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THE TRUTH ABOUT PARTITIONS

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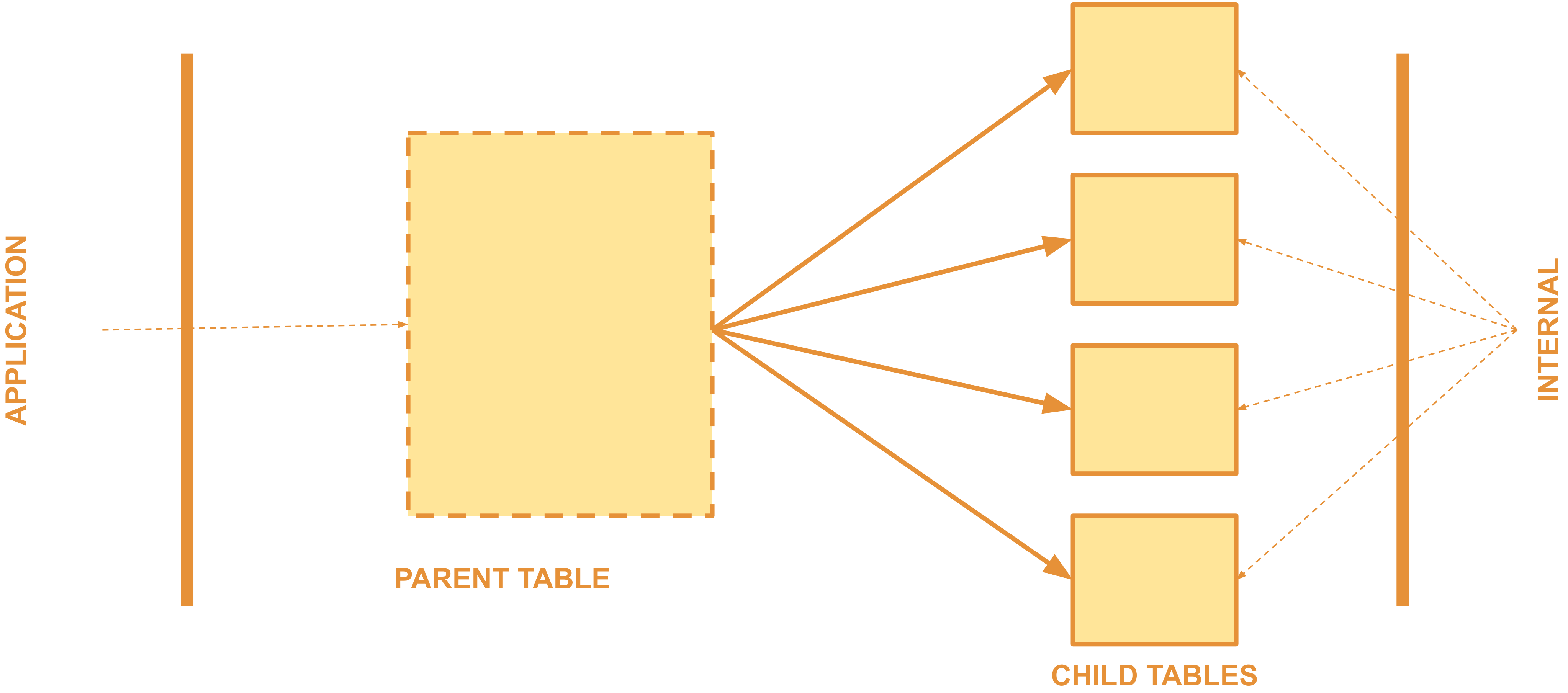
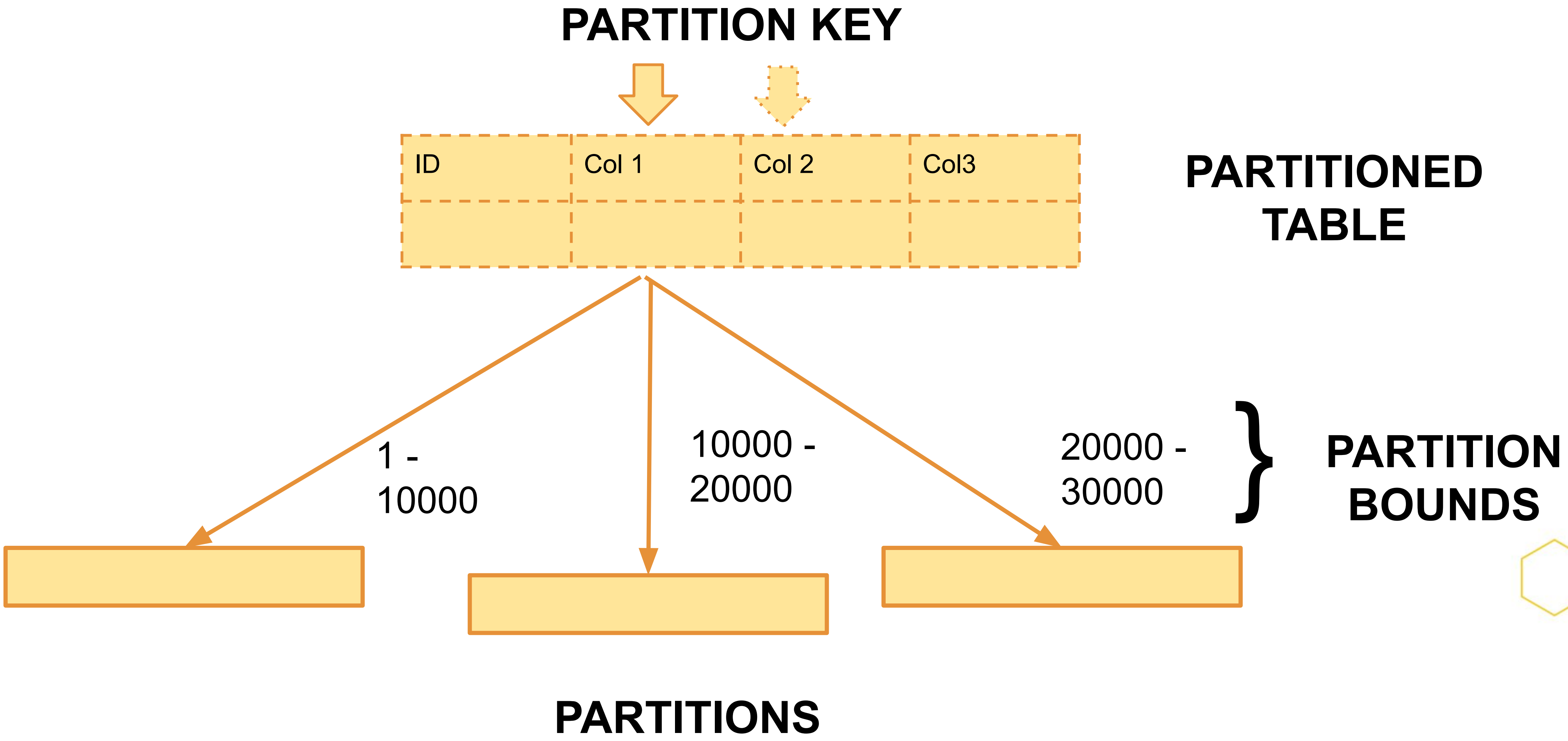
INTRODUCTION

- **What** is Partitioning?
- Key Terms
- Partitioning Benefits

What is Partitioning?

