Starburst
ANALYTICS ANYWHERE

Presto Training Series, Session 2: Understanding & Tuning Presto Query Processing

Try Presto: www.prestosql.io

Martin Traverso and Manfred Moser

12 August 2020

Today's Speakers

Manfred Moser

Developer, author,
and trainer at Starburst

Manfred is an open source developer and advocate. He is co-author of the book Presto: The Definitive Guide, and a seasoned trainer and conference presenter. He has trained over 20,000 developers for companies such as Walmart Labs, Sonatype, and Telus.

Martin Traverso

Co-creator of Presto and
CTO at Starburst

Martin is a co-creator of Presto, co-founder of the Presto Software Foundation, and CTO at Starburst. Prior to Starburst, Martin worked as a Software Engineer at Facebook, and a Software Architect at Proofpoint and Ning.

Agenda

- Presto overview
- Introduction to the Presto query execution
  - Query lifecycle
  - Explain the EXPLAIN
  - Optimizations
- Five minute break
  - Understanding the cost-based optimizer
- Q&A

Questions

- Ask any time
- Use the meeting **Questions** feature
- Manfred screens, collects and interjects
- Dedicated Q&A in break and at end

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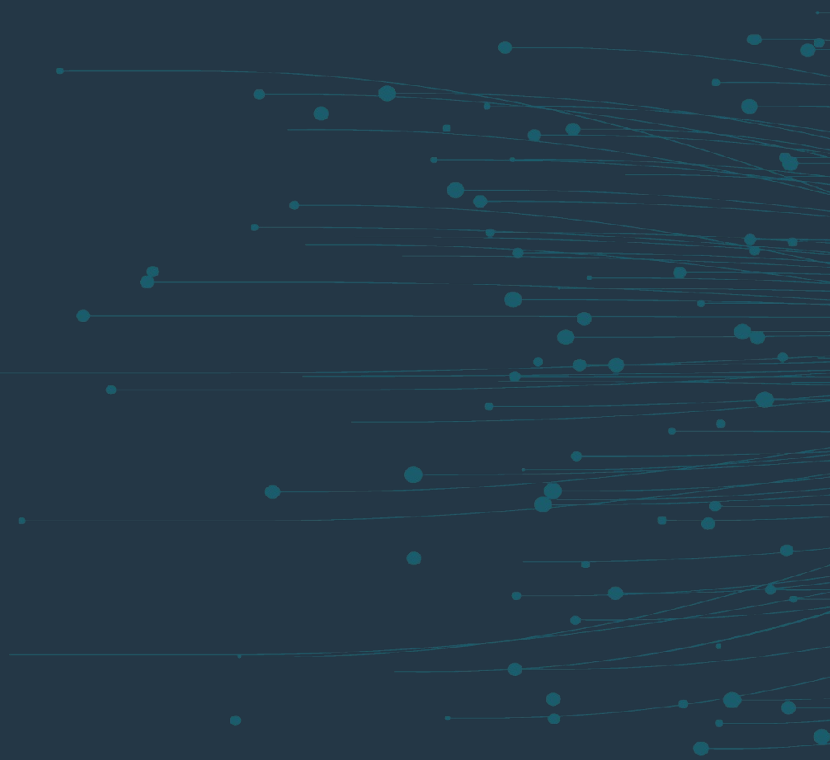
Some advice for attendees

- This is a fast-paced overview – don't try to follow along during class
- Instead focus and pay attention
- Use the demo video after class to setup Presto and CLI locally
- Learn at your own pace
- Use video recording and slides from class as reference to learn more
- Play with the TPC-H data sets and different catalogs and connectors
- Apply skills for your own use case

Presto overview

… probably just a recap for you



What is Presto?

High performance ANSI SQL engine

- SQL support for any connected data source - SQL-on-anything
- Cost-based query optimizer
- Proven horizontal scalability

Open source project

- Very active, large community
- User driven development
- Huge variety of users
- Prestosql.io

Separation of compute and storage

- Scale query processing and data sources independently
- Query storage directly
- No ETL or data integration necessary

Presto everywhere

- No cloud vendor lock-in
- No storage engine vendor lock-in
- No Hadoop distro vendor lock-in
- No database lock in

Why use Presto?

Fastest time-to-insight

- High performance query processing
- Low barrier of entry for users
- Massive scalabilty
- High concurrency
- Direct access to storage

Lower cost

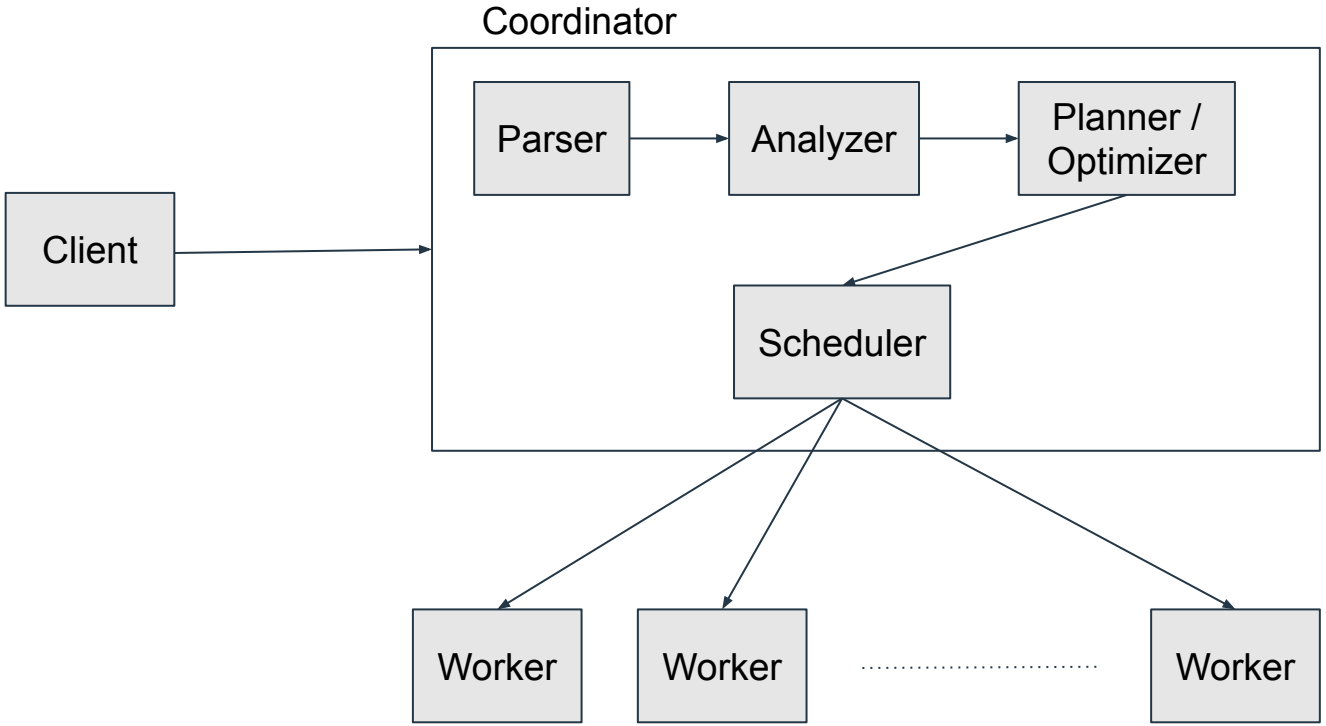
- Reduced need to copy and move data
- Avoid complex data processing
- Scale storage and compute independently
- Only run computes when processing queries
- One data consumption layer

Avoid data lock in

- No more data silos, departmental copies
- Query data with the existing skills and tools - SQL + BI tools
- Query any data source
- Move data
- Create optionality

Let’s look inside Presto with Martin

Query lifecycle



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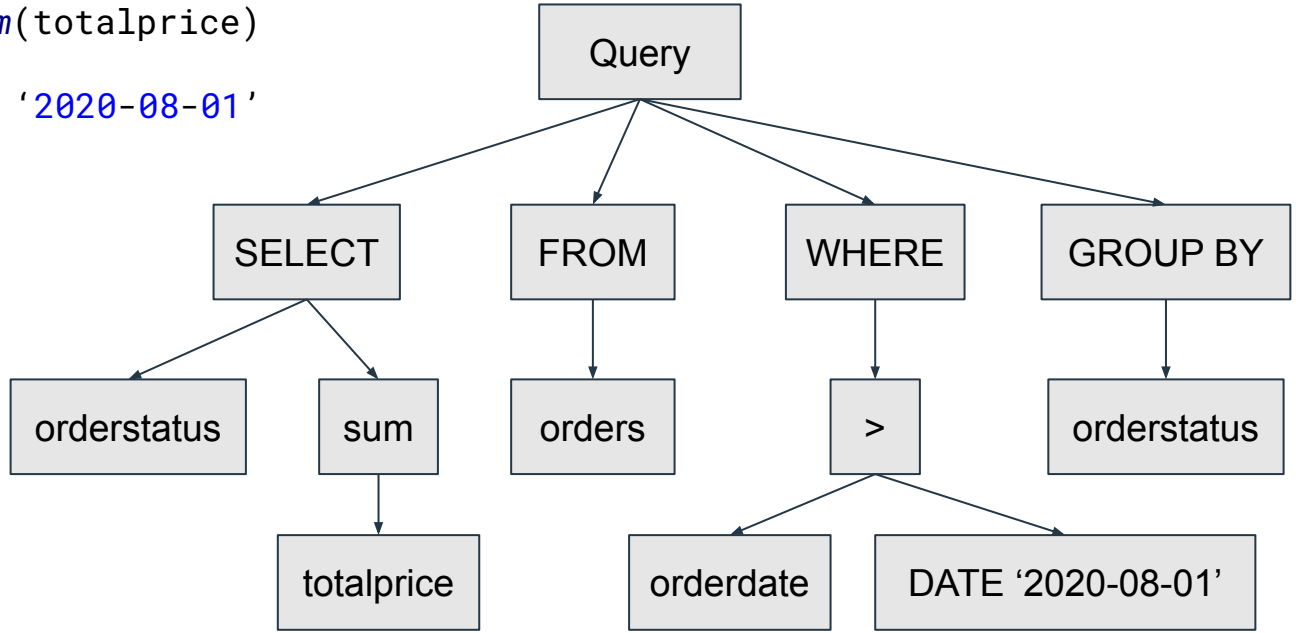
Parsing

```
SELECT orderstatus, sum(totalprice)
FROM orders
WHERE orderdate > DATE '2020-08-01'
GROUP BY orderstatus
```



