



# Transaction Management with Spring

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Transactional Proxies and @Transactional

## Objectives

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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?

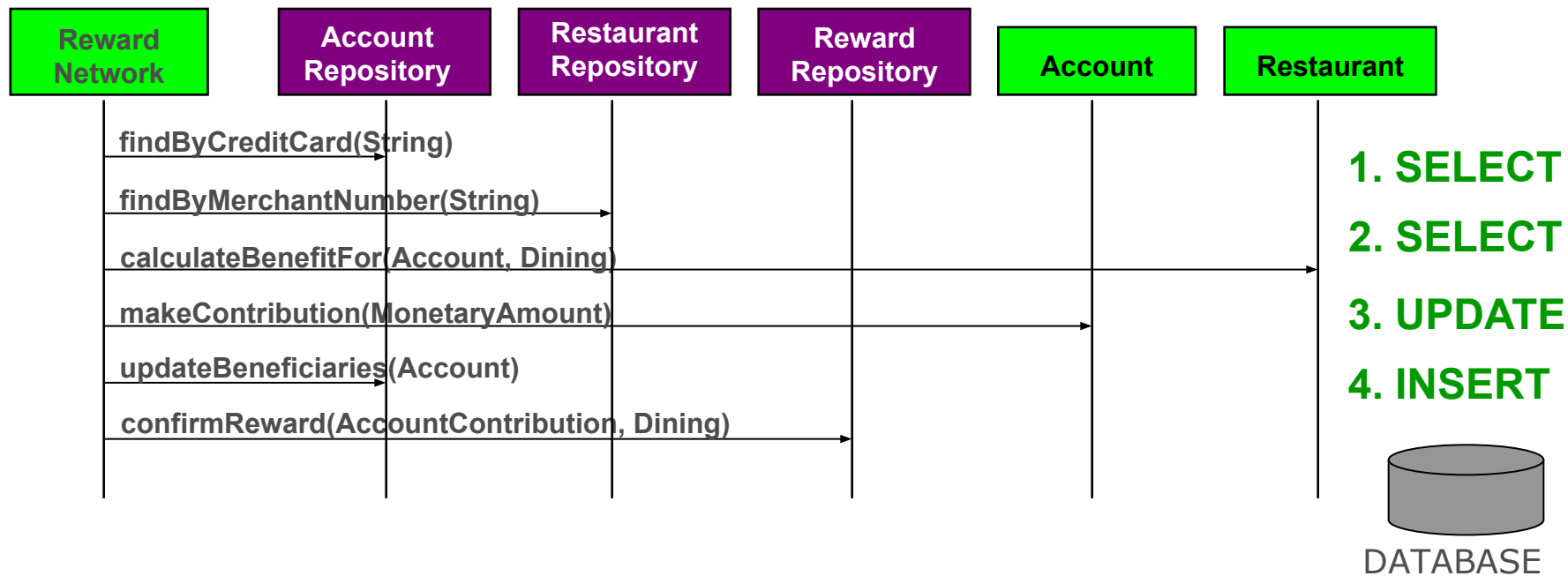
Enable *concurrent* access  
to a *shared* resource