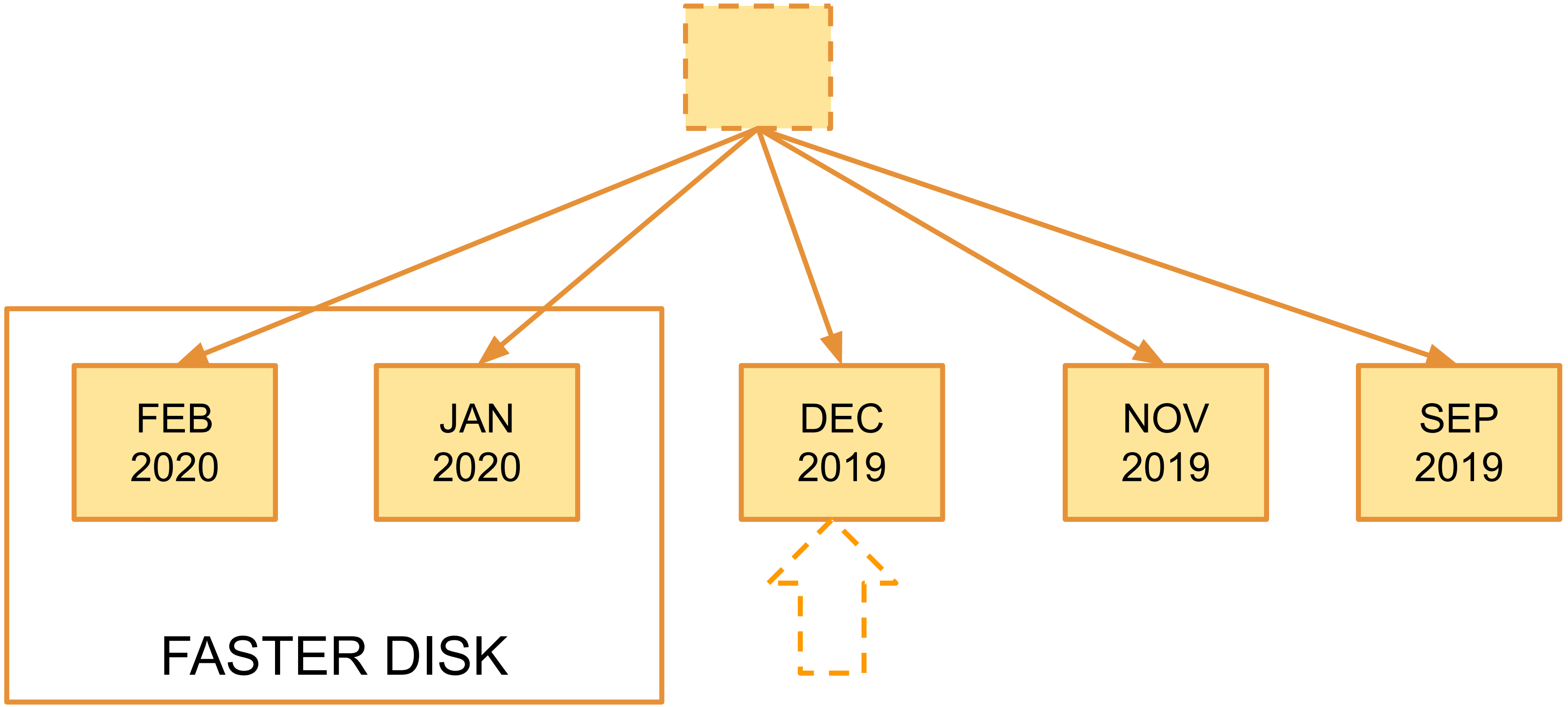


Key Terms


PARTITION KEY
ID
Col 1
Col 2
Col3
PARTITIONED TABLE
1 - 10000
10000 - 20000
20000 - 30000
PARTITION BOUNDS
PARTITIONS

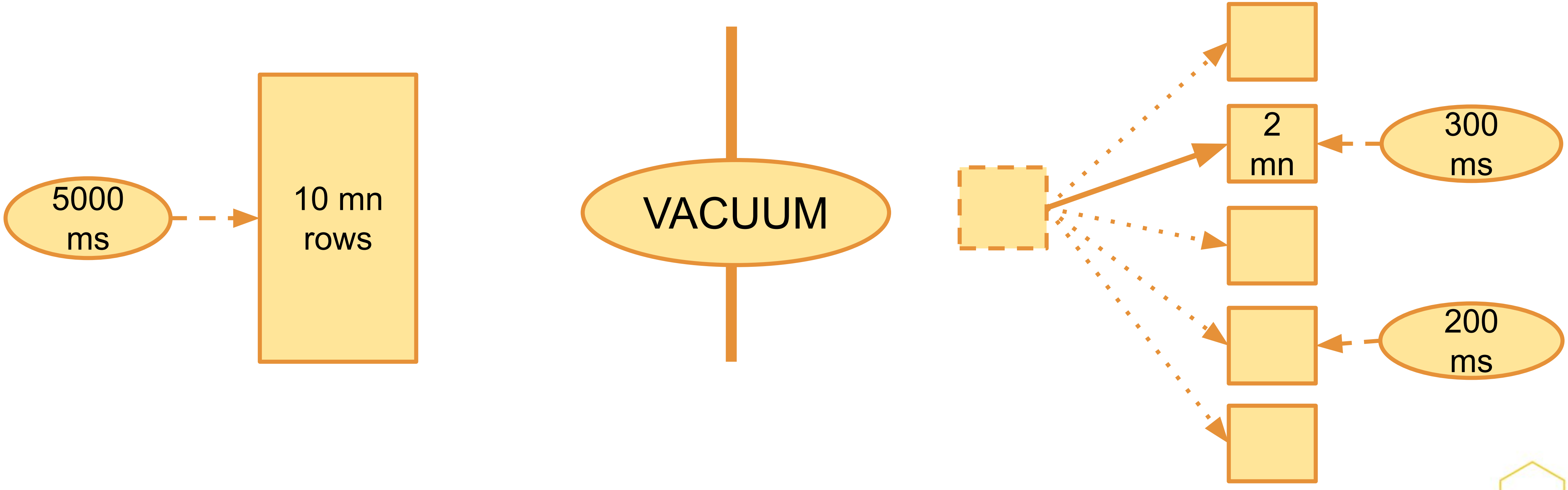
Partitioning Benefits

Data Segregation



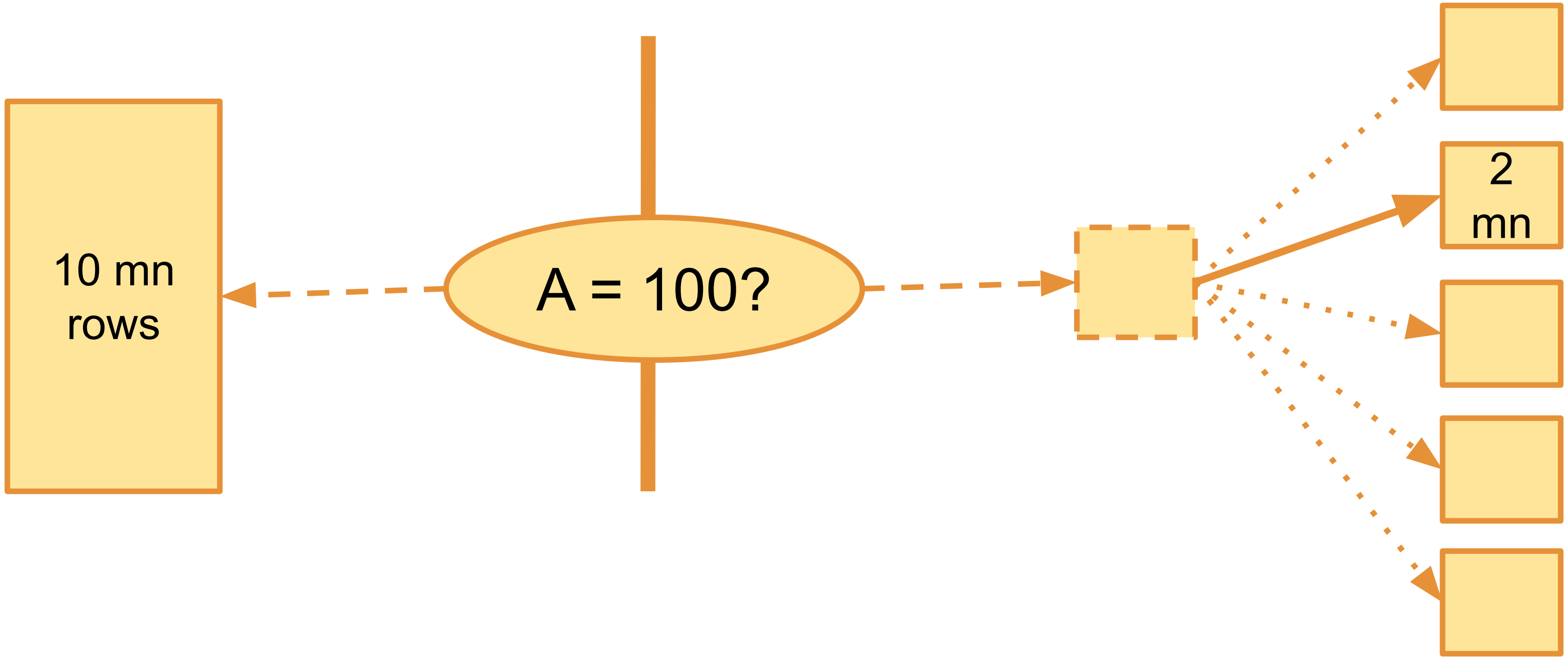
Partitioning Benefits

Maintenance



Partitioning Benefits

Performance / Scalability



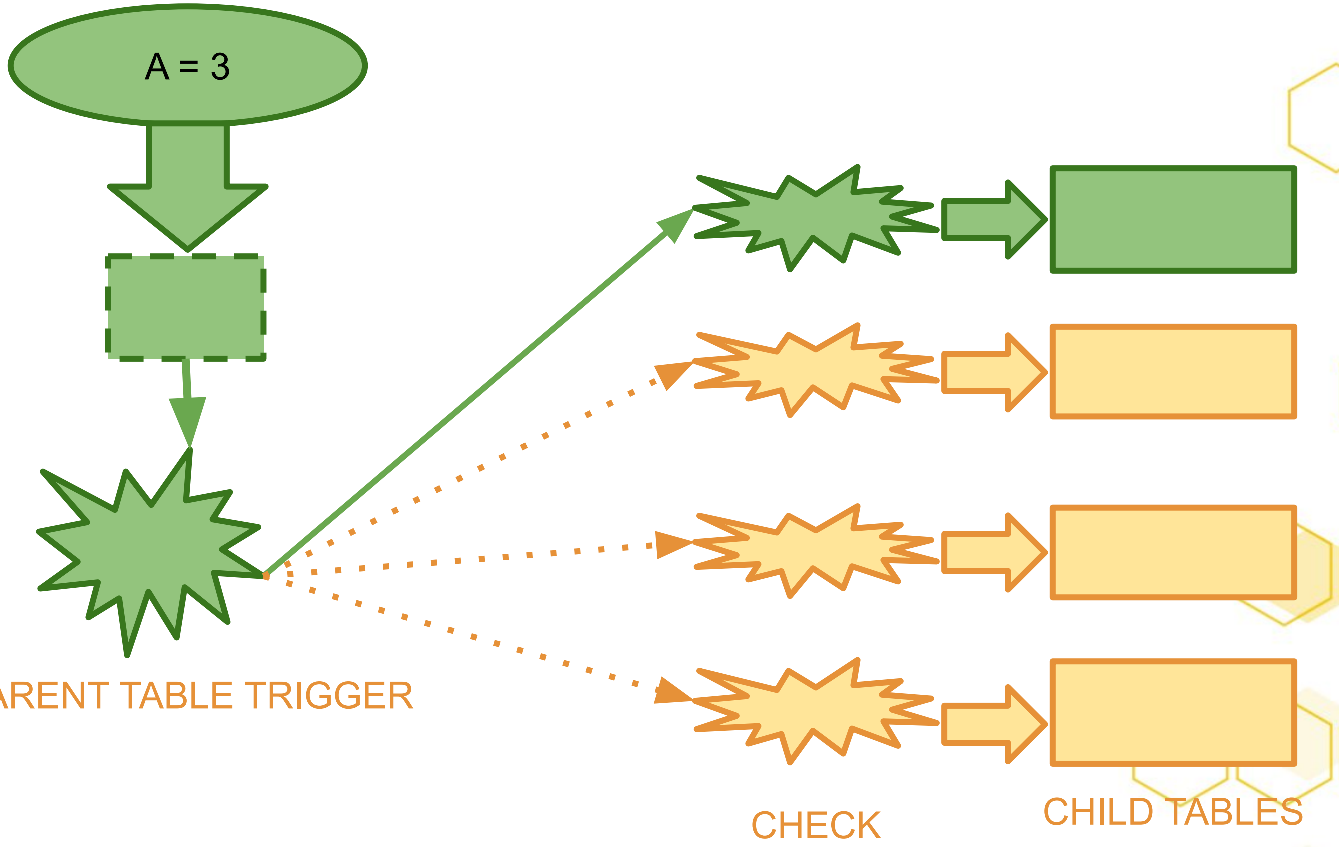
Scanning smaller tables can take less time.

