16 -PostgreSQL 17 Performance Tuning: Why Foreign Keys Need Indexes

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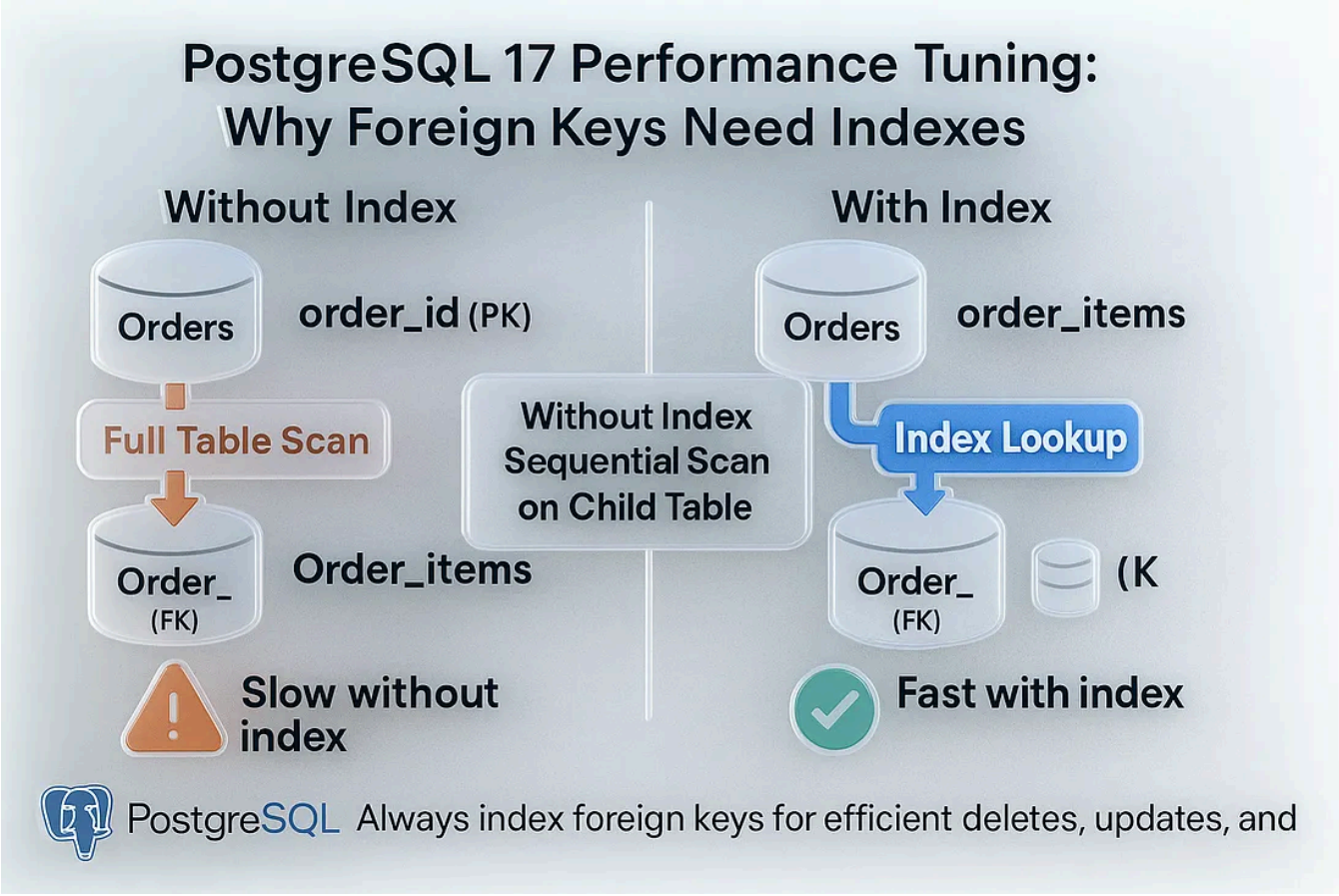
Jeyaram Ayyalusamy Following



When designing relational databases, parent-child relationships are common. A classic case is the **Orders** table (parent) and the **Items** table (child). Each order can have many items, so the child table typically has far more rows than the parent.

👉 In such cases, it's always a good practice to create an index on the **foreign key column** in the child table.

There are two main reasons:

1. **Faster joins** → Queries joining parent and child tables almost always join on the foreign key. An index dramatically speeds this up.
2. **Faster parent changes** → When deleting or updating parent rows, PostgreSQL must check child rows for constraint enforcement. Without an index, these checks can be painfully slow.

Let's build a demo to see the impact.

