CS544

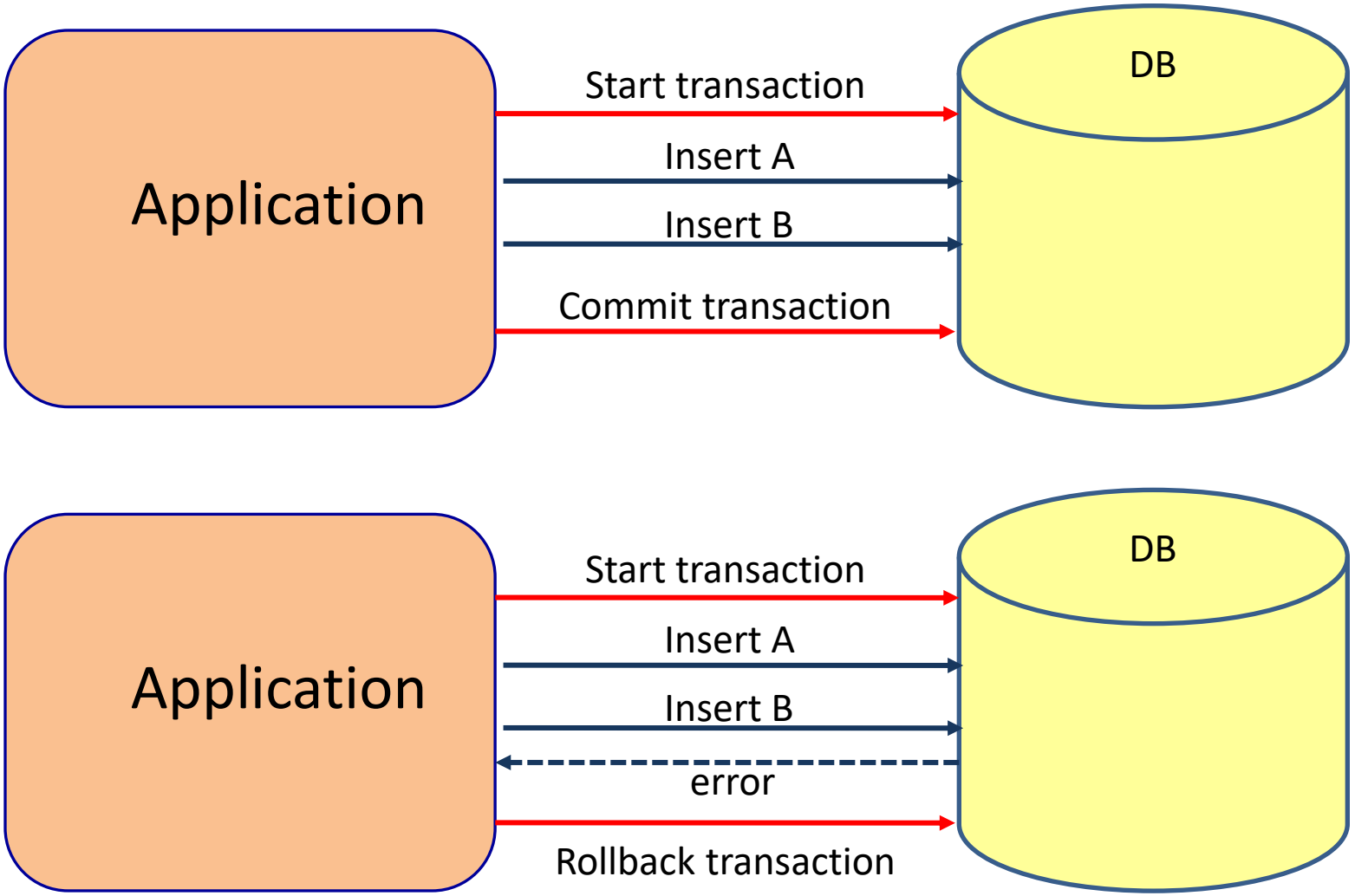
LESSON 7
TRANSACTIONS

BASICS OF TRANSACTIONS

What is a transaction?

- A unit of actions with the following ACID characteristics:
  - **ATOMICITY:** All changes occur together or no change occurs
    - All-or-nothing
  - **CONSISTENCY:** The transaction transforms the system from one consistent state to another consistent state
    - Transaction must be correct according the application rules
  - **ISOLATION:** Data used in one transaction cannot be used in other transactions until the transaction is committed.
  - **DURABILITY:** Once a transaction is committed, its effects are guaranteed to be persistent

How do transactions work?



Local or global transaction

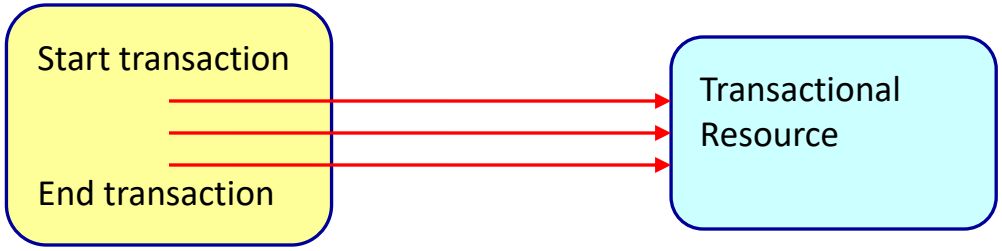
Transaction propagation

Isolation level

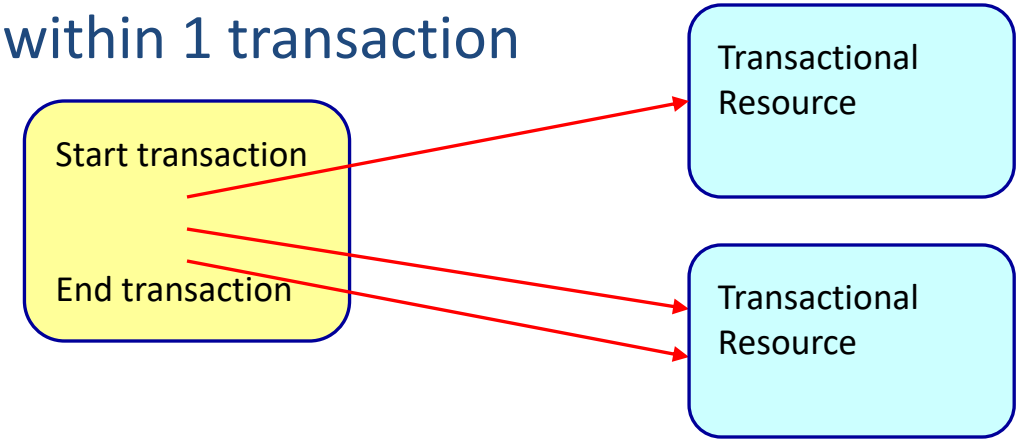
GLOBAL OR LOCAL TRANSACTION

Local or global transactions

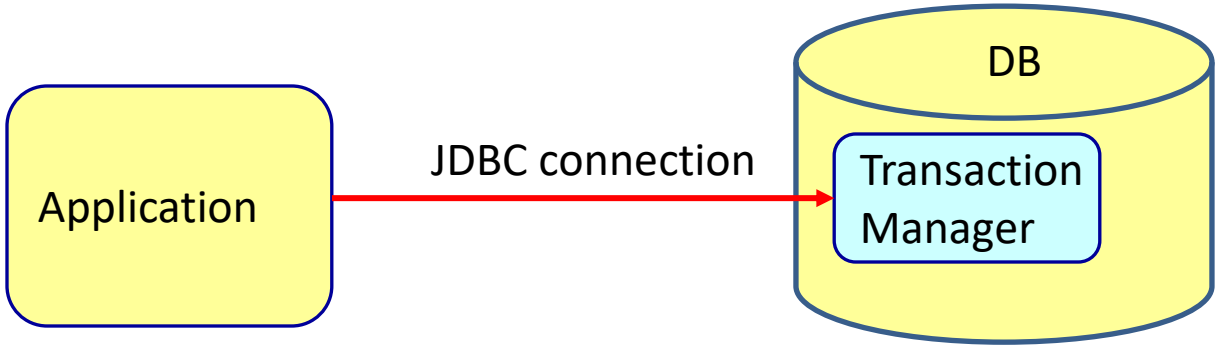
- Local transactions
  - 1 transactional resource (database, message bus)



