Unlocking the Postgres Lock Manager

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This talk explores all aspects of locking in Postgres by showing queries and their locks; covered lock types include row, table, shared, exclusive, and advisory lock types.

https://momjian.us/presentations

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No One Likes Locking But it Is Necessary for Proper Database Operation

https://www.flickr.com/photos/mplemmon/

Outline

1. Locking Introduction

https://www.flickr.com/photos/54409200@N04/

What an Adventure! Xyzzy

Little maze of twisting passages
Little maze of twisty passages
Little twisty maze of passages
Maze of little twisting passages
Maze of little twisty passages
Maze of twisting little passages
Maze of twisty little passages
Twisting little maze of passages
Twisting maze of little passages
Twisty little maze of passages
Twisty maze of little passages

http://en.wikipedia.org/wiki/Colossal_Cave_Adventure#Maze_of_twisty_little_passages

The Real Postgres Lock Types

ACCESS SHARE
ROW SHARE
ROW EXCLUSIVE
SHARE UPDATE EXCLUSIVE
SHARE
SHARE ROW EXCLUSIVE
EXCLUSIVE
ACCESS EXCLUSIVE

Share/Exclusive Types

ACCESS SHARE
ROW SHARE
ROW EXCLUSIVE
SHARE UPDATE EXCLUSIVE
SHARE
SHARE ROW EXCLUSIVE
EXCLUSIVE
ACCESS EXCLUSIVE

Row/Access Types

ACCESS SHARE
ROW SHARE
ROW EXCLUSIVE
SHARE UPDATE EXCLUSIVE
SHARE
SHARE ROW EXCLUSIVE
EXCLUSIVE
ACCESS EXCLUSIVE

MVCC

> *Multiversion Concurrency Control (*MVCC*) allows Postgres to offer high concurrency even during significant database read/write activity.* MVCC *specifically offers behavior where "readers never block writers, and writers never block readers*".

While Multiversion Concurrency Control (MVCC) reduces locking requirements, it does not eliminate locking.

2. Transaction Identifiers

https://www.flickr.com/photos/grendelkhan/

Keep Your Eye on the Red (Text)

https://www.flickr.com/photos/alltheaces/

What Is Our Process Identifier (PID)?

```
SELECT pg_backend_pid();
 pg_backend_pid
----------------
          11306
```

All queries used in this presentation are available at https://momjian.us/main/writings/pgsql/locking.sql.

What Is Our Virtual XID (VXID)

```
SELECT  virtualtransaction AS vxid, transactionid::text
FROM    pg_locks
WHERE   pid = pg_backend_pid()
ORDER BY 1, 2
LIMIT 1;
 vxid | transactionid
------+---------------
 2/7  |
```

2 is the backend id, and 7 is the virtual transaction id for this backend, i.e., backend id/backend-local xid.

What Is Our Backend Id?

```
SELECT  *
FROM    pg_stat_get_backend_idset() AS t(id)
WHERE   pg_stat_get_backend_pid(id) = pg_backend_pid();
 id
----
  2
```

The maximum backend id is set by *max_connections*.

Query courtesy of Phil Sorber.

The VXID Increments

```
SELECT  virtualtransaction AS vxid, transactionid::text
FROM    pg_locks
WHERE   pid = pg_backend_pid()
ORDER BY 1, 2
LIMIT 1;
 vxid | transactionid
------+---------------
 2/10 |
```

```
SELECT  virtualtransaction AS vxid, transactionid::text
FROM    pg_locks
WHERE   pid = pg_backend_pid()
ORDER BY 1, 2
LIMIT 1;
 vxid | transactionid
------+---------------
 2/11 |
```

Getting a Real/External/Non-Virtual XID

```
BEGIN WORK;

SELECT  virtualtransaction AS vxid, transactionid::text
FROM    pg_locks
WHERE   pid = pg_backend_pid()
ORDER BY 1, 2
LIMIT 1;
 vxid | transactionid
------+---------------
 2/12 |

ANALYZE pg_language;
```

Getting a Real/External/Non-Virtual XID

```
SELECT  virtualtransaction AS vxid, transactionid::text
FROM    pg_locks
WHERE   pid = pg_backend_pid()
ORDER BY 1, 2
LIMIT 1;
 vxid | transactionid
------+---------------
 2/12 | 674

SELECT txid_current();
 txid_current
--------------
          674

COMMIT;
```

Transaction identifiers range from 3 to 4 billion (2 ^ 32). Zero(0) is an invalid transaction id, and 1 and 2 are used for setting frozen xids (*committed* and *aborted*).

Requesting Your XID Assigns One

```
BEGIN WORK;

SELECT  virtualtransaction AS vxid, transactionid::text
FROM    pg_locks
WHERE   pid = pg_backend_pid()
ORDER BY 1, 2
LIMIT 1;
 vxid | transactionid
------+---------------
 2/13 |

-- this will assign a non-virtual xid if not already assigned
SELECT txid_current();
 txid_current
--------------
          675
```

Requesting Your XID Assigns One

```
SELECT  virtualtransaction AS vxid, transactionid::text
FROM    pg_locks
WHERE   pid = pg_backend_pid()
ORDER BY 1, 2
LIMIT 1;
 vxid | transactionid
------+---------------
 2/13 | 675

COMMIT;
```

3. Lock Types

https://www.flickr.com/photos/proimos/

Setup: Create View *lockview*

```
-- cannot be a temporary view because other sessions must see it
CREATE VIEW lockview AS
SELECT  pid, virtualtransaction AS vxid, locktype AS lock_type,
        mode AS lock_mode, granted,
        CASE
                WHEN virtualxid IS NOT NULL AND transactionid IS NOT NULL
                THEN    virtualxid || ' ' || transactionid
                WHEN virtualxid::text IS NOT NULL
                THEN    virtualxid
                ELSE    transactionid::text
        END AS xid_lock, relname,
        page, tuple, classid, objid, objsubid
FROM    pg_locks LEFT OUTER JOIN pg_class ON (pg_locks.relation = pg_class.oid)
WHERE   -- do not show our view's locks
        pid != pg_backend_pid() AND
        -- no need to show self-vxid locks
        virtualtransaction IS DISTINCT FROM virtualxid
-- granted is ordered earlier
ORDER BY 1, 2, 5 DESC, 6, 3, 4, 7;
```

Create View *lockview1*

```
CREATE VIEW lockview1 AS
SELECT  pid, vxid, lock_type, lock_mode,
        granted, xid_lock, relname
FROM    lockview
-- granted is ordered earlier
ORDER BY 1, 2, 5 DESC, 6, 3, 4, 7;
```

Create View *lockview2*

```
CREATE VIEW lockview2 AS
SELECT  pid, vxid, lock_type, page,
        tuple, classid, objid, objsubid
FROM    lockview
-- granted is first
-- add non-display columns to match  ordering of lockview
ORDER BY 1, 2, granted DESC, vxid, xid_lock::text, 3, 4, 5, 6, 7, 8;
```

Create and Populate Table *lockdemo*

```
CREATE TABLE lockdemo (col int);

INSERT INTO lockdemo VALUES (1);
```

Explicit ACCESS SHARE Locking

```
BEGIN WORK;

LOCK TABLE lockdemo IN ACCESS SHARE MODE;

-- force future psql commands to use the current database
\setenv PGDATABASE :DBNAME

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid | lock_type |    lock_mode    | granted | xid_lock | relname
        -------+------+-----------+-----------------+---------+----------+----------
         11306 | 2/23 | relation  | AccessShareLock | t       |          | lockdemo
```

Explicit ACCESS SHARE Locking

```
\! psql -e -c 'SELECT * FROM lockview2;' | sed 's/^/\t/g'
        SELECT * FROM lockview2;
          pid  | vxid | lock_type | page | tuple | classid | objid | objsubid
        -------+------+-----------+------+-------+---------+-------+----------
         11306 | 2/23 | relation  |      |       |         |       |

    COMMIT;
```

Future slides will only show *lockview2* if it contains useful information.