Step 1: Create Parent and Child Tables

```
-- Parent table: Orders
CREATE TABLE orders (
    order_no   SERIAL PRIMARY KEY,
    order_date DATE DEFAULT CURRENT_DATE
);
```

```
postgres=# -- Parent table: Orders
CREATE TABLE orders (
    order_no   SERIAL PRIMARY KEY,
    order_date DATE DEFAULT CURRENT_DATE
);
CREATE TABLE
postgres=#
```

```
-- Child table: Items
CREATE TABLE items (
```

```
    item_no       SERIAL PRIMARY KEY,
    order_no      INT,
    product_name  TEXT,
    description   TEXT,
    created_at    TIMESTAMP DEFAULT now(),
    CONSTRAINT fk_order FOREIGN KEY (order_no)
        REFERENCES orders(order_no)
        ON UPDATE CASCADE
        ON DELETE CASCADE
);
```

```
postgres=# -- Child table: Items
CREATE TABLE items (
    item_no       SERIAL PRIMARY KEY,
    order_no      INT,
    product_name  TEXT,
    description   TEXT,
    created_at    TIMESTAMP DEFAULT now(),
    CONSTRAINT fk_order FOREIGN KEY (order_no)
        REFERENCES orders(order_no)
        ON UPDATE CASCADE
        ON DELETE CASCADE
);
CREATE TABLE
postgres=#
```

Step 2: Populate Tables with Data

We'll insert **1 million rows** into `orders` and **3 million rows** into `items` (4 items per order).

```
-- Insert 1M orders
INSERT INTO orders (order_no)
SELECT g FROM generate_series(1, 1000000) g;
```

```
postgres=# -- Insert 1M orders
INSERT INTO orders (order_no)
SELECT g FROM generate_series(1, 1000000) g;
INSERT 0 1000000
postgres=#
```

```
-- Insert 3M items (4 per order)
INSERT INTO items (order_no, product_name, description)
SELECT (g/4)+1, 'Product_' || g, 'Desc_' || g
FROM generate_series(1, 3000000) g;
```

```
postgres=# -- Insert 3M items (4 per order)
INSERT INTO items (order_no, product_name, description)
SELECT (g/4)+1, 'Product_' || g, 'Desc_' || g
FROM generate_series(1, 3000000) g;
INSERT 0 3000000
postgres=#
```

👉 Now:

- `orders` has 1M rows.
- `items` has 3M rows linked by the foreign key.

Step 3: Query Without Index on Foreign Key

Let's try a join query:

```
\timing
SELECT *
FROM orders o
JOIN items i ON o.order_no = i.order_no
WHERE o.order_no = 120;
```

```
postgres=# \timing
Timing is on.
postgres=#
postgres=# SELECT *
FROM orders o
JOIN items i ON o.order_no = i.order_no
WHERE o.order_no = 120;
 order_no | order_date | item_no  | order_no | product_name | description |
----------+------------+----------+----------+--------------+-------------+----
      120 | 2025-09-02 | 12000476 |      120 | Product_476  | Desc_476    | 202
      120 | 2025-09-02 | 12000477 |      120 | Product_477  | Desc_477    | 202
      120 | 2025-09-02 | 12000478 |      120 | Product_478  | Desc_478    | 202
      120 | 2025-09-02 | 12000479 |      120 | Product_479  | Desc_479    | 202
(4 rows)

Time: 194.021 ms
postgres=#
```

Result:

- PostgreSQL performs a **sequential scan** on the `items` table (4 million rows) to find just 4 matches.
- Execution is slow.

Check the plan:

```
EXPLAIN ANALYZE
SELECT *
FROM orders o
JOIN items i ON o.order_no = i.order_no
WHERE o.order_no = 120;
```

```
postgres=# EXPLAIN ANALYZE
SELECT *
FROM orders o
JOIN items i ON o.order_no = i.order_no
WHERE o.order_no = 120;
                                                              QUERY PLAN
---------------------------------------------------------------------------------------
 Nested Loop  (cost=1000.42..44661.88 rows=4 width=51) (actual time=0.249..198.
   ->  Index Scan using orders_pkey on orders o  (cost=0.42..8.44 rows=1 width=
         Index Cond: (order_no = 120)
   ->  Gather  (cost=1000.00..44653.40 rows=4 width=43) (actual time=0.230..198
         Workers Planned: 2
         Workers Launched: 2
         ->  Parallel Seq Scan on items i  (cost=0.00..43653.00 rows=2 width=43
               Filter: (order_no = 120)
               Rows Removed by Filter: 999999
 Planning Time: 0.105 ms
 Execution Time: 198.853 ms
(11 rows)

Time: 200.196 ms
postgres=#
```

👉 You'll see a **Seq Scan on items**, which is inefficient.

