22 - PostgreSQL 17 Performance Tuning: BRIN (Block Range INdex)

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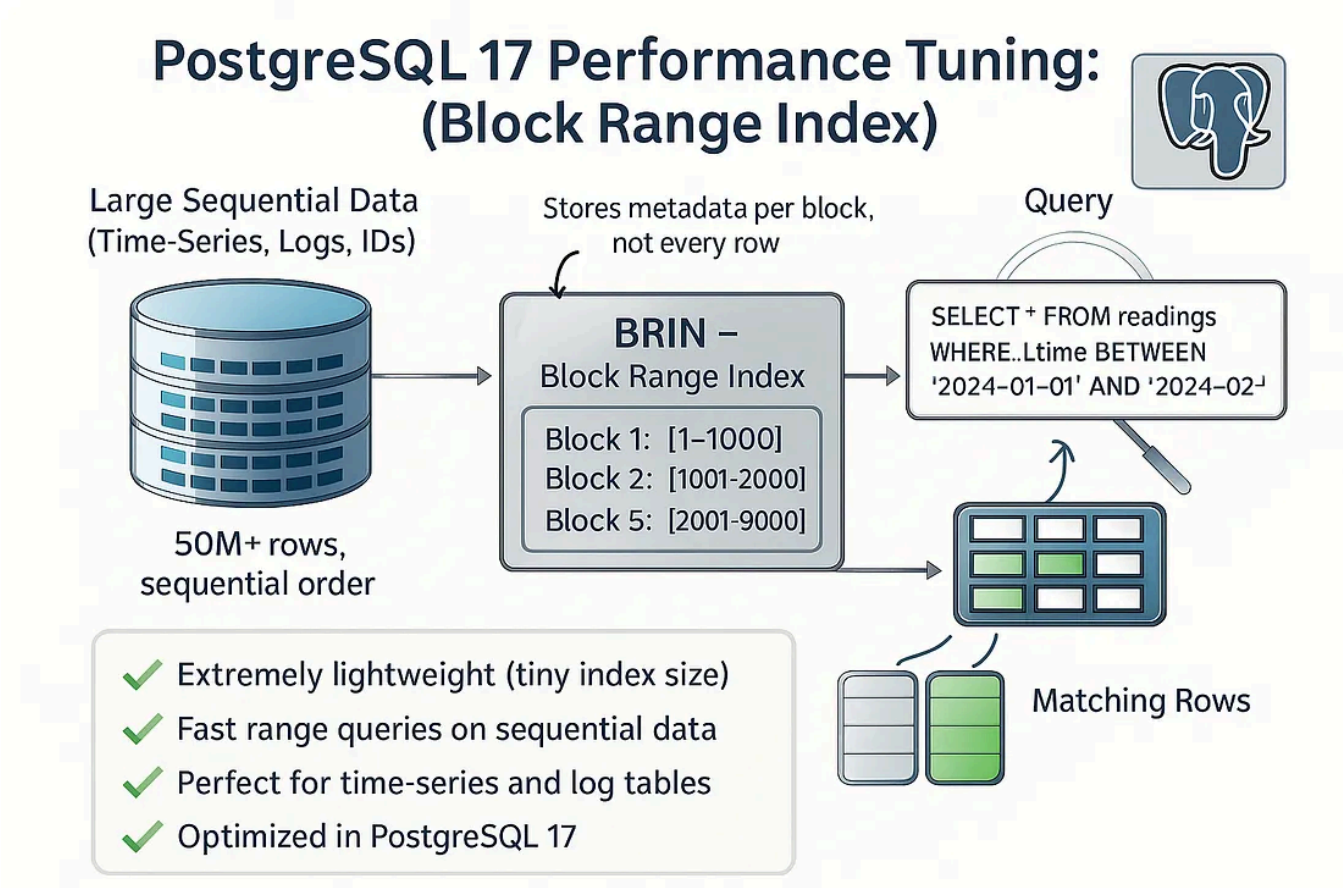
J Jeyaram Ayyalusamy Following



When working with **very large tables** in PostgreSQL, traditional indexes like B-Tree or GiST can grow extremely large and take significant time to maintain. For time-series or sequentially ordered data, PostgreSQL offers a smarter, more lightweight option: the **BRIN (Block Range Index)**.

BRIN indexes summarize data in block ranges instead of storing individual row entries, making them **compact, fast to build, and efficient for range queries** on ordered data.

