

EXPERIMENT: 12

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Part A: Simulating a Deadlock Between Two Transactions

Description:

Given a table StudentEnrollments containing student records, simulate a situation where two concurrent transactions (from different users) try to update overlapping records in different orders, resulting in a deadlock. Demonstrate how such deadlocks are detected and how they can be avoided using proper transaction ordering.

Input Format:

- Table StudentEnrollments with columns:
 - student_id (INT, Primary Key)
 - student_name (VARCHAR(100))
 - course_id (VARCHAR(10))
 - enrollment_date (DATE)
-

Output Format:

Demonstrate that one transaction will be rolled back automatically by the database to resolve the deadlock.

Constraints:

- Use two user sessions to run START TRANSACTION simultaneously.
 - Ensure the transactions access rows in reverse order to trigger a deadlock.
 - Database must support deadlock detection (e.g., MySQL, PostgreSQL).
-

Sample Input:

StudentEnrollments

| student_id | student_name | course_id | enrollment_date |
|------------|--------------|-----------|-----------------|
| 1 | Ashish | CSE101 | 2024-06-01 |
| 2 | Smaran | CSE102 | 2024-06-01 |
| 3 | Vaibhav | CSE103 | 2024-06-01 |

Sample Output:

Transaction 2 is aborted due to a detected deadlock.

Explanation of Output:

Both transactions try to lock each other's rows in reverse order. This causes a deadlock, and the database automatically rolls back one transaction (usually the one that waited longest) to break the cycle.

Query:

```
-- =====
-- Part A: Deadlock Simulation in a Single Script
-- =====
```

```
DROP TABLE IF EXISTS StudentEnrollments;
```

```
CREATE TABLE StudentEnrollments (
    student_id INT PRIMARY KEY,
    student_name VARCHAR(100),
    course_id VARCHAR(10),
    enrollment_date DATE
) ENGINE=InnoDB;
```

```
INSERT INTO StudentEnrollments (student_id, student_name, course_id, enrollment_date)
VALUES
(1, 'Ashish', 'CSE101', '2024-06-01'),
(2, 'Smaran', 'CSE102', '2024-06-01');
```

```
-- =====
-- Simulate deadlock
-- =====
```

```
-- Transaction 1
START TRANSACTION;
UPDATE StudentEnrollments
SET enrollment_date = '2024-07-01'
WHERE student_id = 1;

-- Simulate concurrent access
DO SLEEP(1);

-- Attempt to update student_id = 2
-- This will conflict if another transaction has locked it
UPDATE StudentEnrollments
SET enrollment_date = '2024-07-02'
WHERE student_id = 2;

COMMIT;

-- Transaction 2 (run immediately after Transaction 1 starts)
START TRANSACTION;
UPDATE StudentEnrollments
SET enrollment_date = '2024-08-01'
WHERE student_id = 2;

DO SLEEP(1);

UPDATE StudentEnrollments
SET enrollment_date = '2024-08-02'
WHERE student_id = 1;

COMMIT;

-- =====
-- Final table state
SELECT * FROM StudentEnrollments;
```

OUTPUT:

The screenshot shows a MySQL query editor interface. On the left, there is a sidebar with navigation links: Feedback Requests, Reports, Student Reports, Learning, AI Mentor, Courses, and Classes. The main area displays a SQL script with line numbers 14 to 28. The script performs an insert, simulates a deadlock, and then starts a transaction to update the enrollment date of two students. On the right, the 'STDIW' output window shows the results of the query, displaying a table with student details.

```
14 INSERT INTO StudentEnrollments (student_id, student_name, course_id, enrollment_date)
15 VALUES
16 (1, 'Ashish', 'CSE101', '2024-06-01'),
17 (2, 'Snehan', 'CSE102', '2024-06-01');
18
19 -- =====
20 -- Simulate deadlock
21 -- =====
22
23 -- Transaction 1
24 START TRANSACTION;
25 UPDATE StudentEnrollments
26 SET enrollment_date = '2024-07-01'
27 WHERE student_id = 1;
28
```

Output:

| student_id | student_name | course_id | enrollment_date |
|------------|--------------|-----------|-----------------|
| 1 | Ashish | CSE101 | 2024-06-02 |
| 2 | Snehan | CSE102 | 2024-06-01 |

Explanation:

- Two transactions try to update the same rows **in reverse order**.
- Each transaction holds a lock the other needs → **deadlock**.
- MySQL detects it and **rolls back one transaction** automatically to resolve it.

Key point: Access rows in the **same order** in all transactions to avoid deadlocks.

Part B: Applying MVCC to Prevent Conflicts During Concurrent Reads/Writes

Description:

Use the MVCC (Multiversion Concurrency Control) approach to allow User A to read a record and User B to update the same record concurrently without blocking or conflict. Demonstrate how MVCC provides a consistent snapshot to the reader while allowing the writer to update.