- Global transactions
  - More than 1 transactional resource (database, message bus) used within 1 transaction

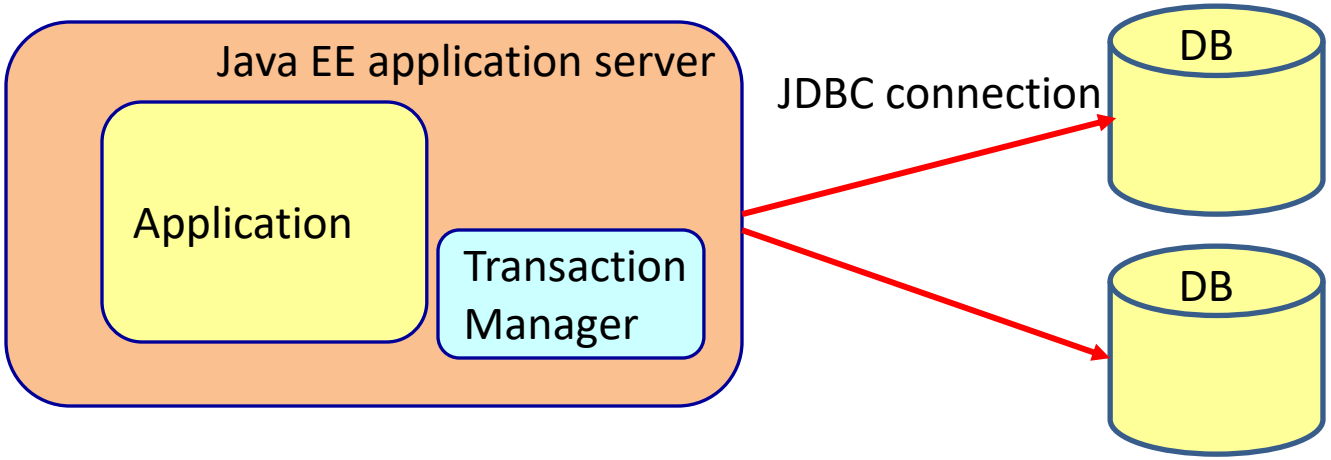


Local transaction



- The transaction is managed by the database
- Simple
- Fast

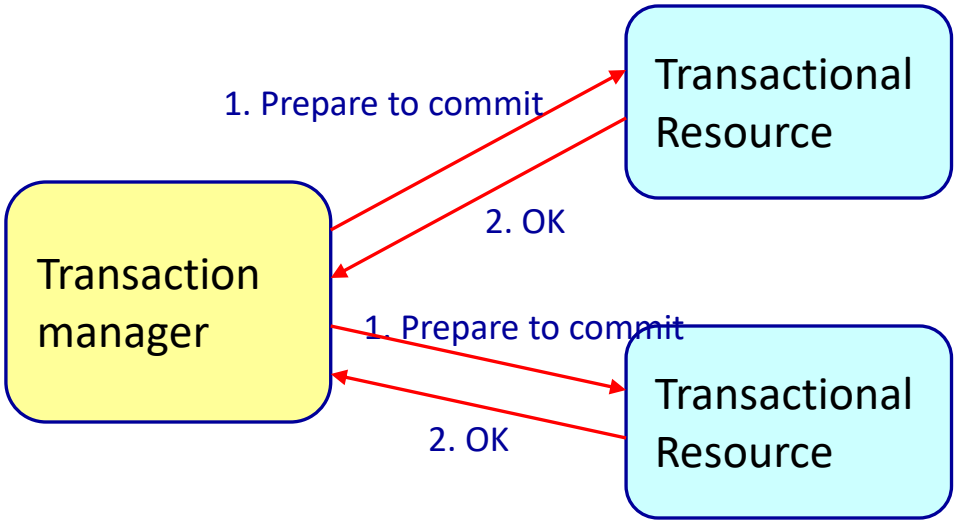
Global transaction



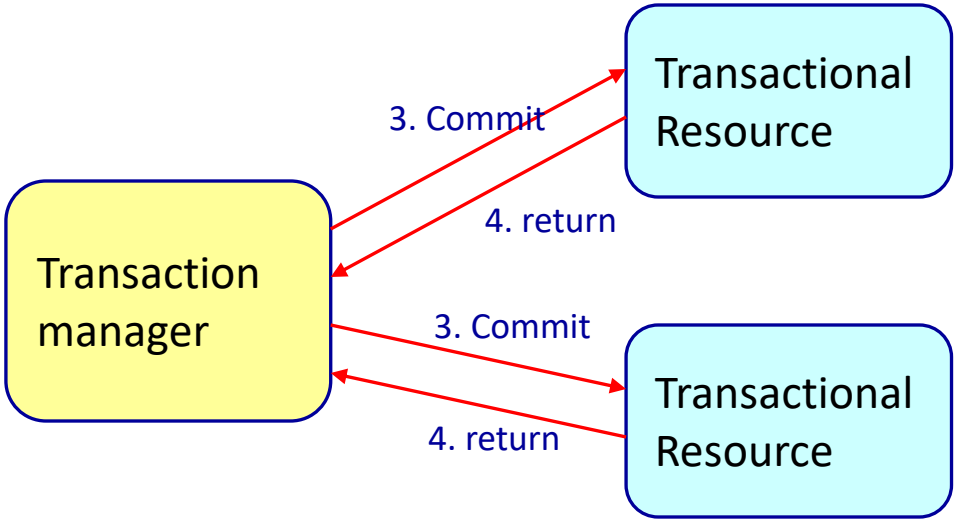
- The transaction is managed by the transaction manager in the Java EE application server
- Also called XA transactions
- Only needed when 2 transactional resources are used within one transaction
- 2 Phase commit