Let's walk through a step-by-step example.

Step 1: Create the `weather_data` table

We'll simulate sensor readings (temperature and humidity) recorded over time.

```
CREATE TABLE weather_data (
    reading_id   BIGSERIAL,
    reading_time TIMESTAMP NOT NULL,
    temperature  NUMERIC(5,2),
    humidity     NUMERIC(5,2)
);
```

```
postgres=# CREATE TABLE weather_data (
    reading_id   BIGSERIAL,
    reading_time TIMESTAMP NOT NULL,
    temperature  NUMERIC(5,2),
    humidity     NUMERIC(5,2)
);
CREATE TABLE
postgres=#
```

- `reading_id` : A unique identifier for each reading.
- `reading_time` : Sequential timestamps, perfect for BRIN indexing.
- `temperature` and `humidity` : Numeric values for our weather data.

Step 2: Insert 50 million rows

Now let's load the table with **50 million rows** of sequential data.

```
-- Insert 50M rows of sequential readings
INSERT INTO weather_data (reading_time, temperature, humidity)
SELECT
   NOW() - (g || ' seconds')::INTERVAL,   -- sequential timestamps
   (20 + random()*15)::NUMERIC(5,2),      -- temperature between 20-35
   (40 + random()*30)::NUMERIC(5,2)       -- humidity between 40-70
FROM generate_series(1, 50000000) AS g;
```

```
postgres=# -- Insert 50M rows of sequential readings
INSERT INTO weather_data (reading_time, temperature, humidity)
SELECT
   NOW() - (g || ' seconds')::INTERVAL,   -- sequential timestamps
   (20 + random()*15)::NUMERIC(5,2),      -- temperature between 20-35
   (40 + random()*30)::NUMERIC(5,2)       -- humidity between 40-70
FROM generate_series(1, 50000000) AS g;
INSERT 0 50000000
postgres=#
```

Here's what's happening:

- We generate 50M readings spaced one second apart.
- Each row has a random temperature (20–35°C) and humidity (40–70%).
- Since timestamps are sequential, PostgreSQL stores them in ordered **block ranges**, making BRIN a great fit.

Step 3: Run ANALYZE

```
ANALYZE weather_data;
```

```
postgres=# ANALYZE weather_data;
ANALYZE
postgres=#
```

This updates PostgreSQL statistics so the planner can make informed choices.

Step 4: Query without index

Now, let's query for data in a **1-day window** without any index.

```
postgres=# EXPLAIN ANALYZE
SELECT * FROM weather_data
WHERE reading_time BETWEEN '2024-01-01' AND '2024-01-02';
```

Output (simplified):

```
postgres=# EXPLAIN ANALYZE
SELECT * FROM weather_data
WHERE reading_time BETWEEN '2024-01-01' AND '2024-01-02';
                                                                QUER
-------------------------------------------------------------------------------
 Gather  (cost=1000.00..681148.90 rows=1 width=28) (actual time=26909.049..2691
   Workers Planned: 2
   Workers Launched: 2
```

```
      ->  Parallel Seq Scan on weather_data  (cost=0.00..680148.80 rows=1 width=28
            Filter: ((reading_time >= '2024-01-01 00:00:00'::timestamp without tim
            Rows Removed by Filter: 16666667
 Planning Time: 0.126 ms
 Execution Time: 26914.260 ms
(8 rows)

postgres=#
```

- PostgreSQL performs a **sequential scan** across all 50M rows.
- This takes around **26.914 seconds** because every row is checked.

Step 5: Create a BRIN index

Now, let's build a BRIN index on the `reading_time` column.

```
CREATE INDEX idx_weather_time_brin ON weather_data USING brin (reading_time);
```

```
postgres=# CREATE INDEX idx_weather_time_brin ON weather_data USING brin (readi
CREATE INDEX
postgres=#
```

- Unlike a B-Tree, this index stores **summaries of block ranges**, not individual row entries.
- This makes it **extremely lightweight**, even on massive datasets.

Run ANALYZE

```
ANALYZE weather_data;
```

```
postgres=# ANALYZE weather_data;
ANALYZE
postgres=#
```

This updates PostgreSQL statistics so the planner can make informed choices.