STYLE OF PARTITIONING IN POSTGRESQL

- Inheritance (Trigger- based) Partition
- Declarative Partitioning

Inheritance (Trigger-Based) Partitions

- Manual
- Error-prone
- Constraints not mutually exclusive
- Hard to maintain partitions



Declarative Partitioning

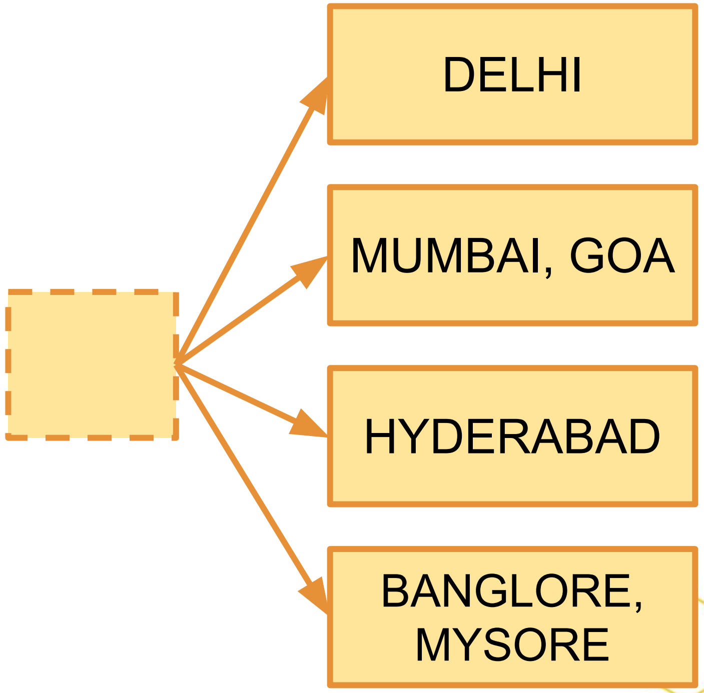
- PostgreSQL 10
- Automated - No manual handling of triggers.
- Simpler syntax
- Easy management of partitions

PARTITIONING STRATEGIES

- List
- Range
- Hash

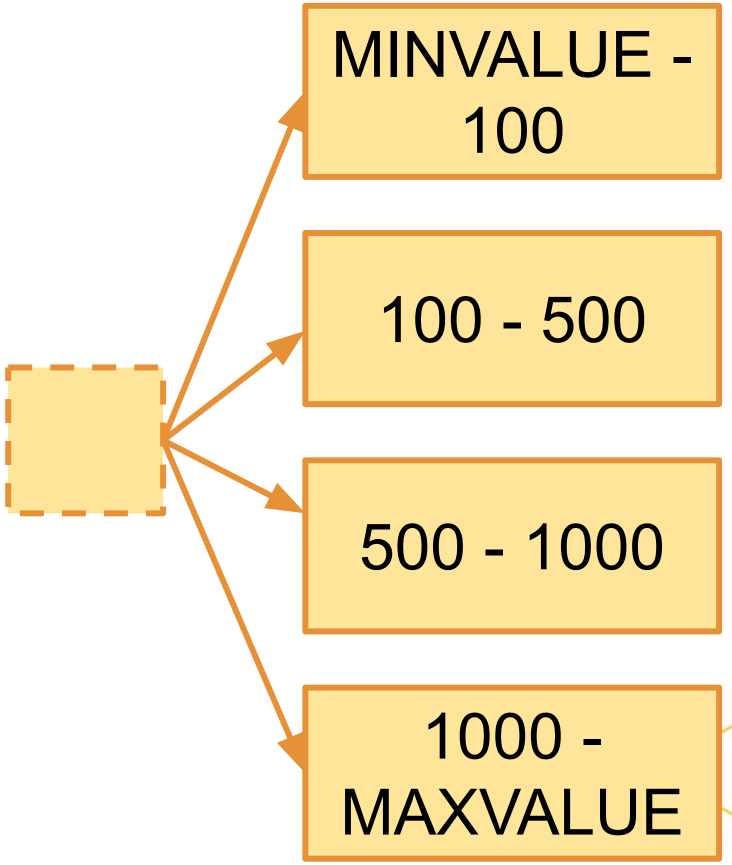
List Partitioning

- PostgreSQL 10
- Explicitly mention values for partition key - single or multiple



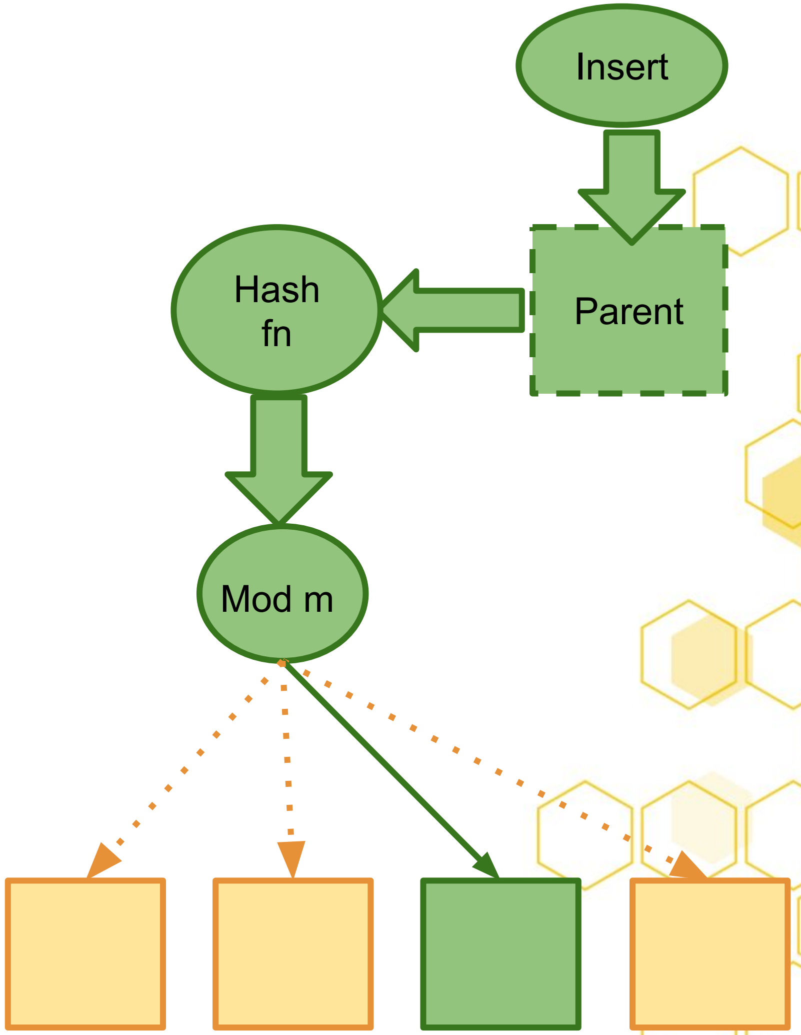
Range Partitioning

- PostgreSQL 10
- Range boundaries
  - Lower inclusive (>=)
  - Upper exclusive (<)
- Unbounded values
  - MINVALUE
  - MAXVALUE



Hash Partitioning

- PostgreSQL 11
- Specify modulus and remainder
  - Modulus - non-zero positive integer
  - Remainder - non-negative integer
  - remainder < modulus
- Rows spread on hash value of the partition key



DECLARATIVE PARTITIONING SYNTAX

- Create partitioned table
- Create partitions
- Add a partition
- Remove a partition

Create Partitioned Table

```
CREATE TABLE parent ( <col list > )
   PARTITION BY <strategy> ( <partition key> );
```

List:

```
CREATE TABLE plist(id int, col1 varchar)
   PARTITION BY LIST (col1);
```

Range:

```
CREATE TABLE prange(id int, col1 int, col2 int)
   PARTITION BY RANGE (col1);
```

Hash:

```
CREATE TABLE phash(id int, col1 int, col2 int)
   PARTITION BY HASH (col1);
```

Create Partitions

```
CREATE TABLE child PARTITION OF parent
    FOR VALUES <partition bounds>
```

List:

```
CREATE TABLE clist PARTITION OF plist
    FOR VALUES IN ('CHENNAI', 'OOTY');
```

Range:

```
CREATE TABLE crange PARTITION OF prange
    FOR VALUES FROM (10) TO (20);
```

Hash:

```
CREATE TABLE chash PARTITION OF phash
    FOR VALUES WITH (MODULUS 5, REMAINDER 0);
```

Add a Partition

```
ALTER TABLE parent ATTACH PARTITION child
FOR VALUES <partition bounds>
```

List:

```
ALTER TABLE plist ATTACH PARTITION clist2
FOR VALUES IN (‘MUMBAI’);
```

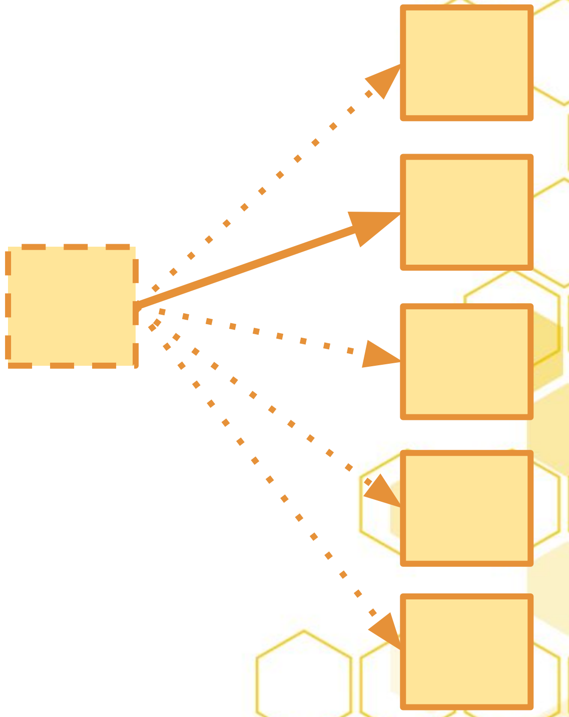
Range:

```
CREATE TABLE prange ATTACH PARTITION
crange2 FOR VALUES FROM (20) TO (50);
```