Implicit ACCESS SHARE Locking

```
BEGIN WORK;

SELECT * FROM lockdemo;
 col
-----
   1

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid | lock_type |    lock_mode    | granted | xid_lock | relname
        -------+------+-----------+-----------------+---------+----------+----------
         11306 | 2/24 | relation  | AccessShareLock | t       |          | lockdemo

COMMIT;
```

Multi-Table ACCESS SHARE Locking

```
BEGIN WORK;

SELECT  pg_class.oid
FROM    pg_class JOIN pg_namespace ON (relnamespace = pg_namespace.oid)
        JOIN pg_attribute ON (pg_class.oid = pg_attribute.attrelid)
LIMIT 1;
 oid
-----
 112
```

Multi-Table ACCESS SHARE Locking

```
\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid | lock_type |     lock_mode     | granted | xid_lock |             relname
        -------+------+-----------+-------------------+---------+----------+--------------------------------
         11306 | 2/25 | relation  | AccessShareLock | t       |          | pg_attribute
         11306 | 2/25 | relation  | AccessShareLock | t       |          | pg_attribute_relid_attnam_index
         11306 | 2/25 | relation  | AccessShareLock | t       |          | pg_attribute_relid_attnum_index
         11306 | 2/25 | relation  | AccessShareLock | t       |          | pg_class
         11306 | 2/25 | relation  | AccessShareLock | t       |          | pg_class_oid_index
         11306 | 2/25 | relation  | AccessShareLock | t       |          | pg_class_relname_nsp_index
         11306 | 2/25 | relation  | AccessShareLock | t       |          | pg_namespace
         11306 | 2/25 | relation  | AccessShareLock | t       |          | pg_namespace_nspname_index
         11306 | 2/25 | relation  | AccessShareLock | t       |          | pg_namespace_oid_index

COMMIT;
```

Explicit ROW SHARE Locking

```
BEGIN WORK;

LOCK TABLE lockdemo IN ROW SHARE MODE;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid | lock_type |  lock_mode   | granted | xid_lock | relname
        -------+------+-----------+--------------+---------+----------+----------
         11306 | 2/26 | relation  | RowShareLock | t       |          | lockdemo

COMMIT;
```

Implicit ROW SHARE Locking

```
BEGIN WORK;

SELECT * FROM lockdemo FOR SHARE;
 col
-----
   1

SELECT txid_current();
 txid_current
--------------
          681
```

Implicit ROW SHARE Locking

```
\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |   lock_mode   | granted | xid_lock | relname
        -------+------+---------------+---------------+---------+----------+----------
         11306 | 2/27 | transactionid | ExclusiveLock | t       | 681      |
         11306 | 2/27 | relation      | RowShareLock  | t       |          | lockdemo

COMMIT;
```

When a transaction is assigned a transaction id, it self-locks its transaction id so other sessions can wait on that lock for the transaction to finish.

Explicit ROW EXCLUSIVE Locking

```
BEGIN WORK;

LOCK TABLE lockdemo IN ROW EXCLUSIVE MODE;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid | lock_type |    lock_mode     | granted | xid_lock | relname
        -------+------+-----------+------------------+---------+----------+----------
         11306 | 2/28 | relation  | RowExclusiveLock | t       |          | lockdemo

COMMIT;
```

Implicit ROW EXCLUSIVE Locking

```
BEGIN WORK;

DELETE FROM lockdemo;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |    lock_mode     | granted | xid_lock | relname
        -------+------+---------------+------------------+---------+----------+----------
         11306 | 2/29 | transactionid | ExclusiveLock    | t       | 682      |
         11306 | 2/29 | relation      | RowExclusiveLock | t       |          | lockdemo

ROLLBACK WORK;
```

Explicit SHARE UPDATE EXCLUSIVE Locking

```
BEGIN WORK;

LOCK TABLE lockdemo IN SHARE UPDATE EXCLUSIVE MODE;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid | lock_type |        lock_mode         | granted | xid_lock | relname
        -------+------+-----------+--------------------------+---------+----------+----------
         11306 | 2/30 | relation  | ShareUpdateExclusiveLock | t       |          | lockdemo

COMMIT;
```

Implicit SHARE UPDATE EXCLUSIVE Locking

```
BEGIN WORK;

ANALYZE lockdemo;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
    SELECT * FROM lockview1;
      pid  | vxid |   lock_type   |        lock_mode         | granted | xid_lock | relname
    -------+------+---------------+--------------------------+---------+----------+----------
     11306 | 2/31 | transactionid | ExclusiveLock            | t       | 683      |
     11306 | 2/31 | relation      | ShareUpdateExclusiveLock | t       |          | lockdemo

ROLLBACK WORK;
```

Explicit SHARE Locking

```
BEGIN WORK;

LOCK TABLE lockdemo IN SHARE MODE;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid | lock_type | lock_mode | granted | xid_lock | relname
        -------+------+-----------+-----------+---------+----------+----------
         11306 | 2/32 | relation  | ShareLock | t       |          | lockdemo

COMMIT;
```

Implicit SHARE Locking

```
BEGIN WORK;

CREATE UNIQUE INDEX i_lockdemo on lockdemo(col);

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |      lock_mode      | granted | xid_lock | relname
        -------+------+---------------+---------------------+---------+----------+----------
         11306 | 2/33 | transactionid | ExclusiveLock       | t       | 684      |
         11306 | 2/33 | relation      | AccessExclusiveLock | t       |          |
         11306 | 2/33 | relation      | AccessShareLock     | t       |          | lockdemo
         11306 | 2/33 | relation      | ShareLock           | t       |          | lockdemo

COMMIT;
```

Explicit SHARE ROW EXCLUSIVE Locking

```
BEGIN WORK;

LOCK TABLE lockdemo IN SHARE ROW EXCLUSIVE MODE;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid | lock_type |       lock_mode       | granted | xid_lock | relname
        -------+------+-----------+-----------------------+---------+----------+----------
         11306 | 2/34 | relation  | ShareRowExclusiveLock | t       |          | lockdemo

COMMIT;
```

Implicit SHARE ROW EXCLUSIVE Locking

```
BEGIN WORK;

CREATE TRIGGER lockdemo_trigger
BEFORE UPDATE ON lockdemo
FOR EACH ROW EXECUTE FUNCTION suppress_redundant_updates_trigger();

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |      lock_mode        | granted | xid_lock | relname
        -------+------+---------------+-----------------------+---------+----------+----------
         11306 | 2/35 | transactionid | ExclusiveLock         | t       | 685      |
         11306 | 2/35 | relation      | ShareRowExclusiveLock | t       |          | lockdemo

ROLLBACK WORK;
```

Explicit EXCLUSIVE Locking

```
BEGIN WORK;

LOCK TABLE lockdemo IN EXCLUSIVE MODE;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid | lock_type |   lock_mode   | granted | xid_lock | relname
        -------+------+-----------+---------------+---------+----------+----------
         11306 | 2/36 | relation  | ExclusiveLock | t       |          | lockdemo

COMMIT;
```

This lock mode is not automatically used by any Postgres SQL commands.

