Materialised views now and the future

Thom Brown | PGDay FOSDEM 2014

Disclaimer

“Materialised” vs “Materialized”

“Optimiser” vs “Optimizer”

“Catalogue” vs “Catalog”

“Behaviour” vs “Behavior”

“Customisable” vs “Customizable”

“Favourite” vs “Favorite”

Materialised Views in PostgreSQL

- Back in 2009, 2nd most-requested PostgreSQL feature on UserVoice was: Materialised Views! (Hot Standby was 1st if you're curious)
- PostgreSQL now has Materialised Views in version 9.3!
- Designed and developed by Kevin Grittner of EDB (major contributor, PostgreSQL committer). (thanks Kevin!)
- Out of 175 people surveyed with the question “What's your favourite 9.3 feature?”, 0 people said Materialized Views... it wasn't in the list of choices though.

Table vs View vs Materialised View

Table

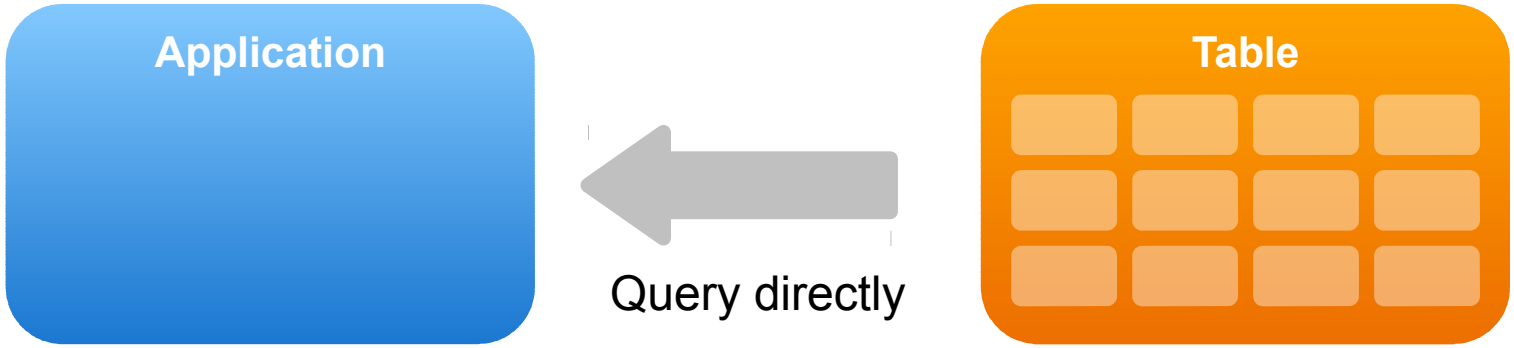


Table vs View vs Materialised View

View

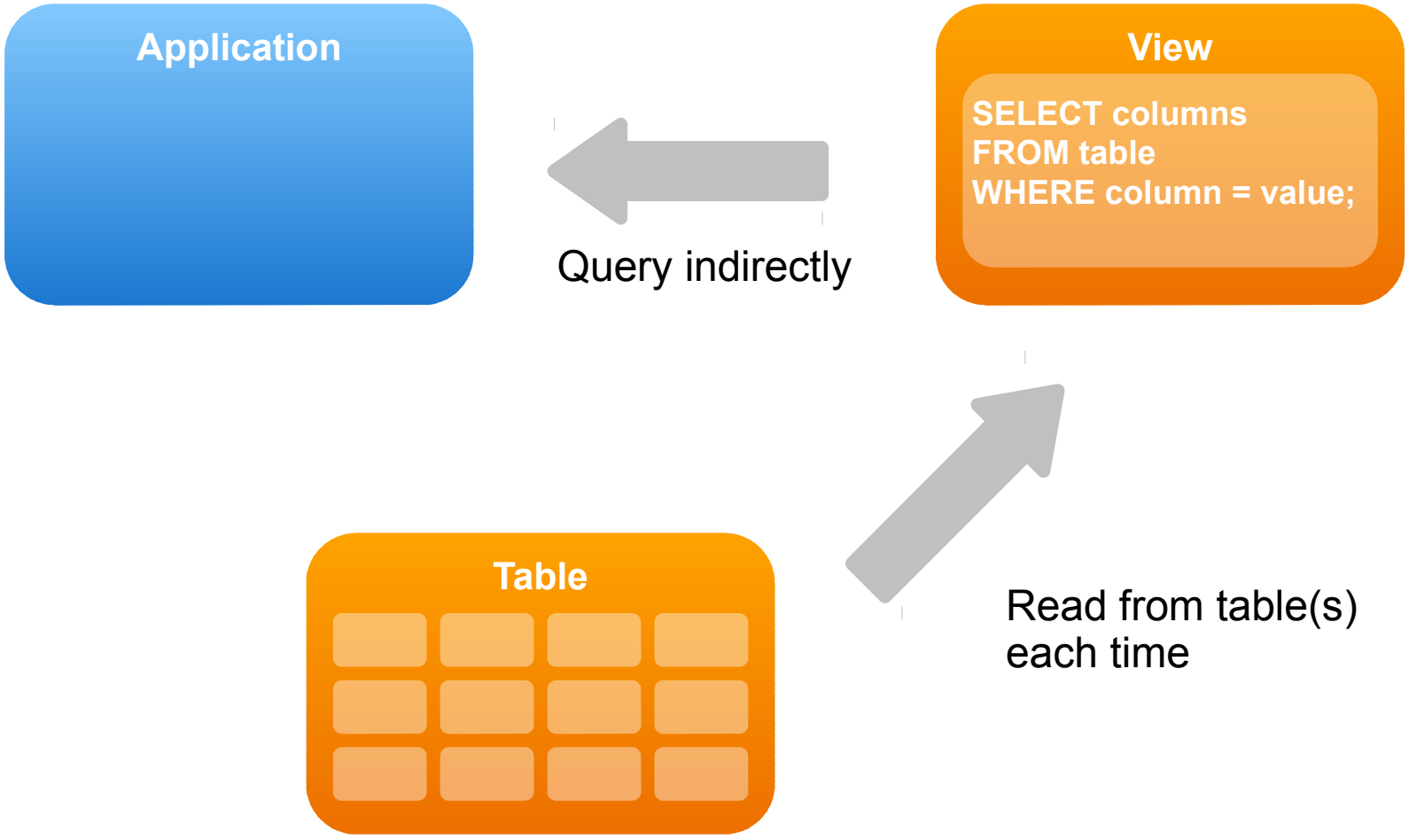


Table vs View vs Materialised View

Materialised View

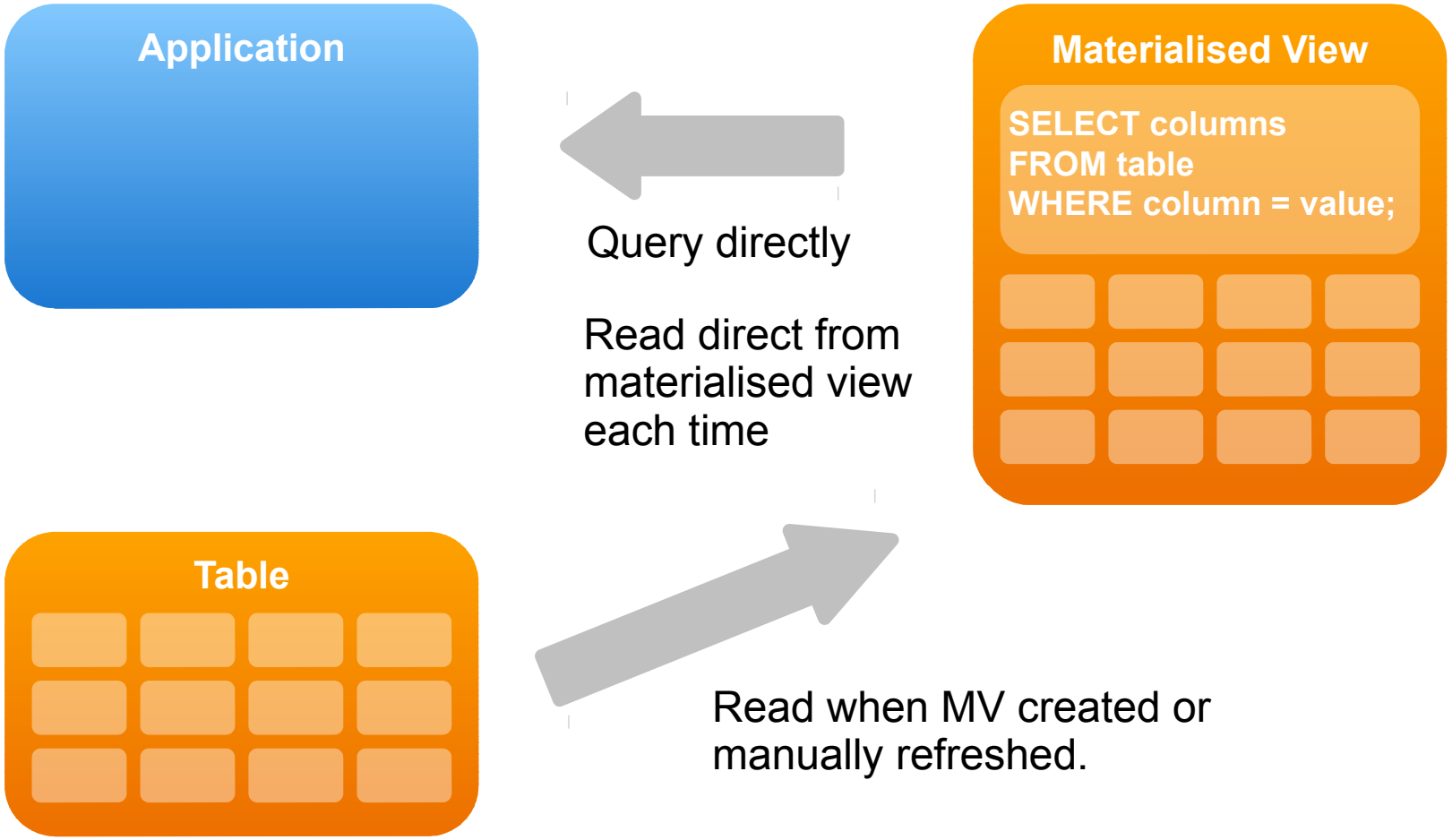
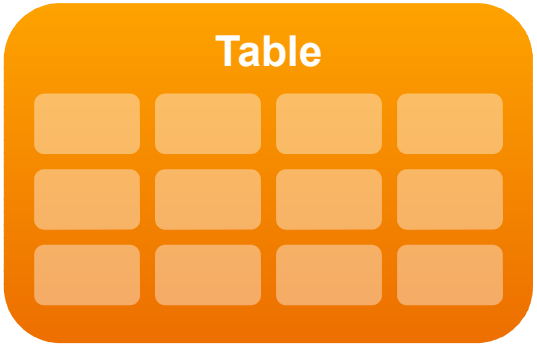
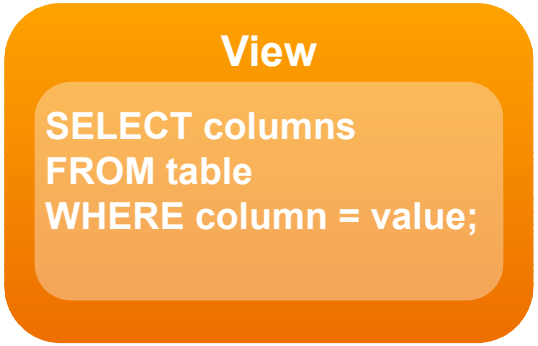