2 phase commit

- Phase 1

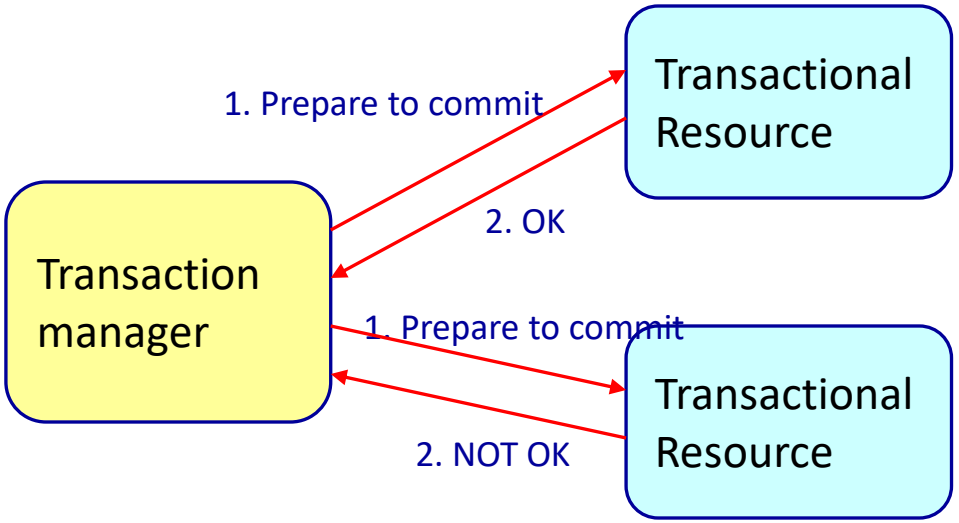


- Phase 2

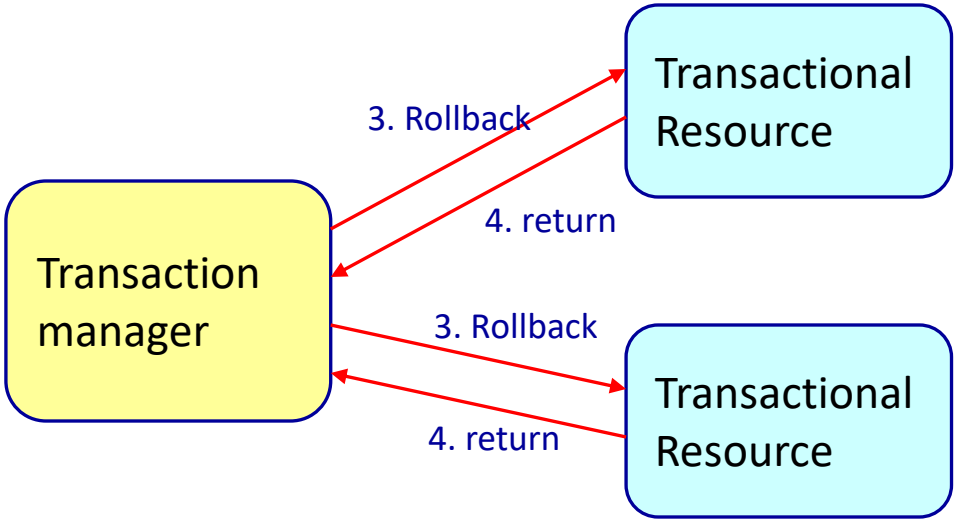


2 phase commit

- Phase 1



- Phase 2



Characteristics of XA transactions

- 2 phase commit does not guarantee that nothing can go wrong anymore
- 2 phase commit is slow
  - Often runs over remote connections
- Transactional resources become dependent on each other
  - You have to keep the locks until ALL resources are finished

Main point

- Always try to use local transactions. Only use global transactions when there is no other choice.

  Science of Consciousness: In higher states of consciousness one always chooses the path of least resistance.

Local or global transaction

Transaction propagation

Isolation level

TRANSACTION PROPAGATION

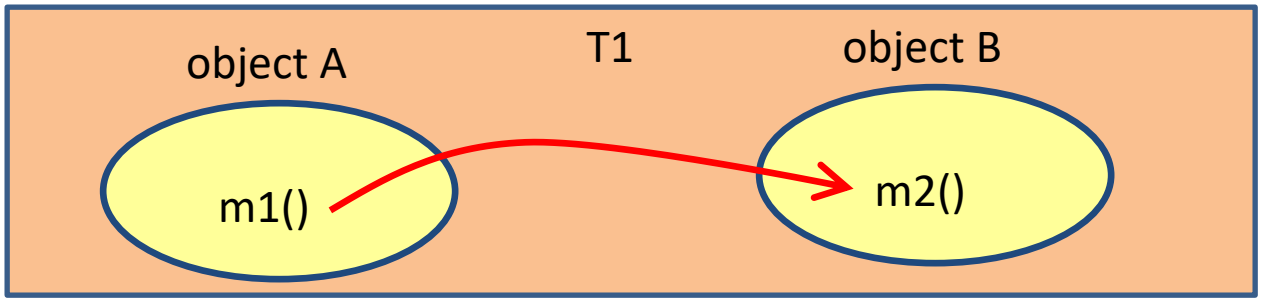
Transaction propagation

- REQUIRED
- REQUIRES_NEW
- MANDATORY
- SUPPORTS
- NEVER
- NOT_SUPPORTED

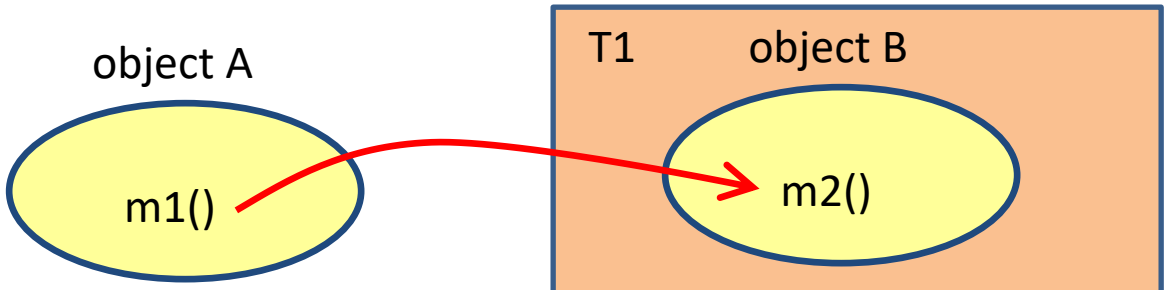
Default, mostly used

Transaction propagation: REQUIRED

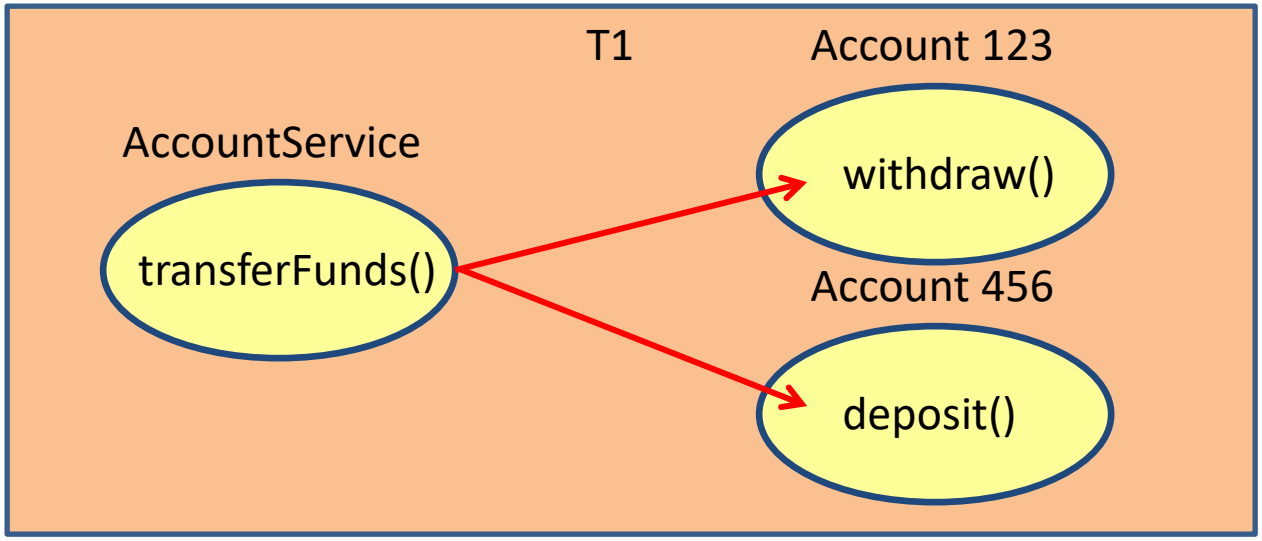
- If the calling method m1() runs in a transaction T1, then method m2() joins the same transaction T1



- If the calling method m1() does not run in a transaction , then method m2() runs in a newly created transaction T1