Explicit ACCESS EXCLUSIVE Locking

```
BEGIN WORK;

LOCK TABLE lockdemo IN ACCESS EXCLUSIVE MODE;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid | lock_type |      lock_mode      | granted | xid_lock | relname
        -------+------+-----------+---------------------+---------+----------+----------
         11306 | 2/37 | relation  | AccessExclusiveLock | t       |          | lockdemo

COMMIT;
```

ACCESS EXCLUSIVE is the default mode for the LOCK command.

Implicit ACCESS EXCLUSIVE Locking

```
BEGIN WORK;

CLUSTER lockdemo USING i_lockdemo;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |       lock_mode       | granted | xid_lock |  relname
        -------+------+---------------+-----------------------+---------+----------+-----------
         11306 | 2/38 | transactionid | ExclusiveLock         | t       | 686      |
         11306 | 2/38 | object        | AccessExclusiveLock   | t       |          |
         11306 | 2/38 | object        | AccessExclusiveLock   | t       |          |
         11306 | 2/38 | relation      | AccessExclusiveLock   | t       |          | i_lockdemo
         11306 | 2/38 | relation      | AccessExclusiveLock   | t       |          | lockdemo
         11306 | 2/38 | relation      | AccessExclusiveLock   | t       |          |
         11306 | 2/38 | relation      | AccessShareLock       | t       |          | i_lockdemo
         11306 | 2/38 | relation      | ShareLock             | t       |          | lockdemo
```

Implicit ACCESS EXCLUSIVE Locking

```
\! psql -e -c 'SELECT * FROM lockview2;' | sed 's/^/\t/g'
        SELECT * FROM lockview2;
          pid  | vxid |   lock_type   | page | tuple | classid | objid | objsubid
        -------+------+---------------+------+-------+---------+-------+----------
         11306 | 2/38 | transactionid |      |       |         |       |
         11306 | 2/38 | object        |      |       |    1247 | 16409 |        0
         11306 | 2/38 | object        |      |       |    1247 | 16410 |        0
         11306 | 2/38 | relation      |      |       |         |       |
         11306 | 2/38 | relation      |      |       |         |       |
         11306 | 2/38 | relation      |      |       |         |       |
         11306 | 2/38 | relation      |      |       |         |       |
         11306 | 2/38 | relation      |      |       |         |       |

COMMIT;
```

1247 is the *pg_class* entry for *pg_type*. 16409 and 16410 are used as temporary file names.

4. Lock Examples

Ponte Milvio

https://www.flickr.com/photos/pricey/

Row Locks Are Not Visible in *pg_locks*

```
DELETE FROM lockdemo;

BEGIN WORK;

INSERT INTO lockdemo VALUES (1);

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |    lock_mode     | granted | xid_lock | relname
        -------+------+---------------+------------------+---------+----------+----------
         11306 | 2/40 | transactionid | ExclusiveLock    | t       | 688      |
         11306 | 2/40 | relation      | RowExclusiveLock | t       |          | lockdemo
```

Two Rows Are Similarly Invisible

```
INSERT INTO lockdemo VALUES (2), (3);

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |    lock_type    |     lock_mode     | granted | xid_lock | relname
        -------+------+-----------------+-------------------+---------+----------+----------
         11306 | 2/40 | transactionid   | ExclusiveLock     | t       | 688      |
         11306 | 2/40 | relation        | RowExclusiveLock  | t       |          | lockdemo

COMMIT;
```

Update Also Causes an Index Lock

```
BEGIN WORK;

UPDATE lockdemo SET col = 1 WHERE col = 1;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |    lock_mode     | granted | xid_lock |  relname
        -------+------+---------------+------------------+---------+----------+------------
         11306 | 2/41 | transactionid | ExclusiveLock    | t       | 689      |
         11306 | 2/41 | relation      | RowExclusiveLock | t       |          | i_lockdemo
         11306 | 2/41 | relation      | RowExclusiveLock | t       |          | lockdemo
```

Two Row Updates Are Similar

```
UPDATE lockdemo SET col = 2 WHERE col = 2;

UPDATE lockdemo SET col = 3 WHERE col = 3;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |    lock_mode     | granted | xid_lock |  relname
        -------+------+---------------+------------------+---------+----------+------------
         11306 | 2/41 | transactionid | ExclusiveLock    | t       | 689      |
         11306 | 2/41 | relation      | RowExclusiveLock | t       |          | i_lockdemo
         11306 | 2/41 | relation      | RowExclusiveLock | t       |          | lockdemo

COMMIT;
```

Delete of One Row Is Similar

```
BEGIN WORK;

DELETE FROM lockdemo WHERE col = 1;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |     lock_mode     | granted | xid_lock |  relname
        -------+------+---------------+-------------------+---------+----------+------------
         11306 | 2/42 | transactionid | ExclusiveLock     | t       | 690      |
         11306 | 2/42 | relation      | RowExclusiveLock  | t       |          | i_lockdemo
         11306 | 2/42 | relation      | RowExclusiveLock  | t       |          | lockdemo
```

Delete of Two Rows Is Similar

```
DELETE FROM lockdemo;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |    lock_mode     | granted | xid_lock |  relname
        -------+------+---------------+------------------+---------+----------+------------
         11306 | 2/42 | transactionid | ExclusiveLock    | t       | 690      |
         11306 | 2/42 | relation      | RowExclusiveLock | t       |          | i_lockdemo
         11306 | 2/42 | relation      | RowExclusiveLock | t       |          | lockdemo

ROLLBACK WORK;
```

Explicit Row Locks Are Similar

```
BEGIN WORK;

SELECT * FROM lockdemo WHERE col = 1 FOR UPDATE;
 col
-----
   1

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |    lock_mode   | granted | xid_lock |  relname
        -------+------+---------------+----------------+---------+----------+------------
         11306 | 2/43 | transactionid | ExclusiveLock  | t       | 691      |
         11306 | 2/43 | relation      | RowShareLock   | t       |          | i_lockdemo
         11306 | 2/43 | relation      | RowShareLock   | t       |          | lockdemo
```

Three Explicit Row Locks Are Similar

```
SELECT * FROM lockdemo FOR UPDATE;
 col
-----
   1
   2
   3

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |    lock_mode   | granted | xid_lock |  relname
        -------+------+---------------+----------------+---------+----------+------------
         11306 | 2/43 | transactionid | ExclusiveLock  | t       | 691      |
         11306 | 2/43 | relation      | RowShareLock   | t       |          | i_lockdemo
         11306 | 2/43 | relation      | RowShareLock   | t       |          | lockdemo

COMMIT;
```