- 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

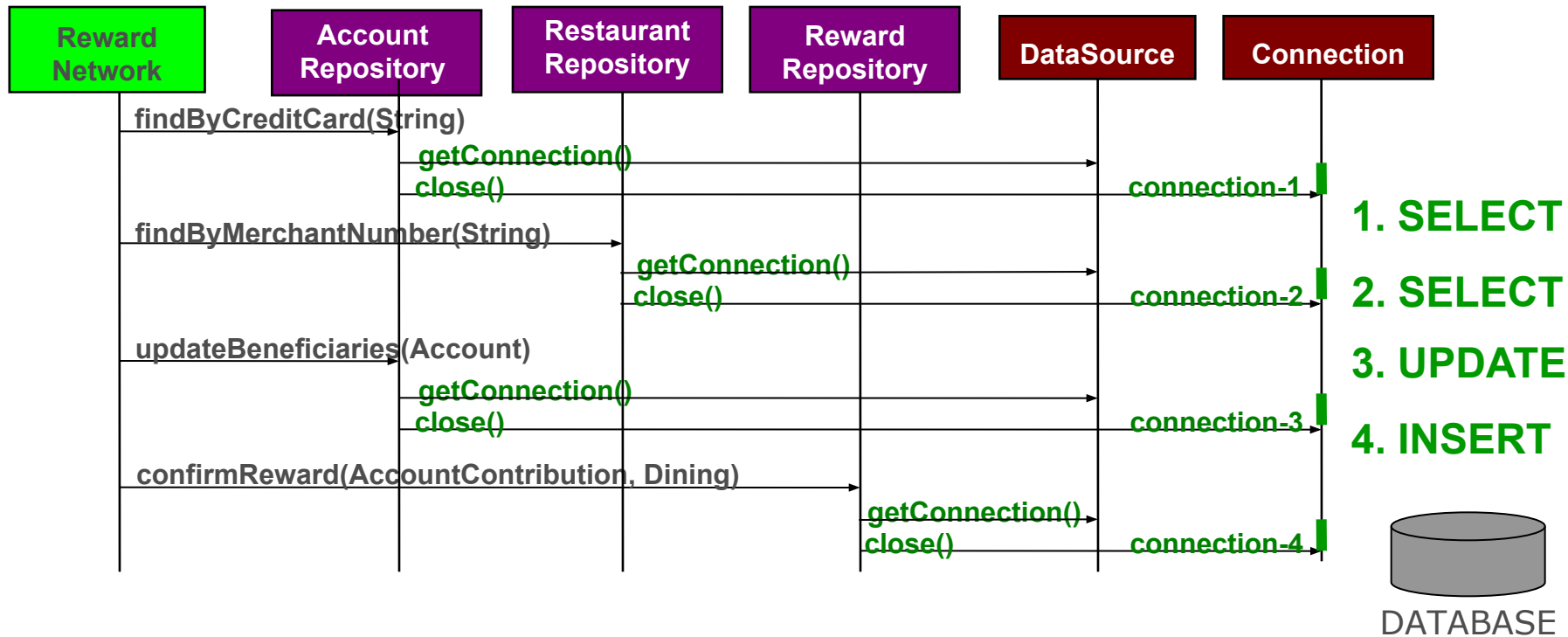
- The *rewardAccountFor(Dining)* method represents a unit-of-work that should be atomic



# Naïve Approach

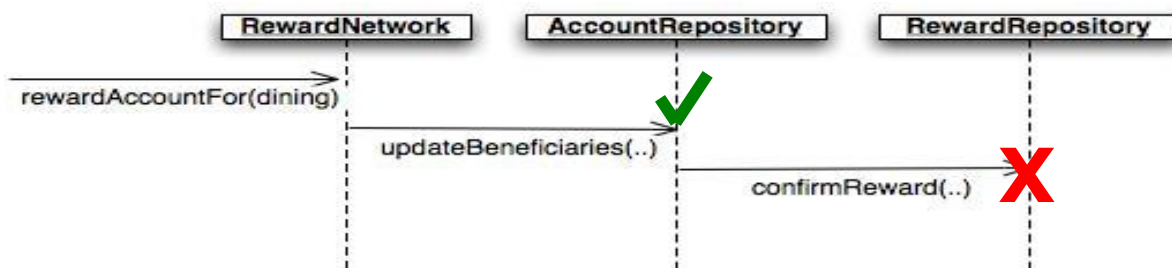
- **Connection per Data Access Operation**
  - This unit-of-work contains 4 data access operations
    - Each acquires, uses, and releases a distinct Connection
  - The unit-of-work is ***non-transactional***