Step 4: Add Index on the Foreign Key Column

Now add an index:

```
CREATE INDEX idx_items_order_no ON items(order_no);
```

```
postgres=# CREATE INDEX idx_items_order_no ON items(order_no);
CREATE INDEX
postgres=#
```

Step 5: Query With Index

Run the same query again:

```
EXPLAIN ANALYZE
SELECT *
FROM orders o
JOIN items i ON o.order_no = i.order_no
WHERE o.order_no = 120;
```

```
postgres=# EXPLAIN ANALYZE
SELECT *
FROM orders o
JOIN items i ON o.order_no = i.order_no
WHERE o.order_no = 120;
                                                          QUERY PLAN
------------------------------------------------------------------------------
 Nested Loop  (cost=0.85..16.98 rows=4 width=51) (actual time=0.030..0.041 rows
   ->  Index Scan using orders_pkey on orders o  (cost=0.42..8.44 rows=1 width=
         Index Cond: (order_no = 120)
   ->  Index Scan using idx_items_order_no on items i  (cost=0.43..8.50 rows=4
```

```
          Index Cond: (order_no = 120)
 Planning Time: 0.091 ms
 Execution Time: 0.060 ms
(7 rows)

Time: 0.442 ms
postgres=#
```

Result:

- PostgreSQL switches to an **Index Scan on items.**
- The query time drops dramatically.

👉 Instead of scanning 3M rows, it jumps directly to the 4 matching rows.

Step 6: Parent Delete Performance

Indexes also help when deleting from the parent:

```
DELETE FROM orders WHERE order_no = 500;
```

```
postgres=# DELETE FROM orders WHERE order_no = 500;
DELETE 1
Time: 4.355 ms
postgres=#
```

- Without an index on `items.order_no`, PostgreSQL must scan the entire `items` table to check for child rows.
- With the index, it can instantly find and remove matching rows.

Key Takeaways

- Always **index foreign key columns** in child tables.
- Benefits:
- **Joins are faster** (avoid sequential scans).
- **Parent updates/deletes are efficient** (quick referential checks).
- Without indexes, queries and deletes on large parent-child datasets can degrade to **full-table scans**, crippling performance.

✅ In PostgreSQL 17, just as in earlier versions, indexing foreign keys is one of the simplest yet most impactful tuning steps for real-world workloads.

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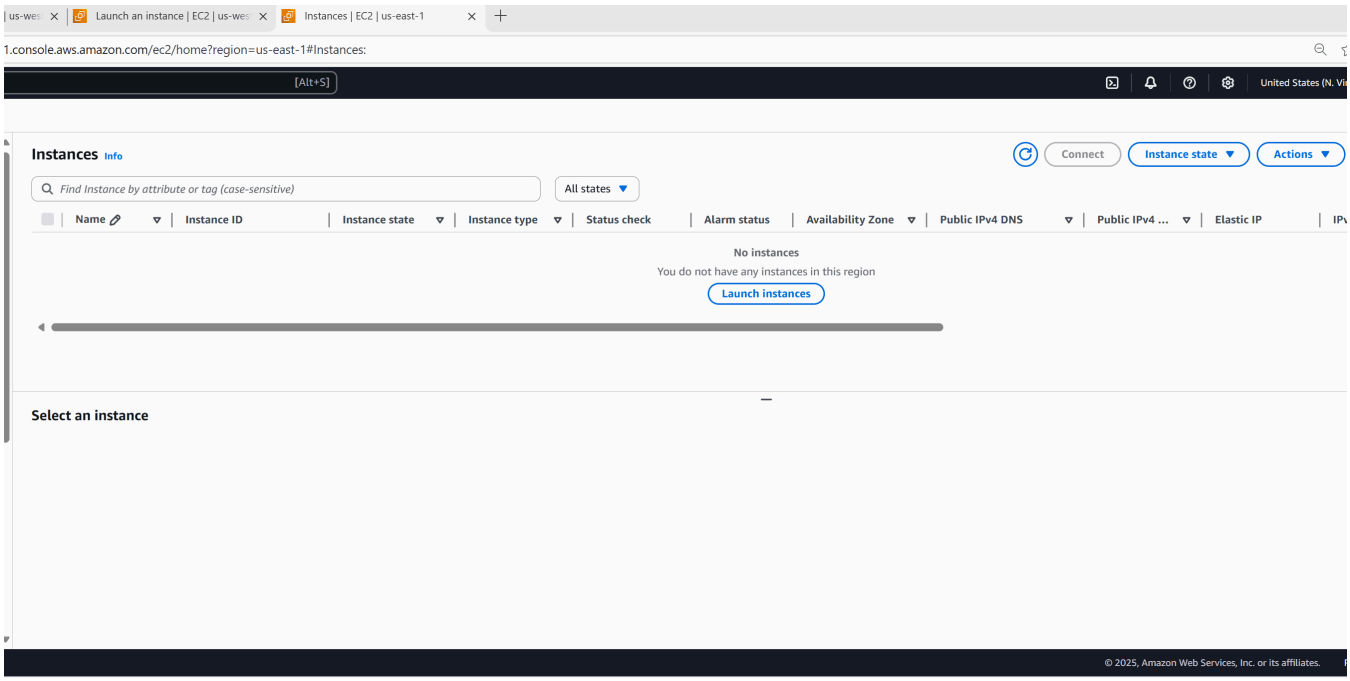

