COMPARING THE ORACLE AND POSTGRESQL TRANSACTION SYSTEMS

BY LAURENZ ALBE
TALKING HEAD

CYBERTEC
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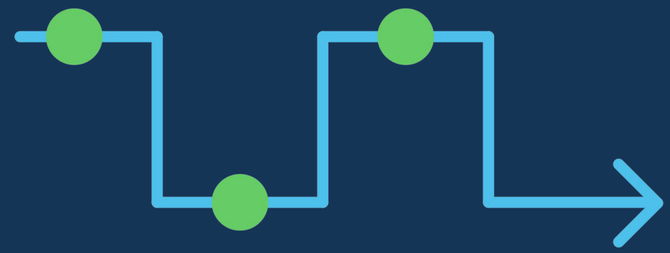
INTRODUCTION

WHY COMPARE ORACLE AND POSTGRESQL?

- Both are relational databases governed (to some extent) by the SQL standard
- The difference is often in the details
- Many people want to move from Oracle to PostgreSQL
  - Lower total cost of ownership
  - More and better support options
  - More insight into and control over the software
- Migration projects often get caught up in minor differences
- It is important to know about the differences!

SCOPE OF THE TALK

- It is impossible to compare all aspects of Oracle and PostgreSQL
- Comparing feature lists is boring
- I will limit myself to database transactions
  - Important for development and porting applications
  - Differences are often not visible at first glance
  - Differences may not show up during testing, but under high concurrency
  - It is an area I know well in both databases



Special thanks to Piotr Vatulik for his help with Oracle internals!

GENERAL OBSERVATIONS

ACID: THE SERVICES A DATABASE TRANSACTION PROVIDES

- **A**tomicity: all statements in a single database transaction form a unit
  - Either all statements succeed or none of them take effect
- **C**onsistency: no database transaction will ever violate a database constraint
- **I**solation: concurrent transactions won't cause certain *anomalies*
  - An anomaly is a visible state of the database that no serial execution of the transactions could ever cause
- **D**urability: a committed (completed) database transaction can never be undone
  - Even by a system crash or localized hardware failure

We will look for differences in each category.

SIMILARITIES BETWEEN ORACLE AND POSTGRESQL

- Use of multiversioning: readers and writers don’t block each other
  - The reader is served the latest committed data
- Locks are held until the end of the transaction
- Row locks are stored in the table, not in the shared memory lock table
  - Row locks cause writes, but there is no need for lock escalation, even though the lock table is of limited size
- Support for `SELECT ... FOR UPDATE` for explicit concurrency control
- Default transaction isolation level is `READ COMMITTED`
  - Behaves pretty similarly on both systems

COMPARING TRANSACTION ATOMICITY

AUTOCOMMIT

- In Oracle, DML automatically starts transaction
  - Explicit COMMIT needed to end a transaction
- PostgreSQL uses autocommit
  - Automatically commits at the end of each statement
  - Start multi-statement transactions with an explicit **`BEGIN`** or **`START TRANSACTION`**
- Many database APIs allow turning autocommit on or off
  - In Oracle, autocommit is simulated by automatically sending **`COMMIT`** as needed
  - In PostgreSQL, disabled autocommit is simulated by automatically sending **`BEGIN`** as needed
  - Using such an API, you don’t need to worry about the difference

STATEMENT-LEVEL ROLLBACK

- In Oracle, a statement that causes an error is rolled back, but the transaction continues
- In PostgreSQL, an error on a statement aborts the transaction:
  `ERROR: current transaction is aborted, commands ignored until end of transaction block`
  - Set a savepoint before the statement that you can rollback to
  - **Warning:** use savepoints sparingly ⇒ performance impact!
- Most well-written applications will roll back after an error
  - In that case, you won't notice the difference

TRANSACTIONAL DDL

- In Oracle, DDL statements automatically commit the transaction
  - Savepoints created before the DDL statement are not lost, but get moved to after the DDL statement!
- In PostgreSQL, DDL statements can be rolled back like all other statements
  - Useful for schema migration (simply roll back on error)
  - Attention: DDL statements normally take heavy locks
  - A few statements must run in their own transaction:
    `CREATE DATABASE, VACUUM, CREATE INDEX CONCURRENTLY, ...`

COMPARING TRANSACTION CONSISTENCY

CONSISTENCY IN ORACLE AND POSTGRESQL

- Both systems maintain database constraints properly
- Oracle can enable and disable constraints with `ALTER TABLE`
  - Constraints can be re-enabled with `ENABLE NOVALIDATE`, which may break consistency (primary and unique keys must be `DEFERRABLE` for that)
- PostgreSQL enables foreign keys and `DEFERRABLE` primary and unique keys with system triggers
  - Such triggers can be disabled by a superuser
  - Another way to break trigger-based consistency as a superuser is setting `session_replication_role` to `replica`

DIFFERENCES IN CONSTRAINT VALIDATION

This script runs fine in Oracle:

```
CREATE TABLE tab (id integer PRIMARY KEY);

INSERT INTO tab (id) VALUES (1);
INSERT INTO tab (id) VALUES (2);

COMMIT;

UPDATE tab SET id = id + 1;

COMMIT;
```

In PostgreSQL, the **UPDATE** fails with

```
ERROR: duplicate key value violates unique constraint "tab_pkey"
DETAIL: Key (id)=(2) already exists.
```

DIFFERENCES IN CONSTRAINT VALIDATION (EXPLANATION & REMEDY)

- PostgreSQL checks primary key and unique key constraints *after the modification of each row*
- This violates the SQL standard:

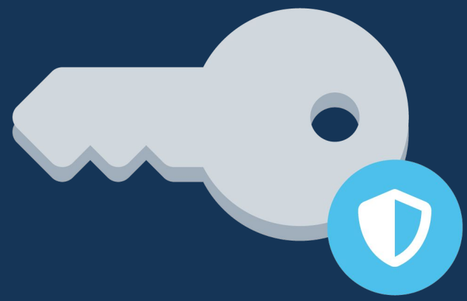
  Whenever an SQL-statement is executed, every enforced constraint whose mode is immediate is checked, at a certain point after any changes to SQL-data and schemas resulting from that execution have been effected, to see if it is satisfied.
- To get unique and primary key constraints checked at the end of the statement, define them as `DEFERRABLE INITIALLY IMMEDIATE`

FOREIGN KEYS AND LOCKS

```
CREATE TABLE parent (pid bigint PRIMARY KEY, val text);
INSERT INTO parent VALUES (1, NULL);
CREATE TABLE child (cid bigint PRIMARY KEY, pid bigint REFERENCES parent);

START TRANSACTION;
INSERT INTO child VALUES (100, 1);

                /* second concurrent session */
                DELETE FROM parent WHERE pid = 1;
```



The **DELETE** must block to maintain integrity.

- In Oracle, the **DELETE** locks the referencing rows in **child**
  ⇒ locks the whole table if there is no index on the foreign key
- In PostgreSQL, the **INSERT** locks referenced rows in **parent**
  ⇒ contention on the lock manager with many **INSERT**s

COMPARING TRANSACTION ISOLATION

SUPPORT FOR TRANSACTION ISOLATION LEVELS

- PostgreSQL supports all isolation levels: **`READ UNCOMMITTED`**, **`READ COMMITTED`**, **`REPEATABLE READ`** and **`SERIALIZABLE`**
  - However, **`READ UNCOMMITTED`** is silently upgraded to **`READ COMMITTED`**
    ⇒ no “dirty data”
  - **`SERIALIZABLE`** is implemented using non-blocking predicate locks (SIRead locks)
- Oracle offers only **`READ COMMITTED`** and **`SERIALIZABLE`**
  - **`SERIALIZABLE`** is a lie ⇒ really, it is **`REPEATABLE READ`**
  - Oracle’s implementation of “**`SERIALIZABLE`**” is so horrible that it is mostly unusable; it gives serialization errors on any pretext:
    - The first insert into a table created with **`SEGMENT CREATION DEFERRED`**
    - Any index page split during an **`INSERT`**
    - . . .

CONCURRENCY AND LOCKING WITH READ COMMITTED IN POSTGRESQL

PostgreSQL example (a bill and positions on the bill):

```
SELECT * FROM bill;

 bill_id | total
---------+-------
       1 | 60.00

SELECT * FROM item;

 item_id | bill_id | amount
---------+---------+--------
     101 |       1 | 10.00
     102 |       1 | 20.00
     103 |       1 | 30.00
```

CONCURRENCY AND LOCKING WITH READ COMMITTED IN POSTGRESQL

Inserting a new position and updating the redundant sum in **`bill`**:

```
BEGIN;

INSERT INTO item
   (item_id, bill_id, amount)
VALUES
   (104, 1, 40.0);

-- really, this should be in a trigger
UPDATE bill SET total = total + 40.0
WHERE bill_id = 1;

COMMIT;
```

CONCURRENCY AND LOCKING WITH READ COMMITTED IN POSTGRESQL

A concurrent report:

```
SELECT bill_id, item.amount, bill.total
FROM bill
   LEFT JOIN item USING (bill_id)
FOR UPDATE OF bill;
```

When run after the `UPDATE` on `bill` and before the `COMMIT`, the statement blocks. After the `COMMIT`, we get the following inconsistent result:

```
 bill_id | amount | total
---------+--------+--------
       1 |  10.00 | 100.00
       1 |  20.00 | 100.00
       1 |  30.00 | 100.00
```

CONCURRENCY AND LOCKING WITH READ COMMITTED IN POSTGRESQL

- After it gets the lock, PostgreSQL fetches the most recent committed version **of the locked rows** and re-evaluates the query conditions for them
- We see different versions for different rows:
  - Rows that were not locked (`item`) appear like at query start
  - Rows where locking blocked (`bill`) appear in their most recent version
- Oracle would simply start the query from the beginning and get consistent results
- PostgreSQL performs better, at the price of a potential (allowed) anomaly

COMPARISON OF PERSISTENCE AND DURABILITY

DIFFERENCES CAUSED BY THE DIFFERENT IMPLEMENTATION

Both systems provide durability. But the implementation is different:

- Oracle uses an UNDO tablespace to keep old versions of the data
  - Long queries/transactions can hit “snapshot too old”
  - (You may need to increase **`UNDO_RETENTION`** or the UNDO tablespace)
  - Rollback can take a long time
  - Big deletes are slow (move data to UNDO)

DIFFERENCES CAUSED BY THE DIFFERENT IMPLEMENTATION

- PostgreSQL keeps old row versions in the table
  - Both commit and rollback are very fast
  - Regular garbage connection necessary (autovacuum)
  - Big updates can make the table grow (“bloat”)
- UPDATE tends to perform worse in PostgreSQL
  - Usually more index maintenance and more dirty pages
  - To mitigate these problems, use “HOT updates”

TRANSACTION ID WRAPAROUND IN POSTGRESQL

- PostgreSQL implements multiversioning by storing transaction IDs in table rows
- Transaction IDs are generated from a 4-byte unsigned integer counter
  - The counter will eventually “wrap around”
- Before transaction IDs can safely wrap around, extra maintenance has to “freeze” old table rows
- On highly transactional systems, this can require special tuning

QUESTIONS?

LAURENZ ALBE

TALKING HEAD

EMAIL

laurenz.albe@cybertec.at

PHONE

+43 670 605 6265

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