# 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!

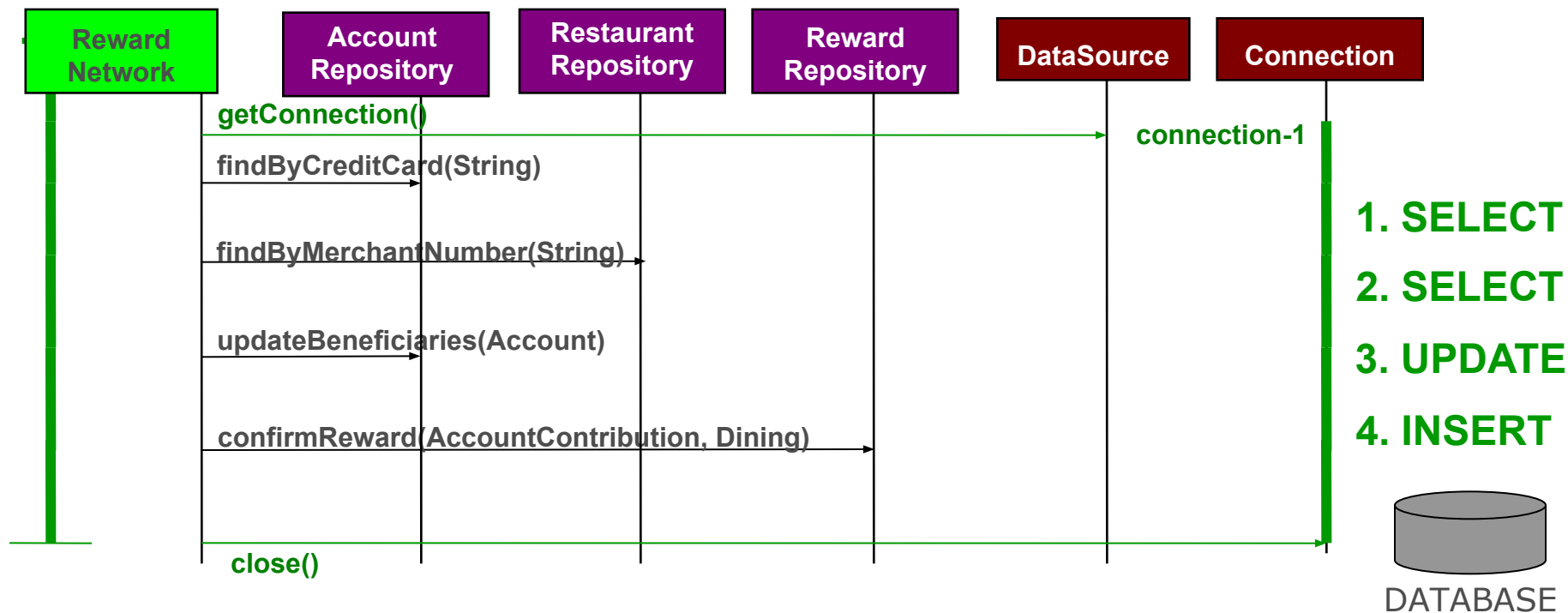
The unit-of-work  
is **not** *atomic*



# 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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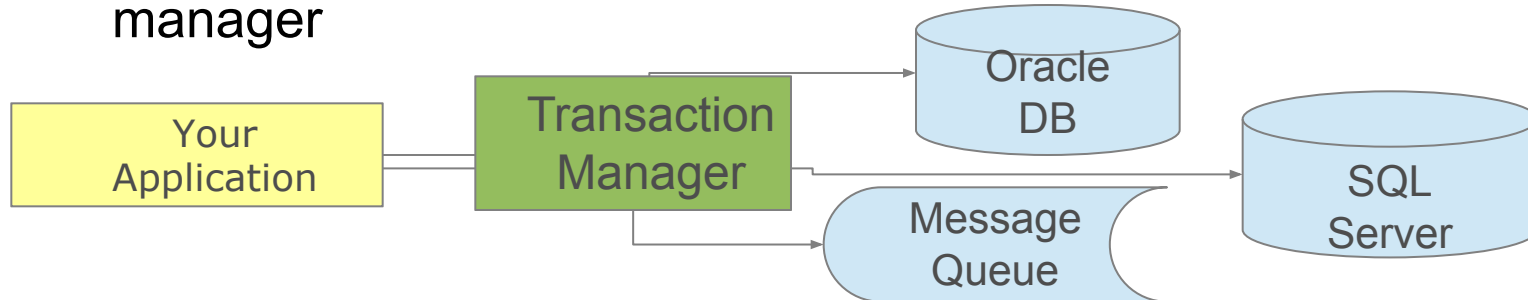


