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SQL Joins: Types and Implementation

Pivotal® Greenplum Database

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Agenda

- What Join Types Are Available to You?
- Row Elimination
- Minimize Data Movement
- Join Implementations Seen in Query Plans
- Try the Lab

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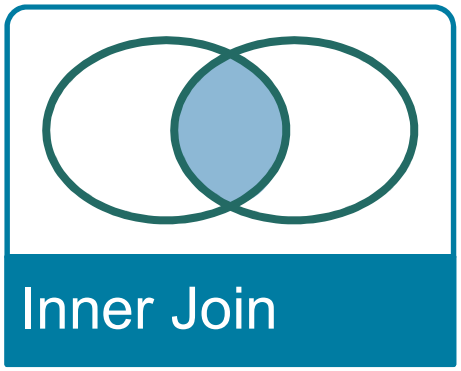
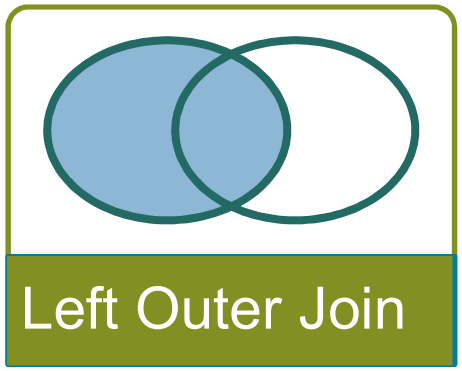
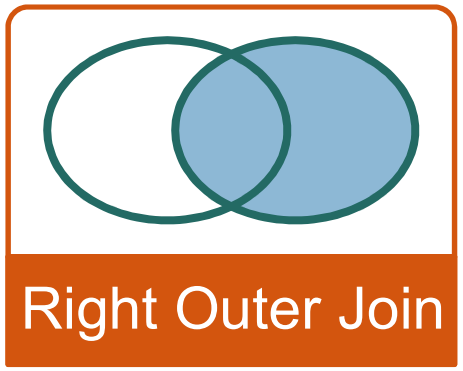
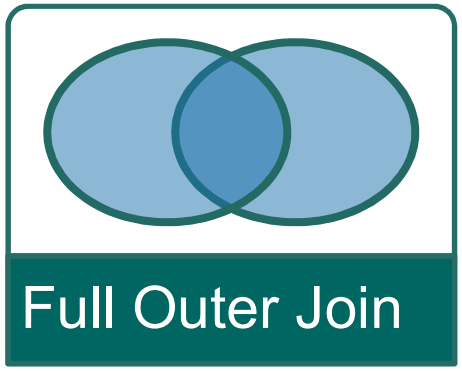
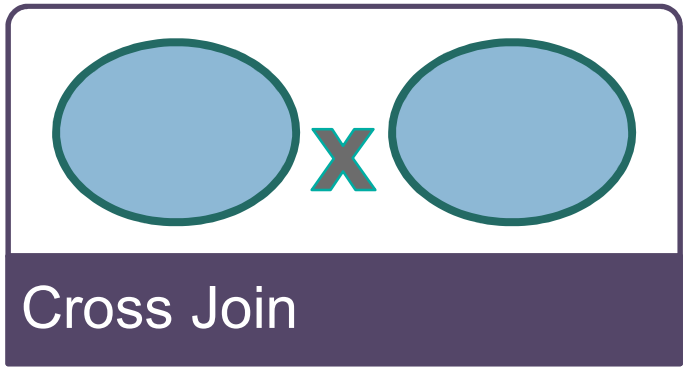
JOIN Types