Explicit Shared Row Locks Are Similar

```
BEGIN WORK;

SELECT * FROM lockdemo WHERE col = 1 FOR SHARE;
 col
-----
   1

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |    lock_mode   | granted | xid_lock |  relname
        -------+------+---------------+----------------+---------+----------+------------
         11306 | 2/44 | transactionid | ExclusiveLock  | t       | 692      |
         11306 | 2/44 | relation      | RowShareLock   | t       |          | i_lockdemo
         11306 | 2/44 | relation      | RowShareLock   | t       |          | lockdemo
```

Three Explicit Shared Row Locks Are Similar

```
SELECT * FROM lockdemo FOR SHARE;
 col
-----
   1
   2
   3

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |    lock_mode   | granted | xid_lock |  relname
        -------+------+---------------+----------------+---------+----------+------------
         11306 | 2/44 | transactionid | ExclusiveLock  | t       | 692      |
         11306 | 2/44 | relation      | RowShareLock   | t       |          | i_lockdemo
         11306 | 2/44 | relation      | RowShareLock   | t       |          | lockdemo

COMMIT;
```

Restore Table *Lockdemo*

```
DELETE FROM lockdemo;

INSERT INTO lockdemo VALUES (1);
```

UPDATE Is Not Blocked by SELECT

```
BEGIN WORK;

SELECT ctid, xmin, * FROM lockdemo;
 ctid  | xmin | col
-------+------+-----
 (0,8) |  694 |   1
```

UPDATE Is Not Blocked by SELECT

```
SELECT pg_backend_pid();
 pg_backend_pid
----------------
          11306

SELECT txid_current();
 txid_current
--------------
          695
```

UPDATE Is Not Blocked by SELECT

```
\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |    lock_mode    | granted | xid_lock |  relname
        -------+------+---------------+-----------------+---------+----------+------------
         11306 | 2/47 | transactionid | ExclusiveLock   | t       | 695      |
         11306 | 2/47 | relation      | AccessShareLock | t       |          | i_lockdemo
         11306 | 2/47 | relation      | AccessShareLock | t       |          | lockdemo

\! psql -e -c 'UPDATE lockdemo SET col = 2; \
   SELECT pg_sleep(0.200); \
   SELECT ctid, xmin, * FROM lockdemo;' | \
   sed 's/^/\t/g' &
```

Backslashes are used to illustrate continued lines, though *psql* does not support the use of backslashes in this way; \! commands must be on a single line.

UPDATE Is Not Blocked by SELECT

```
\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid  |   lock_type   |    lock_mode     | granted | xid_lock |  relname
        -------+-------+---------------+------------------+---------+----------+------------
         11306 | 2/47  | transactionid | ExclusiveLock    | t       | 695      |
         11306 | 2/47  | relation      | AccessShareLock  | t       |          | i_lockdemo
         11306 | 2/47  | relation      | AccessShareLock  | t       |          | lockdemo
         11557 | 3/110 | transactionid | ExclusiveLock    | t       | 696      |
         11557 | 3/110 | relation      | RowExclusiveLock | t       |          | i_lockdemo
         11557 | 3/110 | relation      | RowExclusiveLock | t       |          | lockdemo

         ctid   | xmin | col
        --------+------+-----
         (0,9)  |  696 |   2

COMMIT WORK;
```

Restore Table *Lockdemo*

```
DELETE FROM lockdemo;

INSERT INTO lockdemo VALUES (1);
```

Two Concurrent Updates Show Locking

```
BEGIN WORK;

SELECT ctid, xmin, * FROM lockdemo;
  ctid   | xmin | col
---------+------+-----
 (0,10) |  698 |   1

UPDATE lockdemo SET col = 2;
```

Two Concurrent Updates Show Locking

```
SELECT ctid, xmin, * FROM lockdemo;
  ctid   | xmin | col
---------+------+-----
 (0,11) |  699 |   2

SELECT pg_backend_pid();
 pg_backend_pid
----------------
          11306

SELECT txid_current();
 txid_current
--------------
          699
```

Two Concurrent Updates Show Locking

```
\! psql -e -c 'BEGIN WORK; UPDATE lockdemo SET col = 3; \
    SELECT pg_sleep(0.200); \
    COMMIT;' | \
    sed 's/^/\t/g' &

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid  |   lock_type   |     lock_mode      | granted | xid_lock |  relname
        -------+-------+---------------+--------------------+---------+----------+------------
         11306 | 2/51  | transactionid | ExclusiveLock      | t       | 699      |
         11306 | 2/51  | relation      | AccessShareLock    | t       |          | i_lockdemo
         11306 | 2/51  | relation      | AccessShareLock    | t       |          | lockdemo
         11306 | 2/51  | relation      | RowExclusiveLock   | t       |          | i_lockdemo
         11306 | 2/51  | relation      | RowExclusiveLock   | t       |          | lockdemo
         11575 | 3/112 | transactionid | ExclusiveLock      | t       | 700      |
         11575 | 3/112 | relation      | RowExclusiveLock   | t       |          | i_lockdemo
         11575 | 3/112 | relation      | RowExclusiveLock   | t       |          | lockdemo
         11575 | 3/112 | tuple         | ExclusiveLock      | t       |          | lockdemo
         11575 | 3/112 | transactionid | ShareLock          | f       | 699      |
```

Two Concurrent Updates Show Locking

```
\! psql -e -c 'SELECT * FROM lockview2;' | sed 's/^/\t/g'
        SELECT * FROM lockview2;
          pid  | vxid  |   lock_type   | page | tuple | classid | objid | objsubid
        -------+-------+---------------+------+-------+---------+-------+----------
         11306 | 2/51  | transactionid |      |       |         |       |
         11306 | 2/51  | relation      |      |       |         |       |
         11306 | 2/51  | relation      |      |       |         |       |
         11306 | 2/51  | relation      |      |       |         |       |
         11306 | 2/51  | relation      |      |       |         |       |
         11575 | 3/112 | transactionid |      |       |         |       |
         11575 | 3/112 | relation      |      |       |         |       |
         11575 | 3/112 | relation      |      |       |         |       |
         11575 | 3/112 | tuple         |    0 |    10 |         |       |
         11575 | 3/112 | transactionid |      |       |         |       |

COMMIT;
```

Two Concurrent Updates Show Locking

```
\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid  |   lock_type   |    lock_mode     | granted | xid_lock |  relname
        -------+-------+---------------+------------------+---------+----------+------------
         11575 | 3/112 | transactionid | ExclusiveLock    | t       | 700      |
         11575 | 3/112 | relation      | RowExclusiveLock | t       |          | i_lockdemo
         11575 | 3/112 | relation      | RowExclusiveLock | t       |          | lockdemo
```

Three Concurrent Updates Show Locking

```
CREATE VIEW lockinfo_hierarchy AS
        WITH RECURSIVE lockinfo1 AS (
                SELECT pid, vxid, granted, xid_lock, lock_type, relname, page, tuple
                FROM lockview
                WHERE xid_lock IS NOT NULL AND
                      relname IS NULL AND
                      granted
                UNION ALL
                SELECT lockview.pid, lockview.vxid, lockview.granted, lockview.xid_lock,
                        lockview.lock_type, lockview.relname, lockview.page, lockview.tuple
                FROM lockinfo1 JOIN lockview ON (lockinfo1.xid_lock = lockview.xid_lock)
                WHERE lockview.xid_lock IS NOT NULL AND
                      lockview.relname IS NULL AND
                      NOT lockview.granted AND
                      lockinfo1.granted),
```