# Local and Global Transaction Management

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

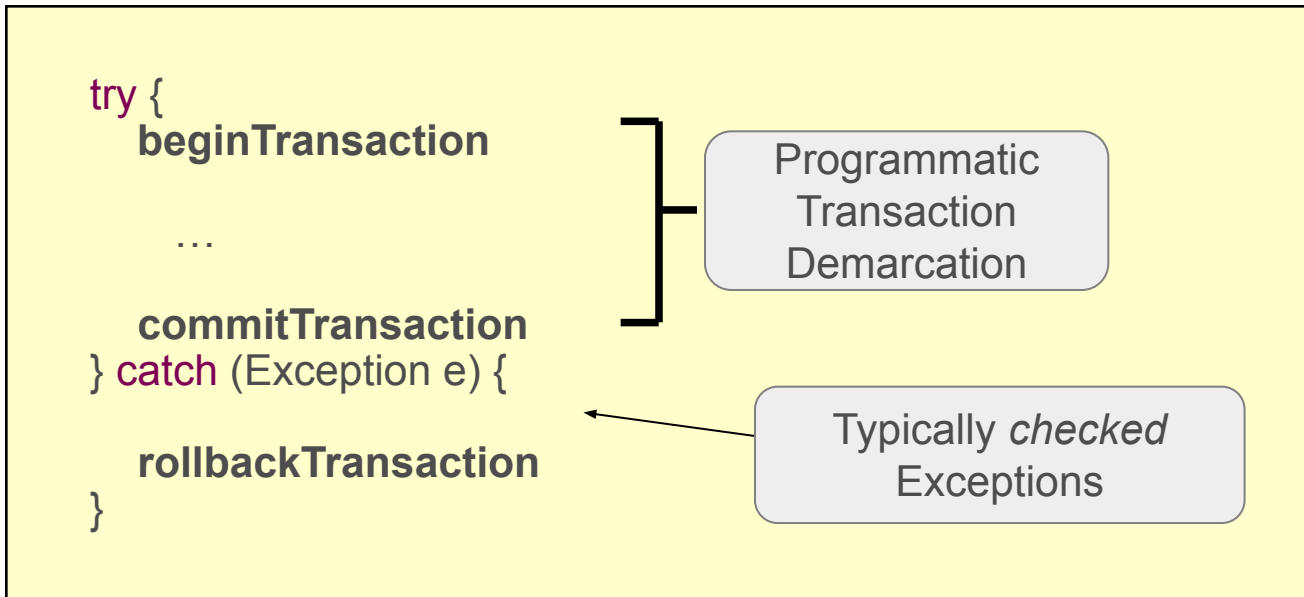


- Global (distributed) Transactions – Multiple Resources
  - Transaction managed by separate, dedicated transaction manager



# Transactional Code Pattern

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



# Java API Transaction Examples

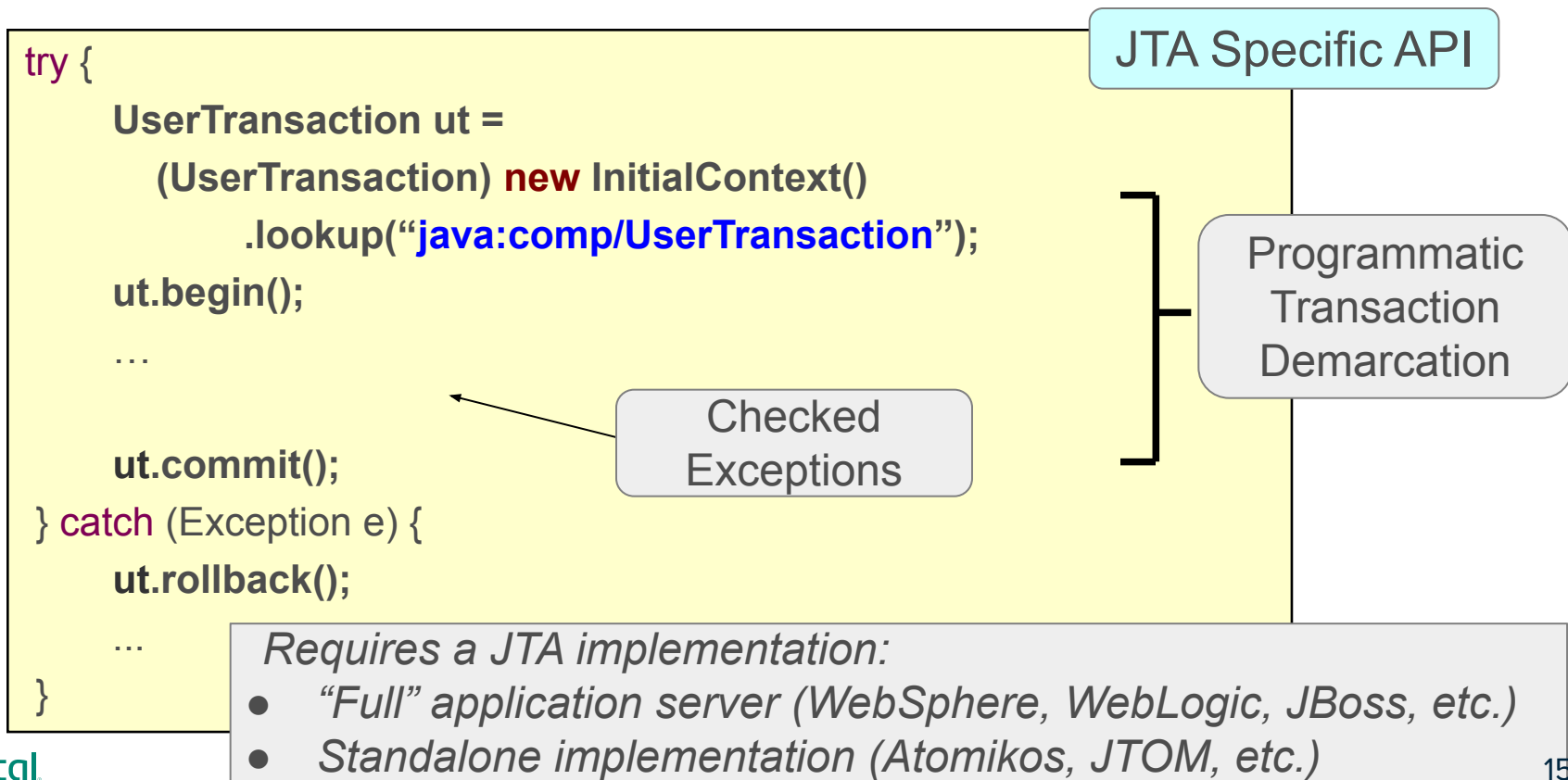
API	Begin Transaction	End Transaction
JDBC	<code>conn = <a href="#">dataSource</a>.getConnection() conn.setAutoCommit(<a href="#">false</a>)</code>	<code>conn.commit() conn.rollback()</code>
JMS	<code>session = <a href="#">connection</a> .createSession ( <a href="#">true</a>, 0 )</code>	<code>session.commit() session.rollback()</code>
JPA	<code>Transaction tx = <a href="#">entityManager</a>.getTransaction(); tx.begin();</code>	<code>tx.commit() tx.rollback()</code>
Hibernate	<code>Transaction tx = <a href="#">session</a>.beginTransaction();</code>	<code>tx.commit() tx.rollback()</code>