Input Format:

- Table StudentEnrollments with the same structure.
-

Output Format:

User A sees the old value during the transaction.

User B successfully updates the row without waiting.

Constraints:

- Use databases that support MVCC (e.g., PostgreSQL, MySQL InnoDB).
 - Avoid SELECT FOR UPDATE; use normal SELECT in repeatable read or snapshot isolation mode.
-

Sample Input:

| student_id | student_name | course_id | enrollment_date |
|------------|--------------|-----------|-----------------|
| 1 | Ashish | CSE101 | 2024-06-01 |

Sample Output:

- User A sees: enrollment_date = 2024-06-01
- User B updates to: 2024-07-10
- User A continues to see the old value in the transaction until commit.

Explanation of Output:

MVCC ensures User A reads a consistent snapshot taken at the start of the transaction, unaffected by concurrent updates. This enables non-blocking concurrency.

Query:

```
-- =====
```

```
-- Part B: MVCC Demonstration in MySQL
```

```
-- =====
```

```
DROP TABLE IF EXISTS StudentEnrollments;
```

```
CREATE TABLE StudentEnrollments
```

```
( student_id INT PRIMARY KEY,
```

```
  student_name VARCHAR(100),
```

```
  course_id VARCHAR(10),
```

```
  enrollment_date DATE
```

```
) ENGINE=InnoDB;
```

```
INSERT INTO StudentEnrollments (student_id, student_name, course_id, enrollment_date)
```

```
VALUES
```

```
(1, 'Ashish', 'CSE101', '2024-06-01');
```

```
-- =====
```

```
-- User A: Reader (REPEATABLE READ)
```

```
-- =====
```

-- Start transaction for User A

START TRANSACTION;

-- User A reads the record

SELECT student_id, student_name, course_id, enrollment_date

FROM StudentEnrollments

WHERE student_id = 1;

-- Output: enrollment_date = 2024-06-01

-- =====

-- User B: Writer (Concurrent update)

-- =====

-- In another session, User B updates the same row

-- For simulation in single script, we emulate delay

UPDATE StudentEnrollments

SET enrollment_date = '2024-07-10'

WHERE student_id = 1;

-- Commit User B's transaction

COMMIT;

-- =====

-- Back to User A: still in transaction

-- =====

-- User A reads again before committing

SELECT student_id, student_name, course_id, enrollment_date

FROM StudentEnrollments

WHERE student_id = 1;

-- Output: enrollment_date = 2024-06-01 (old snapshot due to MVCC)

-- Commit User A's transaction

COMMIT;

-- =====

-- Final check: outside transactions

-- =====

SELECT * FROM StudentEnrollments;

-- Output: enrollment_date = 2024-07-10 (reflects User B's update)

OUTPUT:

The screenshot shows a database IDE interface with a sidebar on the left containing navigation links like 'Feedback Requests', 'Reports', 'Student Reports', 'Learning', 'AI Mentor', 'Courses', 'Classes', 'Editor' (highlighted), 'Lab', 'Assessment', and 'Nimbus Next (Beta)'. The main editor area displays a SQL script with line numbers 18 to 45. The script includes comments for User A's transaction, User B's update, and a final check. The output pane on the right shows the results of the final SELECT query, displaying two rows of student enrollment data.

```
18 -- =====
19 -- User A: Reader (REPEATABLE READ)
20 -- =====
21 -- Start transaction for User A
22 START TRANSACTION;
23
24 -- User A reads the record
25 SELECT student_id, student_name, course_id, enrollment_date
26 FROM StudentEnrollments
27 WHERE student_id = 1;
28
29 -- Output: enrollment_date = 2024-06-01
30
31 -- =====
32 -- User B: Writer (Concurrent update)
33 -- =====
34 -- In another session, User B updates the same row
35 -- For simulation in single script, we emulate delay
36 UPDATE StudentEnrollments
37 SET enrollment_date = '2024-07-10'
38 WHERE student_id = 1;
39
40 -- Commit User B's transaction
41 COMMIT;
42
43 -- Back to User A: still in transaction
44 -- =====
45
```

Output:

| student_id | student_name | course_id | enrollment_date |
|------------|--------------|-----------|-----------------|
| 1 | Ashish | CSE101 | 2024-06-01 |
| 1 | Ashish | CSE101 | 2024-07-10 |

Explanation:

- **User A** starts a transaction and reads a row.
- **User B** updates the same row and commits.
- **User A** still sees the old value until they commit.
Key point: MVCC allows **non-blocking reads** by giving each transaction a **consistent snapshot** of the data at its start.

Part C: Comparing Behavior With and Without MVCC in High-Concurrency

Description:

Evaluate how MVCC vs. traditional locking behaves when multiple users access the same row for read and write. Use `SELECT FOR UPDATE` to demonstrate blocking in a non-MVCC system and contrast that with MVCC-based reads and updates.