Hash:

```
CREATE TABLE phash ATTACH PARTITION
chash2 FOR VALUES WITH (MODULUS 5,
REMAINDER 1);
```

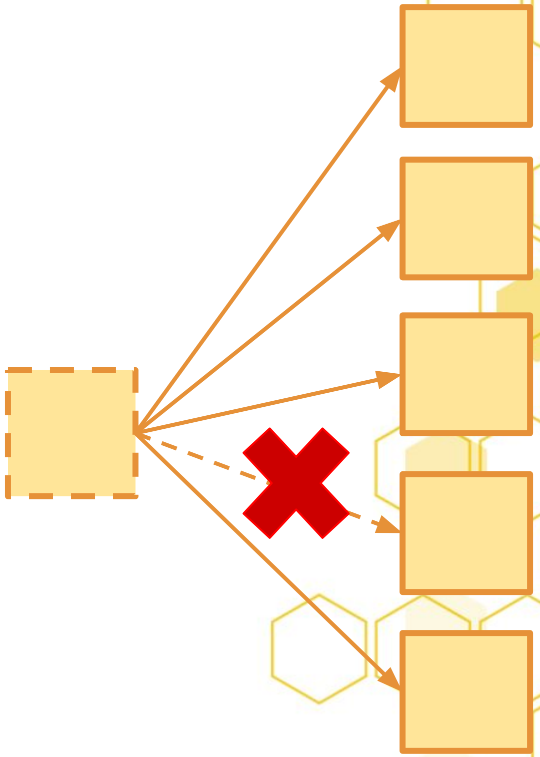
* All entries in the child will be checked to confirm if they meet partition bound.



Remove Partition

```
ALTER TABLE parent
   DETACH PARTITION child;
```

- It will no longer have the partition bound restriction.
- It will retain all the other constraints and triggers.
- If you no longer want the partition data then you may simply use DROP command to remove the table completely.



TYPES OF PARTITIONING

- Multi column partitioning
- Multi level partitioning

Multicolumn Partitioning

- Multiple columns as partition key
- Supported for range and hash
- Column limit : 32

Multicolumn Range Partitioning

- Specify the lower and upper bound for each of the partition key involved.

```
CREATE TABLE prange (col1 int, col2 int, col3 int)
  PARTITION BY RANGE (col1, col2, col3);
```

```
CREATE TABLE crange2 PARTITION OF prange
FOR VALUES FROM (10, 100, 50) TO (500, 500, 150);
```

Multicolumn Range Partitioning

- Every column following `MAXVALUE / MINVALUE` must also be the same.

```
CREATE TABLE crange1 PARTITION OF prange
  FOR VALUES FROM (10, MINVALUE, MINVALUE)
    TO (10, 100, 50);

CREATE TABLE crange3 PARTITION OF prange
  FOR VALUES FROM (500, 500, 150)
    TO (MAXVALUE, MAXVALUE, MAXVALUE);
```

Multicolumn Range Partitioning

- The row comparison operator is used for insert
  - Elements are compared left-to-right, stopping at first unequal pair of elements.
    Consider partition `(0, 0) TO (100, 50)`
    `(0, 199),(100, 49)` fits while
    `(100, 50), (101, 10)` does not.

Multicolumn Hash Partitioning

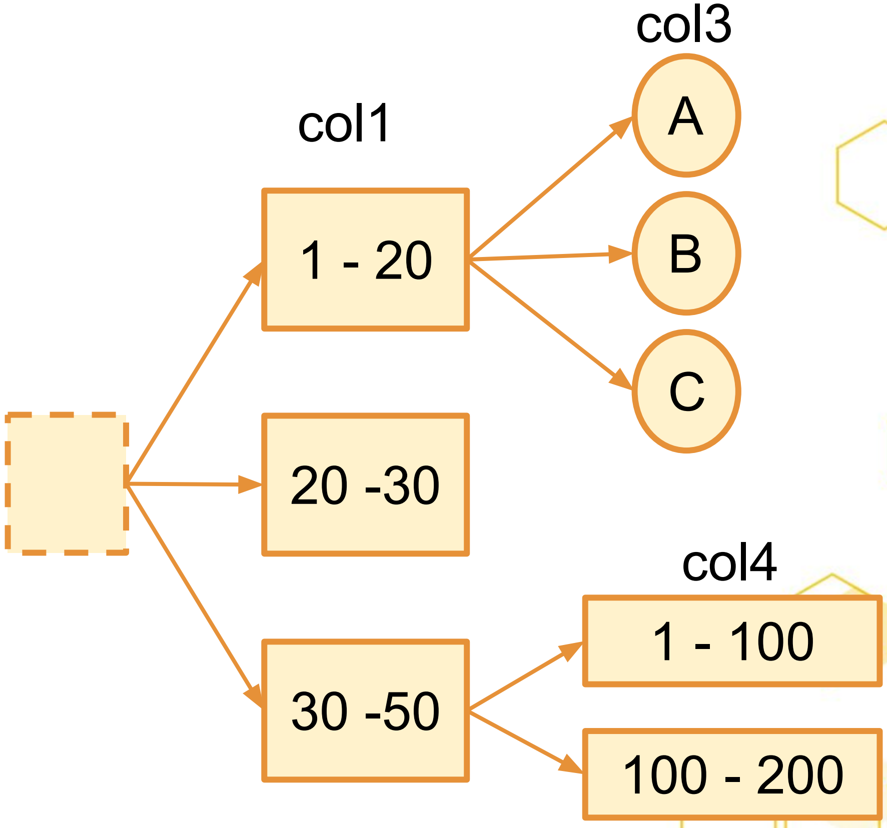
- Only one bound is specified - The hash of each of partition key is calculated and combined to get a single hash value based on which the child partition is determined.

```
CREATE TABLE phash (col1 int, col2 int) PARTITION BY
HASH (col1, col2);

CREATE TABLE phash1 PARTITION OF hparent FOR VALUES
WITH (MODULUS 3, REMAINDER 2);

CREATE TABLE phash2 PARTITION OF hparent FOR VALUES
WITH (MODULUS 3, REMAINDER 1);
```

Multilevel Partitioning

- Different strategies and partition key can be used at different levels.
- Example:

```
CREATE TABLE child1 PARTITION
OF                      parent
FOR VALUES FROM (1) TO (20)
PARTITION BY LIST (col3);
```



BENCHMARKING

- pgbench options
- Bulk load performance
- Read-only query performance
- Sequential scan performance

pgbench options

```
pgbench -i --partitions <integer>
[--partition-method <method>]
```

- `partitions` : positive non-zero integer value
- `partition-method` : Default range. Hash also supported.
- Error if the `--partition-method` is specified without a valid `--partitions` option.
- The pgbench_accounts table is partitioned on `aid`.

pgbench options

- For range partitions, scale is equally split across partitions.
    - lower bound of the first partition is `MINVALUE`,
    - upper bound of the last partition is `MAXVALUE`.

```
pgbench_accounts_1 FOR VALUES FROM (MINVALUE) TO (10001)....
pgbench_accounts_10 FOR VALUES FROM (90001) TO (MAXVALUE)
```

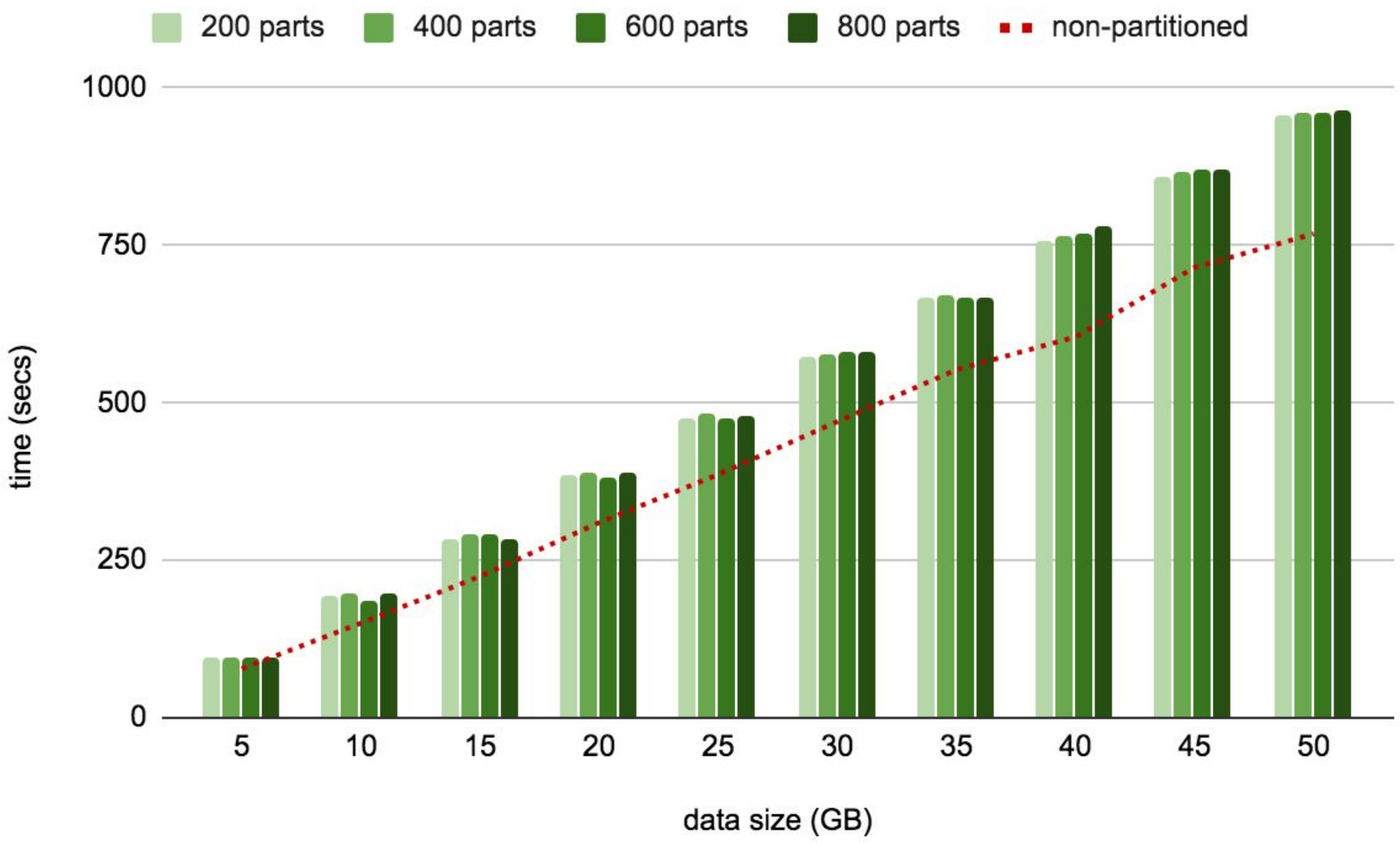
- For hash partitions, the number of partitions specified is used in the modulo operation and the remainder ranges from 0 to partitions - 1

```
pgbench_accounts_1 FOR VALUES WITH (modulus 10, remainder 0)..
pgbench_accounts_10 FOR VALUES WITH (modulus 10, remainder 9)
```

(Examples are using scale 1 and --partitions as 10.)