*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)*



# 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



# Agenda

- Why use Transactions?
- Java Transaction Management
- **Spring Transaction Management**
- Transaction Propagation
- Rollback rules
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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

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

A DataSource  
bean must be  
defined elsewhere



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);

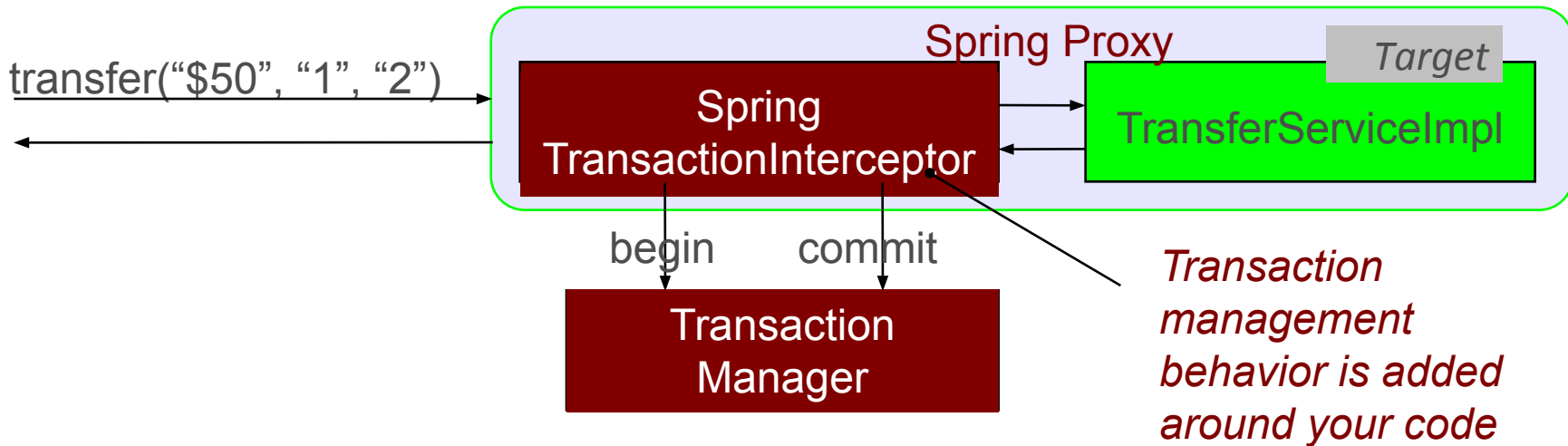
}

Defines a Bean Post-Processor  
– proxies @Transactional beans

In your Spring configuration

# Declarative Transaction Management

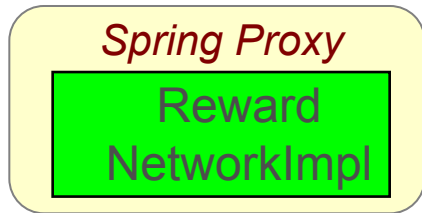
- Target service wrapped in a proxy
  - Uses an “*around*” advice