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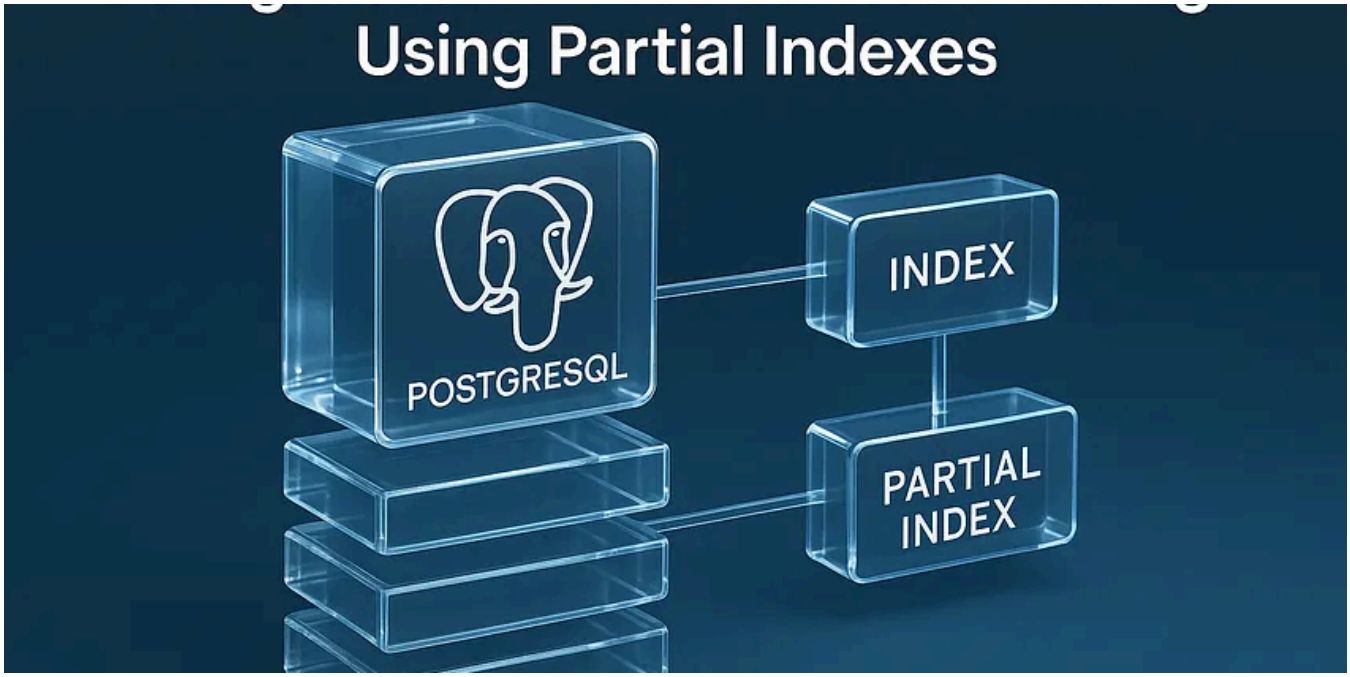