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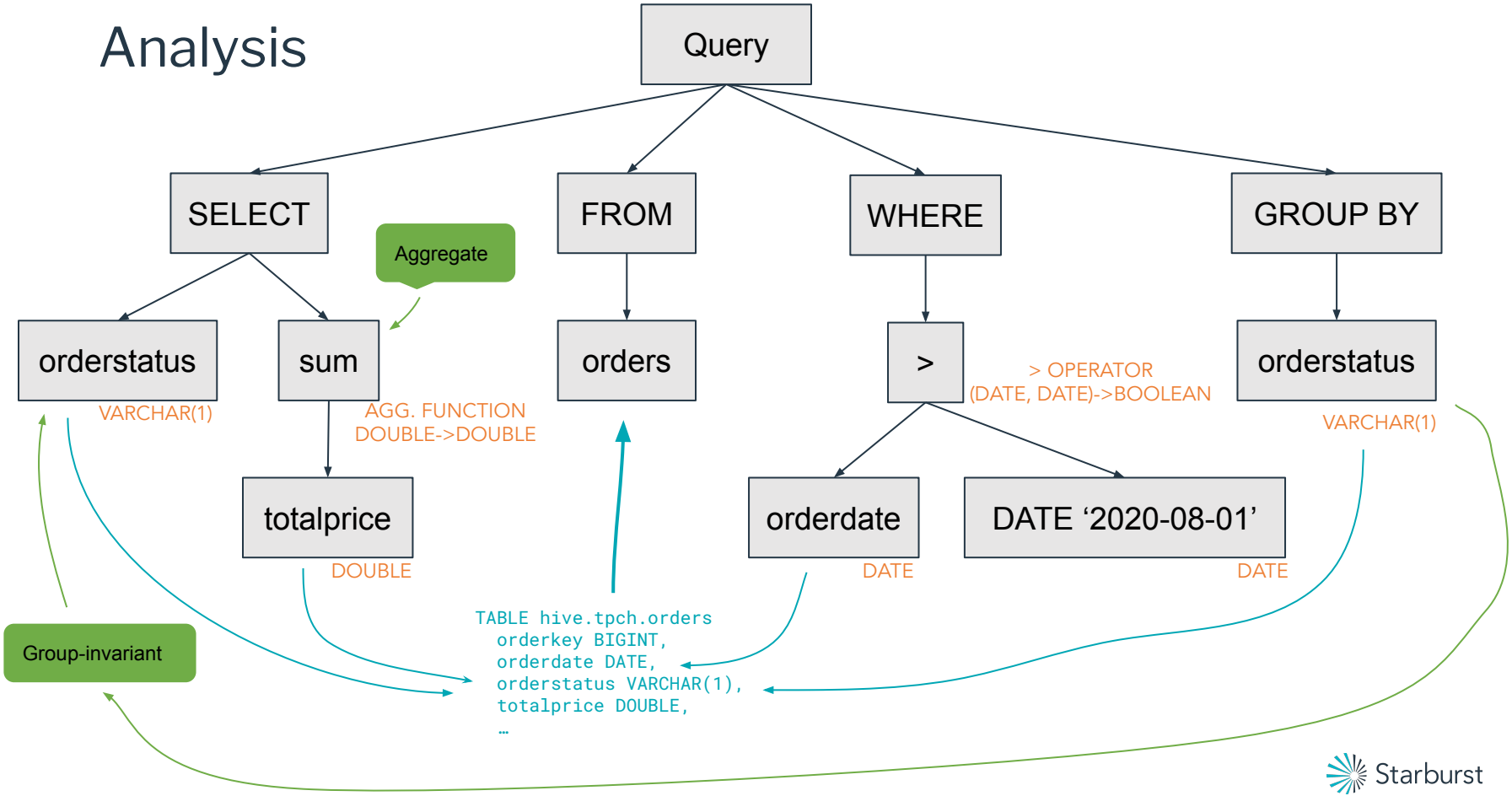
Analysis



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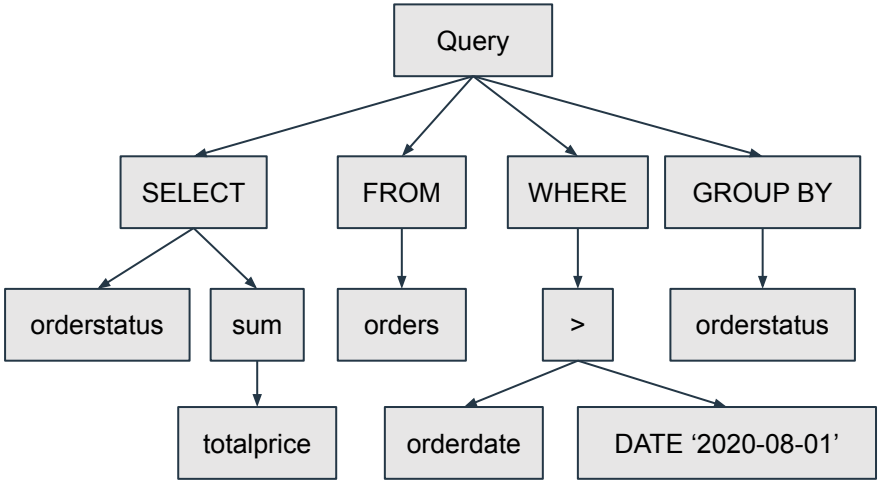
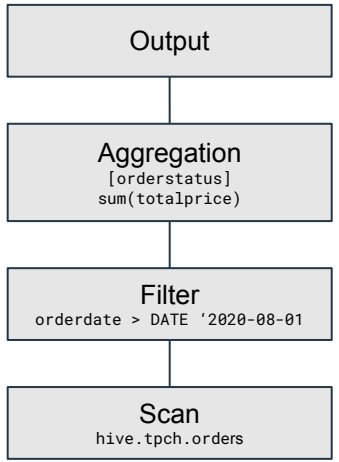
Planning

Syntax tree



Intermediate representation
(Plan IR)



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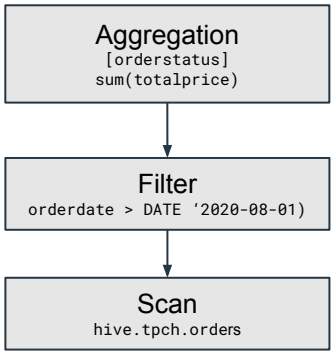
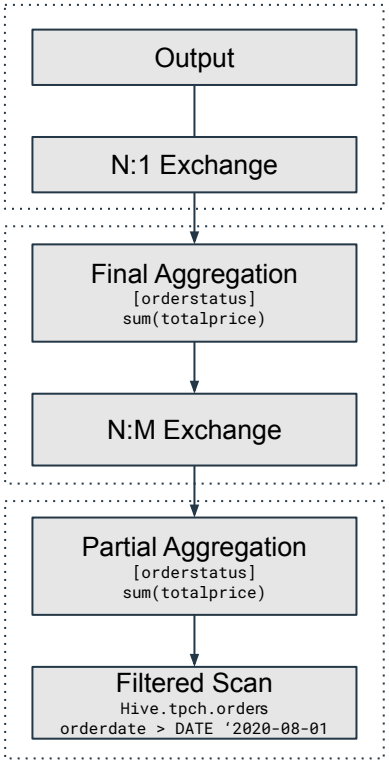
Optimization

Intermediate representation
(Plan IR)



Optimized plan



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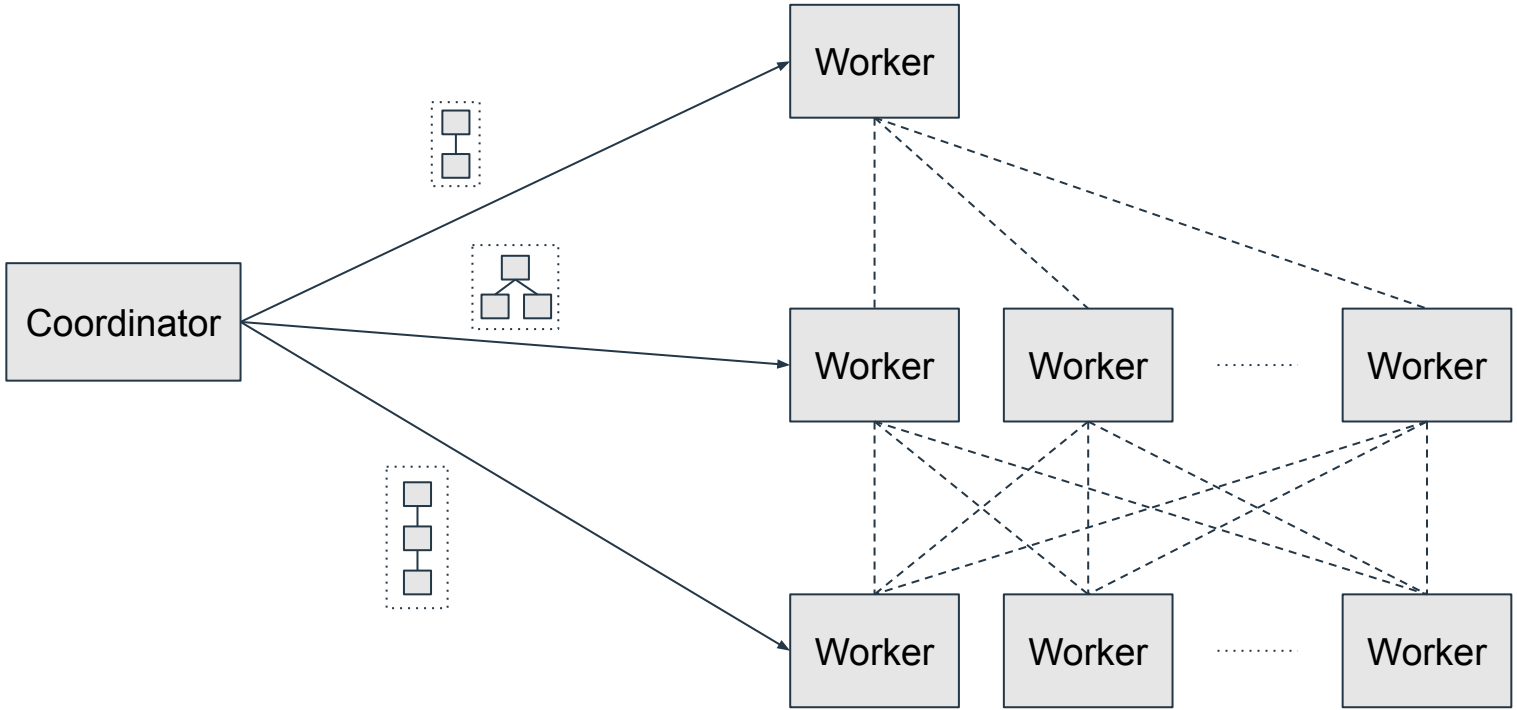
Scheduling and execution