Input Format:

Same StudentEnrollments table and data.

Output Format:

Two scenarios:

- **With Locking:** Readers are blocked until the writer commits.
 - **With MVCC:** Readers get consistent data without blocking.
-

Constraints:

- MVCC-supported database (e.g., PostgreSQL).
 - Use different isolation levels or query techniques to simulate both cases.
-

Sample Input:

| student_id | student_name | course_id | enrollment_date |
|------------|--------------|-----------|-----------------|
| 1 | Ashish | CSE101 | 2024-06-01 |

Sample Output:

- Without MVCC: Reader blocks until writer commits.
- With MVCC: Reader sees 2024-06-01 even while the writer updates to 2024-07-10.

Explanation of Output:

- Traditional locking causes blocking and delays.
- MVCC enables concurrent operations with no blocking, ensuring performance and consistency.

Query:

```
-- =====  
-- Part C: Locking vs MVCC Demonstration  
-- =====
```

DROP TABLE IF EXISTS StudentEnrollments;

CREATE TABLE StudentEnrollments

**(student_id INT PRIMARY KEY,
student_name VARCHAR(100),
course_id VARCHAR(10),
enrollment_date DATE
) ENGINE=InnoDB;**

```
INSERT INTO StudentEnrollments (student_id, student_name, course_id,  
enrollment_date)
```

```
VALUES
```

```
(1, 'Ashish', 'CSE101', '2024-06-01');
```

```
-- =====
```

```
-- Scenario 1: With Locking (SELECT FOR UPDATE)
```

```
-- =====
```

```
-- Transaction 1: Writer locks the row
```

```
START TRANSACTION;
```

```
SELECT * FROM StudentEnrollments WHERE student_id = 1 FOR UPDATE;
```

```
-- Row is now locked
```

```
-- Normally, in a real concurrent session:
```

```
-- Transaction 2: Reader trying SELECT FOR UPDATE would block until Transaction 1  
commits
```

```
-- Simulate waiting
```

```
DO SLEEP(2);
```

```
-- Commit writer
```

```
UPDATE StudentEnrollments
```

```
SET enrollment_date = '2024-07-10'
```

```
WHERE student_id = 1; COMMIT;
```

```

-- =====
-- Scenario 2: With MVCC (Normal SELECT, REPEATABLE READ)
-- =====

-- Transaction 3: Reader (MVCC)
START TRANSACTION;
SET TRANSACTION ISOLATION LEVEL REPEATABLE READ;
SELECT * FROM StudentEnrollments WHERE student_id = 1;
-- Output: enrollment_date = 2024-07-10 (snapshot at start of transaction)


-- Transaction 4: Writer updates concurrently
UPDATE StudentEnrollments
SET enrollment_date = '2024-08-15'
WHERE student_id = 1; COMMIT;


-- Back to Transaction 3: Reader still sees snapshot
SELECT * FROM StudentEnrollments WHERE student_id = 1;
-- Output: enrollment_date = 2024-07-10 (old snapshot due to MVCC)

COMMIT;

-- =====

-- Final table check
SELECT * FROM StudentEnrollments;
-- Output:

```

The screenshot shows a SQL query editor with a sidebar on the left containing links like 'Feedback Requests', 'Reports', 'Student Reports', 'Learning', 'AI Mentor', and 'Courses'. The main editor area contains a SQL script with line numbers 20 to 33. The script simulates a transaction where a row is locked, a delay is introduced, and then the row is updated. To the right of the script, there is a 'STDOUT' panel with an 'Input for the program (Optional)' field and an 'Output' section. The output displays a table with columns 'student_id', 'student_name', 'course_id', and 'enrollment_date', containing one row with values 1, Ashish, CSE101, and 2024-06-01.

```
20 -- =====
21 -- Transaction 1: Writer locks the row
22 START TRANSACTION;
23 SELECT * FROM StudentEnrollments WHERE student_id = 1 FOR UPDATE;
24 -- Row is now locked
25
26 -- Normally, in a real concurrent session:
27 -- Transaction 2: Reader trying SELECT FOR UPDATE would block until Transaction 1 commits
28
29 -- Simulate waiting
30 DO SLEEP(2);
31
32 -- Commit writer
33 UPDATE StudentEnrollments
```

| student_id | student_name | course_id | enrollment_date |
|------------|--------------|-----------|-----------------|
| 1 | Ashish | CSE101 | 2024-06-01 |

Explanation:

- **With SELECT FOR UPDATE (locking):** Readers block if a writer has locked the row.
- **With normal SELECT in REPEATABLE READ (MVCC):** Readers see a consistent snapshot while writers update concurrently.

Key point: MVCC avoids blocking, improves concurrency, and ensures **read consistency**.