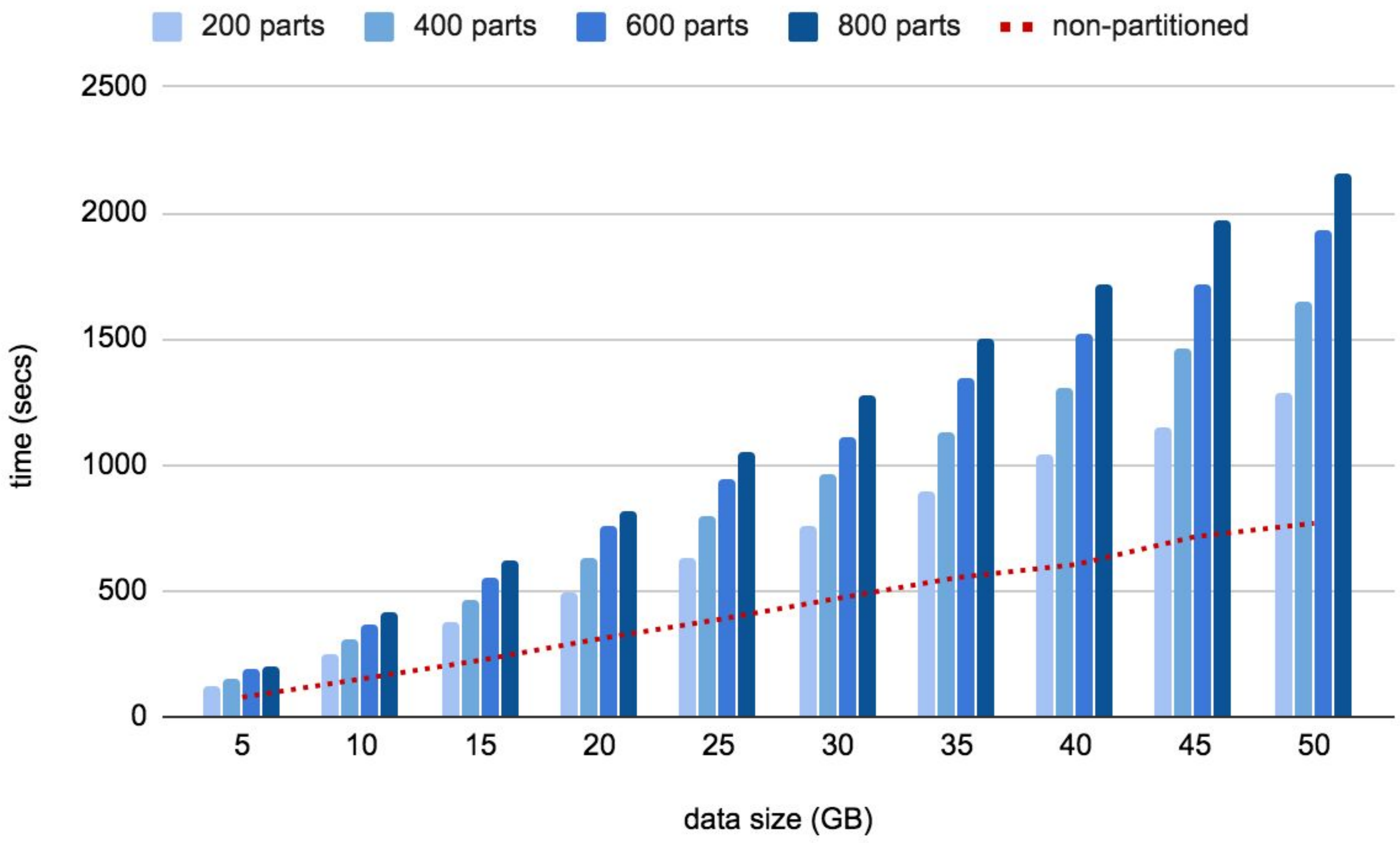
Bulk load: range partitioning

- bulkload command COPY is used to populate accounts table
- range-partitioned table takes a slightly longer time
- partition count hardly influences the load time.



Bulk load: hash partitioning

- number of partitions has heavily impacted the load time
- All partitions (tables) are constantly switched.

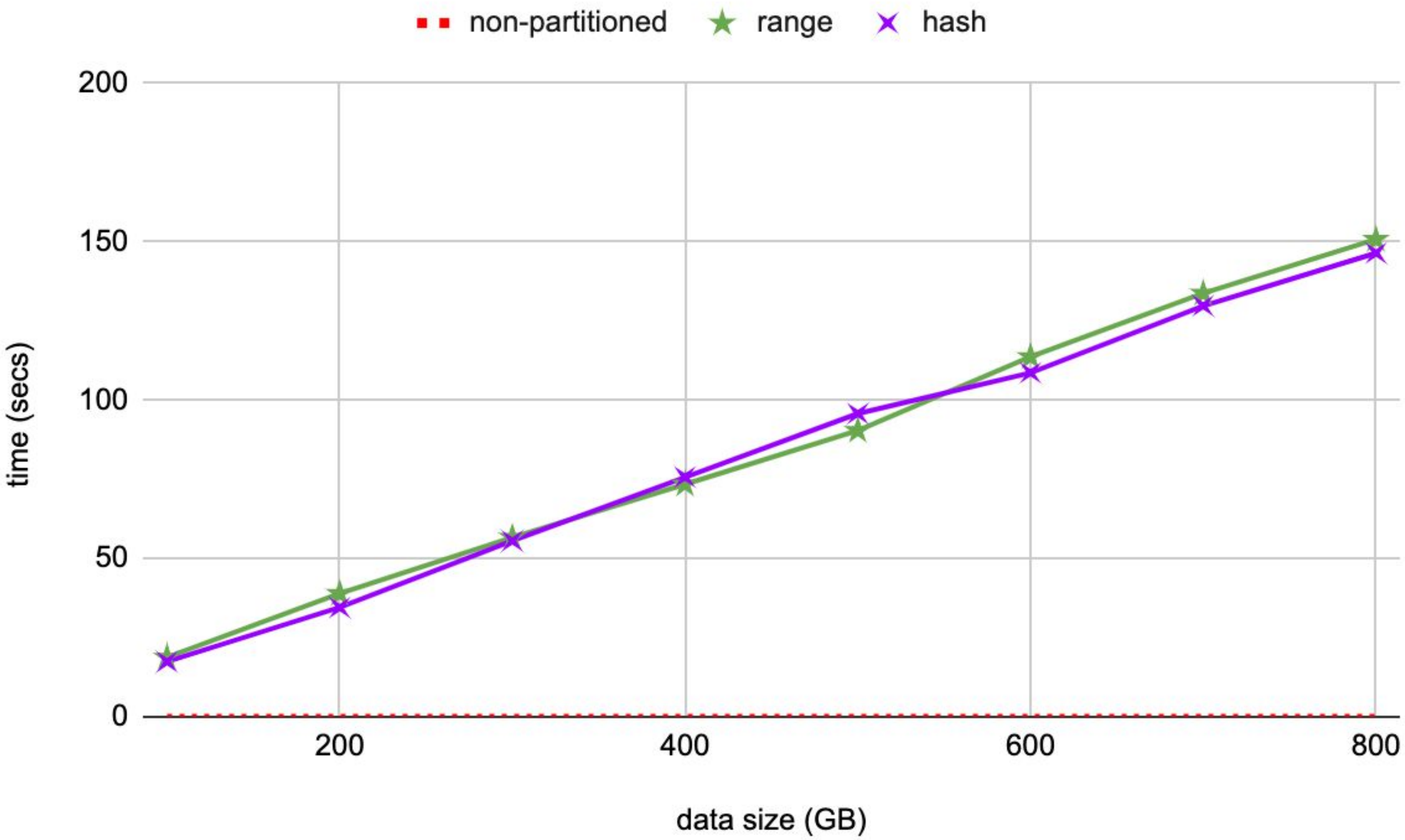


Bulk load: Conclusion

- **data ordered on the partition key column**, no matter the size or the number of partitions, the operation would take about **20–25%** more time than an unpartitioned table.
- If the data being copied is **unordered** with respect to the partition key then the time taken will depend on how often the **partition has to be switched** while insertions.