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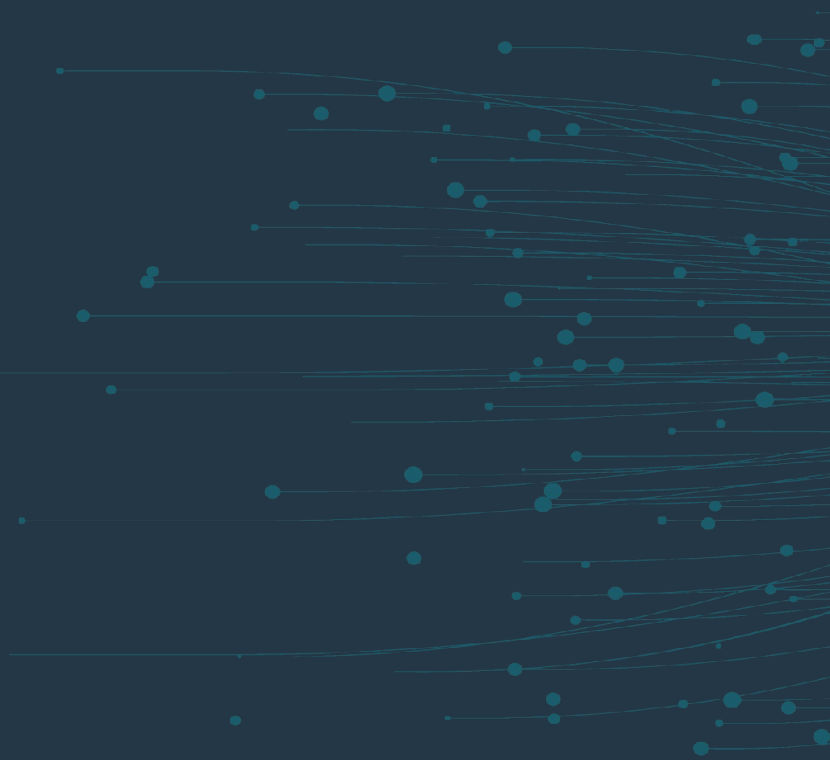
Explain the EXPLAIN



EXPLAIN

```
EXPLAIN
SELECT custkey, sum(totalprice) AS total
FROM orders
WHERE
    orderstatus = 'F' AND
    orderdate BETWEEN
      DATE '1995-01-01' AND DATE '1995-12-31'
GROUP BY custkey
ORDER BY total DESC
```

```
Fragment 1 [SINGLE]
    Output layout: [custkey, sum]
    Output partitioning: SINGLE []
    Stage Execution Strategy: UNGROUPED_EXECUTION
    RemoteMerge[2]
        Layout: [custkey:bigint, sum:double]
```

```
Fragment 2 [ROUND_ROBIN]
    Output layout: [custkey, sum]
    Output partitioning: SINGLE []
    Stage Execution Strategy: UNGROUPED_EXECUTION
    LocalMerge[sum DESC_NULLS_LAST]
    │   Layout: [custkey:bigint, sum:double]
    │   Estimates: {rows: ? (?), cpu: ?, memory: ?, network: ?}
    └─ PartialSort[sum DESC_NULLS_LAST]
       │   Layout: [custkey:bigint, sum:double]
       └─ RemoteSource[3]
              Layout: [custkey:bigint, sum:double]
```

```
Fragment 3 [HASH]
    Output layout: [custkey, sum]
    Output partitioning: ROUND_ROBIN []
    Stage Execution Strategy: UNGROUPED_EXECUTION
    Aggregate(FINAL)[custkey]
    │   Layout: [custkey:bigint, sum:double]
    │   Estimates: {rows: ? (?), cpu: ?, memory: ?, network: ?}
    │   sum := sum("sum_0")
    └─ LocalExchange[HASH] ("custkey")
       │   Layout: [custkey:bigint, sum_0:row(bigint, boolean, double, boolean)]
       │   Estimates: {rows: ? (?), cpu: ?, memory: ?, network: ?}
       └─ RemoteSource[4]
              Layout: [custkey:bigint, sum_0:row(bigint, boolean, double, boolean)]
```

```
Fragment 4 [SOURCE]
    Output layout: [custkey, sum_0]
    Output partitioning: HASH [custkey]
    Stage Execution Strategy: UNGROUPED_EXECUTION
    Aggregate(PARTIAL)[custkey]
    │   Layout: [custkey:bigint, sum_0:row(bigint, boolean, double, boolean)]
    │   sum_0 := sum("totalprice")
    └─ ScanFilterProject[table = tpch:orders, predicate=("orderdate" BETWEEN DATE '1995-01-01' AND DATE '1995-12-31')]
           Layout: [custkey:bigint, totalprice:double]
           Estimates: {rows: 729413 (12.52MB), cpu: 16.00M, memory: 0B, network: 0B}/
                      {rows: 95443 (1.64MB), cpu: 32.00M, memory: 0B, network: 0B}/
                      {rows: 95443 (1.64MB), cpu: 33.64M, memory: 0B, network: 0B}
           custkey := tpch:custkey
           totalprice := tpch:totalprice
           orderdate := tpch:orderdate
           tpch:orderstatus
               :: [[F]]
```

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EXPLAIN vs EXPLAIN ANALYZE

- EXPLAIN: plan structure + cost estimates
- EXPLAIN ANALYZE: plan structure + cost estimates + actual execution statistics

```
Fragment 4 [SOURCE]
    CPU: 34.09s, Scheduled: 41.31s, Input: 729413 rows (0B); per task: avg.: 243137.67 std.dev.: 206.19, Output: 47763 rows (1.64MB)
    Output layout: [custkey, sum_0]
    Output partitioning: HASH [custkey]
    Stage Execution Strategy: UNGROUPED_EXECUTION
    Aggregate(PARTIAL)[custkey]
    │   Layout: [custkey:bigint, sum_0:row(bigint, boolean, double, boolean)]
    │   CPU: 220.00ms (0.64%), Scheduled: 691.00ms (1.65%), Output: 47763 rows (1.64MB)
    │   Input avg.: 1335.61 rows, Input std.dev.: 2.44%
    │   Collisions avg.: 20.89 (105.76% est.), Collisions std.dev.: 142.37%
    │   sum_0 := sum("totalprice")
    └─ ScanFilterProject[table = tpch:orders:sf1.0, grouped = false, filterPredicate = ("orderdate" BETWEEN DATE '1995-01-01' AND DATE '1995-12-31')]
           Layout: [custkey:bigint, totalprice:double]
           Estimates: {rows: 729413 (12.52MB), cpu: 16.00M, memory: 0B, network: 0B}/
                      {rows: 95443 (1.64MB), cpu: 32.00M, memory: 0B, network: 0B}/
                      {rows: 95443 (1.64MB), cpu: 33.64M, memory: 0B, network: 0B}
           CPU: 33.87s (98.57%), Scheduled: 40.62s (97.07%), Output: 48082 rows (845.19kB)
           Input avg.: 20261.47 rows, Input std.dev.: 0.54%
           custkey := tpch:custkey
           totalprice := tpch:totalprice
           orderdate := tpch:orderdate
           tpch:orderstatus
               :: [[F]]
           Input: 729413 rows (0B), Filtered: 93.41%
```

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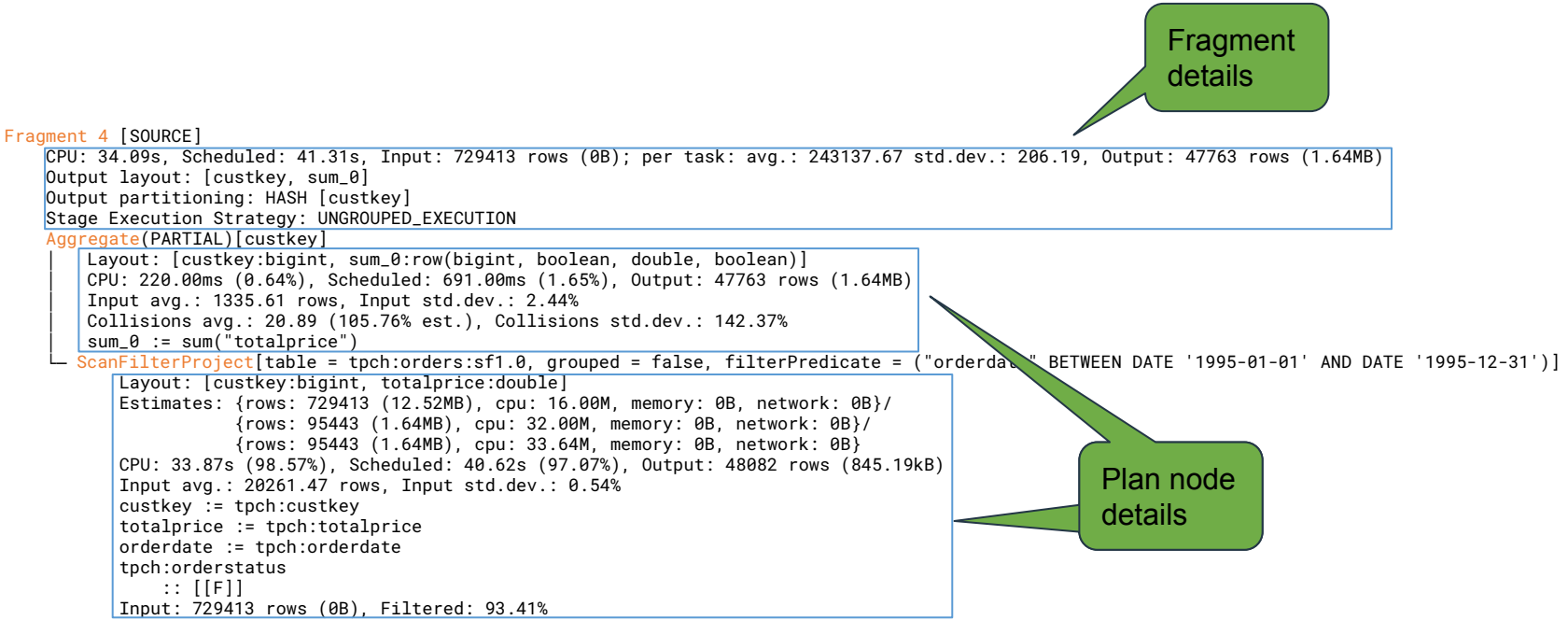
Fragment structure