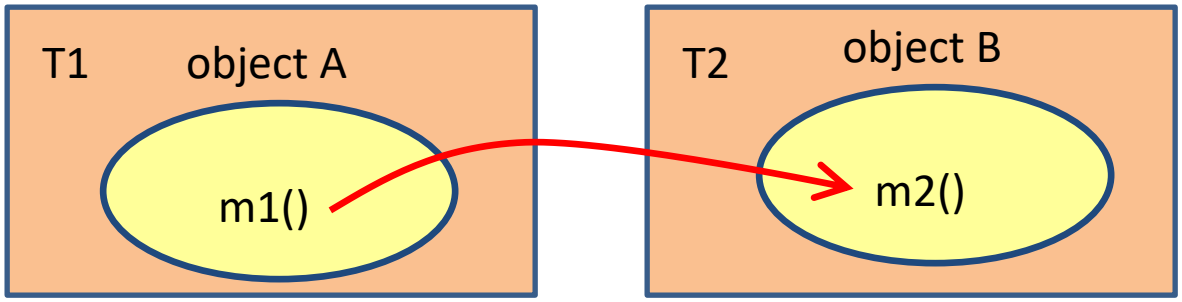


Example of transaction propagation



Transaction propagation: REQUIRES_NEW

- If the calling method m1() runs in a transaction T1, then method m2() runs in a new created transaction T2



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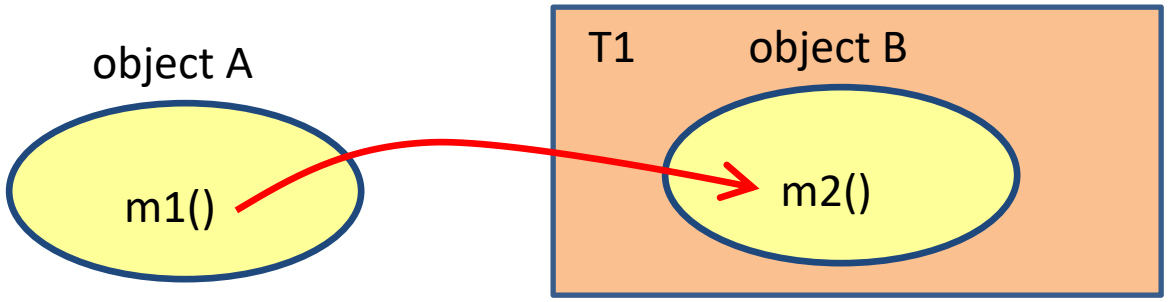
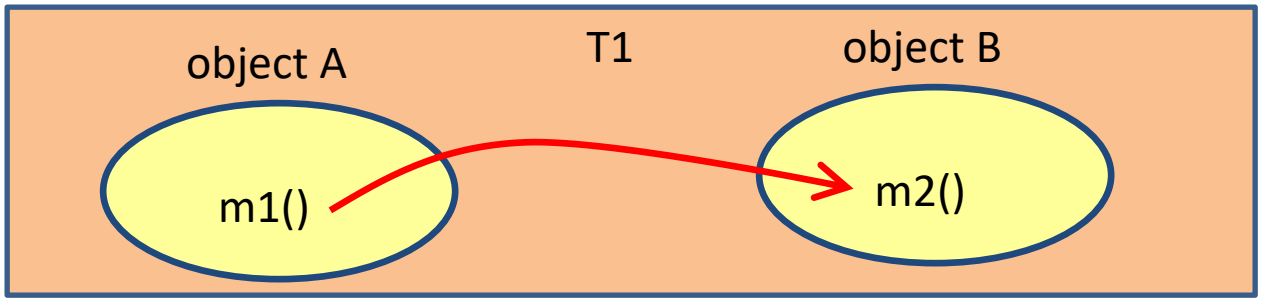
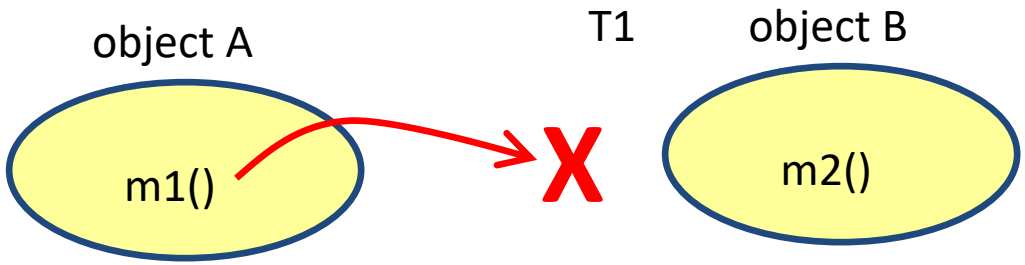


Transaction propagation: MANDATORY

- If the calling method m1() runs in a transaction T1, then method m2() joins the same transaction T1

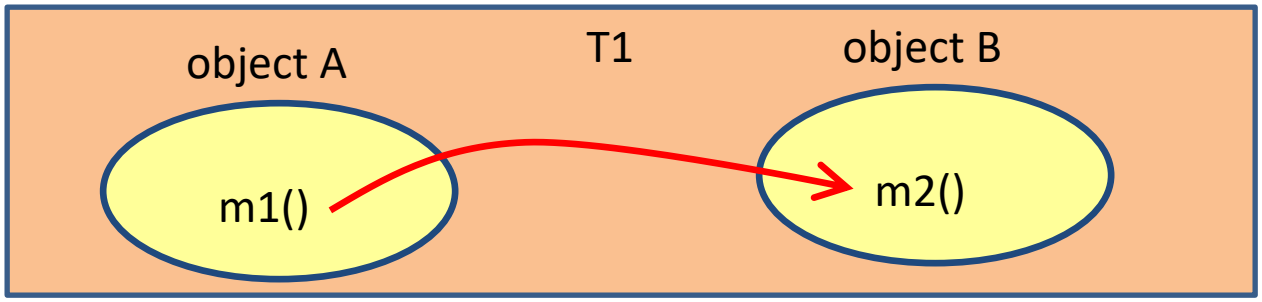


- If the calling method m1() does not run in a transaction , an exception is thrown

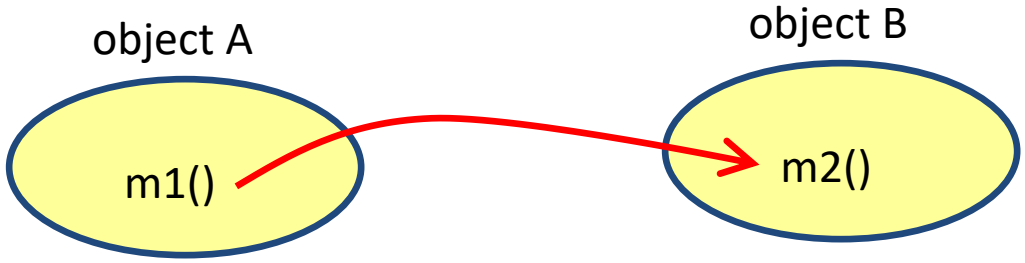


Transaction propagation: SUPPORTS

- If the calling method m1() runs in a transaction T1, then method m2() joins the same transaction T1

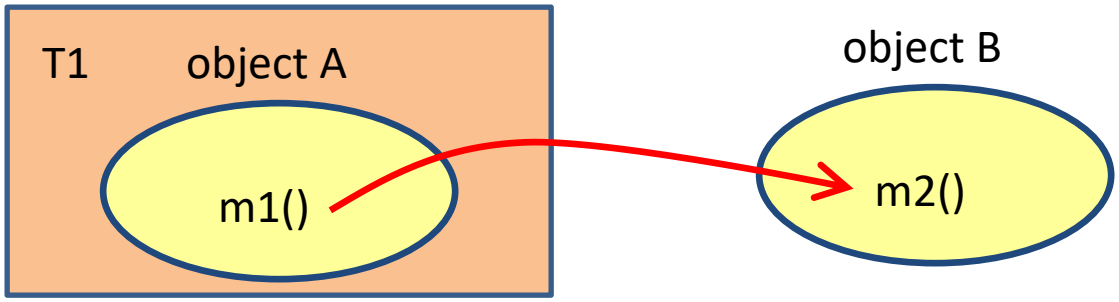


- If the calling method m1() does not run in a transaction , then method m2() also does not run within a transaction



Transaction propagation: NOT_SUPPORTED

- If the calling method m1() runs in a transaction T1, then method m2() does not run within a transaction