Step 6: Query with BRIN index

Let's run the same query again.

```
postgres=# EXPLAIN ANALYZE
SELECT * FROM weather_data
WHERE reading_time BETWEEN '2024-01-01' AND '2024-01-02';
```

Output (simplified):

```
postgres=# EXPLAIN ANALYZE
SELECT * FROM weather_data
WHERE reading_time BETWEEN '2024-01-01' AND '2024-01-02';
                                                                        QU
-------------------------------------------------------------------------------
 Bitmap Heap Scan on weather_data  (cost=50.03..57347.34 rows=1 width=28) (actu
   Recheck Cond: ((reading_time >= '2024-01-01 00:00:00'::timestamp without tim
   ->  Bitmap Index Scan on idx_weather_time_brin  (cost=0.00..50.03 rows=17403
```

```
          Index Cond: ((reading_time >= '2024-01-01 00:00:00'::timestamp without
 Planning Time: 0.155 ms
 Execution Time: 0.341 ms
(6 rows)

postgres=#
```

- PostgreSQL now uses the **BRIN index**.
- Instead of scanning all 50M rows, it jumps directly to block ranges likely containing the data.
- Execution time dropped from **26.914 seconds to 0.341 ms**.

That's nearly a 79,000x speed improvement with a very small index footprint.

Step 7: Compare index sizes

You can check the index size with:

```
postgres=# \di+ idx_weather_time_brin;
```

```
postgres=# \di+ idx_weather_time_brin;
                                                    List of relations
 Schema |          Name          | Type  |  Owner   |    Table     | Persistence
--------+------------------------+-------+----------+--------------+------------
 public | idx_weather_time_brin | index | postgres | weather_data | permanent
(1 row)

postgres=#
```

- For 50M rows, the BRIN index is typically **just a few MB**.
- A B-Tree index on the same column could easily take up **multiple GB**.

This makes BRIN especially attractive when working with **huge time-series or log tables.**

Why BRIN Works Well

- ✅ **Efficient for sequential data:** Time, IDs, or ordered values.
- ✅ **Compact:** Tiny footprint compared to B-Trees.
- ✅ **Fast to create and maintain:** Great for massive tables.
- ⚠️ **Not ideal for point lookups:** If you frequently search for a single exact value, B-Tree is better.

Final Thoughts

In PostgreSQL 17, **BRIN indexes remain a powerful choice for time-series and big-data workloads.** If your dataset is huge and your queries mostly involve ranges on sequential data, BRIN provides a near-perfect balance of speed and efficiency.

Instead of letting your indexes consume gigabytes of storage, try BRIN — a small index that delivers big performance improvements. 🚀

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Quite insightful

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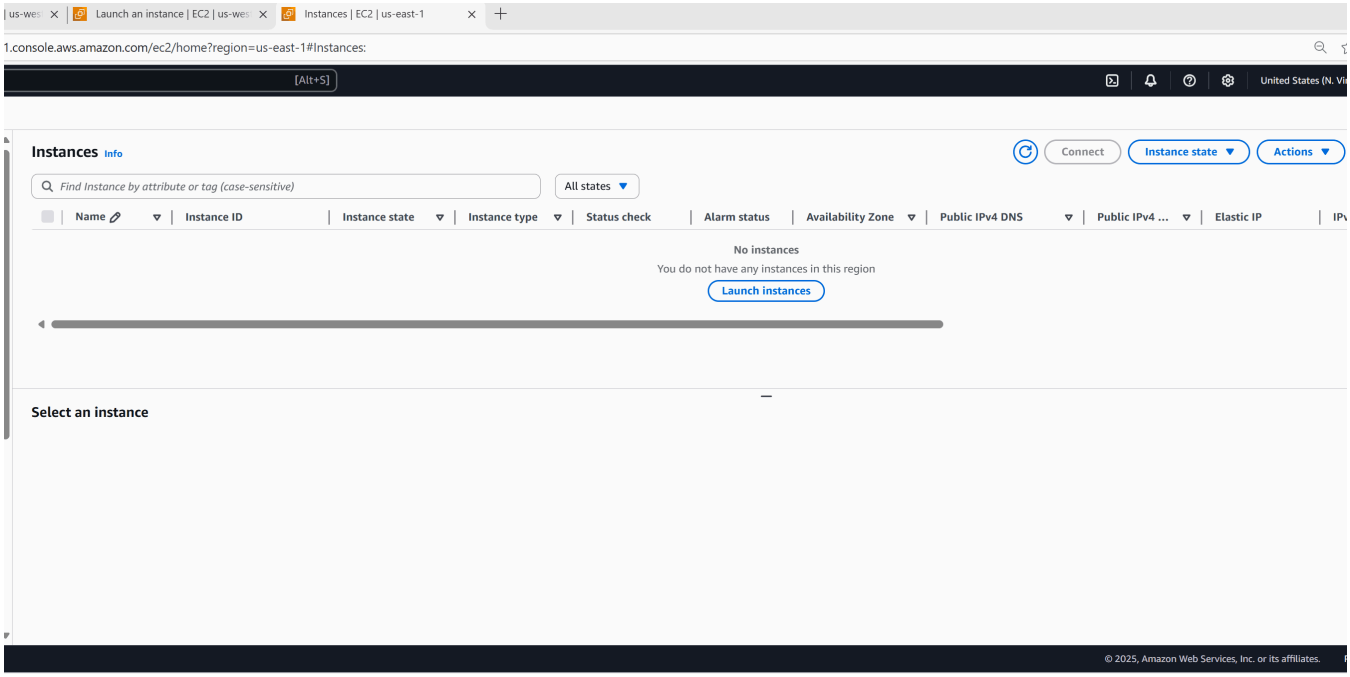