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Distribution


```
Fragment 4 [SOURCE]
    CPU: 34.09s, Scheduled: 41.31s, Input: 729413 rows (0B); per task: avg.: 243137.67 std.dev.: 206.19, Output: 47763 rows (1.64MB)
    Output layout: [custkey, sum_0]
    Output partitioning: HASH [custkey]
    Stage Execution Strategy: UNGROUPED_EXECUTION
    Aggregate(PARTIAL)[custkey]
    │   Layout: [custkey:bigint, sum_0:row(bigint, boolean, double, boolean)]
    │   CPU: 220.00ms (0.64%), Scheduled: 691.00ms (1.65%), Output: 47763 rows (1.64MB)
    │   Input avg.: 1335.61 rows, Input std.dev.: 2.44%
    │   Collisions avg.: 20.89 (105.76% est.), Collisions std.dev.: 142.37%
    │   sum_0 := sum("totalprice")
    └─ ScanFilterProject[table = tpch:orders:sf1.0, grouped = false, filterPredicate = ("orderdate" BETWEEN DATE '1995-01-01' AND DATE '1995-12-31')]
           Layout: [custkey:bigint, totalprice:double]
           Estimates: {rows: 729413 (12.52MB), cpu: 16.00M, memory: 0B, network: 0B}/
                      {rows: 95443 (1.64MB), cpu: 32.00M, memory: 0B, network: 0B}/
                      {rows: 95443 (1.64MB), cpu: 33.64M, memory: 0B, network: 0B}
           CPU: 33.87s (98.57%), Scheduled: 40.62s (97.07%), Output: 48082 rows (845.19kB)
           Input avg.: 20261.47 rows, Input std.dev.: 0.54%
           custkey := tpch:custkey
           totalprice := tpch:totalprice
           orderdate := tpch:orderdate
           tpch:orderstatus
               :: [[F]]
           Input: 729413 rows (0B), Filtered: 93.41%
```

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Row layout

```
Fragment 4 [SOURCE]
    CPU: 34.09s, Scheduled: 41.31s, Input: 729413 rows (0B); per task: avg.: 243137.67 std.dev.: 206.19, Output: 47763 rows (1.64MB)
    Output layout: [custkey, sum_0]
    Output partitioning: HASH [custkey]
    Stage Execution Strategy: UNGROUPED_EXECUTION
    Aggregate(PARTIAL)[custkey]
    │   Layout: [custkey:bigint, sum_0:row(bigint, boolean, double, boolean)]
    │   CPU: 220.00ms (0.64%), Scheduled: 691.00ms (1.65%), Output: 47763 rows (1.64MB)
    │   Input avg.: 1335.61 rows, Input std.dev.: 2.44%
    │   Collisions avg.: 20.89 (105.76% est.), Collisions std.dev.: 142.37%
    │   sum_0 := sum("totalprice")
    └─ ScanFilterProject[table = tpch:orders:sf1.0, grouped = false, filterPredicate = ("orderdate" BETWEEN DATE '1995-01-01' AND DATE '1995-12-31')]
           Layout: [custkey:bigint, totalprice:double]
           Estimates: {rows: 729413 (12.52MB), cpu: 16.00M, memory: 0B, network: 0B}/
                      {rows: 95443 (1.64MB), cpu: 32.00M, memory: 0B, network: 0B}/
                      {rows: 95443 (1.64MB), cpu: 33.64M, memory: 0B, network: 0B}
           CPU: 33.87s (98.57%), Scheduled: 40.62s (97.07%), Output: 48082 rows (845.19kB)
           Input avg.: 20261.47 rows, Input std.dev.: 0.54%
           custkey := tpch:custkey
           totalprice := tpch:totalprice
           orderdate := tpch:orderdate
           tpch:orderstatus
               :: [[F]]
           Input: 729413 rows (0B), Filtered: 93.41%
```

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Estimates

```
Fragment 4 [SOURCE]
    CPU: 34.09s, Scheduled: 41.31s, Input: 729413 rows (0B); per task: avg.: 243137.67 std.dev.: 206.19, Output: 47763 rows (1.64MB)
    Output layout: [custkey, sum_0]
    Output partitioning: HASH [custkey]
    Stage Execution Strategy: UNGROUPED_EXECUTION
    Aggregate(PARTIAL)[custkey]
    │   Layout: [custkey:bigint, sum_0:row(bigint, boolean, double, boolean)]
    │   CPU: 220.00ms (0.64%), Scheduled: 691.00ms (1.65%), Output: 47763 rows (1.64MB)
    │   Input avg.: 1335.61 rows, Input std.dev.: 2.44%
    │   Collisions avg.: 20.89 (105.76% est.), Collisions std.dev.: 142.37%
    │   sum_0 := sum("totalprice")
    └─ ScanFilterProject[table = tpch:orders:sf1.0, grouped = false, filterPredicate = ("orderdate" BETWEEN DATE '1995-01-01' AND DATE '1995-12-31')]
           Layout: [custkey:bigint, totalprice:double]
           Estimates: {rows: 729413 (12.52MB), cpu: 16.00M, memory: 0B, network: 0B}/
                      {rows: 95443 (1.64MB), cpu: 32.00M, memory: 0B, network: 0B}/
                      {rows: 95443 (1.64MB), cpu: 33.64M, memory: 0B, network: 0B}
           CPU: 33.87s (98.57%), Scheduled: 40.62s (97.07%), Output: 48082 rows (845.19kB)
           Input avg.: 20261.47 rows, Input std.dev.: 0.54%
           custkey := tpch:custkey
           totalprice := tpch:totalprice
           orderdate := tpch:orderdate
           tpch:orderstatus
               :: [[F]]
           Input: 729413 rows (0B), Filtered: 93.41%
```

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Performance stats

```
Fragment 4 [SOURCE]
    CPU: 34.09s, Scheduled: 41.31s, Input: 729413 rows (0B); per task: avg.: 243137.67 std.dev.: 206.19, Output: 47763 rows (1.64MB)
    Output layout: [custkey, sum_0]
    Output partitioning: HASH [custkey]
    Stage Execution Strategy: UNGROUPED_EXECUTION
    Aggregate(PARTIAL)[custkey]
    │   Layout: [custkey:bigint, sum_0:row(bigint, boolean, double, boolean)]
    │   CPU: 220.00ms (0.64%), Scheduled: 691.00ms (1.65%), Output: 47763 rows (1.64MB)
    │   Input avg.: 1335.61 rows, Input std.dev.: 2.44%
    │   Collisions avg.: 20.89 (105.76% est.), Collisions std.dev.: 142.37%
    │   sum_0 := sum("totalprice")
    └─ ScanFilterProject[table = tpch:orders:sf1.0, grouped = false, filterPredicate = ("orderdate" BETWEEN DATE '1995-01-01' AND DATE '1995-12-31')]
           Layout: [custkey:bigint, totalprice:double]
           Estimates: {rows: 729413 (12.52MB), cpu: 16.00M, memory: 0B, network: 0B}/
                      {rows: 95443 (1.64MB), cpu: 32.00M, memory: 0B, network: 0B}/
                      {rows: 95443 (1.64MB), cpu: 33.64M, memory: 0B, network: 0B}
           CPU: 33.87s (98.57%), Scheduled: 40.62s (97.07%), Output: 48082 rows (845.19kB)
           Input avg.: 20261.47 rows, Input std.dev.: 0.54%
           custkey := tpch:custkey
           totalprice := tpch:totalprice
           orderdate := tpch:orderdate
           tpch:orderstatus
               :: [[F]]
           Input: 729413 rows (0B), Filtered: 93.41%
```

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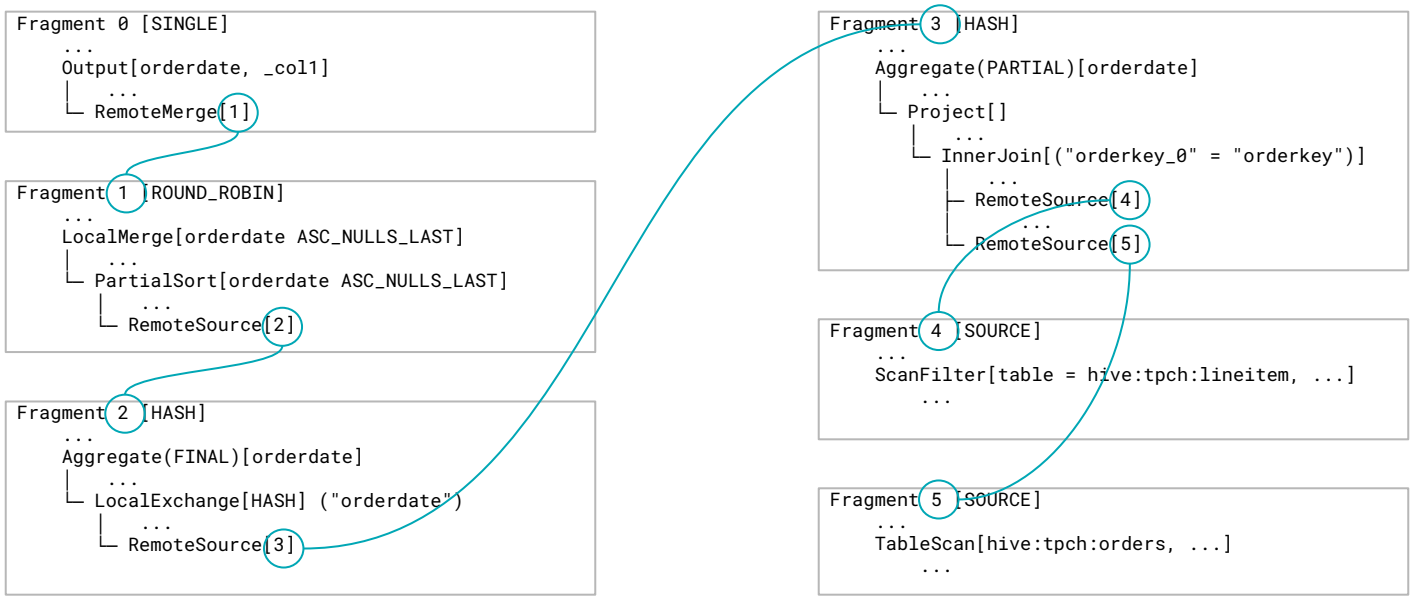
Exchanges



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Optimizations

Optimizations

- Constant folding
- Limit pushdown
- Predicate pushdown
- Aggregation pushdown
- Join reordering and type selection

Constant folding

```
SELECT orderkey
FROM orders
WHERE orderdate >= current_date - INTERVAL '30' DAY
```

```
Fragment 1 [SOURCE]
    Output layout: [orderkey]
    Output partitioning: SINGLE []
    Stage Execution Strategy: UNGROUPED_EXECUTION
    ScanFilterProject[table = tpch:orders:sf0.01,..., filterPredicate = ("orderdate" >= DATE '2020-07-10')]
        Layout: [orderkey:bigint]
        Estimates: ...
        orderkey := tpch:orderkey
        orderdate := tpch:orderdate
        tpch:orderstatus
            :: [[F], [O], [P]]
```