Seq Scan: default point query

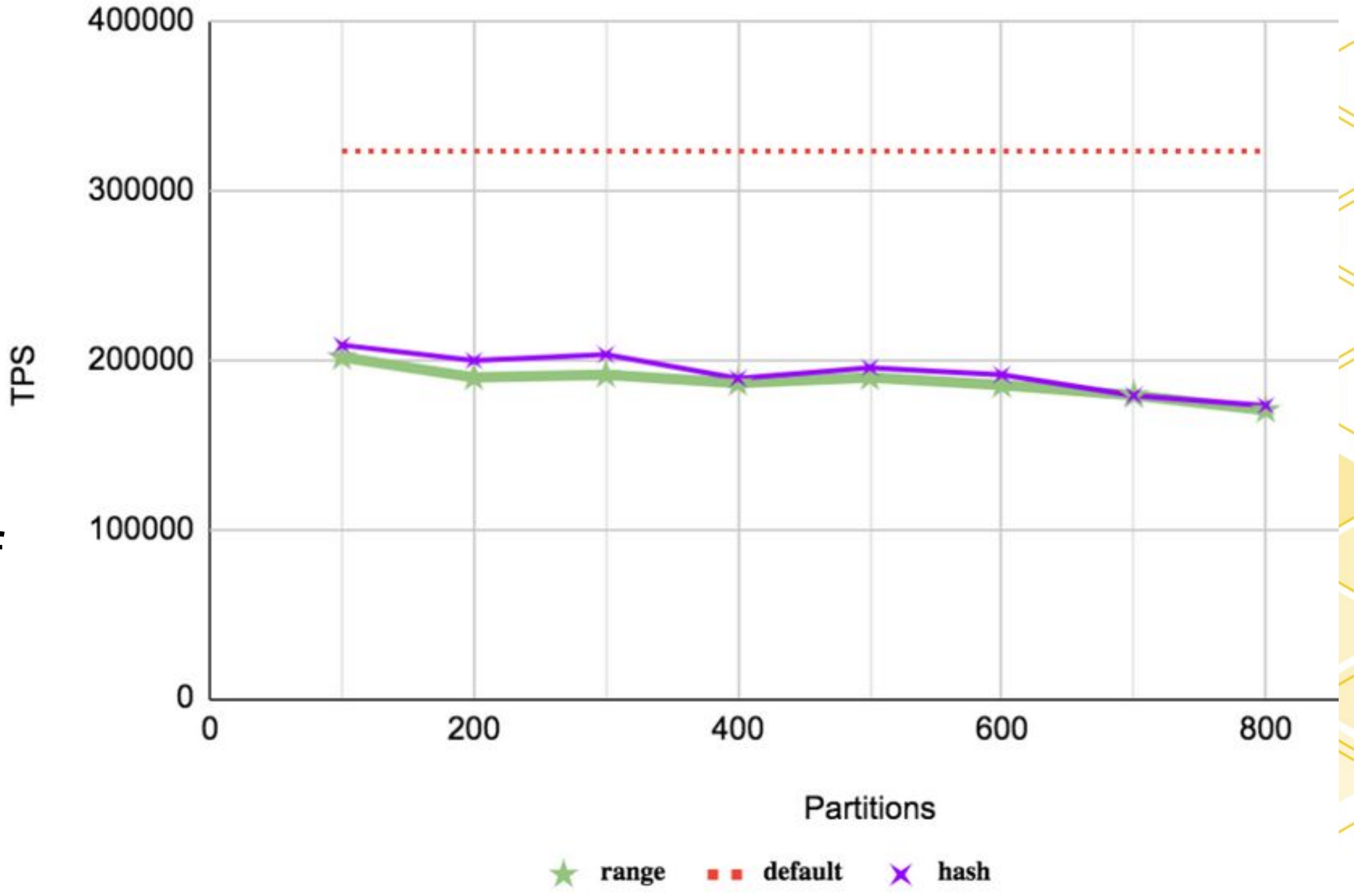
- Remove the index created by pgbench
- non-partitioned table entire data scanned.
- Partition pruning - chosen partition scanned
- ~63 GB data



- The amount of data in each partition reduces as the number of partitions increase

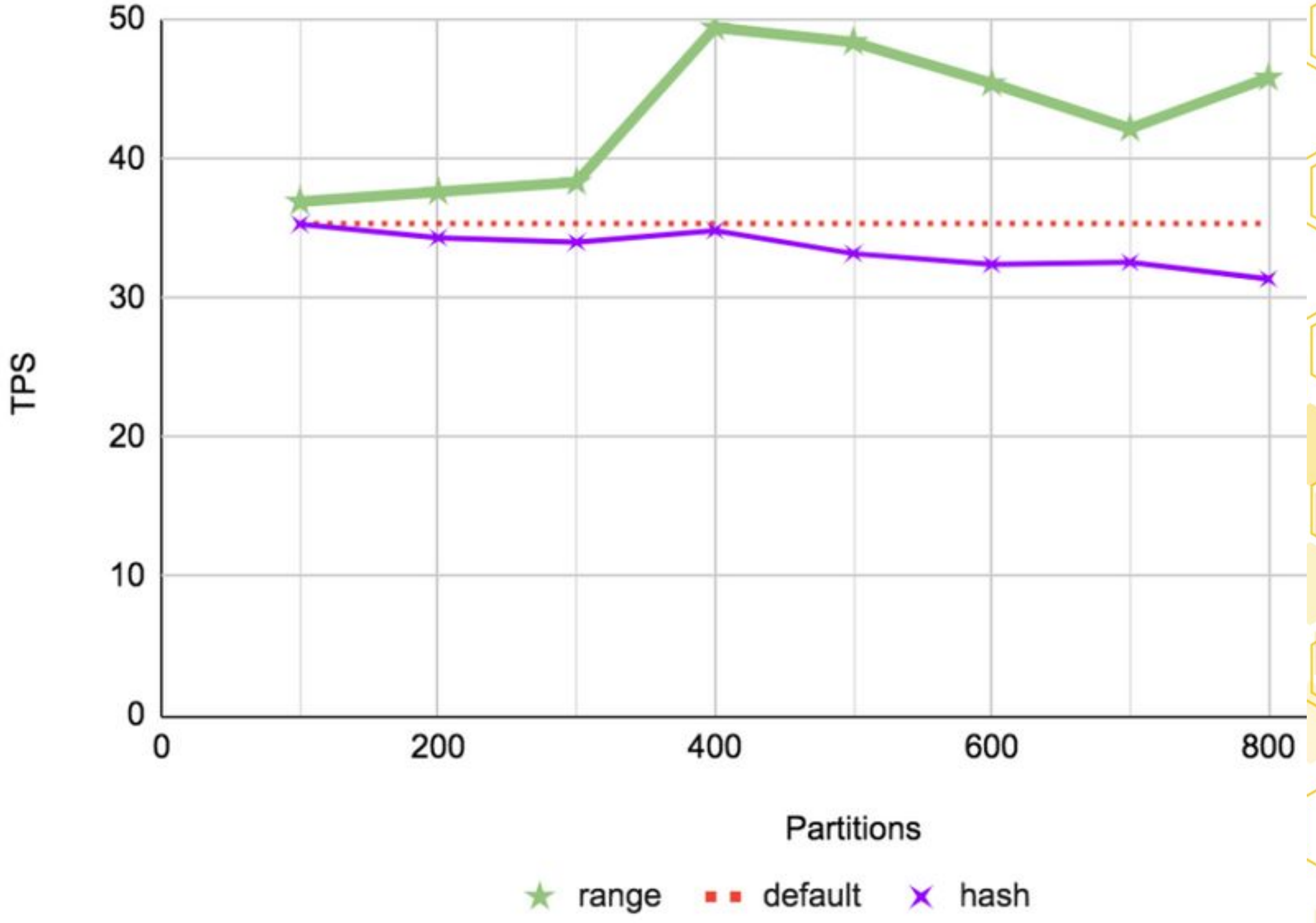
Read-only: default point query

- default query
- ~63GB data + 10GB indexes (scale=5000)
- target only one row in one particular partition.
- 40% drop: overhead of handling of a large number of partitions
- slow degradation as number of partitions increase



Read-only: custom range query

- index scan
- targeting 0.02% rows in sequence
- range: at most two partitions touched
- hash: all partitions touched
- 50 GB



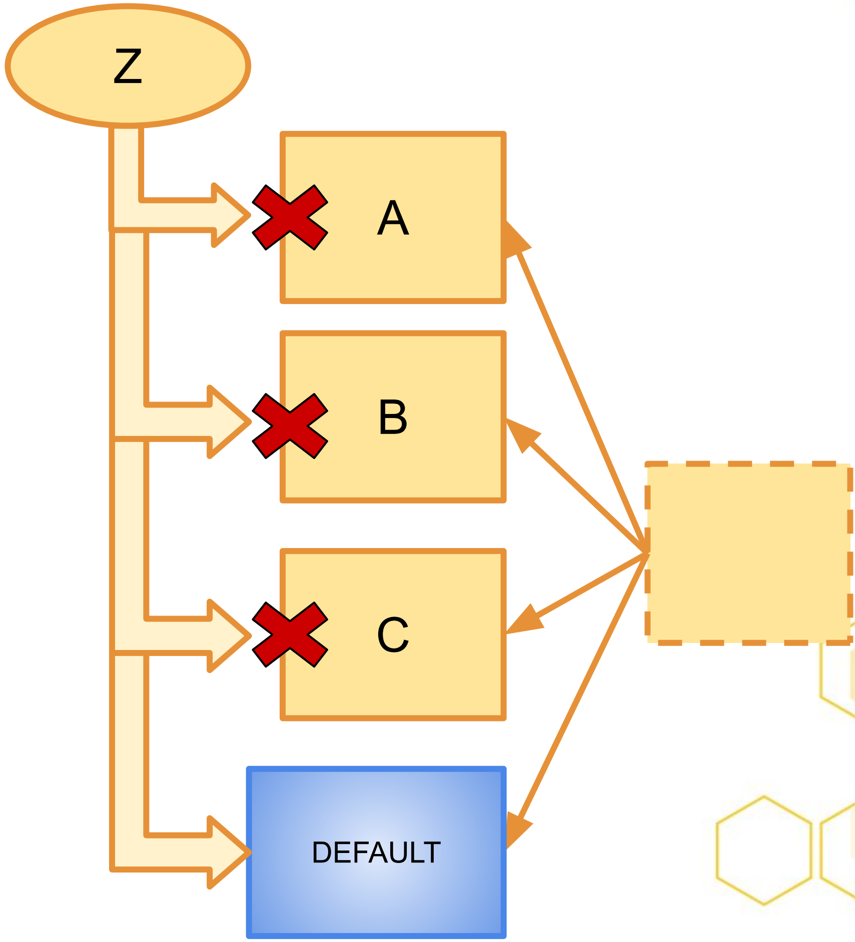
OTHER FEATURES

- Default partitions
- Runtime Partition Pruning
- Partition-wise join
- Partition-level aggregation
- Partition Tree Information