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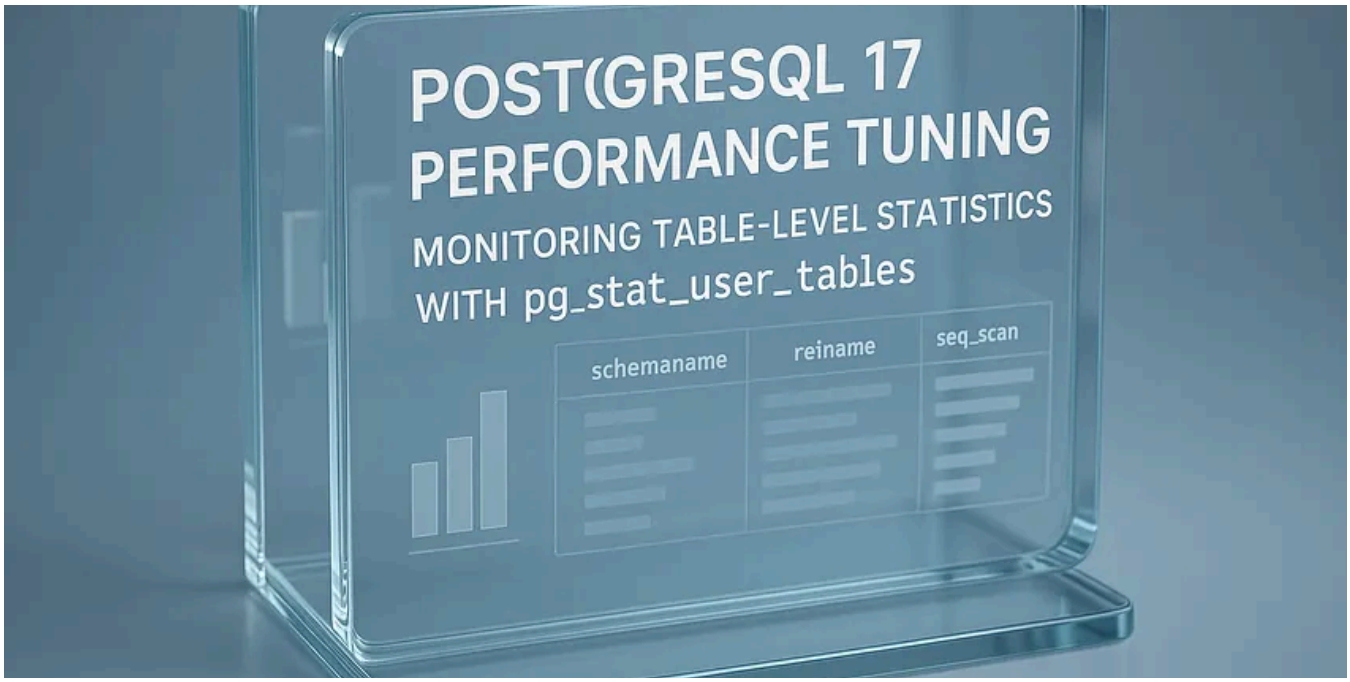