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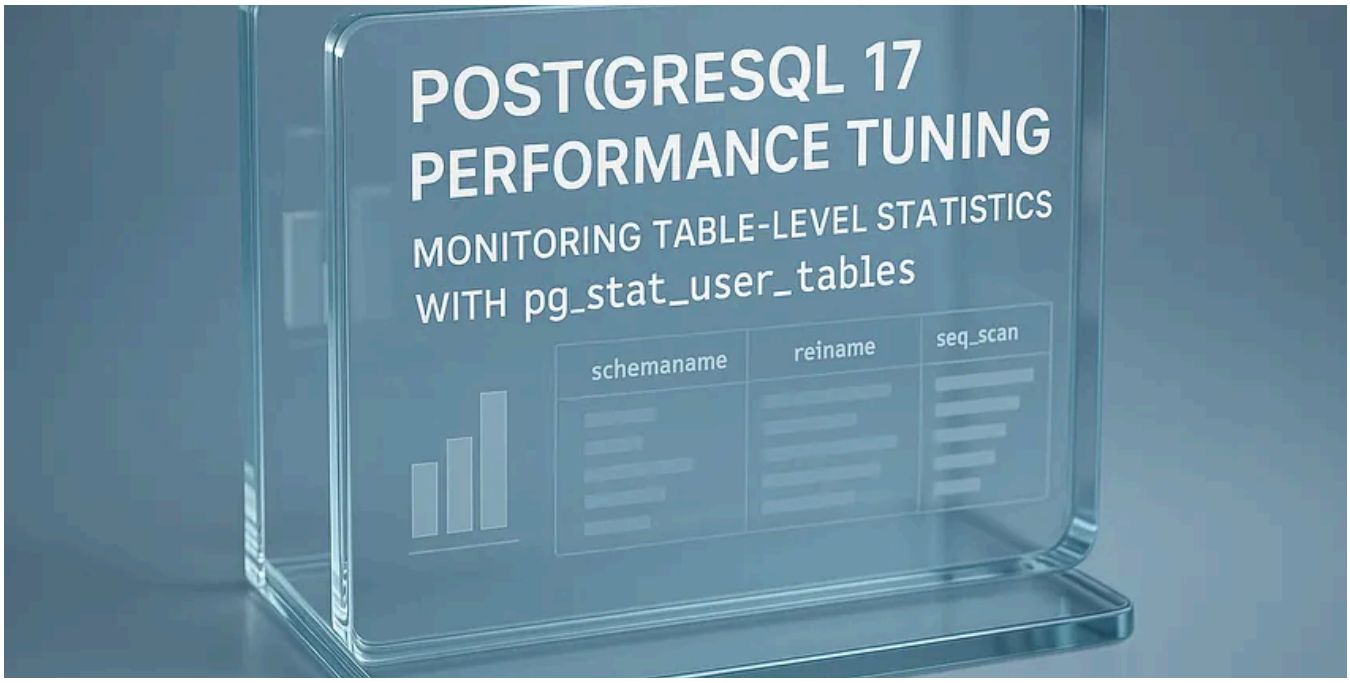

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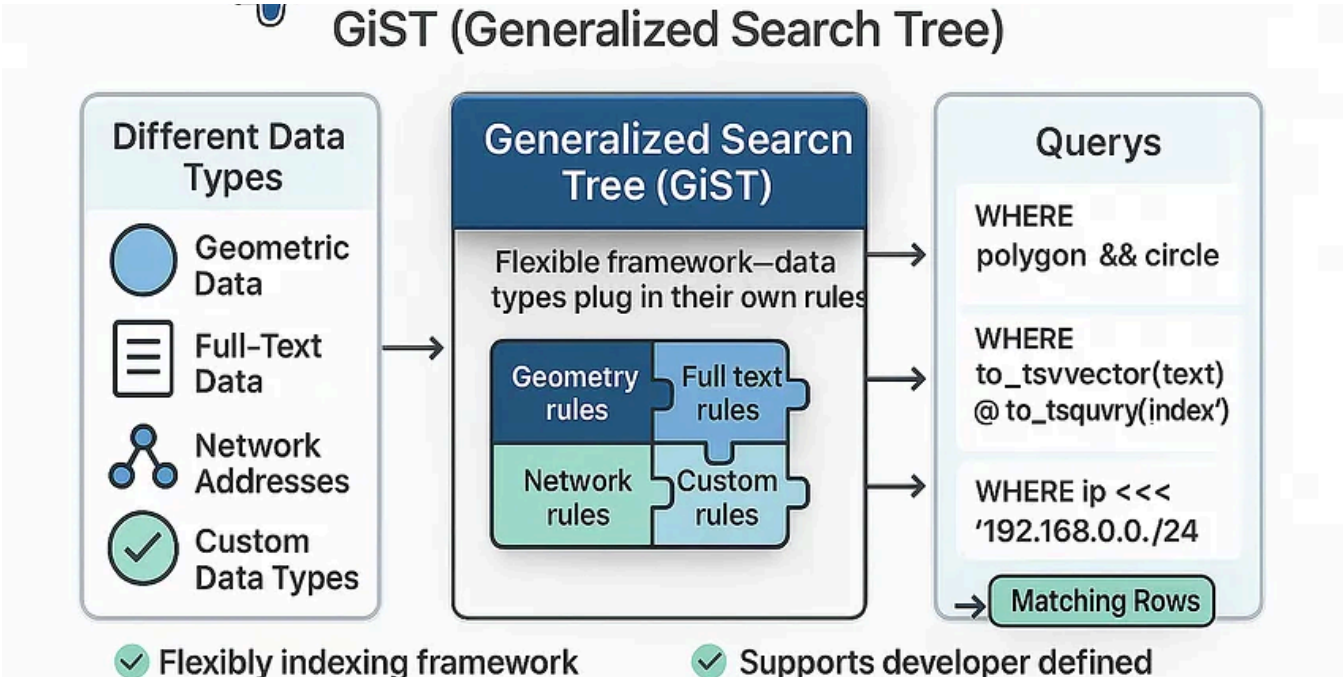