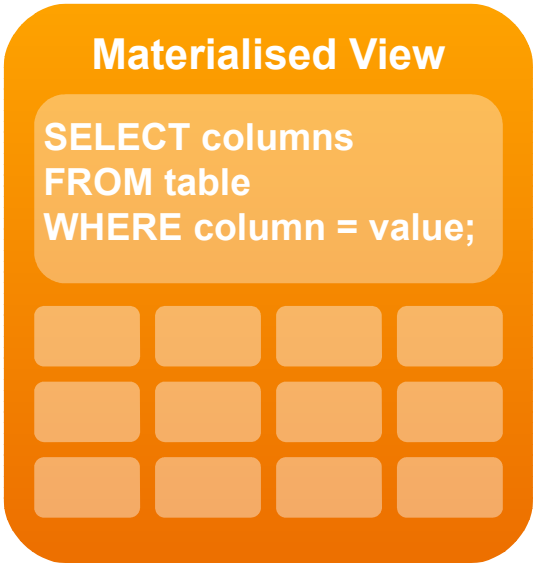
Table vs View vs Materialised View



- Stores data
- Returns its data
- Can modify its data



- Stores a query
- Executes its query
- Returns results



- Stores a query
- Executes its query upon creation or refresh
- Stores results
- Returns stored results
- Cannot modify its data

FYI

pg_class.relkind

- '**r**' for tables
- '**v**' for views
- '**m**' for materialised views

Previously in PostgreSQL...

```
-- Create the initial view
CREATE VIEW v_data AS
   SELECT ...

-- Create a table based on a view
CREATE TABLE mv_data AS
   SELECT * FROM v_data;

-- Refresh the table
BEGIN;
   DROP TABLE mv_data;
   CREATE TABLE mv_data AS
      SELECT *
      FROM v_data;
END;
```

Previously in PostgreSQL...

```
-- Create supporting tracking tables, functions,
triggers...

CREATE TABLE track_mvs...
CREATE FUNCTION create_mv...
CREATE FUNCTION drop_mv...
CREATE FUNCTION refresh_mv...
CREATE TRIGGER t_mv_update...
CREATE TRIGGER t_mv_insert...
CREATE TRIGGER t_mv_delete...
CREATE VIEW v_summary...
```

Using Materialised Views in PostgreSQL 9.3

```
-- Create a materialised view

CREATE MATERIALIZED VIEW mv_data AS
   SELECT d.id, d.department, count(d.department)
   FROM staff s
   INNER JOIN dept d ON s.dept_id = d.dept_id
   GROUP BY d.id, d.department WITH NO DATA;


-- Refresh a materialised view

REFRESH MATERIALIZED VIEW mv_data;
```

Should I use a Materialised View?

- For data that doesn't need to be up-to-date.
- For data that takes a long time to query (e.g. requires lots of joins or processing) but frequently needed or needs to be prepared ahead of time.
- Can be based on any read-only query.
- Can have indexes like regular tables.

Should I use a Materialised View?

- Can be useful for caching foreign table data.
- Sacrifice freshness for speed.
- Takes up disk space to store results.
- Returns an error upon querying if created or refreshed using WITH NO DATA.

Materialised Views in 9.3

- CREATE / DROP / ALTER / REFRESH MATERIALIZED VIEW.
- \dm command in psql to list MVs.
- pg_matviews system catalogue.
  - Contains query definition.
- Requires an exclusive lock to refresh.
  - Needs to wait for all active queries to complete.
  - Cannot be used while refreshing.

Materialised Views in 9.3

- Snapshot implementation
- Can produce a lot of WAL data for large refreshes and therefore a lot of replication traffic.
- Cannot be temporary or unlogged, unlike tables.
- Refreshing “freezes” rows.

What about pg_dump with MVs in 9.3?

- Data not dumped, only the query definition.
- Outputs CREATE MATERIALIZED VIEW statement with WITH NO DATA clause.
- Later outputs REFRESH MATERIALIZED VIEW statement if it was populated at the time of backup dump.