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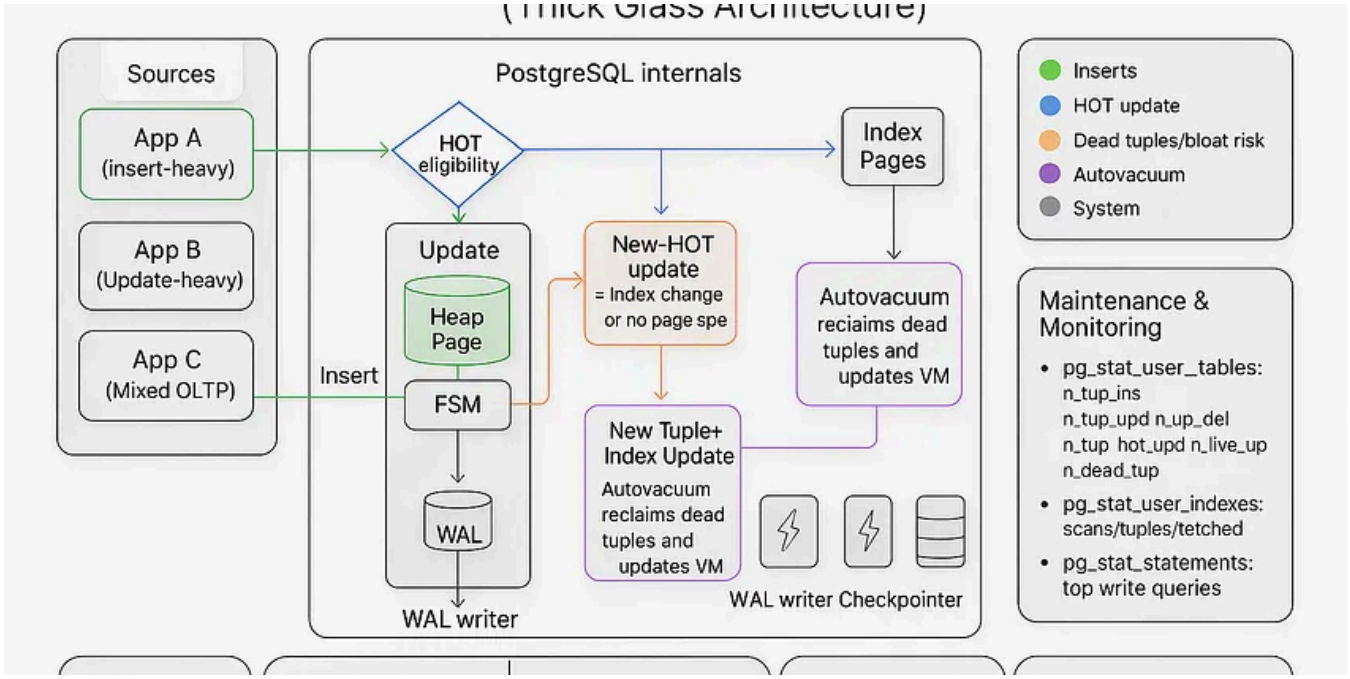