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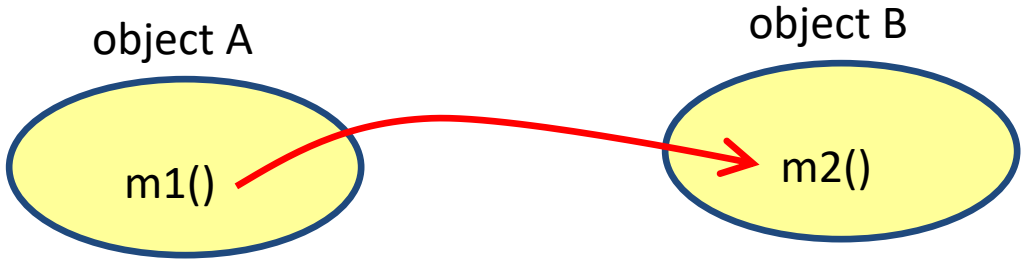
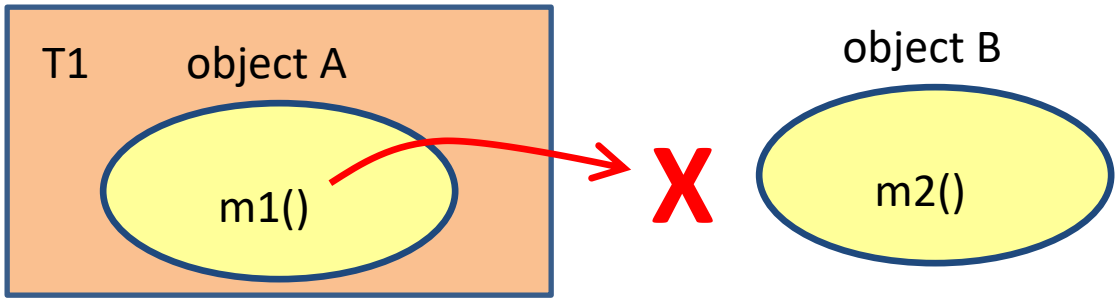
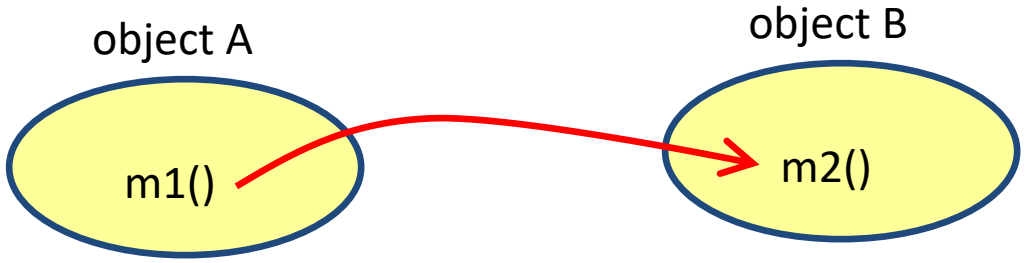


Transaction propagation: NEVER

- If the calling method m1() runs in a transaction T1, an exception is thrown



- If the calling method m1() does not run in a transaction , then method m2() also does not run within a transaction



Local or global transaction

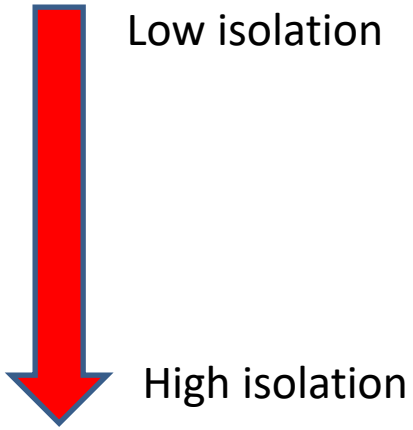
Transaction propagation

Isolation level

ISOLATION LEVEL

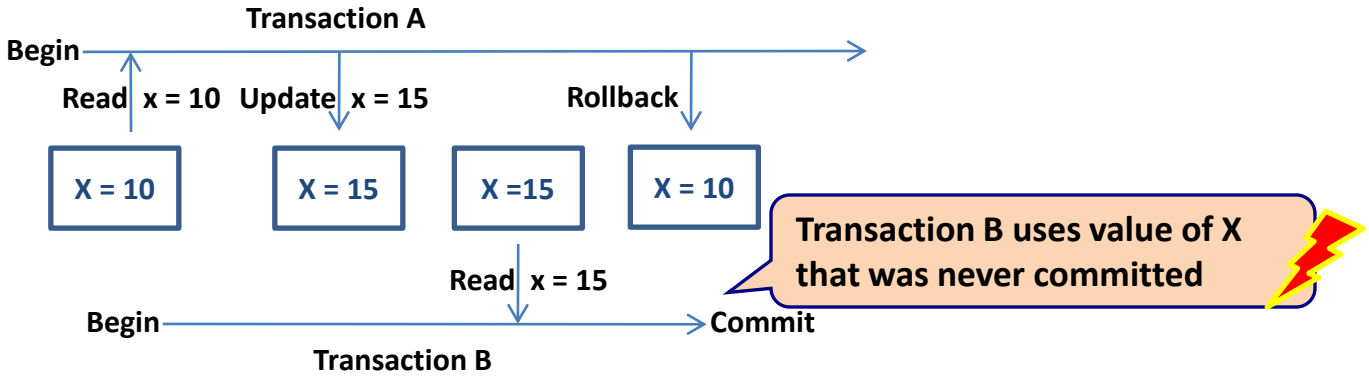
Isolation level

- 4 levels of isolation
  - TransactionReadUncommitted
  - TransactionReadCommitted
  - TransactionRepeatableRead
  - TransactionSerializable



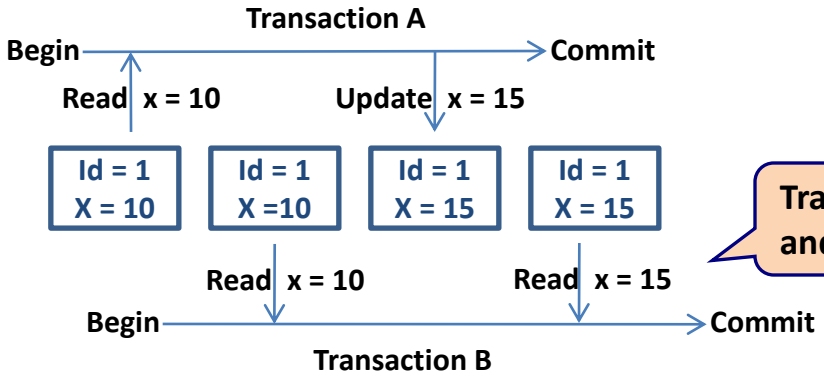
- 3 transaction problems
  - Dirty read
  - Non repeatable read
  - Phantom read

Dirty Read



- Transactions A read X = 10
- Transaction A first increments X by 5 setting X = 15
- Transaction B read X = 15
- Transaction A does a rollback, so X = 10
- Transaction B uses the wrong value of X