Exclusive lock issue explained

```
CREATE TABLE data (id serial PRIMARY KEY, value int);
INSERT INTO data (value) VALUES (1);
CREATE MATERIALIZED VIEW mv_data AS SELECT * FROM data;
```

Session 1	Session 2	Session 3

```
BEGIN;
  SELECT *
  FROM mv_data;
-- Access Share Lock acquired
```

```
INSERT INTO data VALUES (2);
```

```
REFRESH MATERIALIZED VIEW mv_data;
-- Waiting for T2 to finish to
acquire Exclusive Lock
```

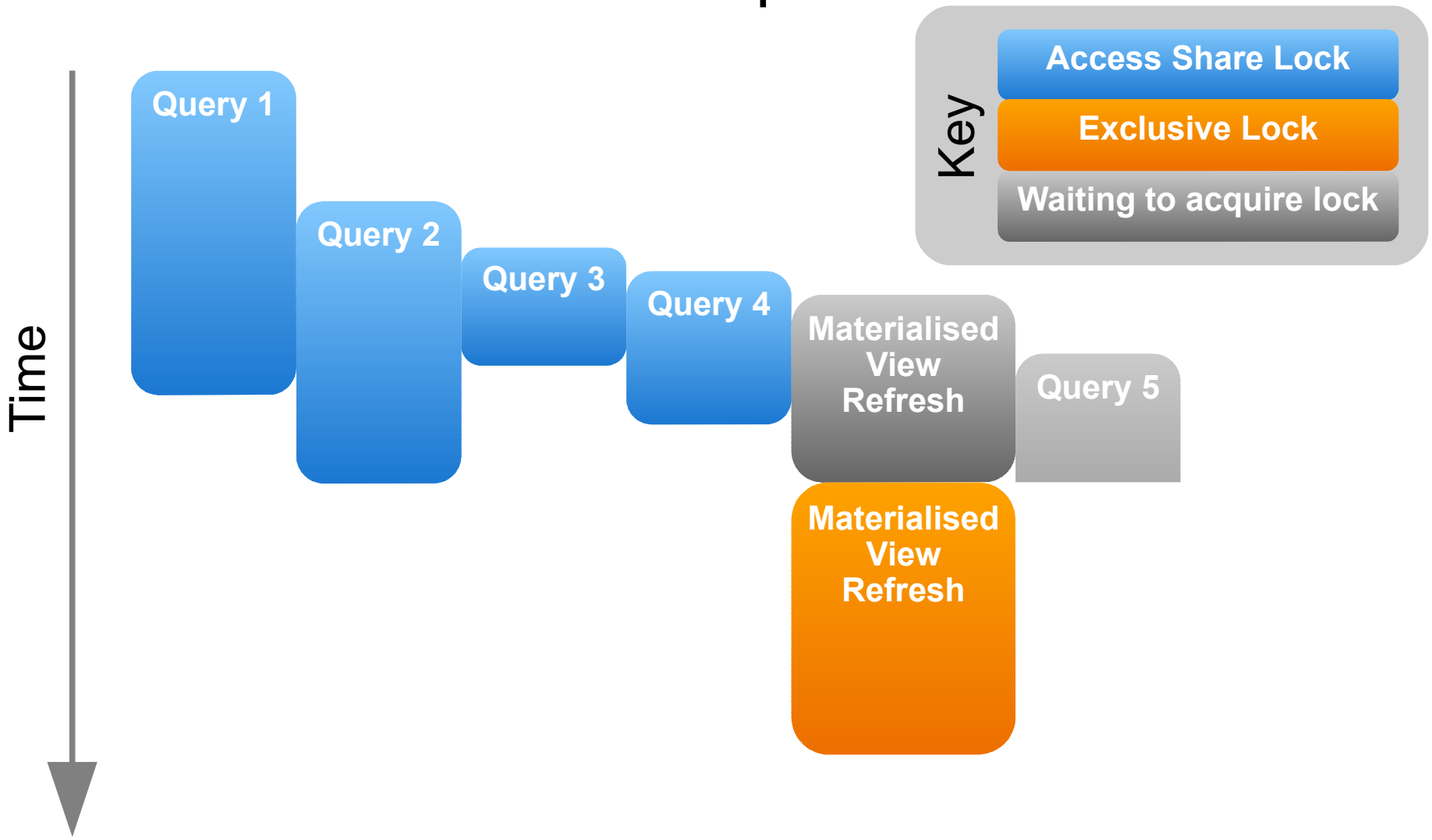
```
BEGIN;
  SELECT * FROM mv_data;
-- Waiting for T1 to
finish to acquire Access
Share Lock
```

```
COMMIT;
-- releases Access Share Lock`
```

```
-- Exclusive Lock acquired
and refresh completes
```

```
-- Access Share Lock
acquired
```