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Column pruning

```
TABLE orders (
  orderkey bigint,
  custkey bigint,
  orderstatus varchar(1),
  totalprice double,
  orderdate date,
  orderpriority varchar(15),
  clerk varchar(15),
  shippriority integer,
  comment varchar(79)
)
```

```
SELECT orderstatus, sum(totalprice)
FROM orders
GROUP BY orderstatus
```

```
Fragment 2 [SOURCE]
   Output layout: [orderstatus, sum_0]
   Output partitioning: HASH [orderstatus]
   Stage Execution Strategy: UNGROUPED_EXECUTION
   Aggregate(PARTIAL)[orderstatus]
   |   Layout: [orderstatus:varchar(1), sum_0:row(bigint, boolean, double, boolean)]
   |   CPU: 24.06s (51.10%), Scheduled: 39.11s (37.50%), Output: 180 rows (5.80kB)
   |   Input avg.: 1339285.71 rows, Input std.dev.: 93.43%
   |   sum_0 := sum("totalprice")
   └─ TableScan[hive:tpch:orders, grouped = false]
          Layout: [totalprice:double, orderstatus:varchar(1)]
          Estimates: {rows: 150000000 (2.10GB), cpu: 2.10G, memory: 0B, network: 0B}
          CPU: 23.00s (48.86%), Scheduled: 1.09m (62.46%), Output: 150000000 rows (2.10GB)
          Input avg.: 1339285.71 rows, Input std.dev.: 93.43%
          orderstatus := orderstatus:varchar(1):REGULAR
          totalprice := totalprice:double:REGULAR
```

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Nested column pruning

```
TABLE orders (
  orderkey bigint,
  details ROW(
     custkey bigint,
     orderstatus varchar(1),
     totalprice double,
     orderdate date,
     orderpriority varchar(15),
     clerk varchar(15),
     shippriority integer,
     comment varchar(79)
  )
)
```

```
SELECT details.orderstatus, sum(details.totalprice)
FROM orders_nested
GROUP BY details.orderstatus;
```

```
Fragment 2 [SOURCE]
   Output layout: [details#orderstatus, sum_1]
   Output partitioning: HASH [details#orderstatus]
   Stage Execution Strategy: UNGROUPED_EXECUTION
   Aggregate(PARTIAL)[details#orderstatus]
   |   Layout: [details#orderstatus:varchar(1), sum_1:row(bigint, boolean, double, boolean)]
   |   CPU: 21.44s (27.23%), Scheduled: 24.52s (21.81%), Output: 48 rows (1.55kB)
   |   Input avg.: 2830188.68 rows, Input std.dev.: 169.04%
   |   sum_1 := sum("details#totalprice")
   └─ TableScan[hive:tpch:orders_nested, grouped = false]
          Layout: [details#totalprice:double, details#orderstatus:varchar(1)]
          Estimates: {rows: 150000000 (8.94GB), cpu: 8.94G, memory: 0B, network: 0B}
          CPU: 57.28s (72.76%), Scheduled: 1.46m (78.14%), Output: 150000000 rows (2.10GB)
          Input avg.: 2830188.68 rows, Input std.dev.: 169.04%
          details#totalprice := details#totalprice:double:REGULAR
          details#orderstatus := details#orderstatus:varchar(1):REGULAR
```

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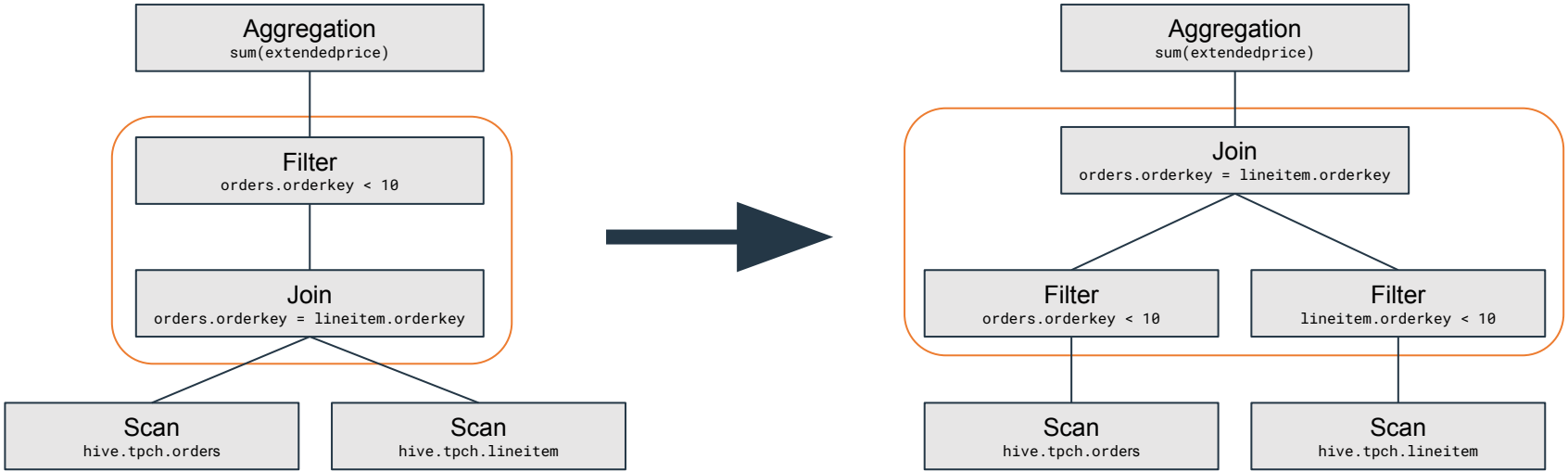
Predicate pushdown

```
SELECT sum(extendedprice)
FROM orders JOIN lineitem ON orders.orderkey = lineitem.orderkey
WHERE orders.orderkey < 10
```



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Predicate pushdown into connectors

```
SELECT *
FROM orders
```

```
Fragment 1 [SOURCE]
    CPU: 114.47ms, Scheduled: 225.06ms, Input: 15000 rows (1.86MB); per task: avg.: 15000.00 std.dev.: 0.00, Output: 15000 rows (1.86MB)
    ...
    TableScan[postgresql:tpch.orders tpch.orders, grouped = false]
        ...
        CPU: 115.00ms (100.00%), Scheduled: 225.00ms (100.00%), Output: 15000 rows (1.86MB)
        Input avg.: 15000.00 rows, Input std.dev.: 0.00%
        ...
```

```
SELECT *
FROM orders
WHERE orderdate BETWEEN DATE '1995-01-01' AND DATE '1995-12-31'
```

```
Fragment 1 [SOURCE]
    CPU: 28.32ms, Scheduled: 56.24ms, Input: 2204 rows (279.58kB); per task: avg.: 2204.00 std.dev.: 0.00, Output: 2204 rows (279.58kB)
    ...
    TableScan[postgresql:tpch.orders tpch.orders, grouped = false]
        ...
        CPU: 28.00ms (100.00%), Scheduled: 56.00ms (100.00%), Output: 2204 rows (279.58kB)
        Input avg.: 2204.00 rows, Input std.dev.: 0.00%
```

Starburst

Predicate pushdown into connectors - Limitations

`((col0 BETWEEN ? AND ?) OR (col0 BETWEEN ? and ?) OR ...)) AND`
`((col1 BETWEEN ? AND ?) OR (col1 BETWEEN ? and ?) OR ...)) AND`
`...`
	✅

`column IN (1, 2, 3)`	✅
`column LIKE '%hello%world%'`	❌
`log10(column) > 1`	❌
`(col1 = 1 OR col2 = 10) AND` `(col1 = 2 OR col2 = 20)`	❌

Starburst

Predicate pushdown into the Hive connector

- Partition pruning
- Bucket pruning
- Row group skipping for ORC and Parquet

Hive partition pruning

```
CREATE TABLE orders_partitioned (...)
WITH (
   format = 'ORC',
   partitioned_by = array['orderstatus', 'orderpriority'])
```

```
SELECT orderdate, sum(totalprice) total
FROM orders_partitioned
WHERE orderstatus = 'F'
GROUP BY orderdate
ORDER BY total DESC
LIMIT 10
```

```
Fragment 3 [SOURCE]
   CPU: 22.14s, Scheduled: 1.06m, Input: 73072502 rows (975.62MB); per task: avg.: 18268125.50 std.dev.: 1588835.53, Output: 50510 rows (1.54MB)
   Output layout: [orderdate, sum_0]
   Output partitioning: HASH [orderdate]
   Stage Execution Strategy: UNGROUPED_EXECUTION
   Aggregate(PARTIAL)[orderdate]
   |   Layout: [orderdate:date, sum_0:row(bigint, boolean, double, boolean)]
   |   CPU: 13.18s (59.21%), Scheduled: 27.72s (40.07%), Output: 50510 rows (1.54MB)
   |   Input avg.: 1217875.03 rows, Input std.dev.: 84.18%
   |   Collisions avg.: 22213.65 (156965.32% est.), Collisions std.dev.: 172.70%
   |   sum_0 := sum("totalprice")
   └─ TableScan[hive:tpch:orders_partitioned, grouped = false]
          Layout: [orderdate:date, totalprice:double]
          Estimates: {rows: 73072502 (975.62MB), cpu: 975.62M, memory: 0B, network: 0B}
          CPU: 8.96s (40.26%), Scheduled: 41.16s (59.50%), Output: 73072502 rows (975.62MB)
          Input avg.: 1217875.03 rows, Input std.dev.: 84.18%
          totalprice := totalprice:double:REGULAR
          orderdate := orderdate:date:REGULAR
          orderstatus:varchar(1):PARTITION_KEY
              :: [[F]]
          orderpriority:varchar(15):PARTITION_KEY
              :: [[1-URGENT], [2-HIGH], [3-MEDIUM], [4-NOT SPECIFIED], [5-LOW]]
```

Table contains
150,000,000 rows

Starburst

Hive partition pruning

```
CREATE TABLE orders_partitioned (...)
WITH (
   format = 'ORC',
   partitioned_by = array['orderstatus', 'orderpriority'])
```

```
SELECT orderdate, sum(totalprice) total
FROM orders_partitioned
WHERE cast(substr(orderpriority, 1, 1) as tinyint) = 1
GROUP BY orderdate
ORDER BY total DESC
LIMIT 10
```

```
Fragment 3 [SOURCE]
   CPU: 7.15s, Scheduled: 13.90s, Input: 29995209 rows (400.85MB); per task: avg.: 7498802.25 std.dev.: 1730167.46, Output: 20682 rows (646.31kB)
   Output layout: [orderdate, sum_0]
   Output partitioning: HASH [orderdate]
   Stage Execution Strategy: UNGROUPED_EXECUTION
   Aggregate(PARTIAL)[orderdate]
   |   Layout: [orderdate:date, sum_0:row(bigint, boolean, double, boolean)]
   |   CPU: 3.50s (48.52%), Scheduled: 4.98s (34.53%), Output: 20682 rows (646.31kB)
   |   Input avg.: 1071257.46 rows, Input std.dev.: 94.74%
   |   Collisions avg.: 18307.11 (142692.06% est.), Collisions std.dev.: 189.30%
   |   sum_0 := sum("totalprice")
   └─ ScanFilterProject[table = ..., filterPredicate = (CAST("substr"("orderpriority", BIGINT '1', BIGINT '1') AS tinyint) = TINYINT '1')]
         Layout: [totalprice:double, orderdate:date]
         Estimates: ...
         CPU: 3.66s (50.73%), Scheduled: 9.19s (63.72%), Output: 29995209 rows (400.48MB)
         Input avg.: 1071257.46 rows, Input std.dev.: 94.74%
         totalprice := totalprice:double:REGULAR
         orderdate := orderdate:date:REGULAR
         orderpriority := orderpriority:varchar(15):PARTITION_KEY
             :: [[1-URGENT]]
         orderstatus:varchar(1):PARTITION_KEY
             :: [[F], [O], [P]]
         Input: 29995209 rows (400.85MB), Filtered: 0.00%
```