Non Repeatable Read

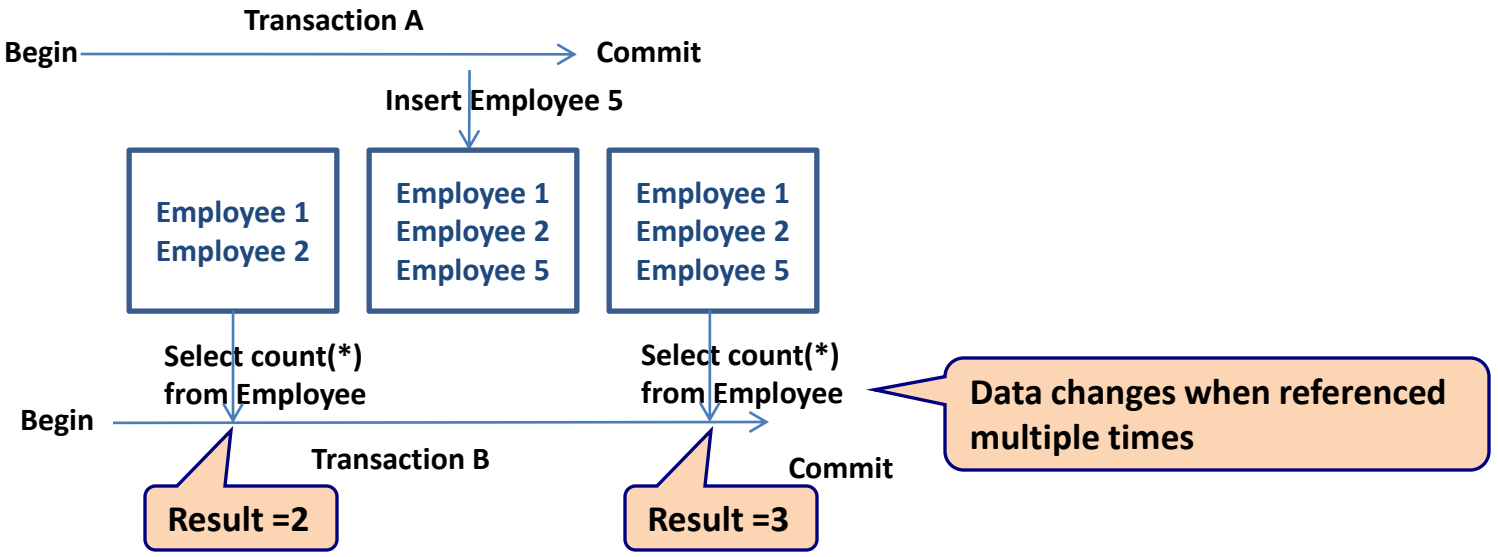


Transaction B reads X twice, and the value is different

- Transactions A and B read X = 10
- Transaction A first increments X by 5 setting X = 15
- Transaction B read X=15

Data changes when referenced multiple times

Phantom Read



Isolation levels

Isolation	Dirty read	Non repeatable read	Phantom read
TransactionReadUncommitted	✓	✓	✓
TransactionReadCommitted		✓	✓
TransactionRepeatableRead			✓
TransactionSerializable			

- TransactionReadUncommited
  - Violates the ACID properties
  - Not supported by many database vendors (Oracle)
  - Do not use this level of isolation in a multithreaded system
- TransactionReadcommited
  - Default for most databases
- TransactionRepeatableRead
- TransactionSerializable
  - Highest level of isolation, lowest level of performance

JDBC transaction

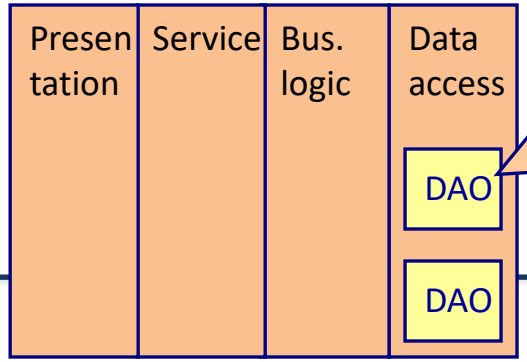
```
public void update(Employee employee) {
        Connection conn = null;
        PreparedStatement prepareUpdateEmployee = null;
        try {
            conn = getConnection();
            conn.setAutoCommit(false);
            prepareUpdateEmployee = conn.prepareStatement("UPDATE Employee SET
                        firstname= ?, lastname= ? WHERE employeenumber=?");
            prepareUpdateEmployee.setString(1, employee.getFirstName());
            prepareUpdateEmployee.setString(2, employee.getLastName());
            prepareUpdateEmployee.setLong(3, employee.getEmployeeNumber());

            int updateresult = prepareUpdateEmployee.executeUpdate();
            conn.commit();
        } catch (SQLException e) {
            conn.rollback();
            System.out.println("SQLException in EmployeeDAO update() :" + e);
        } finally {
            try {
                prepareUpdateEmployee.close();
                closeConnection(conn);
            } catch (SQLException e1) {
                // no action needed
            }
        }
    }
```

Start transaction

Commit transaction

Rollback transaction



Transaction demarcation in the DAO classes

Spring-JPA transaction

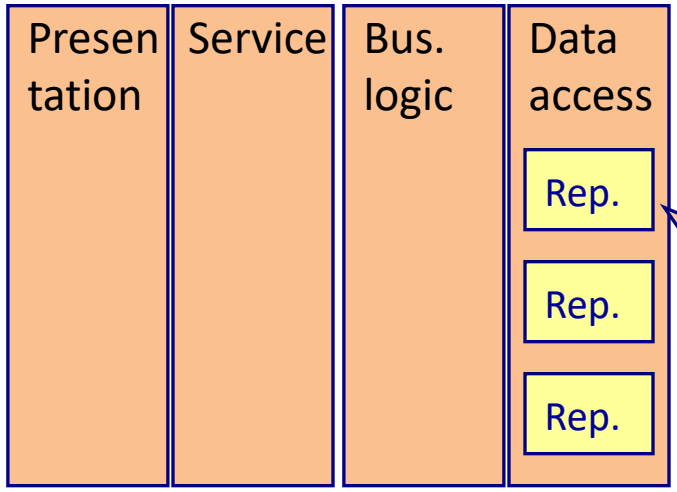
```
public interface CustomerRepository extends JpaRepository<Customer, Long> {

}
```

```
  @Override
  public void run(String... args) throws Exception {
    customerrepository.save(new Customer("Jack", "Bauer", "jack@acme.com"));
    customerrepository.save(new Customer("Chloe", "O'Brian", "chloe@acme.com"));

  }
```

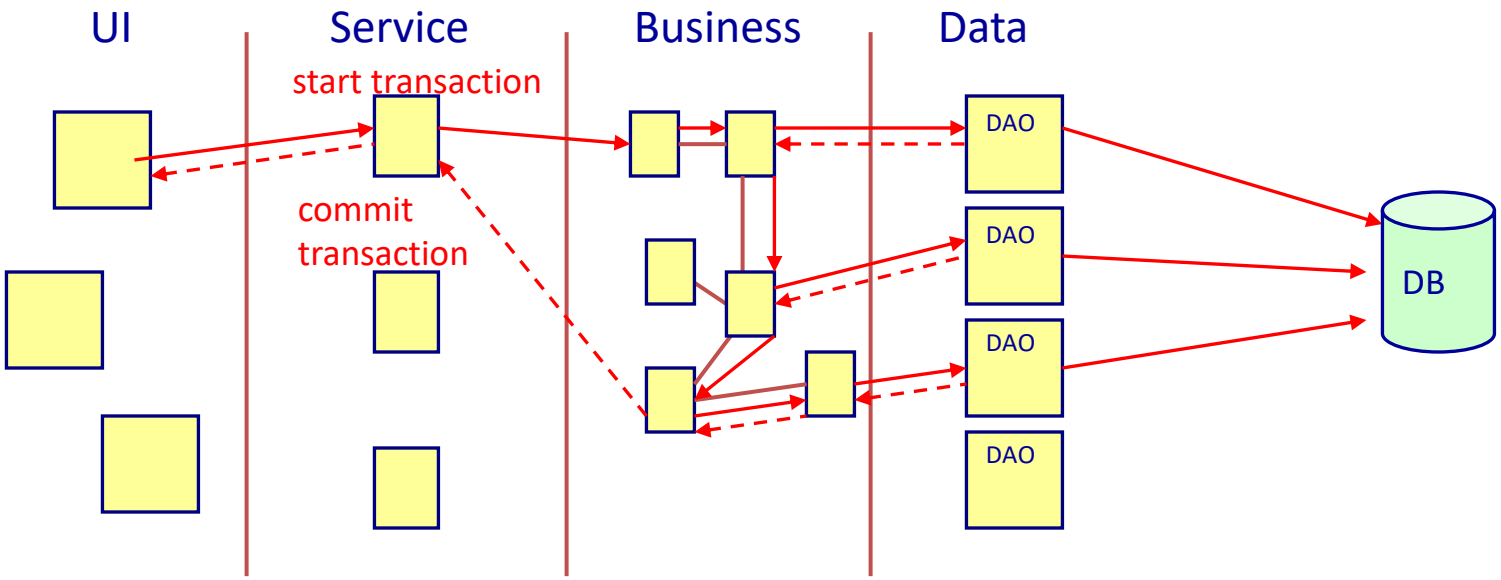
Every save runs in its own transaction



Transaction demarcation in the Repository classes

Typical transaction demarcation

- Transaction demarcation is typical at the level of the service classes
  - Multiple DAOs can be involved in one transaction
- Spring allows us to perform transaction demarcation for service level methods