Exclusive lock issue explained



MV exclusive lock mitigation in 9.3

- Shamelessly stolen from Depesz (www.depesz.com)

```
-- Create a copy of the materialised view
DO $$
BEGIN
   EXECUTE 'CREATE MATERIALIZED VIEW mv_new AS '
   || pg_get_viewdef('mv'::regclass);
END $$;

-- Replace the MV atomically
BEGIN;
   DROP MATERIALIZED VIEW mv;
   ALTER MATERIALIZED VIEW mv_new RENAME TO mv;
COMMIT;
```

- Transactions don't need to wait for MV build, but still requires Access Exclusive Lock for DROP step.

Back To The Future...

A quirk with using materialised views:

- With a materialised view that is refreshed non-concurrently it's possible for a single transaction to see data in a materialised view that is newer than that of the underlying tables.
- Concurrently-refreshed materialised views don't exhibit this behaviour.

Back To The Future...

Session 1	Session 2

```
CREATE TABLE data (
  id serial PRIMARY KEY,
  ts timestamp);

INSERT INTO data (ts) VALUES (now());

CREATE MATERIALIZED VIEW mv_data AS
SELECT id, ts FROM data;
```

```
SET SESSION CHARACTERISTICS AS
TRANSACTION ISOLATION LEVEL
SERIALIZABLE;
```

```
BEGIN;
  SELECT * FROM data;
```

```
UPDATE data SET ts = now();

REFRESH MATERIALIZED VIEW mv_data;
```