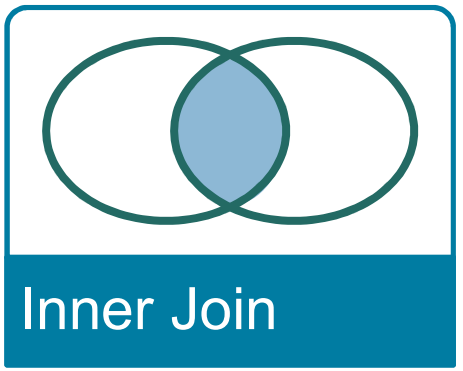






Inner Join

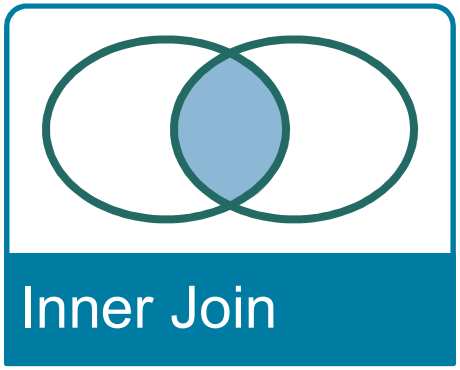
- Can be simple to write
- Require a join condition be specified
- Are also known as a SIMPLE JOIN or EQUI-JOIN




```
-- Inner join
SELECT c.id, c.name, o.value FROM clients c, orders o
WHERE c.id = o.id
ORDER BY c.id ASC;
```

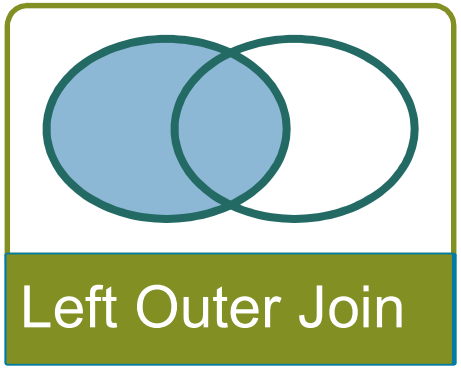
ANSI Syntax for Joins

```
joindb=# select * from clients join orders on
clients.id=orders.id;
 id | name  | id | value
----+-------+----+-------
  1 | bob   |  1 | val1
  2 | alice |  2 | val2
(2 rows)
```



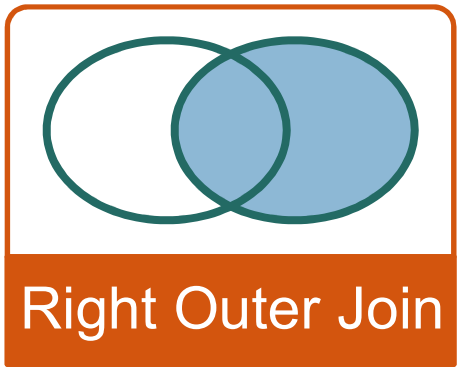
Left Outer Join

```
joindb=# select * from clients left join orders on
clients.id=orders.id;
 id | name  | id | value
----+-------+----+-------
  0 | joe   |    |
  1 | bob   |  1 | val1
  2 | alice |  2 | val2
(3 rows)
```



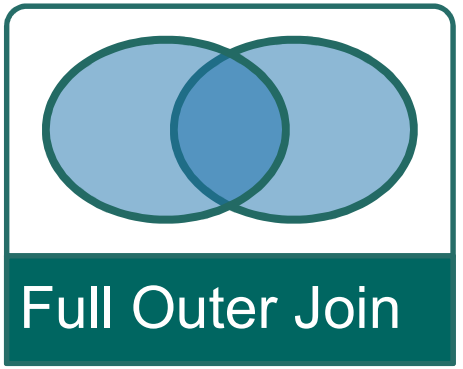
Right Outer Join

```
joindb=# select * from clients right join orders on
clients.id=orders.id;
 id | name  | id | value
----+-------+----+-------
  1 | bob   |  1 | val1
  2 | alice |  2 | val2
    |       |  3 | val3
(3 rows)
```