Spring transaction support

- Spring is not a transaction manager
  - We still need a transaction manager
    - JDBC transaction manager
    - Hibernate transaction manager
    - XA transaction manager (JTS)
- Spring provides an abstraction for transaction management
  - Spring talks to the underlying transaction manager

CONFIGURING TRANSACTIONS IN SPRING

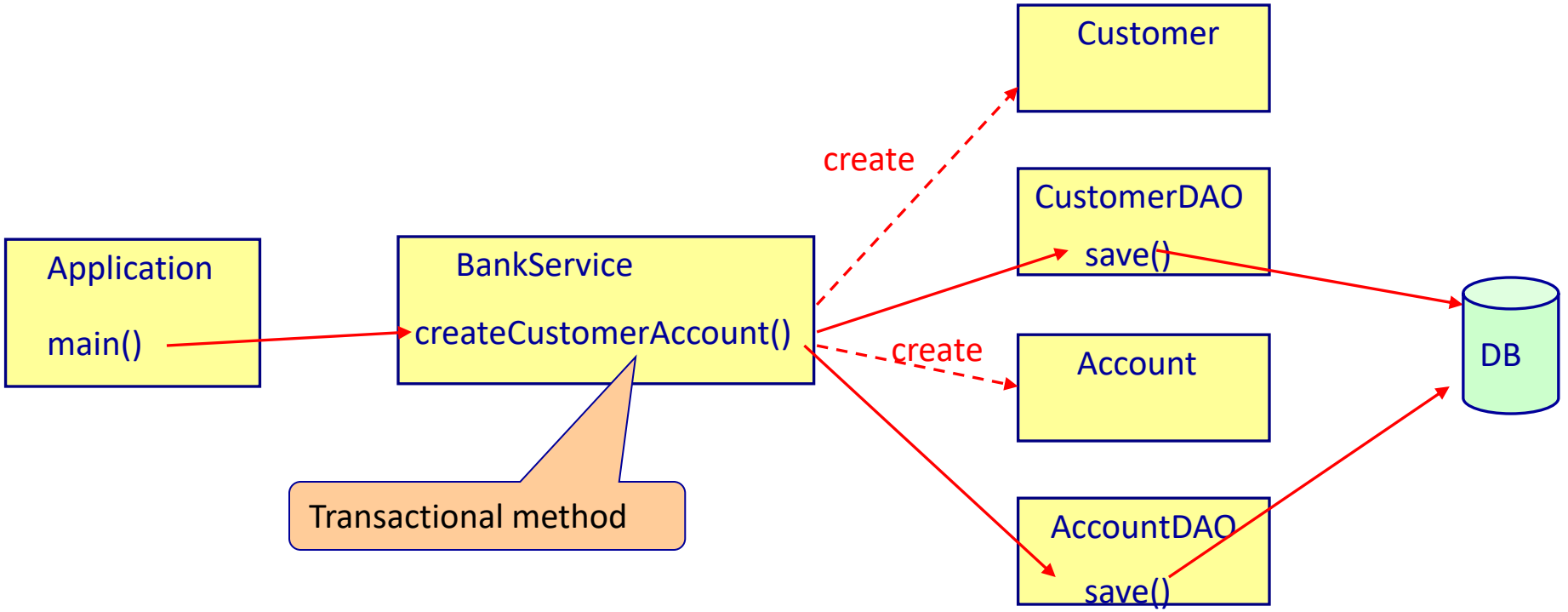
Transactions in Spring

```
public class …{

   @Transactional
    public void transactionalMethod();
    }
}
```

All methods annotated with @Transactional are transactional

Transaction Example



Transaction Example

```
@Service
public class BankingService {
  @Autowired
  private CustomerRepository customerRepository;
  @Autowired
  private AccountRepository accountRepository;

  @Transactional
  public void createCustomerAccount(int customerid, String customerName, int
   accountnumber, double balance, boolean throwException) throws Exception {
    Customer customer = new Customer(customerid, customerName);
    customerRepository.save(customer);
    if(throwException) {
      throw new RuntimeException();
    }
    Account account = new Account(accountnumber, balance);
    accountRepository.save(account);
  }
}
```

Service method executes within a transaction

Transaction Example

```
public interface CustomerRepository extends JpaRepository<Customer, Long> {

}
```

```
@Entity
public class Customer {
  @Id
  private int id;
  private String name;

  …
}
```

```
public interface AccountRepository extends JpaRepository<Account, Integer> {

}
```

```
@Entity
public class Account {
  @Id
  private int accountnumber;
  private double balance;
  …
}
```

Transaction Example

```
@SpringBootApplication
@EnableJpaRepositories("repositories")
@EntityScan("domain")
@ComponentScan("service")
public class Application implements CommandLineRunner{

  @Autowired
  BankService bankService;

  public static void main(String[] args) {
    SpringApplication.run(Application.class, args);
  }

  @Override
  public void run(String... args) throws Exception {
    bankService.createCustomerAndAccount(12, "Jack Bauer", "1223",false);
    bankService.createCustomerAndAccount(14, "Frank Brown", "1248",true);
  }
}
```

application.properties

```
spring.datasource.url=jdbc:hsqldb:hsql://localhost/trainingdb
spring.datasource.username=SA
spring.datasource.password=
spring.datasource.driver-class-name=org.hsqldb.jdbcDriver

spring.jpa.hibernate.ddl-auto=create
spring.jpa.show-sql=true
spring.jpa.properties.hibernate.dialect=org.hibernate.dialect.HSQLDialect
```

Transaction Example

With transaction

```
@Transactional
public void createCustomerAccount(int customerid, String customerName, int
 accountnumber, double balance, boolean throwException) throws Exception {
  Customer customer = new Customer(customerid, customerName);
  customerRepository.save(customer);
  if(throwException) {
    throw new RuntimeException();
  }
  Account account = new Account(accountnumber, balance);
  accountRepository.save(account);
}
```

ID	NAME
120	Frank Brown

ACCOUNTNUMBER	BALANCE
312	0

Without transaction

```
public void createCustomerAccount(int customerid, String customerName, int
 accountnumber, double balance, boolean throwException) throws Exception {
  Customer customer = new Customer(customerid, customerName);
  customerRepository.save(customer);
  if(throwException) {
    throw new RuntimeException();
  }
  Account account = new Account(accountnumber, balance);
  accountRepository.save(account);
}
```

ID	NAME
120	Frank Brown
121	John Doe

ACCOUNTNUMBER	BALANCE
312	0

Rollback with checked exceptions

- The transaction manager by default only does a rollback for runtime exceptions.
- If you want to rollback for checked exceptions, you have to explicitly specify this.