Three Concurrent Updates Show Locking

```
lockinfo2 AS (
        SELECT pid, vxid, granted, xid_lock, lock_type, relname, page, tuple
        FROM lockview
        WHERE lock_type = 'tuple' AND
              granted
        UNION ALL
        SELECT lockview.pid, lockview.vxid, lockview.granted, lockview.xid_lock,
                lockview.lock_type, lockview.relname, lockview.page, lockview.tuple
        FROM lockinfo2 JOIN lockview ON (
                lockinfo2.lock_type = lockview.lock_type AND
                lockinfo2.relname = lockview.relname AND
                lockinfo2.page = lockview.page AND
                lockinfo2.tuple = lockview.tuple)
        WHERE lockview.lock_type = 'tuple' AND
              NOT lockview.granted AND
              lockinfo2.granted
)
SELECT * FROM lockinfo1
UNION ALL
SELECT * FROM lockinfo2;
```

Three Concurrent Updates Show Locking

```
BEGIN WORK;

SELECT ctid, xmin, * FROM lockdemo;
  ctid   | xmin | col
---------+------+-----
 (0,12) |  700 |   3

UPDATE lockdemo SET col = 4;
```

Three Concurrent Updates Show Locking

```
SELECT ctid, xmin, * FROM lockdemo;
  ctid   | xmin | col
---------+------+-----
 (0,13) |  702 |   4

SELECT pg_backend_pid();
 pg_backend_pid
----------------
          11306

SELECT txid_current();
 txid_current
--------------
          702
```

Three Concurrent Updates Show Locking

```
\! psql -e -c 'BEGIN WORK; UPDATE lockdemo SET col = 5; \
    SELECT pg_sleep(0.200); \
    COMMIT;' | \
    sed 's/^/\t/g' &
\! psql -e -c 'BEGIN WORK; UPDATE lockdemo SET col = 6; \
    SELECT pg_sleep(0.200); \
    COMMIT;' | \
    sed 's/^/\t/g' &
\! psql -e -c 'BEGIN WORK; UPDATE lockdemo SET col = 7; \
    SELECT pg_sleep(0.200); \
    COMMIT;' | \
    sed 's/^/\t/g' &
```

Three Concurrent Updates Show Locking

```
\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |     lock_mode      | granted | xid_lock |  relname
        -------+------+---------------+--------------------+---------+----------+-----------
         11306 | 2/54 | transactionid | ExclusiveLock      | t       | 702      |
         11306 | 2/54 | relation      | AccessShareLock    | t       |          | i_lockdemo
         11306 | 2/54 | relation      | AccessShareLock    | t       |          | lockdemo
         11306 | 2/54 | relation      | RowExclusiveLock   | t       |          | i_lockdemo
         11306 | 2/54 | relation      | RowExclusiveLock   | t       |          | lockdemo
         11596 | 3/114| transactionid | ExclusiveLock      | t       | 703      |
         11596 | 3/114| relation      | RowExclusiveLock   | t       |          | i_lockdemo
         11596 | 3/114| relation      | RowExclusiveLock   | t       |          | lockdemo
         11596 | 3/114| tuple         | ExclusiveLock      | t       |          | lockdemo
         11596 | 3/114| transactionid | ShareLock          | f       | 702      |
         11600 | 4/14 | transactionid | ExclusiveLock      | t       | 704      |
         11600 | 4/14 | relation      | RowExclusiveLock   | t       |          | i_lockdemo
         11600 | 4/14 | relation      | RowExclusiveLock   | t       |          | lockdemo
         11600 | 4/14 | tuple         | ExclusiveLock      | f       |          | lockdemo
         11604 | 5/2  | transactionid | ExclusiveLock      | t       | 705      |
         11604 | 5/2  | relation      | RowExclusiveLock   | t       |          | i_lockdemo
         11604 | 5/2  | relation      | RowExclusiveLock   | t       |          | lockdemo
         11604 | 5/2  | tuple         | ExclusiveLock      | f       |          | lockdemo
```

Three Concurrent Updates Show Locking

```
\! psql -e -c 'SELECT * FROM lockview2;' | sed 's/^/\t/g'
        SELECT * FROM lockview2;
          pid  | vxid |    lock_type    | page | tuple | classid | objid | objsubid
        -------+------+-----------------+------+-------+---------+-------+----------
         11306 | 2/54 | transactionid   |      |       |         |       |
         11306 | 2/54 | relation        |      |       |         |       |
         11306 | 2/54 | relation        |      |       |         |       |
         11306 | 2/54 | relation        |      |       |         |       |
         11306 | 2/54 | relation        |      |       |         |       |
         11596 | 3/114 | transactionid  |      |       |         |       |
         11596 | 3/114 | relation       |      |       |         |       |
         11596 | 3/114 | relation       |      |       |         |       |
         11596 | 3/114 | tuple          |    0 |    12 |         |       |
         11596 | 3/114 | transactionid  |      |       |         |       |
         11600 | 4/14 | transactionid   |      |       |         |       |
         11600 | 4/14 | relation        |      |       |         |       |
         11600 | 4/14 | relation        |      |       |         |       |
         11600 | 4/14 | tuple           |    0 |    12 |         |       |
         11604 | 5/2  | transactionid   |      |       |         |       |
         11604 | 5/2  | relation        |      |       |         |       |
         11604 | 5/2  | relation        |      |       |         |       |
         11604 | 5/2  | tuple           |    0 |    12 |         |       |
```

Three Concurrent Updates Show Locking

```
\! psql -e -c 'SELECT * FROM lockinfo_hierarchy;' | sed 's/^/\t/g'
        SELECT * FROM lockinfo_hierarchy;
          pid  | vxid  | granted | xid_lock |   lock_type   | relname  | page | tuple
        -------+-------+---------+----------+---------------+----------+------+-------
         11306 | 2/54  | t       | 702      | transactionid |          |      |
         11596 | 3/114 | t       | 703      | transactionid |          |      |
         11600 | 4/14  | t       | 704      | transactionid |          |      |
         11604 | 5/2   | t       | 705      | transactionid |          |      |
         11596 | 3/114 | f       | 702      | transactionid |          |      |
         11596 | 3/114 | t       |          | tuple         | lockdemo |    0 |    12
         11600 | 4/14  | f       |          | tuple         | lockdemo |    0 |    12
         11604 | 5/2   | f       |          | tuple         | lockdemo |    0 |    12
```