Full Outer Join

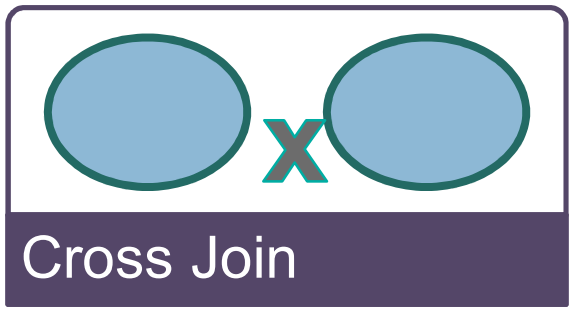
```
joindb=# select * from clients full join orders on
clients.id=orders.id;
 id | name  | id | value
----+-------+----+-------
  0 | joe   |    |
  1 | bob   |  1 | val1
  2 | alice |  2 | val2
    |       |  3 | val3
(4 rows)
```



Natural Full Outer Join

```
joindb=# select * from clients natural full join orders;
 id | name  | value
----+-------+-------
  0 | joe   |
  1 | bob   | val1
  2 | alice | val2
  3 |       | val3
(4 rows)
```

Cross Join (Cartesian Product)



- Often, this is used unintentionally
- Combines every row in the left table with every row in the right table
- Specified with the CROSS JOIN syntax or by comma separating the table names, with *no predicates*

*	id	name	id	value
1	0	Joe	1	val1
2	0	Joe	3	val3
3	0	Joe	2	val2
4	1	Bob	2	val2
5	1	Bob	3	val3
6	1	Bob	1	val1
7	2	Alice	1	val1
8	2	Alice	3	val3
9	2	Alice	2	val2

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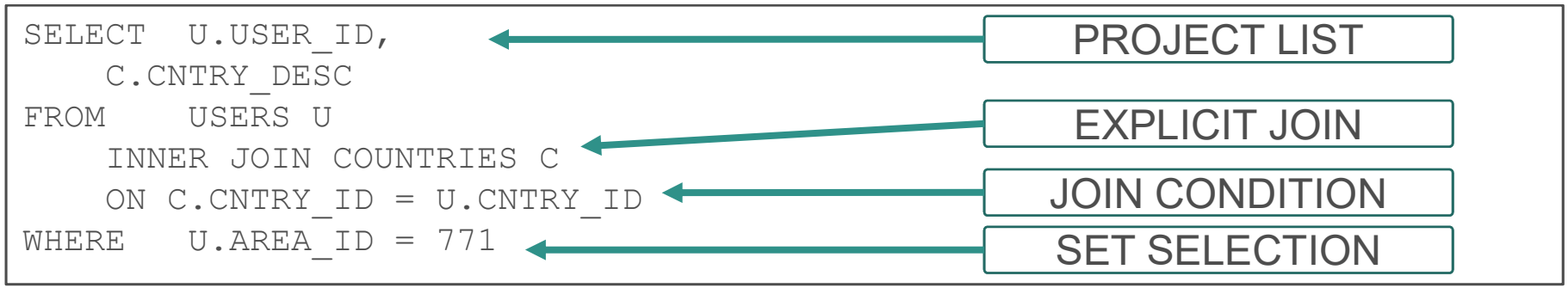
Row Elimination During Joins

- Greenplum often has to use disk space to temporarily store data.
- Query optimizer minimizes the amount of memory and disk space required by:
  - Projecting (copying) only those columns that the query requires
  - Doing single-table set selections first (qualifying rows)
  - Eliminating rows early

Analyzing Row Elimination

- Copies selected rows into temporary tables or spill files
- Projects needed columns into spill file
- Restricts data starting from the `WHERE` clause, then to the `FROM` statement, and finally to the `SELECT` statement



- Temp space consumed is a function of the number of rows times the number of columns

Joins: Parallel Implementation

- The core join algorithms will be the same as in non-distributed systems.
- Additional details: how do we partition data and still guarantee correctness in a distributed system?
- For the most part, these details are the same, regardless of the join algorithm (e.g. Merge, Hash, Nested Loop).

Row Redistribution / Motion During Joins

- Generally speaking, if you can do a **co-located join,** you do.
- Between broadcast and redistributed joins, the optimizer looks at the cost of motion that gets introduced and chooses **the plan that it believes to be cheaper**.
- The optimizer depends on up-to-date statistics on the tables.