## @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*



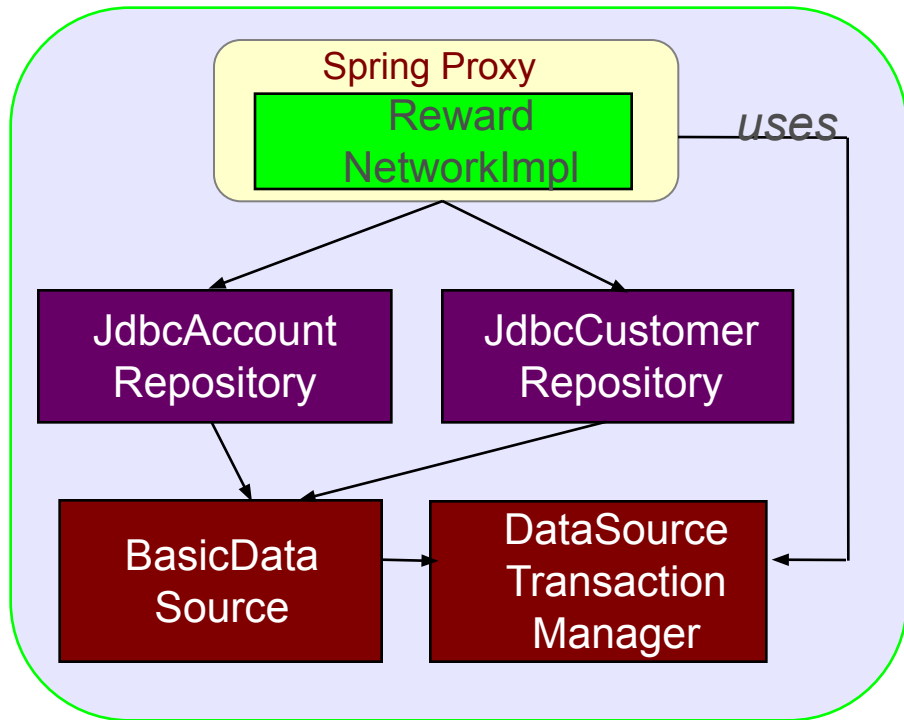
# Transaction Bound to Current Thread

- 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)
```

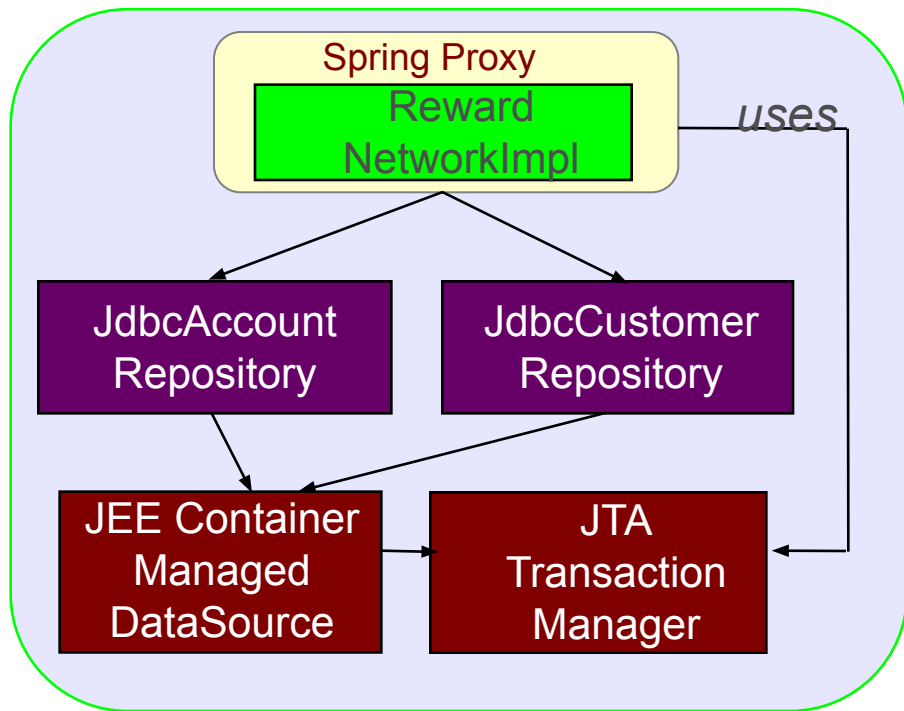


# Local JDBC Configuration



- 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(RewardConfirmation 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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# Understanding Transaction Propagation

- What should happen if `ClientServiceImpl` calls `AccountServiceImpl`?


- Single transaction?
- Two separate transactions?

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

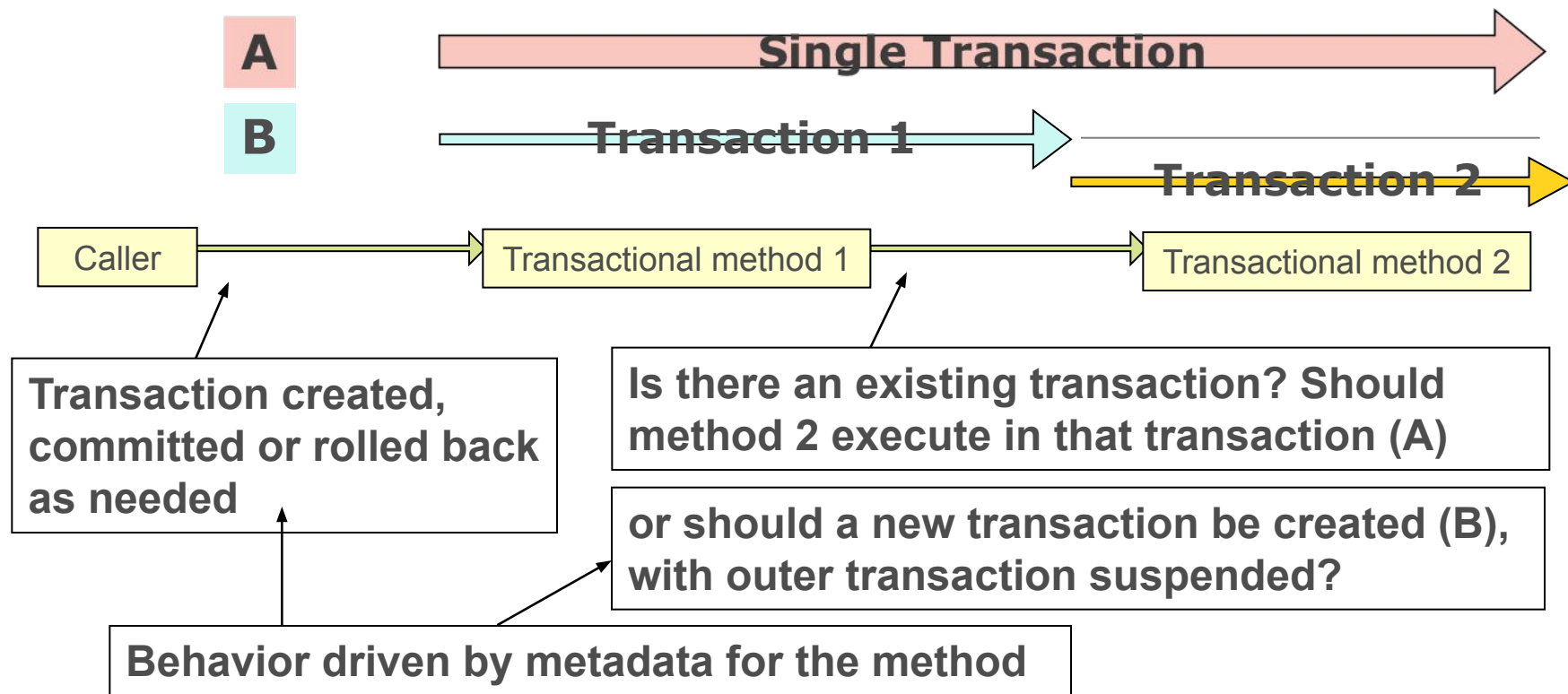
    @Transactional
    public void updateClient(Client c) {
        // ...