Default Partition

- PostgreSQL 11
- Catch tuples that do not match partition bounds of others.
- Support for: list, range
- Syntax:

```
CREATE TABLE child
    PARTITION OF parent
        DEFAULT;
```



(NOT (col1 IS NOT NULL) AND
(col1 = ANY (ARRAY['A', 'B', 'C'])))

Default Partition

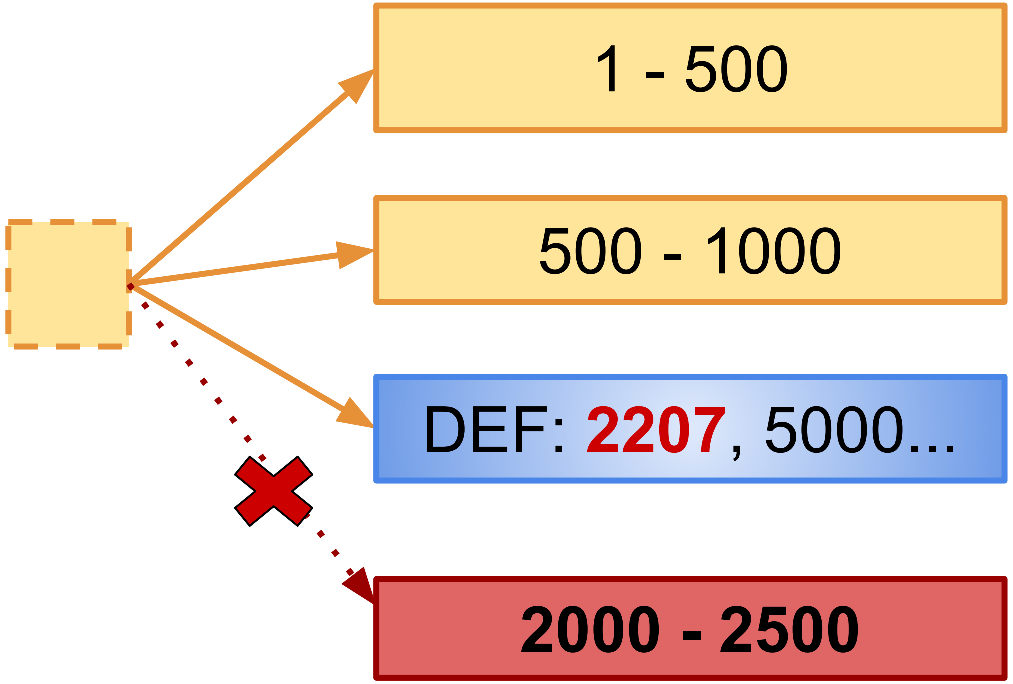
Add new partition

All the rows in default partition are scanned.

Amount of time taken depends on the number of rows in the default partition

Sample:

1382 ms to add partition when one Cr rows in default partition but **2 ms** when it is empty.



```
ERROR:  updated partition constraint for default partition "part_def" would be violated by some row
```

Runtime Partition Pruning

- PostgreSQL 11
- Performed at two levels
    - Executor Initialization - prepared query
    - Actual Execution
- SET enable_partition_pruning. Default is on.

Runtime Partition Pruning

Executor Initialization

```
PREPARE prep (int) as SELECT * from t1 where pkey < $1;
EXPLAIN EXECUTE prep(1500);

 Append  (cost=0.00..168.06 rows=3012 width=8)
   Subplans Removed: 2
   ->  Seq Scan on p1 t1_1  (cost=0.00..38.25 rows=753 width=8)
         Filter: (pkey < $1)
   ->  Seq Scan on p2 t1_2  (cost=0.00..38.25 rows=753 width=8)
         Filter: (pkey < $1)
(6 rows)
```

Runtime Partition Pruning

Actual Execution - Unpartitoined Case

Considering a table with 6000 rows performs nest loop join with another containing 4000 rows but only 2000 rows match the join condition.

```
 Nested Loop (actual rows=1000 loops=1)
   ->  Seq Scan on ltbl (actual rows=6000 loops=1)
   ->  Index Scan using rtbl_pkey on rtbl (actual rows=0 loops=6000)
         Index Cond: (col1 = ltbl.col1)
 Planning Time: 0.248 ms
 Execution Time: 15.265 ms
(6 rows)
```

Runtime Partition Pruning

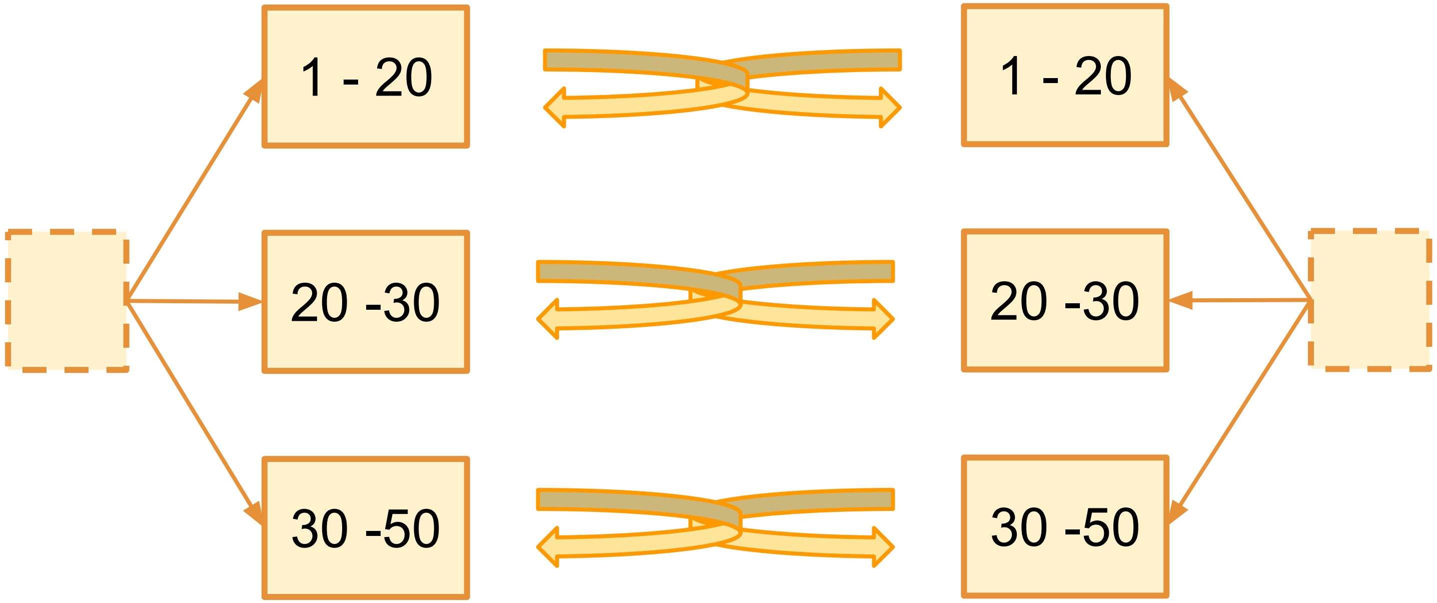
Actual Execution - Partitoined Case

Consider that the table with 4000 rows is partitioned.

```
Nested Loop (actual rows=1000 loops=1)
  ->  Seq Scan on ltbl (actual rows=6000 loops=1)
  ->  Append (actual rows=0 loops=6000)
        ->  Index Scan using p1_pkey on p1 t1_1 (actual rows=1 loops=1500)
              Index Cond: (pkey = ltbl.col1)
        ->  Index Scan using p2_pkey on p2 t1_2 (never executed)
              Index Cond: (pkey = ltbl.col1)
        ->  Index Scan using p3_pkey on p3 t1_3 (actual rows=0 loops=500)
              Index Cond: (pkey = ltbl.col1)
Planning Time: 0.325 ms
Execution Time: 10.632 ms (~30% drop)
```

Partition-wise join

- PostgreSQL 11
- SET enable_partitionwise_join. Default is off.
- Join should be on partition key and both partitions should have same bounds for partitions.



Partition-wise join

```
Hash Join (actual rows=20000 loops=1)
  Hash Cond: (a.col1 = b.col1)
  ->  Append (actual rows=40000 loops=1)
        ->  Seq Scan on a1 a_1 (actual rows=10000 loops=1)
        ->  Seq Scan on a2 a_2 (actual rows=10000 loops=1)
        ->  Seq Scan on a3 a_3 (actual rows=10000 loops=1)
        ->  Seq Scan on a4 a_4 (actual rows=10000 loops=1)
  ->  Hash (actual rows=20000 loops=1)
        Buckets: 32768  Batches: 1  Memory Usage: 1038kB
        ->  Append (actual rows=20000 loops=1)
              ->  Seq Scan on b1 b_1 (actual rows=10000 loops=1)
              ->  Seq Scan on b2 b_2 (actual rows=10000 loops=1)
              ->  Seq Scan on b3 b_3 (actual rows=0 loops=1)
              ->  Seq Scan on b4 b_4 (actual rows=0 loops=1)
Planning Time: 0.119 ms
Execution Time: 37.121 ms
```

Partition-wise join

```
SET enable_partitionwise_join =on;
Append (actual rows=20000 loops=1)
   ->  Hash Join (actual rows=10000 loops=1)
         Hash Cond: (a_1.col1 = b_1.col1)
         ->  Seq Scan on a1 a_1 (actual rows=10000 loops=1)
         ->  Hash (actual rows=10000 loops=1)
               ->  Seq Scan on b1 b_1 (actual rows=10000 loops=1)
   ->  Hash Join (actual rows=10000 loops=1)
         Hash Cond: (a_2.col1 = b_2.col1)
         ->  Seq Scan on a2 a_2 (actual rows=10000 loops=1)
         ->  Hash (actual rows=10000 loops=1)
               ->  Seq Scan on b2 b_2 (actual rows=10000 loops=1)
```

.(repeat for a3, b3 and a4, b4)

.

```
 Planning Time: 0.250 ms
 Execution Time: 19.422 ms
```

Almost 50% reduction in execution time.