Three Concurrent Updates Show Locking

```
\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |    lock_mode         | granted | xid_lock |  relname
        -------+------+---------------+----------------------+---------+----------+------------
         11596 | 3/114 | transactionid | ExclusiveLock        | t       | 703      |
         11596 | 3/114 | relation      | AccessShareLock      | t       |          | i_lockdemo
         11596 | 3/114 | relation      | AccessShareLock      | t       |          | lockdemo
         11596 | 3/114 | relation      | RowExclusiveLock     | t       |          | i_lockdemo
         11596 | 3/114 | relation      | RowExclusiveLock     | t       |          | lockdemo
         11600 | 4/14  | transactionid | ExclusiveLock        | t       | 704      |
         11600 | 4/14  | relation      | RowExclusiveLock     | t       |          | i_lockdemo
         11600 | 4/14  | relation      | RowExclusiveLock     | t       |          | lockdemo
         11600 | 4/14  | relation      | AccessExclusiveLock  | t       |          | lockdemo
         11600 | 4/14  | transactionid | ShareLock            | f       | 703      |
         11604 | 5/2   | transactionid | ExclusiveLock        | t       | 705      |
         11604 | 5/2   | relation      | RowExclusiveLock     | t       |          | i_lockdemo
         11604 | 5/2   | relation      | RowExclusiveLock     | t       |          | lockdemo
         11604 | 5/2   | relation      | AccessExclusiveLock  | f       |          | lockdemo
         11604 | 5/2   | transactionid | ExclusiveLock        | t       | 703      |
         11604 | 5/2   | transactionid | RowExclusiveLock     | t       |          | i_lockdemo
         11604 | 5/2   | transactionid | RowExclusiveLock     | t       |          | lockdemo
         11604 | 5/2   | transactionid | AccessExclusiveLock  | f       |          | lockdemo

COMMIT;
```

Deadlocks

```
DELETE FROM lockdemo;

INSERT INTO lockdemo VALUES (50), (80);
```

Deadlocks

```
BEGIN WORK;

UPDATE lockdemo SET col = 50 WHERE col = 50;

SELECT pg_backend_pid();
 pg_backend_pid
----------------
          11306

SELECT txid_current();
 txid_current
--------------
          710
```

Deadlocks

```
\! psql -e -c 'BEGIN WORK; \
    UPDATE lockdemo SET col = 81 WHERE col = 80; \
    UPDATE lockdemo SET col = 51 WHERE col = 50; \
    COMMIT;' | \
    sed 's/^/\t/g' &

SELECT pg_sleep(0.200);
```

Deadlocks

```
\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid  |    lock_type   |     lock_mode     | granted | xid_lock |  relname
        -------+-------+----------------+-------------------+---------+----------+------------
         11306 | 2/61  | transactionid  | ExclusiveLock     | t       | 710      |
         11306 | 2/61  | relation       | RowExclusiveLock  | t       |          | i_lockdemo
         11306 | 2/61  | relation       | RowExclusiveLock  | t       |          | lockdemo
         11642 | 3/116 | transactionid  | ExclusiveLock     | t       | 711      |
         11642 | 3/116 | relation       | RowExclusiveLock  | t       |          | i_lockdemo
         11642 | 3/116 | relation       | RowExclusiveLock  | t       |          | lockdemo
         11642 | 3/116 | tuple          | ExclusiveLock     | t       |          | lockdemo
         11642 | 3/116 | transactionid  | ShareLock         | f       | 710      |
```

Deadlocks

```
\! psql -e -c 'SELECT * FROM lockview2;' | sed 's/^/\t/g'
        SELECT * FROM lockview2;
          pid  | vxid  |    lock_type    | page | tuple | classid | objid | objsubid
        -------+-------+-----------------+------+-------+---------+-------+----------
         11306 | 2/61  | transactionid   |      |       |         |       |
         11306 | 2/61  | relation        |      |       |         |       |
         11306 | 2/61  | relation        |      |       |         |       |
         11642 | 3/116 | transactionid   |      |       |         |       |
         11642 | 3/116 | relation        |      |       |         |       |
         11642 | 3/116 | relation        |      |       |         |       |
         11642 | 3/116 | tuple           |    0 |    18 |         |       |
         11642 | 3/116 | transactionid   |      |       |         |       |
```

Deadlocks

```
-- show lockview while waiting for deadlock_timeout
\! psql -e -c 'SELECT pg_sleep(0.200); \
    SELECT * FROM lockview1;' | \
    sed 's/^/\t/g' &
\! psql -e -c 'SELECT pg_sleep(0.400); \
    SELECT * FROM lockview2;' | \
    sed 's/^/\t/g' &

-- the next line hangs waiting for deadlock timeout
UPDATE lockdemo SET col = 80 WHERE col = 80;
```

Deadlocks

```
SELECT pg_sleep(0.200); SELECT * FROM lockview1;
  pid  | vxid |   lock_type   |     lock_mode     | granted | xid_lock |  relname
-------+------+---------------+-------------------+---------+----------+------------
 11306 | 2/61 | transactionid | ExclusiveLock     | t       | 710      |
 11306 | 2/61 | relation      | RowExclusiveLock  | t       |          | i_lockdemo
 11306 | 2/61 | relation      | RowExclusiveLock  | t       |          | lockdemo
 11306 | 2/61 | tuple         | ExclusiveLock     | t       |          | lockdemo
 11306 | 2/61 | transactionid | ShareLock         | f       | 711      |
 11642 | 3/116| transactionid | ExclusiveLock     | t       | 711      |
 11642 | 3/116| relation      | RowExclusiveLock  | t       |          | i_lockdemo
 11642 | 3/116| relation      | RowExclusiveLock  | t       |          | lockdemo
 11642 | 3/116| tuple         | ExclusiveLock     | t       |          | lockdemo
 11642 | 3/116| transactionid | ShareLock         | f       | 710      |
```

Deadlocks

```
SELECT pg_sleep(0.400); SELECT * FROM lockview2;
  pid  | vxid  |   lock_type   | page | tuple | classid | objid | objsubid
-------+-------+---------------+------+-------+---------+-------+----------
 11306 | 2/61  | transactionid |      |       |         |       |
 11306 | 2/61  | relation      |      |       |         |       |
 11306 | 2/61  | relation      |      |       |         |       |
 11306 | 2/61  | tuple         |    0 |    19 |         |       |
 11306 | 2/61  | transactionid |      |       |         |       |
 11642 | 3/116 | transactionid |      |       |         |       |
 11642 | 3/116 | relation      |      |       |         |       |
 11642 | 3/116 | relation      |      |       |         |       |
 11642 | 3/116 | tuple         |    0 |    18 |         |       |
 11642 | 3/116 | transactionid |      |       |         |       |
```

Deadlocks

```
ERROR:  deadlock detected
DETAIL:  Process 11306 waits for ShareLock on transaction 711; blocked by process 11642.
Process 11642 waits for ShareLock on transaction 710; blocked by process 11306.
HINT:  See server log for query details.
CONTEXT:  while updating tuple (0,18) in relation "lockdemo"

COMMIT;
```

The Postgres server log will report the queries involved in the deadlock.