Table contains 150,000,000 rows

Starburst

Hive bucket pruning

```
CREATE TABLE orders_bucketed (...)
WITH (
   format = 'ORC',
   bucketed_by = array['orderkey'])
```

```
SELECT *
FROM orders_unbucketed
WHERE orderkey IN (1, 2, 3, 4)

Query 20200810_024110_00017_utfmj, FINISHED, 4 nodes
Splits: 116 total, 116 done (100.00%)
0.48 [10K rows, 37.4MB] [21K rows/s, 78.6MB/s]
```

```
SELECT *
FROM orders_bucketed
WHERE orderkey IN (1, 2, 3, 4)

Query 20200810_024059_00016_utfmj, FINISHED, 4 nodes
Splits: 8 total, 8 done (100.00%)
0.43 [40K rows, 59.5MB] [93.5K rows/s, 139MB/s]
```

Starburst

Row group skipping

```
CREATE TABLE lineitem (...)
WITH (
    bucketed_by=...,
    sorted_by=ARRAY['orderkey']
)
```

```
SELECT sum(extendedprice)
FROM lineitem
WHERE orderkey = 999
```

```
Fragment 2
   CPU: 17.80s, Scheduled: 1.29m, Input: 9987786 rows (85.78MB); per task: avg.: 2496946.50 std.dev.: 218060.73, Output: 450 rows (11.87kB)
   ...
   Aggregate(PARTIAL)
   │   ...
   └─ ScanFilterProject[table = hive:tpch:lineitem, filterPredicate = ("orderkey" = BIGINT '999')]
          ...
          CPU: 17.68s (99.19%), Scheduled: 1.53m (99.67%), Output: 6 rows (54B)
          Input avg.: 22195.08 rows, Input std.dev.: 84.57%
          Input: 9987786 rows (85.78MB), Filtered: 100.00%
```

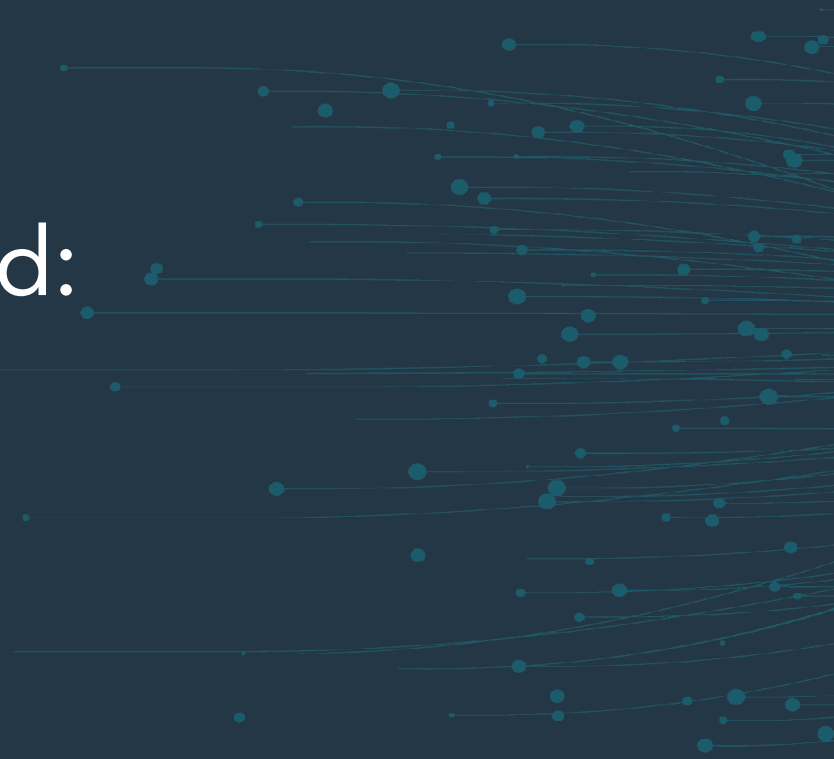
```
Fragment 2
   CPU: 1.33s, Scheduled: 3.18s, Input: 310000 rows (2.66MB); per task: avg.: 77500.00 std.dev.: 4330.13, Output: 372 rows (9.81kB)
   ...
   Aggregate(PARTIAL)
   │   ...
   └─ ScanFilterProject[table = hive:tpch:lineitem, filterPredicate = ("orderkey" = BIGINT '999')]
          ...
          CPU: 1.28s (95.88%), Scheduled: 3.37s (97.20%), Output: 6 rows (54B)
          Input avg.: 833.33 rows, Input std.dev.: 331.66%
          Input: 310000 rows (2.66MB), Filtered: 100.00%
```

Starburst

5 minute break

And if you stick around:

- Browse prestosql.io
- Join us on Slack
- Submit questions



Limit pushdown

```
SELECT *
FROM orders
WHERE orderdate BETWEEN DATE '1995-01-01' AND DATE '1995-12-31'
LIMIT 10
```

```
Fragment 1 [SOURCE]
   CPU: 5.27ms, Scheduled: 24.19ms, Input: 10 rows (1.28kB); per task: avg.: 10.00 std.dev.: 0.00, Output: 10 rows (1.28kB)
   Output layout: [orderkey, custkey, orderstatus, totalprice, orderdate, orderpriority, clerk, shippriority, comment]
   Output partitioning: SINGLE []
   Stage Execution Strategy: UNGROUPED_EXECUTION
   TableScan[postgresql:tpch.orders tpch.orders limit=10, grouped = false]
       Layout: ...
       Estimates: {rows: ? (?), cpu: ?, memory: 0B, network: 0B}
       CPU: 5.00ms (100.00%), Scheduled: 24.00ms (100.00%), Output: 10 rows (1.28kB)
       Input avg.: 10.00 rows, Input std.dev.: 0.00%
       clerk := clerk:varchar(15):varchar
       orderkey := orderkey:bigint:int8
       orderstatus := orderstatus:varchar(1):varchar
       custkey := custkey:bigint:int8
       totalprice := totalprice:double:float8
       comment := comment:varchar(79):varchar
       orderdate := orderdate:date:date
       orderpriority := orderpriority:varchar(15):varchar
       shippriority := shippriority:integer:int4
```

Starburst

Partial limit pushdown

```
SELECT *
FROM orders
LIMIT 10
```

```
Fragment 1 [SINGLE]
    CPU: 1.86ms, Scheduled: 4.00ms, Input: 10 rows (3.88kB); per task: avg.: 10.00 std.dev.: 0.00, Output: 10 rows (3.88kB)
    Output layout: [_id, _source, _score, clerk, comment, custkey, orderdate, orderkey, orderpriority, orderstatus, shippriority, totalprice]
    Output partitioning: SINGLE []
    Stage Execution Strategy: UNGROUPED_EXECUTION
    Limit[10]
    │   Layout: ...
    └─ LocalExchange[SINGLE] ()
       │   Layout: ...
       └─ RemoteSource[2]
              Layout: ...
              CPU: 0.00ns (0.00%), Scheduled: 0.00ns (0.00%), Output: 10 rows (3.88kB)
              Input avg.: 2.50 rows, Input std.dev.: 173.21%

Fragment 2 [SOURCE]
    CPU: 3.74ms, Scheduled: 19.56ms, Input: 10 rows (3.88kB); per task: avg.: 10.00 std.dev.: 0.00, Output: 10 rows (3.88kB)
    Output layout: [_id, _source, _score, clerk, comment, custkey, orderdate, orderkey, orderpriority, orderstatus, shippriority, totalprice]
    Output partitioning: SINGLE []
    LimitPartial[10]
    │   Layout: ...
    └─ TableScan[elasticsearch:SCAN:orders limit=10, grouped = false]
           Layout: ...
           Estimates: {rows: ? (?), cpu: ?, memory: 0B, network: 0B}
           CPU: 3.00ms (100.00%), Scheduled: 28.00ms (100.00%), Output: 10 rows (3.88kB)
           Input avg.: 10.00 rows, Input std.dev.: 0.00%
           ...
```

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Aggregation pushdown

```
SELECT orderstatus, sum(totalprice)
FROM orders
WHERE orderdate BETWEEN DATE '1995-01-01' AND DATE '1995-12-31'
GROUP BY orderstatus
```

```
Fragment 1 [SOURCE]
    CPU: 5.13ms, Scheduled: 26.73ms, Input: 3 rows (45B); per task: avg.: 3.00 std.dev.: 0.00, Output: 3 rows (45B)
    Output layout: [sum, orderstatus]
    Output partitioning: SINGLE []
    Stage Execution Strategy: UNGROUPED_EXECUTION
    TableScan[postgresql:tpch.orders tpch.orders
        columns=[orderstatus:varchar(1):varchar, sum("totalprice"):_presto_generated_1:double:float8]
        groupingSets=[[orderstatus:varchar(1):varchar]]]
          Layout: [sum:double, orderstatus:varchar(1)]
          Estimates: {rows: ? (?), cpu: ?, memory: 0B, network: 0B}
          CPU: 4.00ms (100.00%), Scheduled: 27.00ms (100.00%), Output: 3 rows (45B)
          Input avg.: 3.00 rows, Input std.dev.: 0.00%
          orderstatus := orderstatus:varchar(1):varchar
          sum := sum("totalprice"):_presto_generated_1:double:float8
```