Partition-level Aggregation

- PostgreSQL 11
- manually set enable_partitionwise_aggregate (default is off)
- When GROUP BY uses partition key, aggregate individual partition.
- When grouped on non-partition key, PartialAggregate performed on partitions and then combined.
- Aggregate pushed down if partition is foreign table.

Partition-level Aggregation : Example

Table is partitioned on col1 and has 3 partitions with total of 25,000 rows.

```
SELECT col1, count(*) FROM t1 GROUP BY col1;

 HashAggregate (actual rows=8 loops=1)
   Group Key: t1_p1.col1
   ->  Append (actual rows=25000 loops=1)
         ->  Seq Scan on t1_p1 (actual rows=10000 loops=1)
         ->  Seq Scan on t1_p2 (actual rows=6000 loops=1)
         ->  Seq Scan on t1_p3 (actual rows=9000 loops=1)
 Planning Time: 0.193 ms
 Execution Time: 11.498 ms
```

Partition-level Aggregation : Example

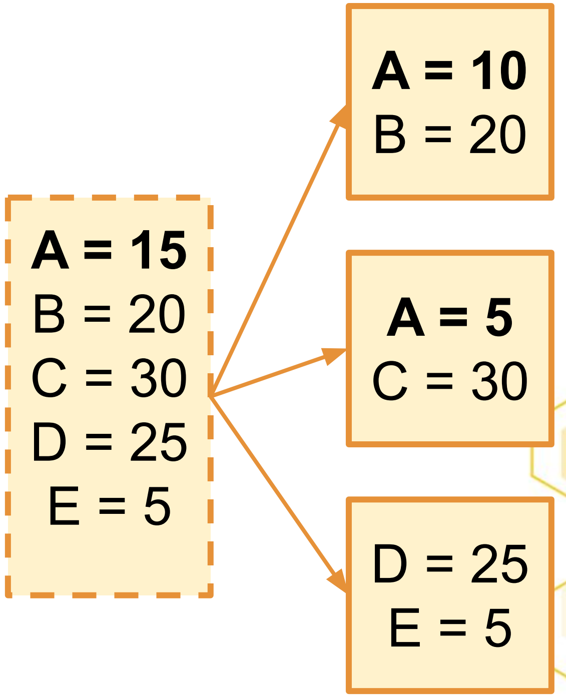
```
SET enable_partitionwise_aggregate=on;

Append (actual rows=7 loops=1)
   ->  HashAggregate (actual rows=2 loops=1)
         Group Key: t1_p1.col1
         ->  Seq Scan on t1_p1 (actual rows=10000 loops=1)
   ->  HashAggregate (actual rows=2 loops=1)
         Group Key: t1_p2.col1
         ->  Seq Scan on t1_p2 (actual rows=6000 loops=1)
   ->  HashAggregate (actual rows=3 loops=1)
         Group Key: t1_p3.col1
         ->  Seq Scan on t1_p3 (actual rows=9000 loops=1)
 Planning Time: 0.161 ms
 Execution Time: 9.046 ms
```

about 20% decrease in execution time

Partition-level Aggregation : Example

When Aggregate does not use partition key

```
Finalize HashAggregate (actual rows=7 loops=1)
  Group Key: t1_p1.col2
  ->  Append (actual rows=10 loops=1)
     ->  Partial HashAggregate (actual rows=2 loops=1)
         Group Key: t1_p1.col2
         ->  Seq Scan on t1_p1 (actual rows=10000 loops=1)
     ->  Partial HashAggregate (actual rows=2 loops=1)
         Group Key: t1_p2.col2
         ->  Seq Scan on t1_p2 (actual rows=6000 loops=1)
     ->  Partial HashAggregate (actual rows=3 loops=1)
         Group Key: t1_p3.col2
         ->  Seq Scan on t1_p3 (actual rows=9000 loops=1)
Planning Time: 0.235 ms
Execution Time: 9.541 ms
```

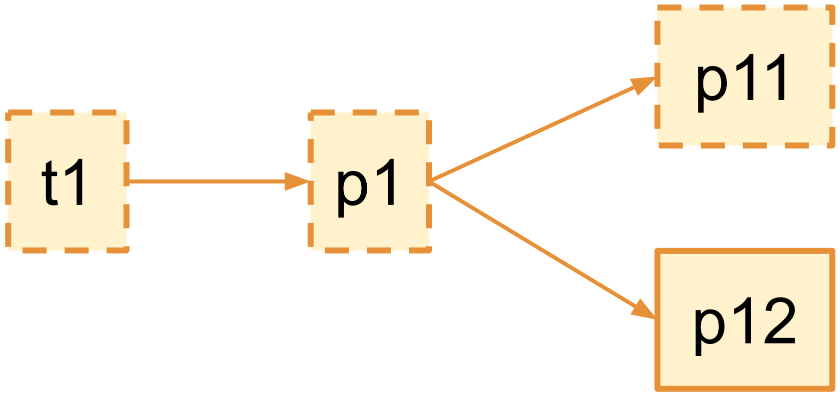


Partition Tree Information

- PostgreSQL 12
- pg_partition_tree: Displays the entire partition tree in table format.
- pg_partition_ancestors: Displays all the ancestors from the partition specified to the root.
- pg_partition_root: Displays the topmost root partitioned table.

Partition Tree Information

```
SELECT * FROM pg_partition_tree ('t1');
 relid | parentrelid | isleaf | level
-------+-------------+--------+-------
 t1    |             | f      |     0
 p1    | t1          | f      |     1
 p11   | p1          | f      |     2
 p12   | p1          | t      |     2
(4 rows)
```



Partition Tree Information

```
SELECT * FROM pg_partition_root('p12');
 pg_partition_root
-------------------
 t1
(1 row)

SELECT * FROM pg_partition_ancestors('p12');
 relid
-------
 p12
 p1
 t1
(3 rows)
```

CONCLUSION

- Partition helps in certain scenarios not all.
- Know your data and experiment to detemine the best partition parameters for your database table.

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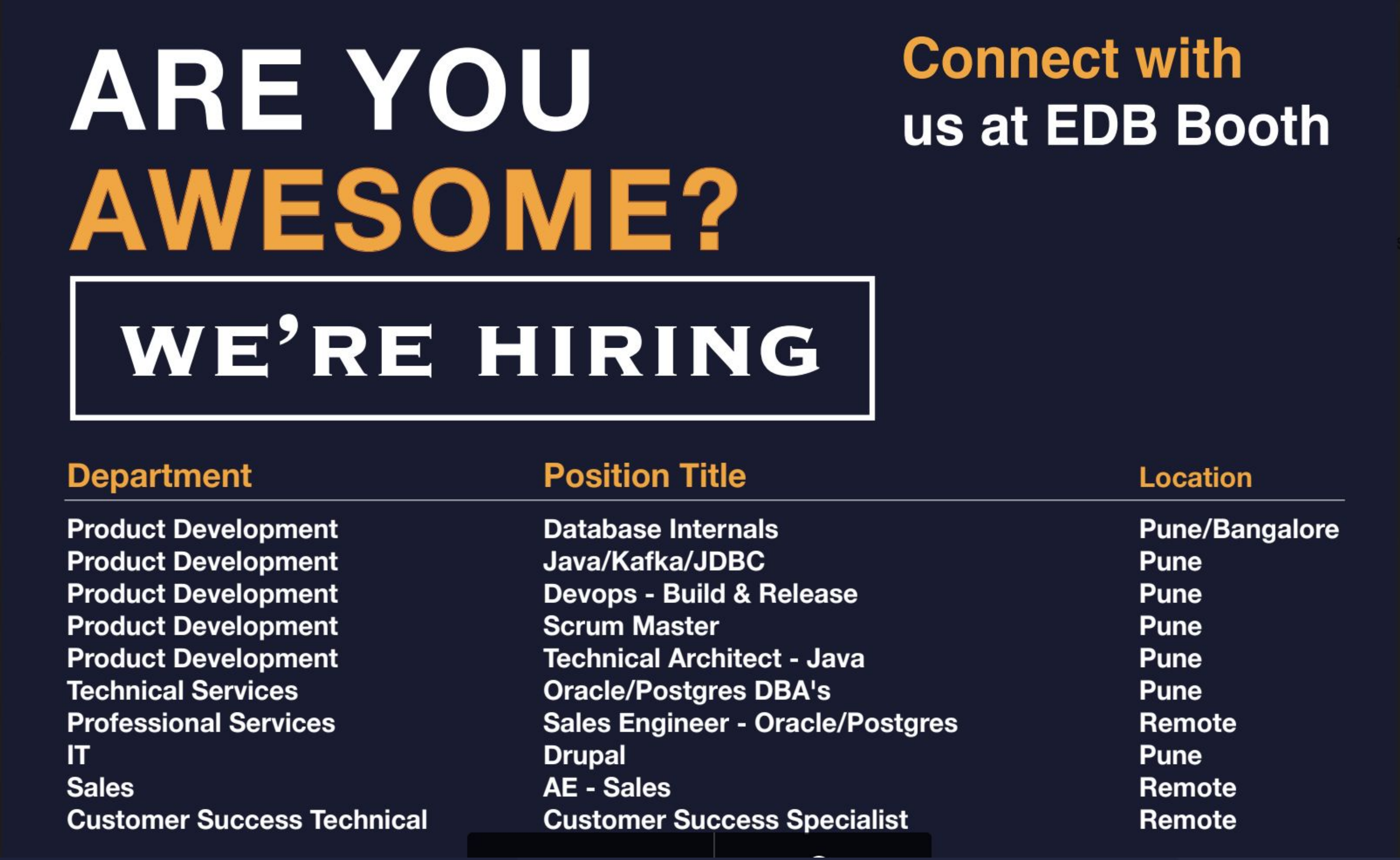

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Professional Services	Sales Engineer - Oracle/Postgres	Remote
IT	Drupal	Pune
Sales	AE - Sales	Remote
Customer Success Technical	Customer Success Specialist	Remote