Three-Way Deadlocks

```
DELETE FROM lockdemo;

INSERT INTO lockdemo VALUES (40), (60), (80);
```

Three-Way Deadlocks

```
BEGIN WORK;

UPDATE lockdemo SET col = 40 WHERE col = 40;

SELECT pg_backend_pid();
 pg_backend_pid
----------------
          11306

SELECT txid_current();
 txid_current
--------------
          714
```

Three-Way Deadlocks

```
\! psql -e -c 'BEGIN WORK; \
    UPDATE lockdemo SET col = 61 WHERE col = 60; \
    UPDATE lockdemo SET col = 41 WHERE col = 40; \
    COMMIT;' | \
    sed 's/^/\t/g' &
\! psql -e -c 'BEGIN WORK; \
    UPDATE lockdemo SET col = 81 WHERE col = 80; \
    UPDATE lockdemo SET col = 61 WHERE col = 60; \
    COMMIT;' | \
    sed 's/^/\t/g' &

SELECT pg_sleep(0.200);
```

Three-Way Deadlocks

```
\! psql -e -c 'SELECT pg_sleep(0.200); \
    SELECT * FROM lockview1;' | \
    sed 's/^/\t/g' &
\! psql -e -c 'SELECT pg_sleep(0.400); \
    SELECT * FROM lockview2;' | \
    sed 's/^/\t/g' &

-- the next line hangs waiting for deadlock timeout
UPDATE lockdemo SET col = 80 WHERE col = 80;
```

Three-Way Deadlocks

```
SELECT pg_sleep(0.200); SELECT * FROM lockview1;
  pid  | vxid |   lock_type   |     lock_mode      | granted | xid_lock |  relname
-------+------+---------------+--------------------+---------+----------+------------
 11306 | 2/65 | transactionid | ExclusiveLock      | t       | 714      |
 11306 | 2/65 | relation      | RowExclusiveLock   | t       |          | i_lockdemo
 11306 | 2/65 | relation      | RowExclusiveLock   | t       |          | lockdemo
 11306 | 2/65 | tuple         | AccessExclusiveLock| t       |          | lockdemo
 11306 | 2/65 | transactionid | ShareLock          | f       | 716      |
 11662 | 3/118| transactionid | ExclusiveLock      | t       | 715      |
 11662 | 3/118| relation      | RowExclusiveLock   | t       |          | i_lockdemo
 11662 | 3/118| relation      | RowExclusiveLock   | t       |          | lockdemo
 11662 | 3/118| tuple         | AccessExclusiveLock| t       |          | lockdemo
 11662 | 3/118| transactionid | ShareLock          | f       | 714      |
 11666 | 4/22 | transactionid | ExclusiveLock      | t       | 716      |
 11666 | 4/22 | relation      | RowExclusiveLock   | t       |          | i_lockdemo
 11666 | 4/22 | relation      | RowExclusiveLock   | t       |          | lockdemo
 11666 | 4/22 | tuple         | AccessExclusiveLock| t       |          | lockdemo
 11666 | 4/22 | transactionid | ShareLock          | f       | 715      |
```

Three-Way Deadlocks

```
SELECT pg_sleep(0.400); SELECT * FROM lockview2;
  pid  | vxid |   lock_type   | page | tuple | classid | objid | objsubid
-------+------+---------------+------+-------+---------+-------+----------
 11306 | 2/65 | transactionid |      |       |         |       |
 11306 | 2/65 | relation      |      |       |         |       |
 11306 | 2/65 | relation      |      |       |         |       |
 11306 | 2/65 | tuple         |    0 |    24 |         |       |
 11306 | 2/65 | transactionid |      |       |         |       |
 11662 | 3/118 | transactionid |      |       |         |       |
 11662 | 3/118 | relation      |      |       |         |       |
 11662 | 3/118 | relation      |      |       |         |       |
 11662 | 3/118 | tuple         |    0 |    22 |         |       |
 11662 | 3/118 | transactionid |      |       |         |       |
 11666 | 4/22 | transactionid |      |       |         |       |
 11666 | 4/22 | relation      |      |       |         |       |
 11666 | 4/22 | relation      |      |       |         |       |
 11666 | 4/22 | tuple         |    0 |    23 |         |       |
 11666 | 4/22 | transactionid |      |       |         |       |
```

Three-Way Deadlocks

```
ERROR:  deadlock detected
DETAIL:  Process 11662 waits for ShareLock on transaction 714; blocked by process 11306.
Process 11306 waits for ShareLock on transaction 716; blocked by process 11666.
Process 11666 waits for ShareLock on transaction 715; blocked by process 11662.
HINT:  See server log for query details.
CONTEXT:  while updating tuple (0,22) in relation "lockdemo"

COMMIT;
```

Restore Table *Lockdemo*

```
DELETE FROM lockdemo;

INSERT INTO lockdemo VALUES (1);
```

Serializable

```
BEGIN WORK;

SELECT * FROM lockdemo;
 col
-----
   1
```

Serializable

```
SELECT pg_backend_pid();
 pg_backend_pid
----------------
          11306

SELECT txid_current();
 txid_current
--------------
          719
```

Serializable

```
\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |    lock_mode    | granted | xid_lock |  relname
        -------+------+---------------+-----------------+---------+----------+------------
         11306 | 2/70 | transactionid | ExclusiveLock   | t       | 719      |
         11306 | 2/70 | relation      | AccessShareLock | t       |          | i_lockdemo
         11306 | 2/70 | relation      | AccessShareLock | t       |          | lockdemo

COMMIT;
```

Serializable

```
BEGIN WORK;

SET TRANSACTION ISOLATION LEVEL SERIALIZABLE;

SELECT * FROM lockdemo;
 col
-----
   1
```

Serializable

```
SELECT pg_backend_pid();
 pg_backend_pid
----------------
          11306

SELECT txid_current();
 txid_current
--------------
          720
```

Serializable

```
\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |    lock_mode    | granted | xid_lock |  relname
        -------+------+---------------+-----------------+---------+----------+------------
         11306 | 2/71 | transactionid | ExclusiveLock   | t       | 720      |
         11306 | 2/71 | relation      | AccessShareLock | t       |          | i_lockdemo
         11306 | 2/71 | relation      | AccessShareLock | t       |          | lockdemo
         11306 | 2/71 | relation      | SIReadLock      | t       |          | lockdemo

COMMIT;
```

Unique Insert Locking

```
\d lockdemo
   Table "public.lockdemo"
 Column |  Type   | Modifiers
--------+---------+-----------
 col    | integer |
Indexes:
    "i_lockdemo" UNIQUE, btree (col) CLUSTER
```

Unique Insert Locking

```
BEGIN WORK;

INSERT INTO lockdemo VALUES (2);

SELECT pg_backend_pid();
 pg_backend_pid
----------------
          11306

SELECT txid_current();
 txid_current
--------------
          721
```

Unique Insert Locking

```
\! PGOPTIONS='-c statement_timeout=200' \
    psql -e -c 'INSERT INTO lockdemo VALUES (2);' | \
    sed 's/^/\t/g' &
\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid  |   lock_type   |    lock_mode     | granted | xid_lock |  relname
        -------+-------+---------------+------------------+---------+----------+------------
         11306 | 2/78  | transactionid | ExclusiveLock    | t       | 721      |
         11306 | 2/78  | relation      | RowExclusiveLock | t       |          | lockdemo
         11696 | 3/128 | transactionid | ExclusiveLock    | t       | 722      |
         11696 | 3/128 | relation      | RowExclusiveLock | t       |          | i_lockdemo
         11696 | 3/128 | relation      | RowExclusiveLock | t       |          | lockdemo
         11696 | 3/128 | transactionid | ShareLock        | f       | 721      |

SELECT pg_sleep(0.400);
ERROR:  canceling statement due to statement timeout

ROLLBACK WORK;
```