        this.accountService.update(c.getAccounts());
    }
}
```

```
public class AccountServiceImpl
    implements AccountService {

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



# Understanding Transaction Propagation



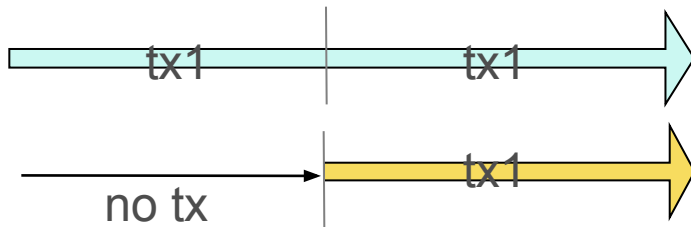
# Transaction Propagation with Spring

- 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

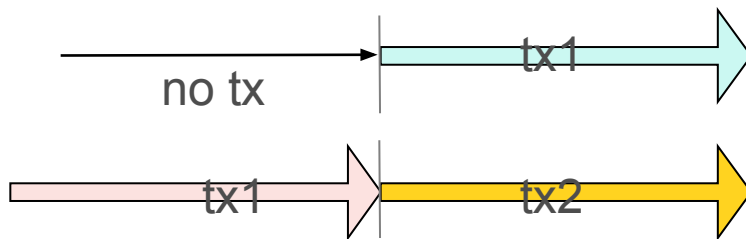
- Default value
- Execute within a current transaction, create a new one if none exists



`@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
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- Transaction Propagation
- **Rollback Rules**
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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();  
    }  
}
```