Co-located Join

- If the join key is the distribution key for both tables:
- We can guarantee[1] the join can be handled locally on each segment without redistribution.
- This is the most efficient option.
- This is a key consideration when designing your schema.
- *All equal keys are hashed to the same node, so join results will be correct.*

[1] This assumes that the datatypes of the join keys is the same so that the hash algorithm for the join keys will hash the keys to the same segment.

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Broadcast Join

- Neither table is distributed by the join keys.
- One table is considerably smaller than the other table.
- We may broadcast the smaller table.
- All segments see **a complete copy** of the smaller table.
- They perform a co-located join.
- *Each row of the larger table can see all target rows in the smaller table, so join results will be correct.*

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Redistributed Join

- One, or both, of the tables are not distributed on the join keys.
- We can redistribute the table(s).
- They perform a co-located join.
- *All equal keys are hashed to the same node, so join results will be correct.*

Join Implementations

- The means that GPDB uses to join two tables
- These are what you will see in query plans:
  - Sort Merge
  - Hash
  - Nested Loop

Sort Merge Join

- Common when the join condition is based an inequality operator, like <, <=, >, >= (**but not** <>)
- Steps:
  - Sort the tables by the join attribute.
  - Scan the two tables in parallel.
  - Combine matching rows to form join rows.

Illustration of the Sort Merge Join Process

```
3   Relation output = new Relation();
4   while (!left.IsPastEnd() && !right.IsPastEnd())
5   {
6       if (left.Key == right.Key) {
7           output.Add(left.Key);
8           left.Advance();
9           right.Advance();
10      } else if (left.Key < right.Key) {
11          left.Advance();
12      } else {
13          right.Advance();
14      }
15      return output;
16  }
17
```

Hash Join

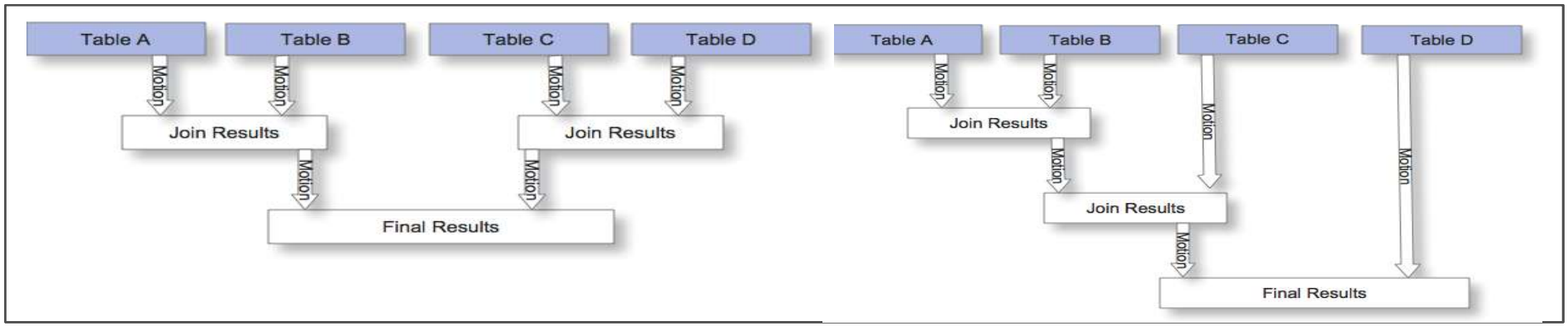
- Build phase:
  - Scan smaller table, creating in-memory hash table.
  - Keys are join columns
  - Values are the corresponding rows
- Probe phase:
  - Scan the larger table and find the relevant rows from the smaller relation by looking in the hash table.

Nested Loop Join

- Can be one of the most efficient types of joins.
- For each row of the “left table” (loop):
  - Scan the right table to find a match (nested loop)
- Indexes on the join columns make this more efficient
- This type of join is typically inefficient, though

N-Tables

- All *n*-table joins are reduced to a series of two-table joins
- The query engine can only work on two tables at a time
- The final result must be built up by a tree of join steps, each with two inputs.



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Wrap Up

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- Row Elimination
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- Join Implementations Seen in Query Plans
- Do the Lab
- Thank You!


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