Subtransactions

```
BEGIN WORK;

UPDATE lockdemo SET col = 1;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |    lock_mode     | granted | xid_lock |  relname
        -------+------+---------------+------------------+---------+----------+------------
         11306 | 2/79 | transactionid | ExclusiveLock    | t       | 723      |
         11306 | 2/79 | relation      | RowExclusiveLock | t       |          | i_lockdemo
         11306 | 2/79 | relation      | RowExclusiveLock | t       |          | lockdemo
```

Subtransactions

```
SAVEPOINT lockdemo1;

UPDATE lockdemo SET col = 2;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |    lock_mode     | granted | xid_lock |  relname
        -------+------+---------------+------------------+---------+----------+------------
         11306 | 2/79 | transactionid | ExclusiveLock    | t       | 723      |
         11306 | 2/79 | transactionid | ExclusiveLock    | t       | 724      |
         11306 | 2/79 | relation      | RowExclusiveLock | t       |          | i_lockdemo
         11306 | 2/79 | relation      | RowExclusiveLock | t       |          | lockdemo
```

Subtransactions

```
ROLLBACK WORK TO SAVEPOINT lockdemo1;

UPDATE lockdemo SET col = 3;

\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid |   lock_type   |     lock_mode     | granted | xid_lock |  relname
        -------+------+---------------+-------------------+---------+----------+------------
         11306 | 2/79 | transactionid | ExclusiveLock     | t       | 723      |
         11306 | 2/79 | transactionid | ExclusiveLock     | t       | 725      |
         11306 | 2/79 | relation      | RowExclusiveLock  | t       |          | i_lockdemo
         11306 | 2/79 | relation      | RowExclusiveLock  | t       |          | lockdemo

COMMIT;
```

Advisory Locks

```
BEGIN WORK;

SELECT pg_advisory_lock(col) FROM lockdemo;
 pg_advisory_lock
------------------


\! psql -e -c 'SELECT * FROM lockview1;' | sed 's/^/\t/g'
        SELECT * FROM lockview1;
          pid  | vxid | lock_type |    lock_mode    | granted | xid_lock |  relname
        -------+------+-----------+-----------------+---------+----------+------------
         11306 | 2/80 | advisory  | ExclusiveLock   | t       |          |
         11306 | 2/80 | relation  | AccessShareLock | t       |          | i_lockdemo
         11306 | 2/80 | relation  | AccessShareLock | t       |          | lockdemo
```

Advisory Locks

```
\! psql -e -c 'SELECT * FROM lockview2;' | sed 's/^/\t/g'
        SELECT * FROM lockview2;
          pid  | vxid | lock_type | page | tuple | classid | objid | objsubid
        -------+------+-----------+------+-------+---------+-------+----------
         11306 | 2/80 | advisory  |      |       |       0 |     3 |        1
         11306 | 2/80 | relation  |      |       |         |       |
         11306 | 2/80 | relation  |      |       |         |       |

SELECT pg_advisory_unlock(col) FROM lockdemo;
 pg_advisory_unlock
--------------------
 t

COMMIT;
```

Joining *Pg_locks* and *Pg_stat_activity*

```
-- cannot be a temporary view because other sessions must see it
CREATE VIEW lock_stat_view AS
SELECT  pg_stat_activity.pid AS pid,
        query, wait_event, vxid, lock_type,
        lock_mode, granted, xid_lock
FROM    lockview JOIN pg_stat_activity ON (lockview.pid = pg_stat_activity.pid);
```

Joining *Pg_locks* and *Pg_stat_activity*

```
BEGIN WORK;

UPDATE lockdemo SET col = 1;

SELECT pg_backend_pid();
 pg_backend_pid
----------------
          11306

SELECT txid_current();
 txid_current
--------------
          727
```

Joining *Pg_locks* and *Pg_stat_activity*

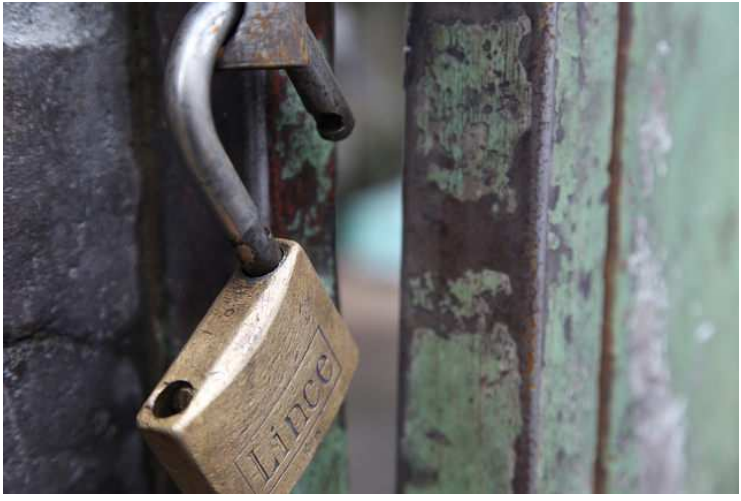
```
\! psql -e -c 'UPDATE lockdemo SET col = 2;' | sed 's/^/\t/g' &
\! psql -e -c 'UPDATE lockdemo SET col = 3;' | sed 's/^/\t/g' &
\! psql -e -c 'SELECT * FROM lock_stat_view;' | sed 's/^/\t/g'
  pid  |            query             |   wait_event   | vxid |   lock_type   |    lock_mode     | granted | xid_lock
-------+------------------------------+----------------+------+---------------+------------------+---------+----------
 11306 | SELECT txid_current();       | ClientRead     | 2/83 | transactionid | ExclusiveLock    | t       | 727
 11306 | SELECT txid_current();       | ClientRead     | 2/83 | relation      | RowExclusiveLock | t       |
 11306 | SELECT txid_current();       | ClientRead     | 2/83 | relation      | RowExclusiveLock | t       |
 11740 | UPDATE lockdemo SET col = 2; | transactionid  | 3/146| transactionid | ExclusiveLock    | t       | 728
 11740 | UPDATE lockdemo SET col = 2; | transactionid  | 3/146| relation      | RowExclusiveLock | t       |
 11740 | UPDATE lockdemo SET col = 2; | transactionid  | 3/146| relation      | RowExclusiveLock | t       |
 11740 | UPDATE lockdemo SET col = 2; | transactionid  | 3/146| tuple         | ExclusiveLock    | t       |
 11740 | UPDATE lockdemo SET col = 2; | transactionid  | 3/146| transactionid | ShareLock        | f       | 727
 11748 | UPDATE lockdemo SET col = 3; | tuple          | 4/30 | transactionid | ExclusiveLock    | t       | 729
 11748 | UPDATE lockdemo SET col = 3; | tuple          | 4/30 | relation      | RowExclusiveLock | t       |
 11748 | UPDATE lockdemo SET col = 3; | tuple          | 4/30 | relation      | RowExclusiveLock | t       |
 11748 | UPDATE lockdemo SET col = 3; | tuple          | 4/30 | tuple         | ExclusiveLock    | f       |

SELECT pg_blocking_pids(11740);
 pg_blocking_pids
------------------
{11306}

SELECT pg_blocking_pids(11748);
 pg_blocking_pids
------------------
 {11740}

COMMIT;
```

Conclusion



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