Triggers a rollback



## 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 {  
        // ...  
    }  
  
}
```

# Agenda

- Why use Transactions?
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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(...);  
}
```

Two connections

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

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

## 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(...);
}
```

Uses the bean with id  
*"myOtherTransactionManager"*

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

Defaults to use the bean  
annotated as the *primary*

**Important:** Separate transaction  
managers = separate transactions!

## 5. Transaction Manager Naming

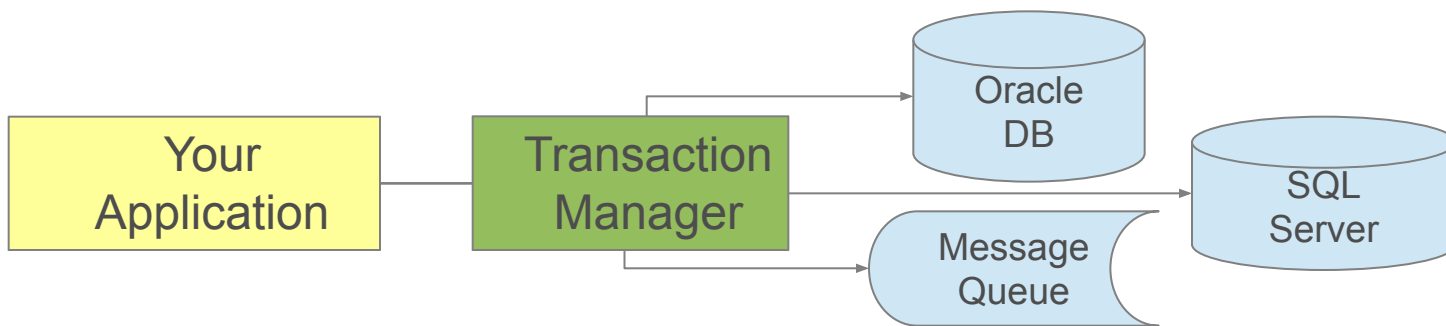
- **@EnableTransactionManagement**
  - Expects a bean called **txManager**
  - Or looks for **PlatformTransactionManager** by *type*
- **Spring Boot**
  - Creates a bean called **transactionManager** by default
- **@Transactional**
  - Looks for *primary* transaction manager if exists
  - Or looks for 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)
<b>MANDATORY</b>	Throw exception	Use current txn
<b>NEVER</b>	Don't create a txn, run method without a txn	Throw exception
<b>NOT_SUPPORTED</b>	Don't create a txn, run method without a txn	Suspend current txn, run method without a txn
<b>SUPPORTS</b>	Don't create a txn, run method without a txn	Use current txn
<b>REQUIRED</b> (default)	Create a new txn	Use current txn
<b>REQUIRES_NEW</b>	Create a new txn	Suspend current txn, create a new independent txn
<b>NESTED</b>	Create a new txn	Create a new nested txn