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Skew

```
SELECT count(*)
FROM visits JOIN pages USING (page_id)
WHERE url = 'index.html'
```

```
Fragment 2 [HASH]
    CPU: 8.17s, Scheduled: 9.22s, Input: 100000001 rows (858.31MB); per task: avg.: 10000000.10 std.dev.: 881640.09, Output: 40 rows (360B)
    Output layout: [count_7]
    Output partitioning: SINGLE []
    Stage Execution Strategy: UNGROUPED_EXECUTION
    Aggregate(PARTIAL)
    │   Layout: [count_7:bigint]
    │   CPU: 29.00ms (0.16%), Scheduled: 35.00ms (0.14%), Output: 40 rows (360B)
    │   Input avg.: 24781.15 rows, Input std.dev.: 345.72%
    │   count_7 := count(*)
    └─ InnerJoin[("page_id" = "page_id_0")]
       │   Layout: []
       │   Estimates: {rows: 578035 (0B), cpu: 2.51G, memory: 9B, network: 858.31MB}
       │   CPU: 7.53s (40.41%), Scheduled: 8.34s (33.31%), Output: 991246 rows (0B)
       │   Left (probe) Input avg.: 2500000.00 rows, Input std.dev.: 58.92%
       │   Right (build) Input avg.: 0.03 rows, Input std.dev.: 624.50%
       │   Distribution: PARTITIONED
       ├─ RemoteSource[3]
       │      Layout: [page_id:bigint]
       │      CPU: 568.00ms (3.05%), Scheduled: 735.00ms (2.94%), Output: 100000000 rows (858.31MB)
       │      Input avg.: 2500000.00 rows, Input std.dev.: 58.92%
       └─ LocalExchange[HASH] ("page_id_0")
          │   Layout: [page_id_0:bigint]
          │   Estimates: {rows: 1 (9B), cpu: 75, memory: 0B, network: 9B}
          │   CPU: 0.00ns (0.00%), Scheduled: 4.00ms (0.02%), Output: 1 row (9B)
          │   Input avg.: 0.03 rows, Input std.dev.: 624.50%
          └─ RemoteSource[4]
                 Layout: [page_id_0:bigint]
                 CPU: 0.00ns (0.00%), Scheduled: 0.00ns (0.00%), Output: 1 row (9B)
                 Input avg.: 0.03 rows, Input std.dev.: 624.50%
```

Starburst

Cost-based optimizations

Cost-based optimizations

Data-dependent, based on statistics

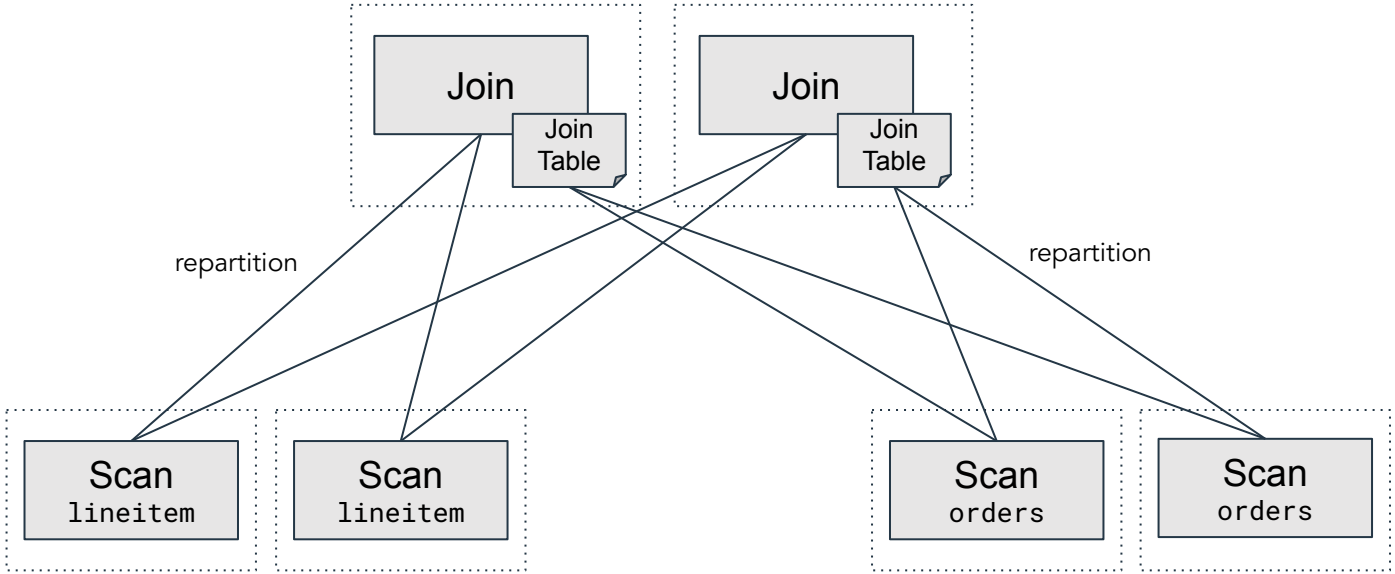
Optimize for

- CPU
- Memory requirements
- Network re-shuffles
- Skew avoidance

Optimizations

- Join type selection (Partitioned vs Broadcast)
- Join reordering

Partitioned join



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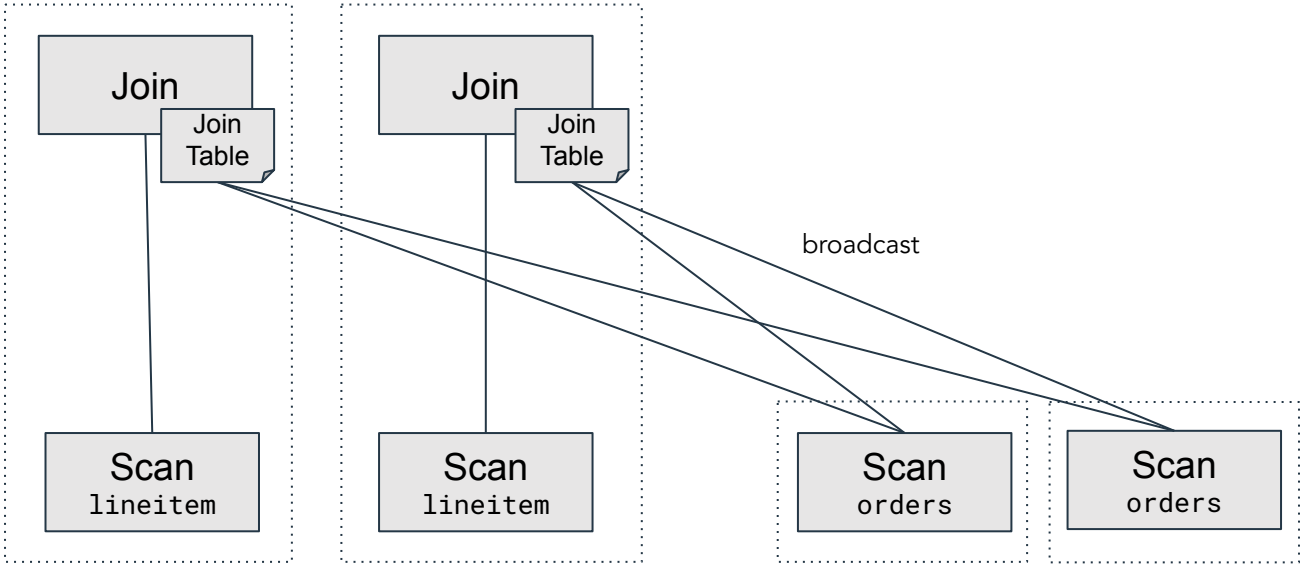
Broadcast join



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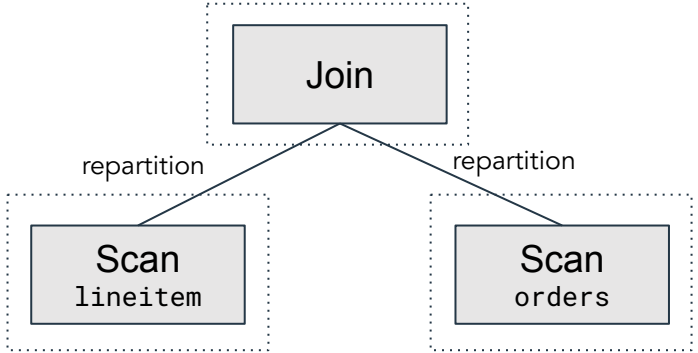
Join type selection - Partitioned

```
SELECT orderpriority, SUM(extendedprice * discount)
FROM lineitem JOIN orders USING (orderkey)
GROUP BY orderpriority
```




```
Fragment 2 [HASH]
    ...
    Aggregate(PARTIAL)[orderpriority]
    │   ...
    └─ Project[]
       │   ...
       └─ InnerJoin[("orderkey_0" = "orderkey")]
          │   ...
          │   Distribution: PARTITIONED
          ├─ RemoteSource[3]
          │      ...
          └─ LocalExchange[HASH] ("orderkey")
             │   ...
             └─ RemoteSource[4]
                    ...

Fragment 3 [SOURCE]
    Output partitioning: HASH [orderkey]
    ScanFilter[table = hive:tpch:lineitem, filterPredicate = true, dynamicFilter = {df_355 -> "orderkey_0"}]
        ...
        Estimates: {rows: 60175000 (1.51GB), cpu: 1.51G, memory: 0B, network: 0B}

Fragment 4 [SOURCE]
    Output partitioning: HASH [orderkey]
    TableScan[hive:tpch:orders]
        ...
        Estimates: {rows: 15000000 (200.39MB), cpu: 200.39M, memory: 0B, network: 0B}
```

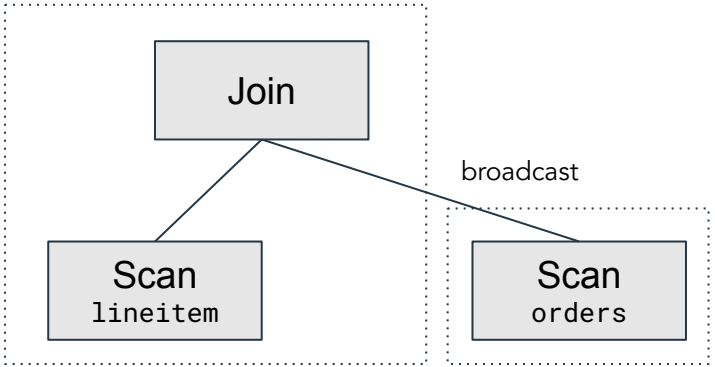
Starburst

Join type selection - Broadcast

```
SELECT orderpriority, SUM(extendedprice * discount)
FROM lineitem JOIN orders USING (orderkey)
WHERE orderdate BETWEEN DATE '1995-01-01' AND DATE '1995-01-31'
GROUP BY orderpriority
```

```
Fragment 2 [SOURCE]
    ...
    Aggregate(PARTIAL)[orderpriority]
    │   ...
    └─ Project[]
       │   ...
       └─ InnerJoin[("orderkey_0" = "orderkey")]
          │   ...
          │   Distribution: REPLICATED
          ├─ TableScan[hive:tpch:lineitem, grouped = false]
          │      Estimates: {rows: 60175000 (1.51GB), cpu: 1.51G, memory: 0B, network: 0B}
          └─ LocalExchange[HASH] ("orderkey")
             │   ...
             └─ RemoteSource[3]
                    ...

Fragment 3 [SOURCE]
    Output partitioning: BROADCAST []
    ScanFilterProject[table = hive:tpch:orders, filterPredicate = ("orderdate" BETWEEN DATE '1995-01-01' AND DATE '1995-01-31')]
        Estimates: {rows: 15000000 (200.39MB), cpu: 271.92M, memory: 0B, network: 0B}/
                   {rows: 187110 (2.50MB), cpu: 543.84M, memory: 0B, network: 0B}/
                   {rows: 187110 (2.50MB), cpu: 546.33M, memory: 0B, network: 0B}
```