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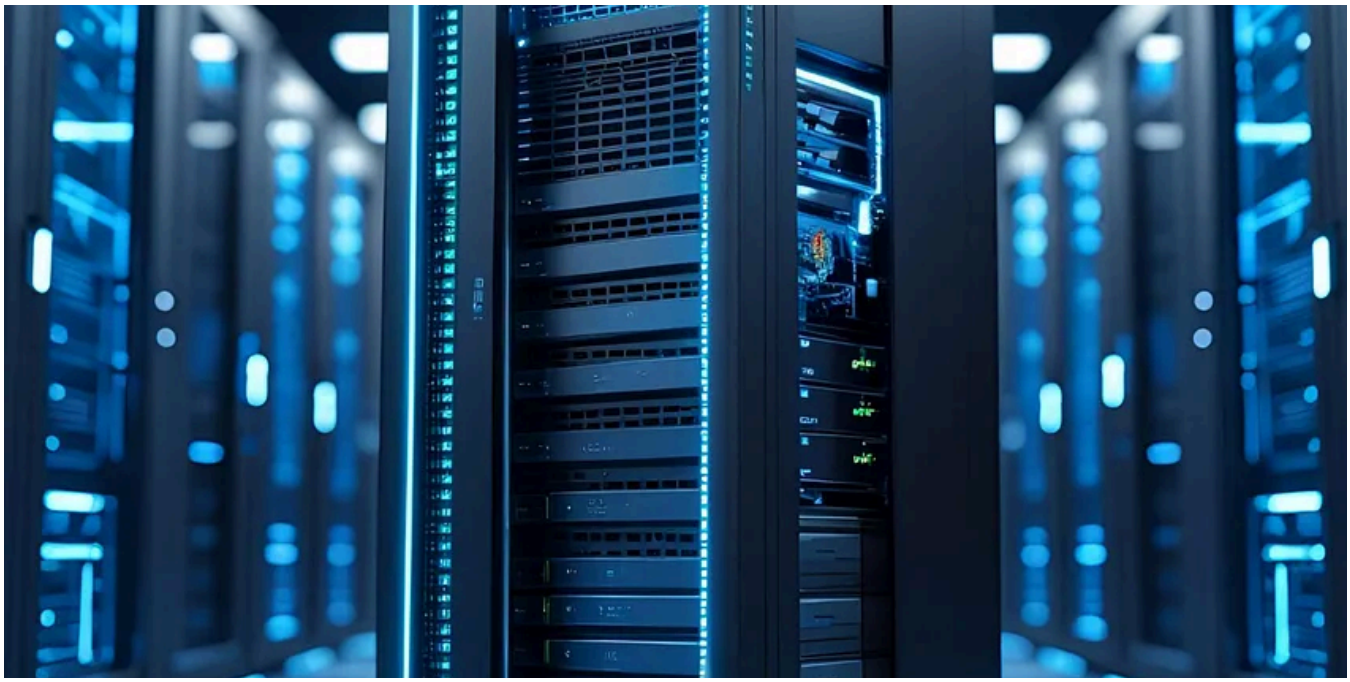

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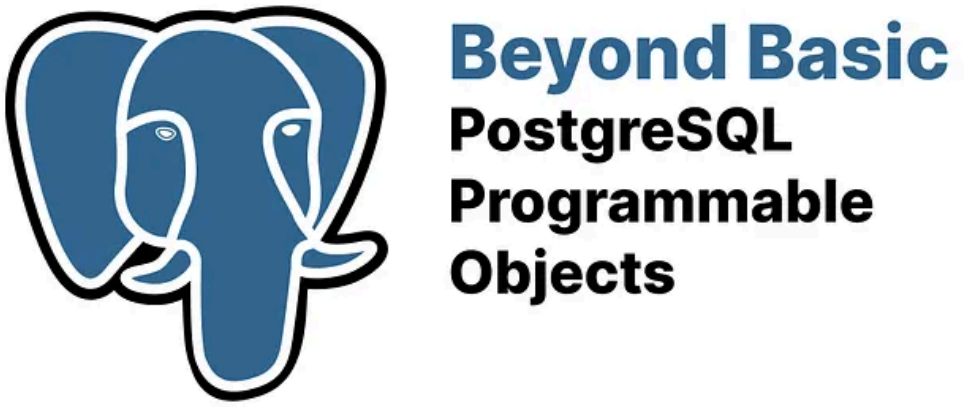