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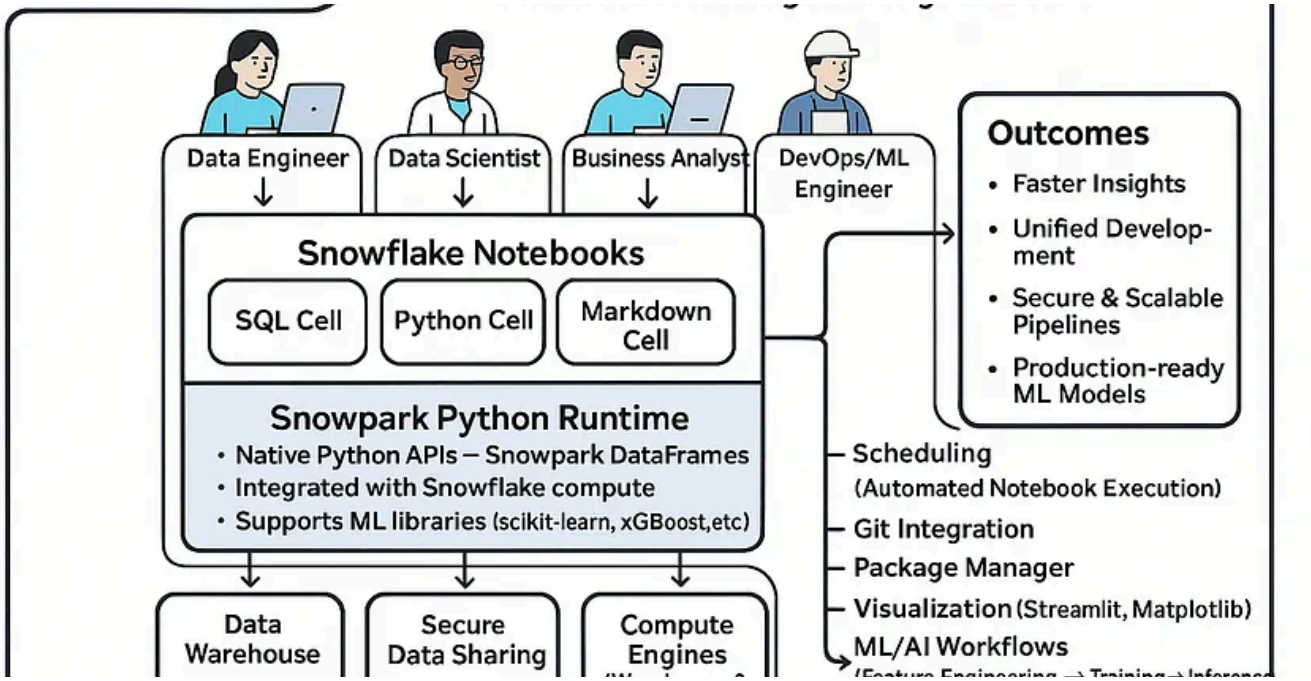

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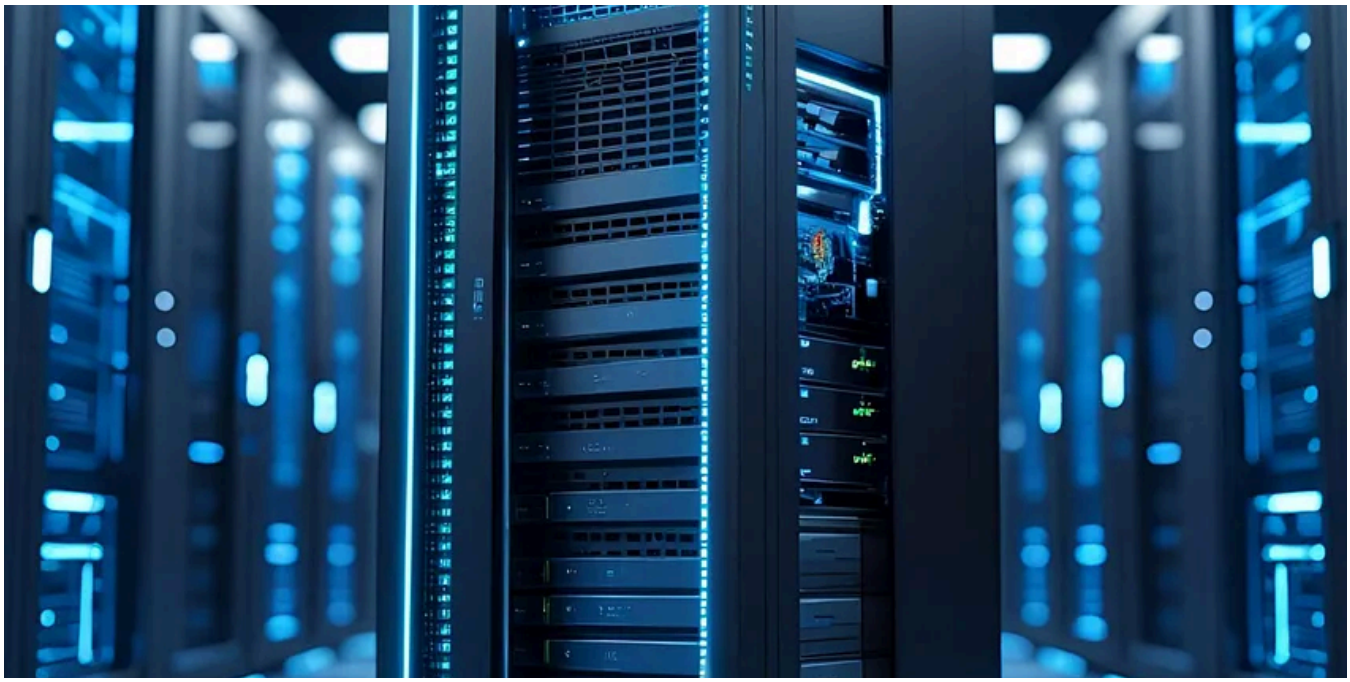