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Disabling cost-based optimizations

```
SET SESSION join_distribution_type = 'BROADCAST'
SET SESSION join_distribution_type = 'PARTITIONED'

SET SESSION join_reordering_strategy = 'NONE'
```

Join reordering

```
SELECT c.custkey, sum(l.extendedprice * l.discount) discount
FROM customer c, orders o, lineitem l
WHERE c.custkey = o.custkey AND l.orderkey = o.orderkey
GROUP BY c.custkey
ORDER BY discount DESC
```

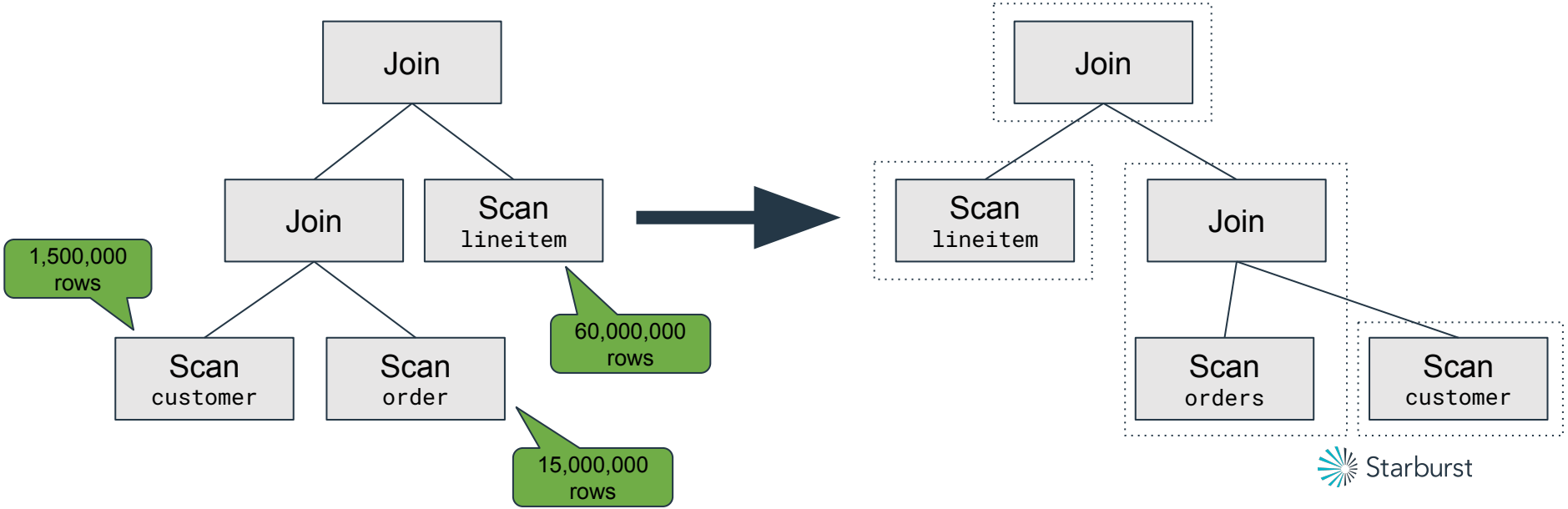
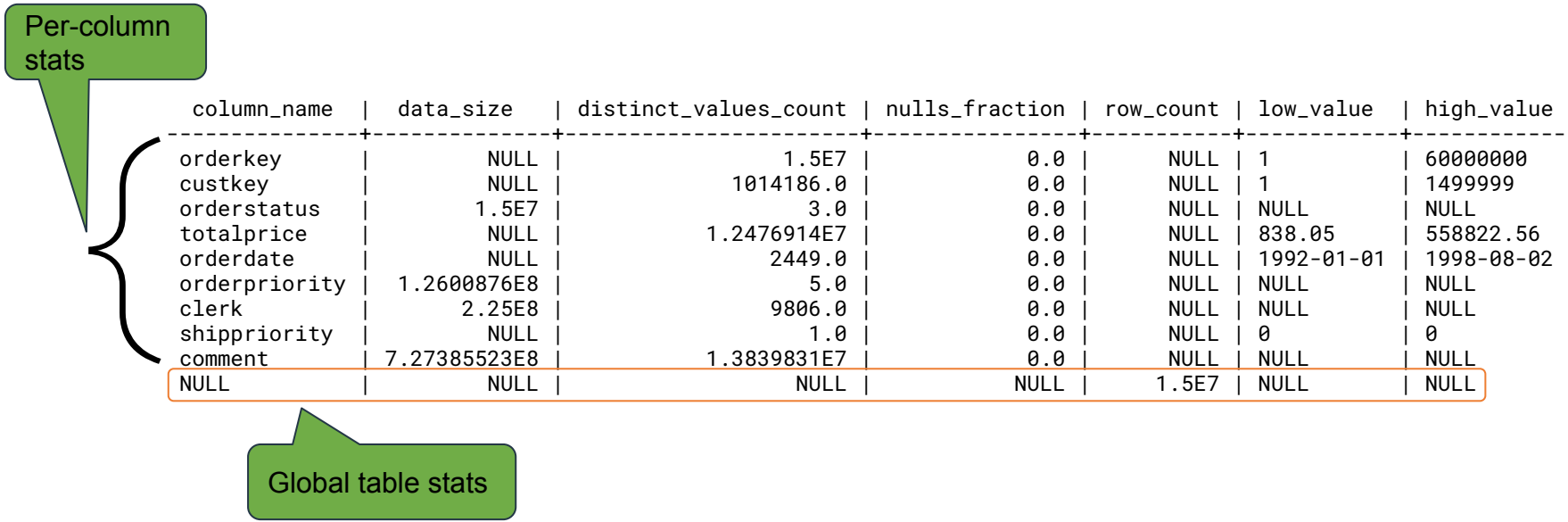


Table statistics

```
SHOW STATS FOR orders
```



column_name	data_size	distinct_values_count	nulls_fraction	row_count	low_value	high_value
orderkey	NULL	1.5E7	0.0	NULL	1	60000000
custkey	NULL	1014186.0	0.0	NULL	1	1499999
orderstatus	1.5E7	3.0	0.0	NULL	NULL	NULL
totalprice	NULL	1.2476914E7	0.0	NULL	838.05	558822.56
orderdate	NULL	2449.0	0.0	NULL	1992-01-01	1998-08-02
orderpriority	1.2600876E8	5.0	0.0	NULL	NULL	NULL
clerk	2.25E8	9806.0	0.0	NULL	NULL	NULL
shippriority	NULL	1.0	0.0	NULL	0	0
comment	7.27385523E8	1.3839831E7	0.0	NULL	NULL	NULL
NULL	NULL	NULL	NULL	1.5E7	NULL	NULL

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Computing statistics

Automatically when inserting data into tables

Via `ANALYZE` command

Resources

Blog Posts:

- Intro to Cost-based Optimizer: https://prestosql.io/blog/2019/07/04/cbo-introduction.html
- Dynamic partition pruning: https://prestosql.io/blog/2020/06/14/dynamic-partition-pruning.html
- Dynamic filtering: https://prestosql.io/blog/2019/06/30/dynamic-filtering.html
- Cast Optimization: https://prestosql.io/blog/2019/05/21/optimizing-the-casts-away.html
- Removing redundant ORDER BY: https://prestosql.io/blog/2019/06/03/redundant-order-by.html

Documentation

- Optimizer: https://prestosql.io/docs/current/optimizer.html
- ANALYZE: https://prestosql.io/docs/current/sql/analyze.html
- SHOW STATS: https://prestosql.io/docs/current/sql/show-stats.html

Wrapping up

Presto Training Series

Join the Presto creators again for more:

- Advanced SQL in Presto with David - recording available
- Securing Presto with Dain (26 Aug)
- Configuring and Tuning Presto Performance with Dain (9 Sept)

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Presto Summit series

Diverse information about Presto and real world usage

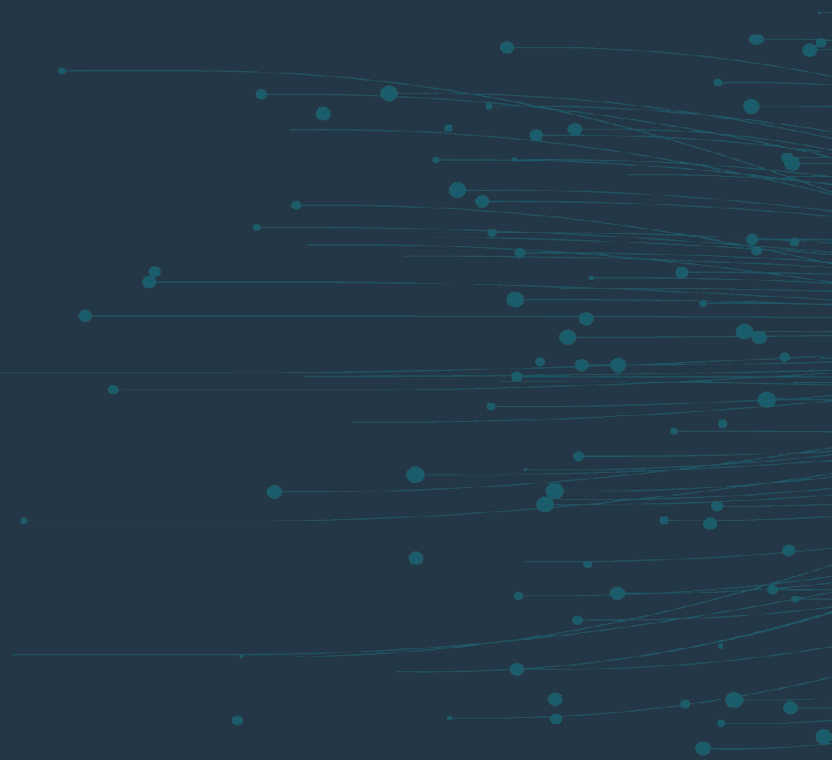
- State of Presto - recording available
- Presto as Query Layer at Zuora - recording available
- Presto Migration at Arm Treasure Data - recording available
- Presto for Analytics at Pinterest - 19 Aug

And finally ...

- Learn more from our website and documentation at prestosql.io
- Join us on slack at prestosql.io/slack
- Get a free digital copy of Presto: The Definitive Guide
- Thank you for hanging out with us
- See you next time

Starburst

Your question
Our answers …



Starburst