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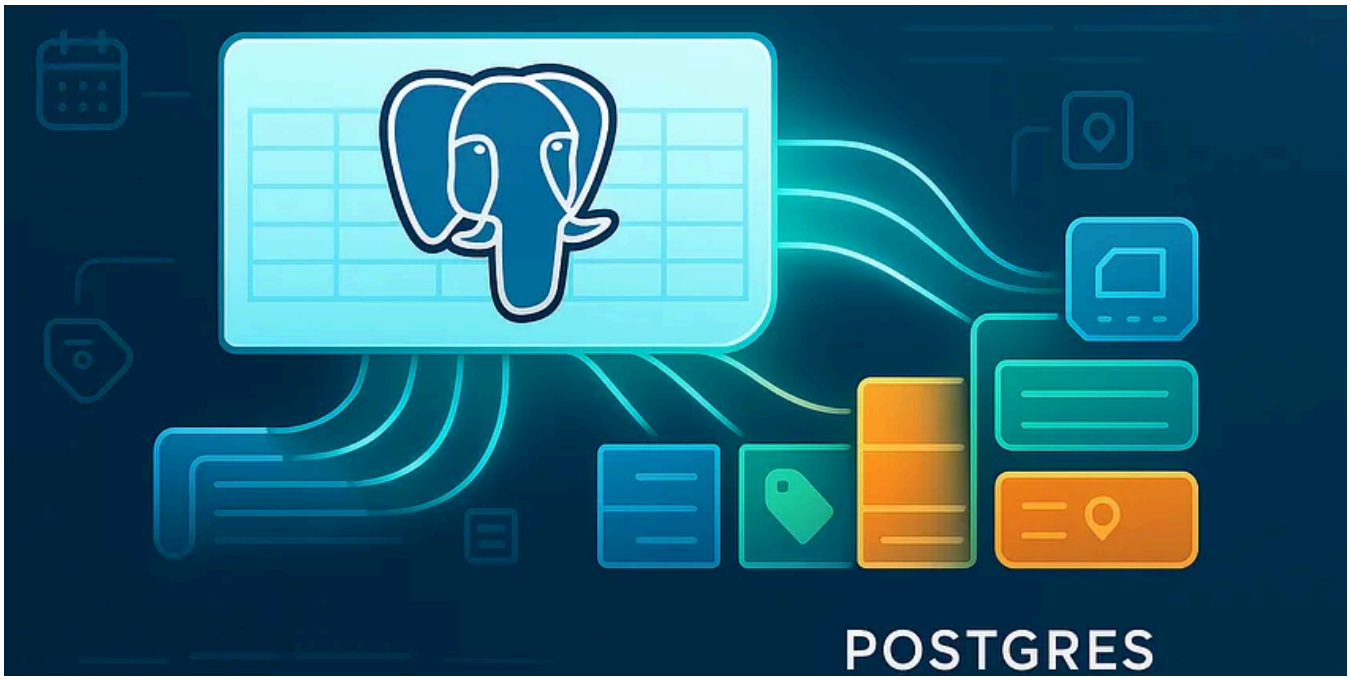