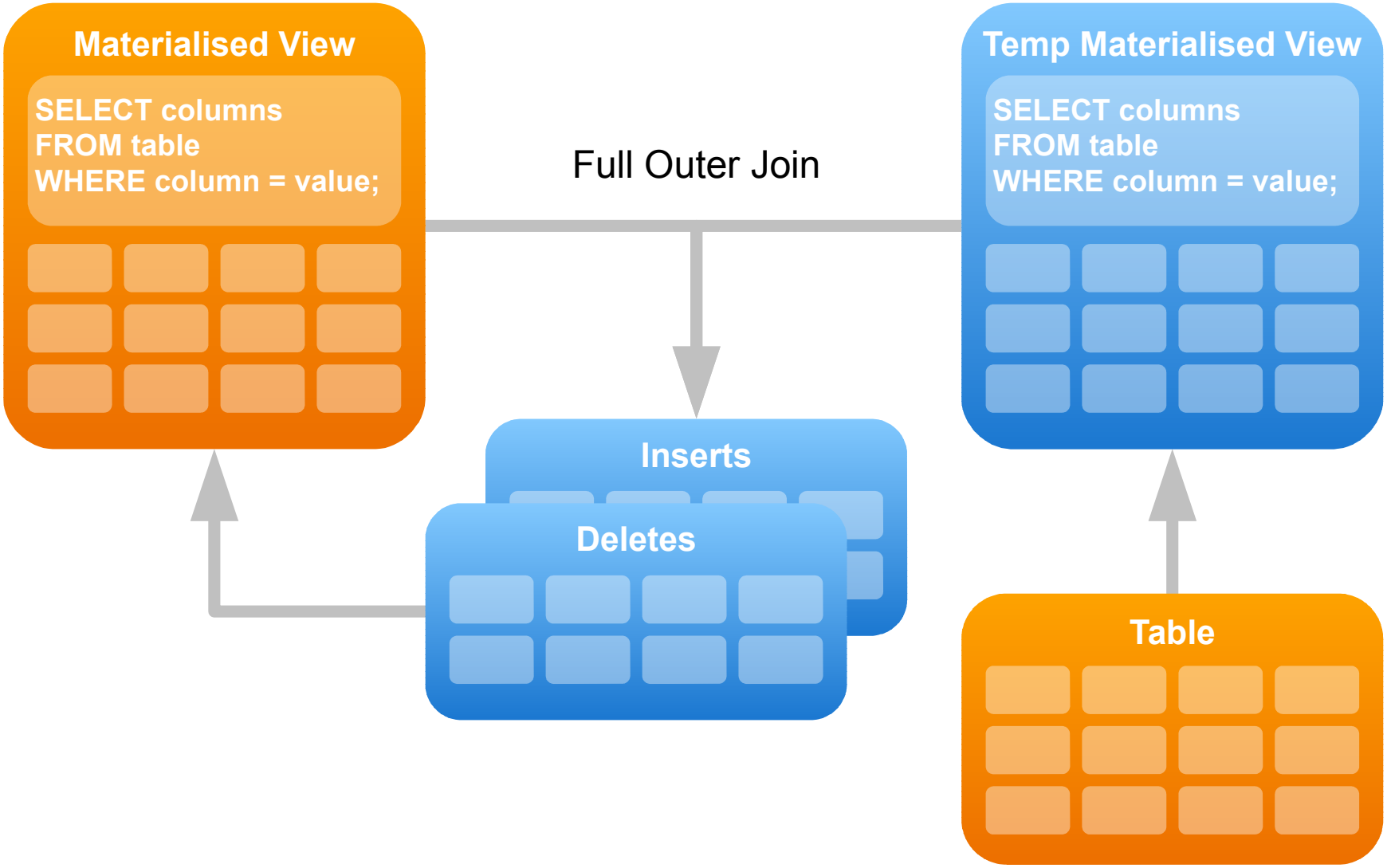
```
  SELECT * FROM data
  UNION
  SELECT * FROM mv_data;

-- Two rows returned with
different ts values.
```

Materialised Views in 9.4

- REFRESH MATERIALIZED VIEW **CONCURRENTLY.**
  - Doesn't block reads.
  - Can produce more or less WAL than non-concurrent refresh depending on number of changes.
  - Only one refresh allowed at any one time.
  - MV needs to be already populated.
  - Requires a unique index.
  - VACUUMing becomes relevant.
  - Unlike non-concurrent form, doesn't freeze rows.
  - Cannot be used with WITH NO DATA option (as it wouldn't make sense).

“CONCURRENTLY” implementation



Materialised Views roadmap

(These are not necessarily going to be implemented)

- Unlogged materialised views.
  - Same as WITH NO DATA state upon crash.
- Incremental materialised views.
  - Updates the MV as tables are updated.
  - Customisable level of “eagerness”.
  - Complicated by features such as aggregates and NOT EXISTS.
  - Support for recursive queries will likely arrive more than 1 release later.

Materialised Views roadmap

- CREATE **OR REPLACE** MATERIALIZED VIEW
  - Just an oversight that it wasn't added.
- Updates for concurrent refreshes.
  - Would allow for HOT updates.
- Lazy automatic refresh based on table modification statistics.
  - Staleness testing.
- Optimiser awareness of materialised views.
  - Pull in MV data if fresh enough.
  - Treat MVs like indexes.

Materialised Views roadmap

- Incremental update “eagerness”
  - **Very Eager** – Applied before incrementing command counter so appears up-to-date within the transaction.
  - **Eager** – Applied at commit time, and visible with all other changes in the transaction.
  - **Inbetween** – Queued to apply immediately after transaction commit asynchronously.
  - **Lazy** – Queued to apply on a specified schedule.
  - **Very Lazy** – Queued to be applied on demand.
  - Trade-off: More eager = fresh more frequently but with the price of greater overhead.

Fin