T> {
   public T doInTransaction(TransactionStatus status)
            throws Exception;
}
```

2. Read-only Transactions – Faster

- Why use transactions if you're only planning to read data?
  - Performance: allows Spring to optimize the transactional resource for read-only data access

```
public void rewardAccount1() {
      jdbcTemplate.queryForList(…);
      jdbcTemplate.queryForInt(…);
}

@Transactional(readOnly=true)
public void rewardAccount2() {
      jdbcTemplate.queryForList(…);
      jdbcTemplate.queryForInt(…);
}
```

Two connections

One single connection

Read-only Transactions – Isolation

- Why use transactions if you're only planning to read data?
  - With a high isolation level, a read-only transaction prevents data from being modified until the transaction commits

```
@Transactional(readOnly=true, isolation=Isolation.REPEATABLE_READ)
public void myAccounts(long userId) {
   List accounts = jdbcTemplate.queryForList
                ("SELECT * FROM Accounts WHERE user = ?", userId);
   process(accounts);
   int nAccounts = jdbcTemplate.queryForInt
                ("SELECT count(*) FROM Accounts WHERE user = ?", userId);
   assert accounts.size() == nAccounts;
}
```

3. Transactional Tests

@BeforeEach vs @BeforeTransaction

```
@SpringJUnitConfig(RewardsConfig.class)
public class RewardNetworkTest {

    @BeforeTransaction
    public void verifyInitialDatabaseState() {…}

    @BeforeEach
    public void setUpTestDataInTransaction() {…}

    @Test  @Transactional
    public void testRewardAccountFor() { … }
```

Run *before* transaction is started

Run *within* the transaction

@AfterEach and *@AfterTransaction* work in same way as *@BeforeEach* and *@BeforeTransaction*

@Sql and Transaction Control

- Transaction control options
  - ***ISOLATED****:* Uses *own* txn, a PTM *must* exist
  - ***INFERRED****:* If PTM exists, txn started using default propagation (same txn as test method)
    otherwise a DataSource *must* exist (used with *no* txn)
  - ***DEFAULT***: Whatever @Sql defines at class level, *INFERRED* otherwise

```
@Sql(  scripts = "/test-user-data.sql",
       config = @SqlConfig
            ( transactionMode = TransactionMode.ISOLATED,
              transactionManager = "myTxnMgr",
              dataSource= "myDataSource" )
```

Optionally specify bean ids

PTM = PlatformTransactionManager, txn = transaction

4. Multiple Transaction Managers

- Configuration – mark *one* as primary

Java Config

```
@Bean
public PlatformTransactionManager myOtherTransactionManager() {
    return new DataSourceTransactionManager(dataSource1());
}

@Bean
@Primary
public PlatformTransactionManager transactionManager() {
    return new DataSourceTransactionManager(dataSource2());
}
```

XML

```
<bean id="transactionManager" primary="true" … > … </bean>
```

@Transactional with Multiple Managers

- @Transactional can declare the id of the transaction manager that should be used

```
@Transactional("myOtherTransactionManager")
public void rewardAccount1() {
    jdbcTemplate.queryForList(…);
    jdbcTemplate.queryForInt(…);
}

@Transactional
public void rewardAccount2() {
    jdbcTemplate.queryForList(…);
    jdbcTemplate.queryForInt(…);
}
```

Uses the bean with id "*myOtherTransactionManager*"

Defaults to use the bean annotated as the *primary*

Important: Separate transaction managers = separate transactions!

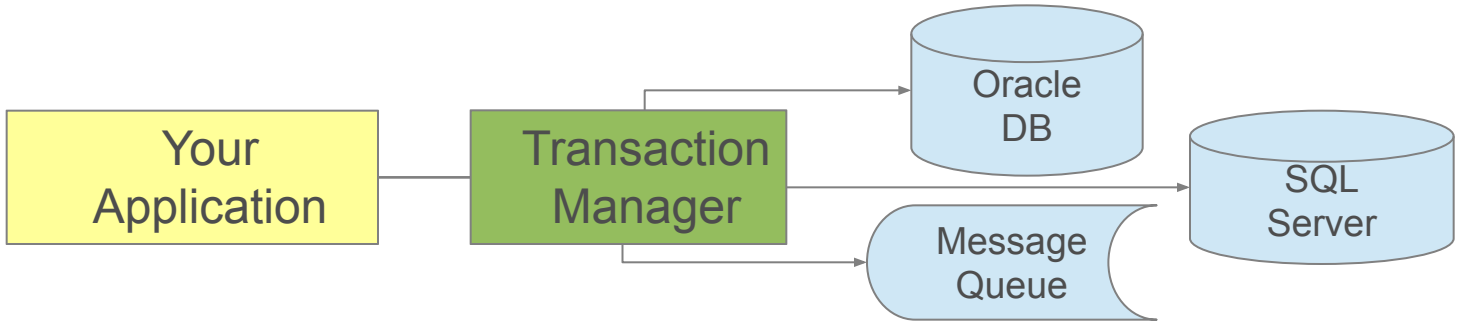
5. Transaction Manager Naming

- **`@EnableTransactionManagement`**
  - Expects a bean called **`txManager`**
  - Or looks for **`PlatformTransactionManager`** by *type*
- **`Spring Boot`**
  - Creates a bean called **`transactionManager`** by default
- **`@Transactional`**
  - Looks for *primary* transaction manager if exists
  - Or looks for singleton **`PlatformTransactionManager`**
  - Or bean called **`transactionManager`** by default

Recall: bean id "*transactionManager*" is recommended name and **`@EnableTransactionManagement`** will find it by type.

6. Global Transactions

- Also called *distributed* transactions
- Involve multiple dissimilar resources:



- Global transactions typically require JTA and specific drivers (XA drivers)
  - Two-phase commit protocol

Global Transactions → Spring Integration

- Many possible strategies
  - Spring allows you to switch easily from a non-JTA to a JTA transaction policy
  - Just change the type of the transaction manager
- Reference:
  - *"Distributed transactions with Spring, with and without XA"* by Dr. Dave Syer

http://www.javaworld.com/javaworld/jw-01-2009/jw-01-spring-transactions.html

7. Propagation Levels and their Behaviors

Propagation Type	If NO current transaction (txn) exists	If there IS a current transaction (txn)
MANDATORY	Throw exception	Use current txn
NEVER	Don't create a txn, run method without a txn	Throw exception
NOT_SUPPORTED	Don't create a txn, run method without a txn	Suspend current txn, run method without a txn
SUPPORTS	Don't create a txn, run method without a txn	Use current txn
REQUIRED (default)	Create a new txn	Use current txn
REQUIRES_NEW	Create a new txn	Suspend current txn, create a new independent txn
NESTED	Create a new txn	Create a new nested txn