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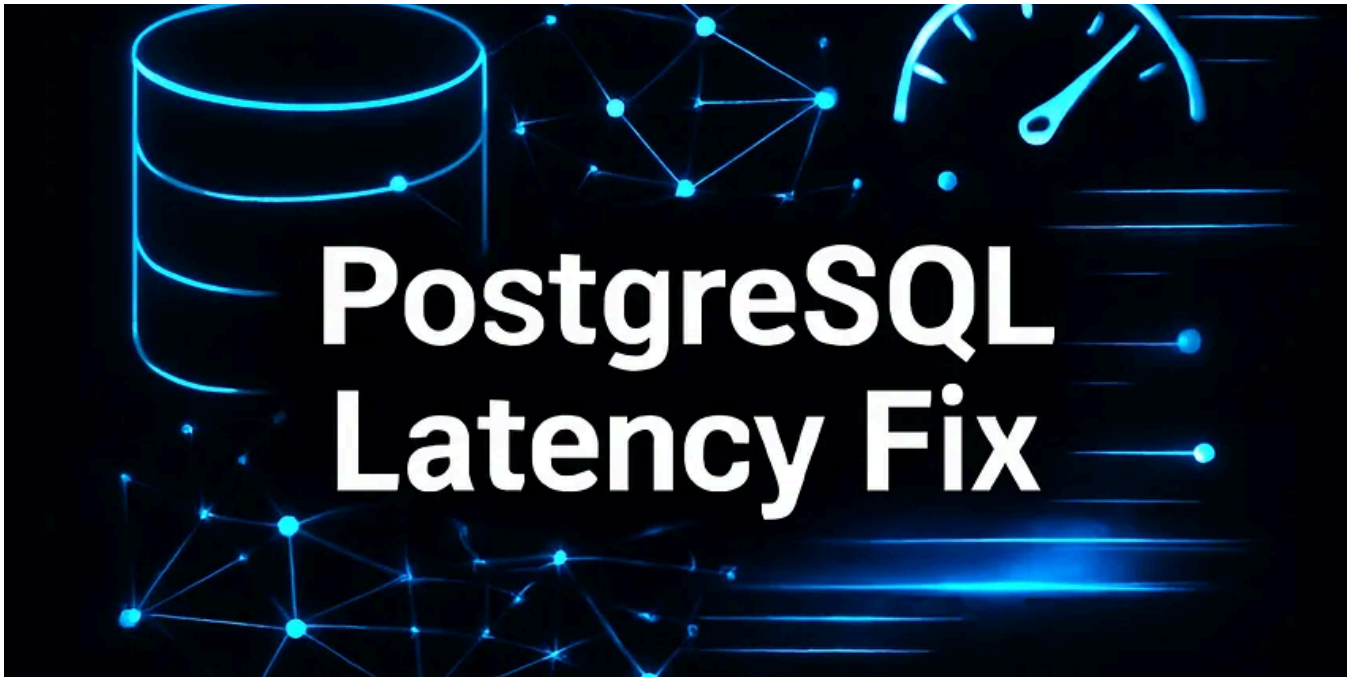

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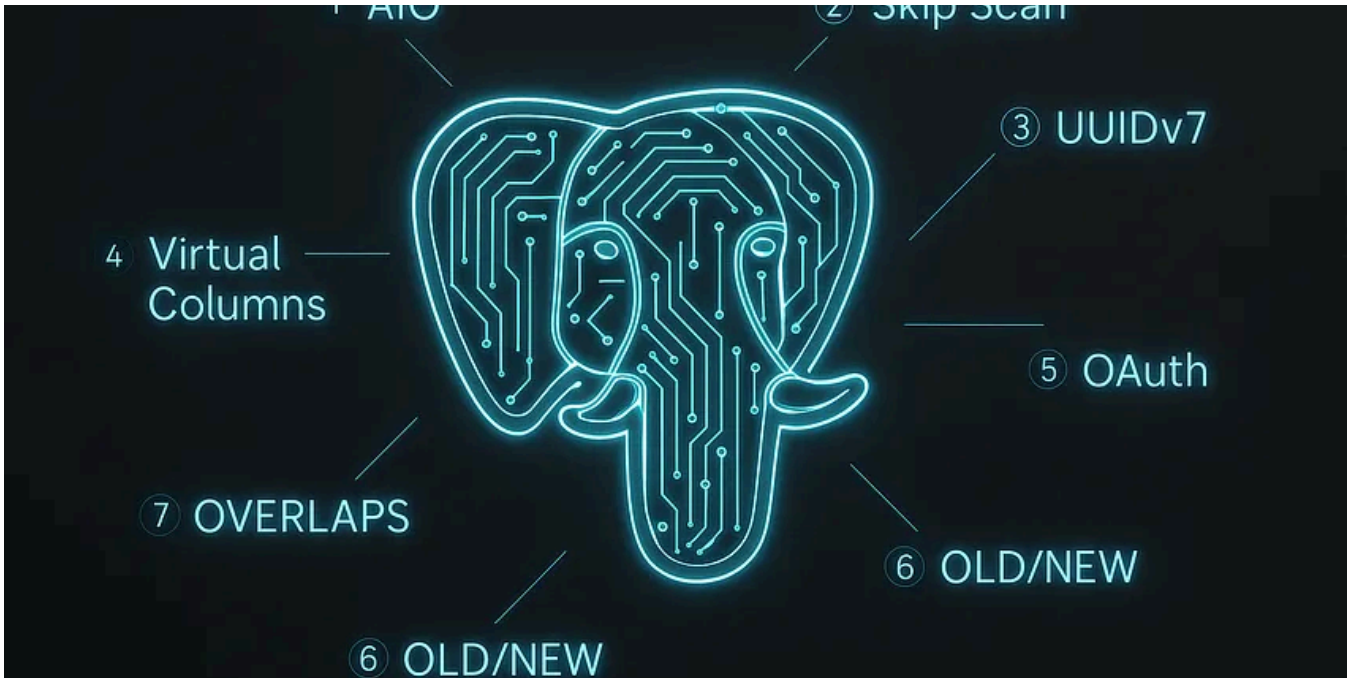

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