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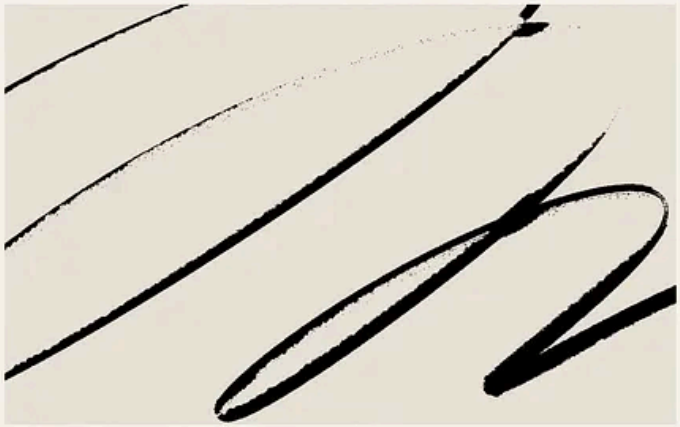

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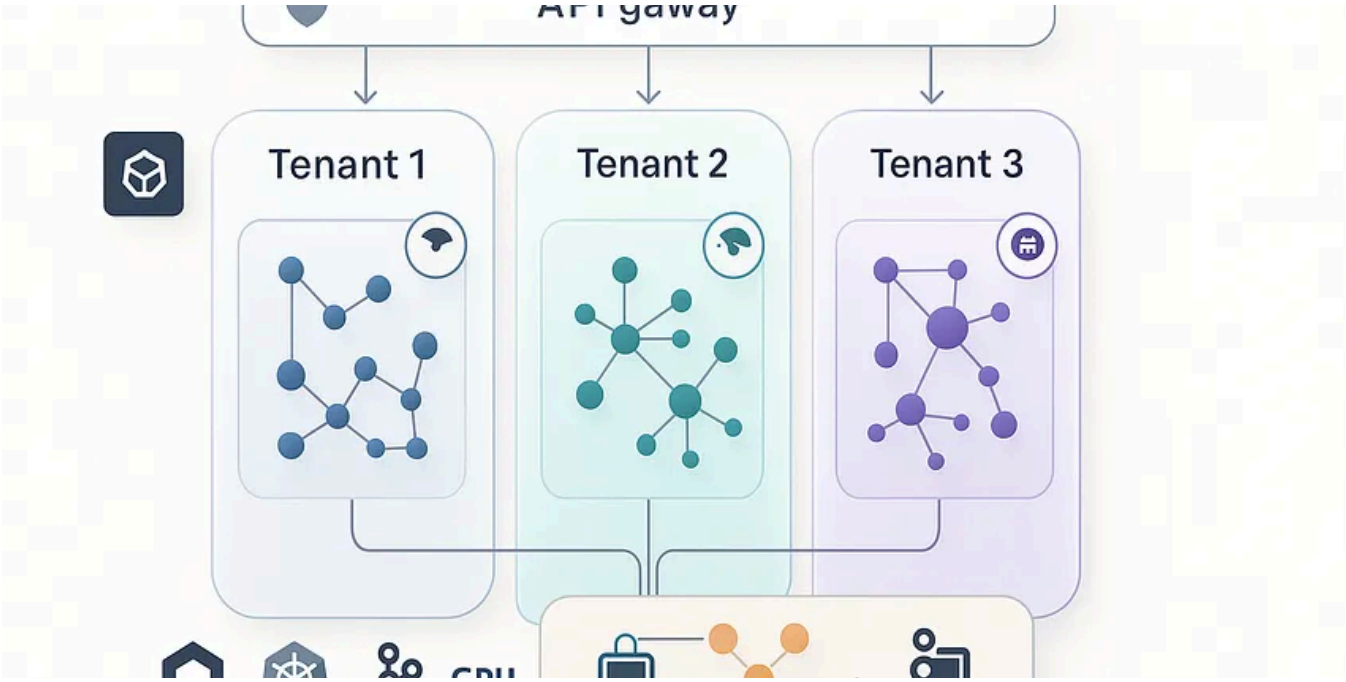