Checked exception rollback

```
public class BankingService implements IBankingService{
   private CustomerDAO customerDao;
   private AccountDAO accountDao;

   @Transactional(rollbackFor = {DAOException.class})
   public void createCustomerAccount(String customerName, int accountnumber)throws Exception{
      Customer customer= new Customer(customerName);
      customerDao.save(customer);
      Account account = new Account(accountnumber);
      accountDao.save(account);
   }
   public void setCustomerDao(CustomerDAO customerDao) {
      this.customerDao = customerDao;
   }
   public void setAccountDao(AccountDAO accountDao) {
      this.accountDao = accountDao;
   }
}
```

Rollback for a runtime exception and a DAOException

Set Propagation and Isolation with Spring

Set propagation to REQUIRES_NEW

Set isolation to REPEATABLE_READ

```
public class BankingService implements IBankingService{
   private CustomerDAO customerDao;
   private AccountDAO accountDao;

   @Transactional(propagation=Propagation.REQUIRES_NEW, isolation=Isolation.REPEATABLE_READ)
   public void createCustomerAccount(String customerName, int accountnumber)throws Exception{
      Customer customer= new Customer(customerName);
      customerDao.save(customer);
      Account account = new Account(accountnumber);
      accountDao.save(account);
   }

   public void setCustomerDao(CustomerDAO customerDao) {
      this.customerDao = customerDao;
   }

   public void setAccountDao(AccountDAO accountDao) {
      this.accountDao = accountDao;
   }
}
```

Main point

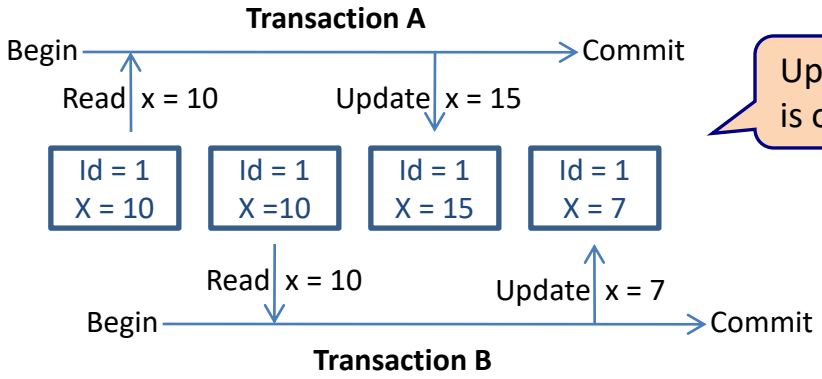
- The Spring framework makes it very easy to specify transactions on methods of Spring beans.

  Science of Consciousness: Do Less and Accomplish More, the transactions are automatically applied in an additional AOP layer.

Transactions and Concurrency

OPTIMISTIC CONCURRENCY

Lost Update



Update made by Transaction A is overwritten by Transaction B

- Transactions A and B read X = 10
- Transaction A first increments X by 5 setting X = 15
- Transaction B next decrements X by 3 and sets X = 7

believing X is still 10

- The update made by A is permanently lost, and neither A nor B is aware that it happened

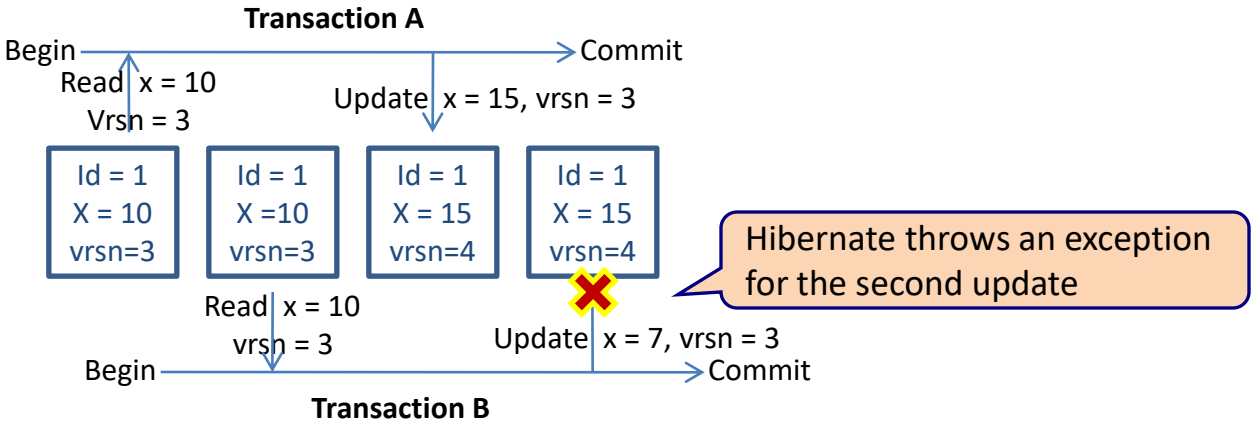
Optimistic Concurrency

- Optimistic concurrency assumes that lost update conflicts generally don't occur
  - But keeps versions# so that it knows when they do
  - Uses read committed transaction level
  - Guarantees best performance and scalability
  - The default way to deal with concurrency

- First commit wins instead of last commit wins
  - An exception is thrown if a conflict would occur

Versioning

- Additional version column to tracks updates



- Update Fails due to the version check
  - UPDATE table SET x = 15, vrsn = 4 WHERE id = 1 AND vrsn = 3
  - If the version has changed, the update is not executed
  - Hibernate throws an exception when the update fails

Version Column

- The best way to enable versioning for a class is by using an additional version column
  - Should have no semantic value in the table

```
@Entity
public class Customer {
  @Id
  @GeneratedValue
  private int id;
  private String firstname;
  private String lastname;

  @Version
  private int version;

  ...
```

Use the @Version annotation to specify the version column

StaleObjectStateException

- When a version conflict occurs Hibernate throws a StaleObjectStateException
  - Catching this exception allows you to notify the user about the conflict
  - The user can then reload the data and apply their updates against the latest data

```
org.hibernate.StaleObjectStateException: Row was updated
or deleted by another transaction (or unsaved-value
mapping was incorrect): [optimistic.nocolumn.Customer#1]

...
```

First or Last commit wins

```java
public class Application1 {
  public static void main(String[] args) throws InterruptedException {
    SessionFactory sessionFactory = new Configuration().configure().buildSessionFactory();
    Session session = sessionFactory.openSession();
    Transaction tx = session.beginTransaction();
    Car car = (Car) session.get(Car.class, "SDA231");
    Thread.sleep(10000);
    car.setBrand("Audi");
    tx.commit();
    session.close();
  }
}
```

```java
public class Application2 {
  public static void main(String[] args) throws InterruptedException {
    SessionFactory sessionFactory = new Configuration().configure().buildSessionFactory();
    Session session = sessionFactory.openSession();
    Transaction tx = session.beginTransaction();
    Car car = (Car) session.get(Car.class, "SDA231");
    Thread.sleep(20000);
    car.setBrand("Skoda");
    tx.commit();
    session.close();
  }
}
```

Last commit wins

```
@Entity
public class Car {
    @Id
    private String licencenumber;
    private String brand;
    private String year;
  ...
}
```

Initial database state

LICENCENUMBER	BRAND	YEAR
SDA231	BMW	2008

Run application1 — Change to Audi

Run application2 — Change to Skoda — No exception thrown

Final database state

LICENCENUMBER	BRAND	YEAR
SDA231	Skoda	2008

First commit wins

```
public class Car {
    @Id
    private String licencenumber;
    private String brand;
    private String year;
    @Version
    private int version;
  ...
}
```

Initial database state

LICENCENUMBER	BRAND	VERSION	YEAR
SDA231	BMW	0	2008

Run application1 — Change to Audi

Run application2 — Change to Skoda — StaleObjectStateException thrown

Final database state

LICENCENUMBER	BRAND	VERSION	YEAR
SDA231	Audi	1	2008

Connecting the parts of knowledge with the wholeness of knowledge

1. When defining transactions boundaries in your application it is important to define the correct transaction propagation
2. The TransactionReadCommited isolation level is the default level of most databases.

3. **Transcendental consciousness** is the foundation of all thoughts.
4. **Wholeness moving within itself:** In Unity Consciousness, we experience how both the silence at the basis of thought, and the most expressed thoughts and actions are nothing but the Self.