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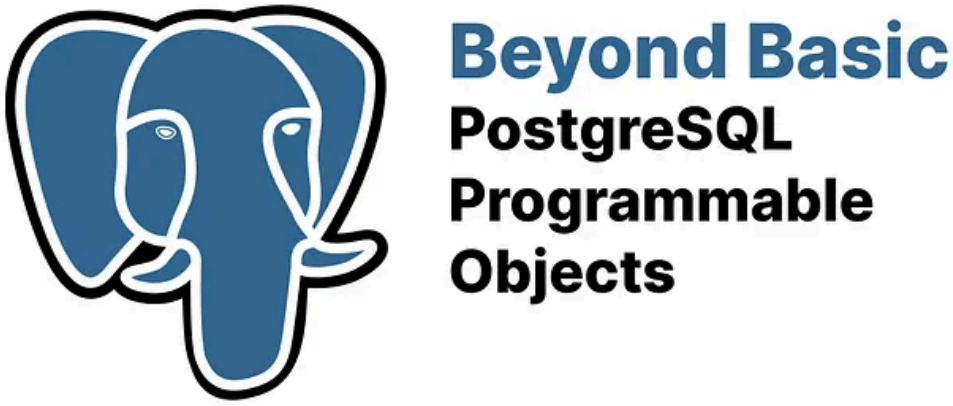

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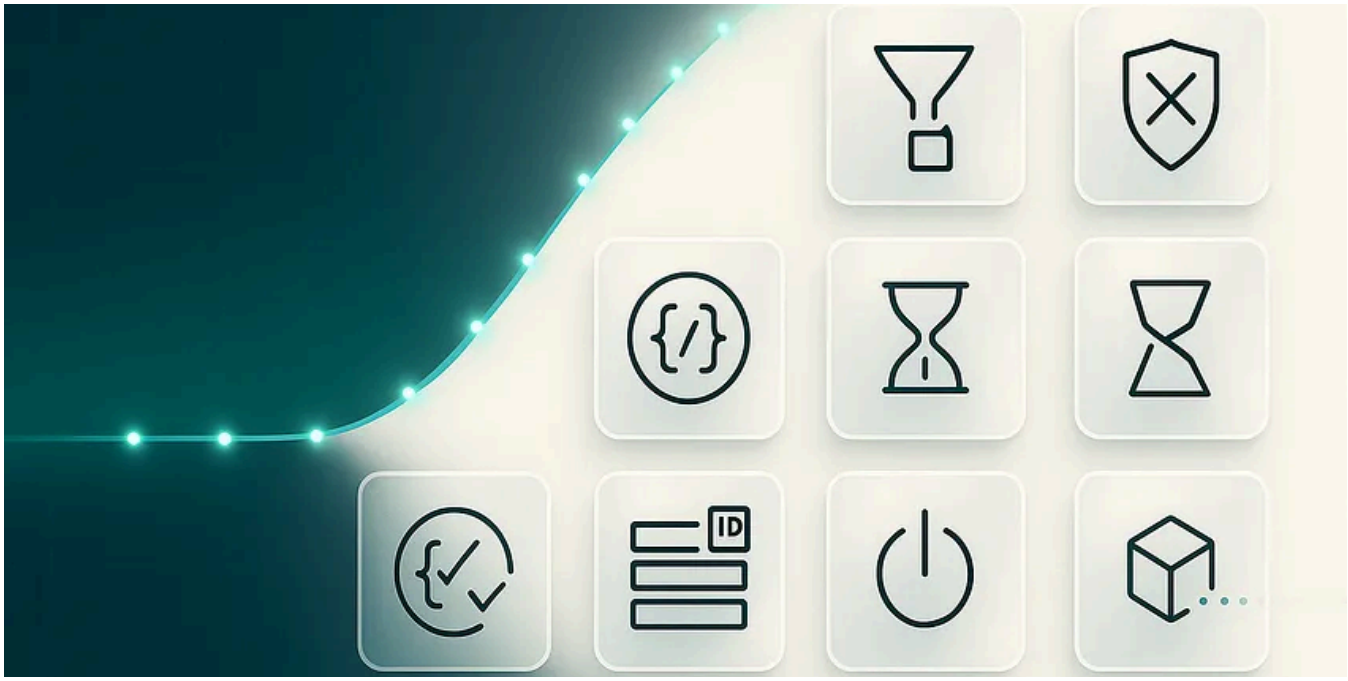

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