When and How to Take Advantage of New Optimizer Features in MySQL 5.6

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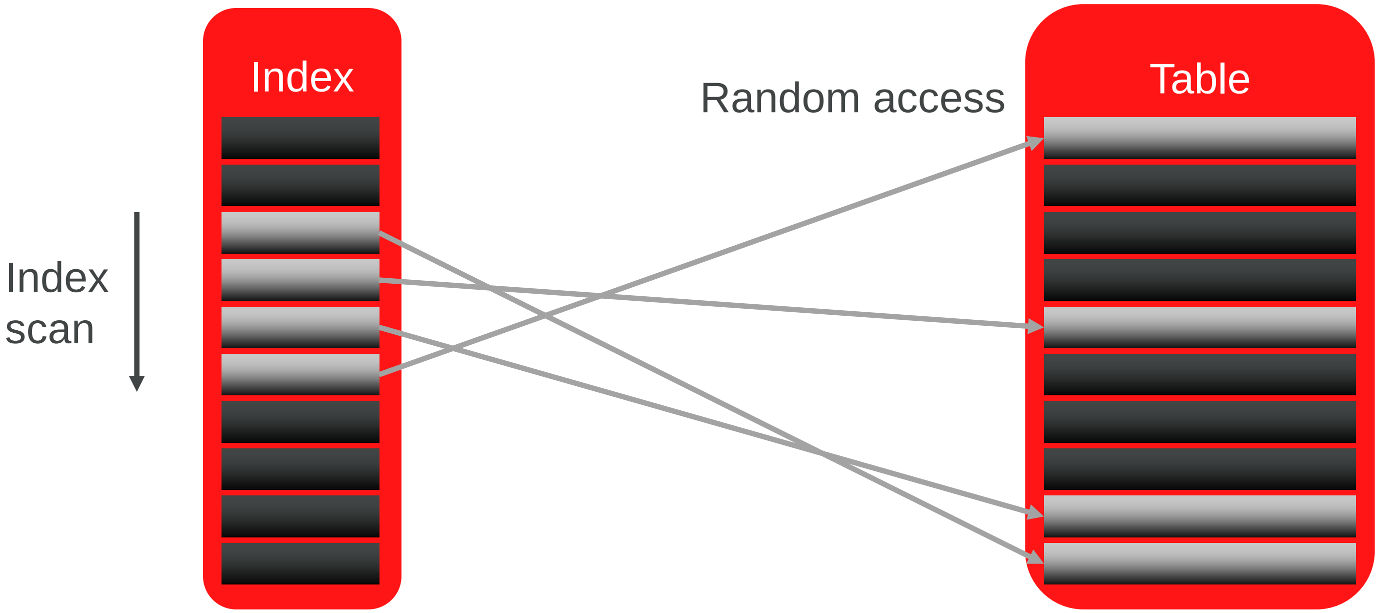
Program Agenda

- Improvements for disk-bound queries
- Subquery improvements
- Index condition pushdown
- Misc. optimizer improvements

MySQL 5.6: Improvements for Disk-Bound Queries

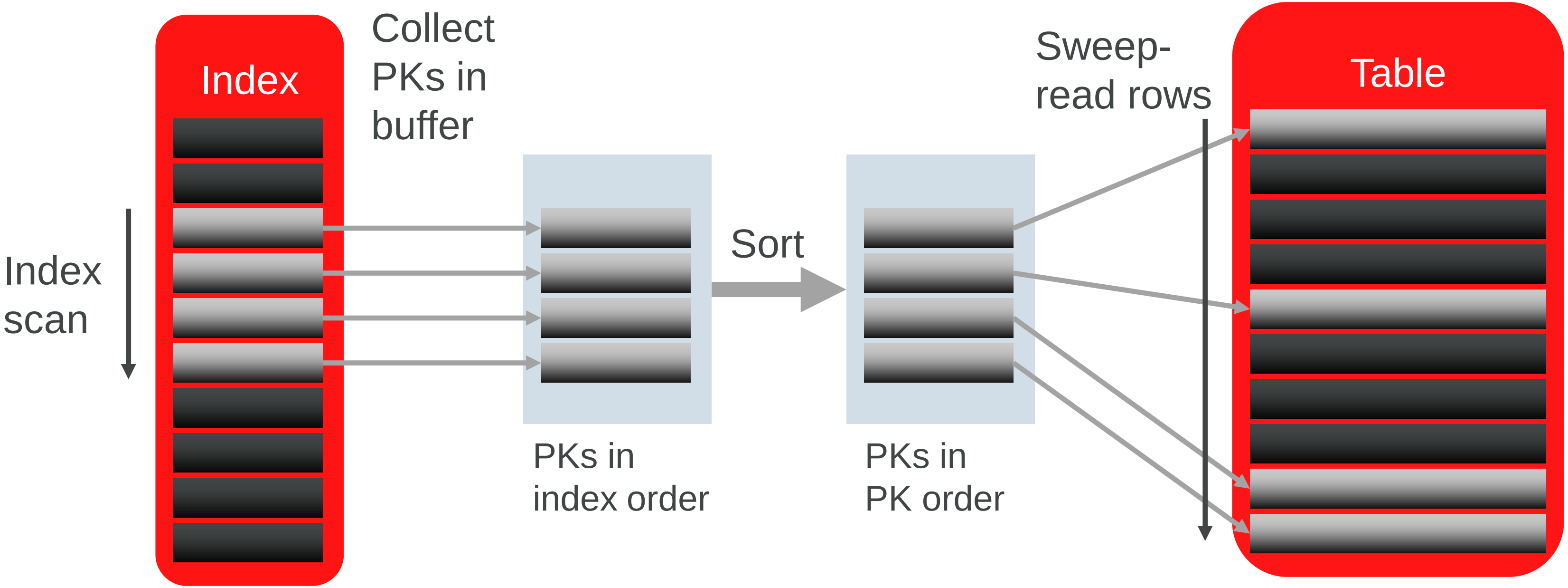
- Main idea: Sort keys retrieved from index before accessing table
- Benefits:
  - Read more rows from a page while it is still in buffer pool
  - Increased benefits from prefetching pages into the buffer pool
  - Sequential instead of random disk access?
- Range scan:
  - Disk Sweep Multi-Range Read (DS-MRR)
- Index lookup (Ref access):
  - Batched Key Access

MySQL 5.5: Data Access without DS-MRR



MySQL 5.6: Data Access with DS-MRR

InnoDB Example

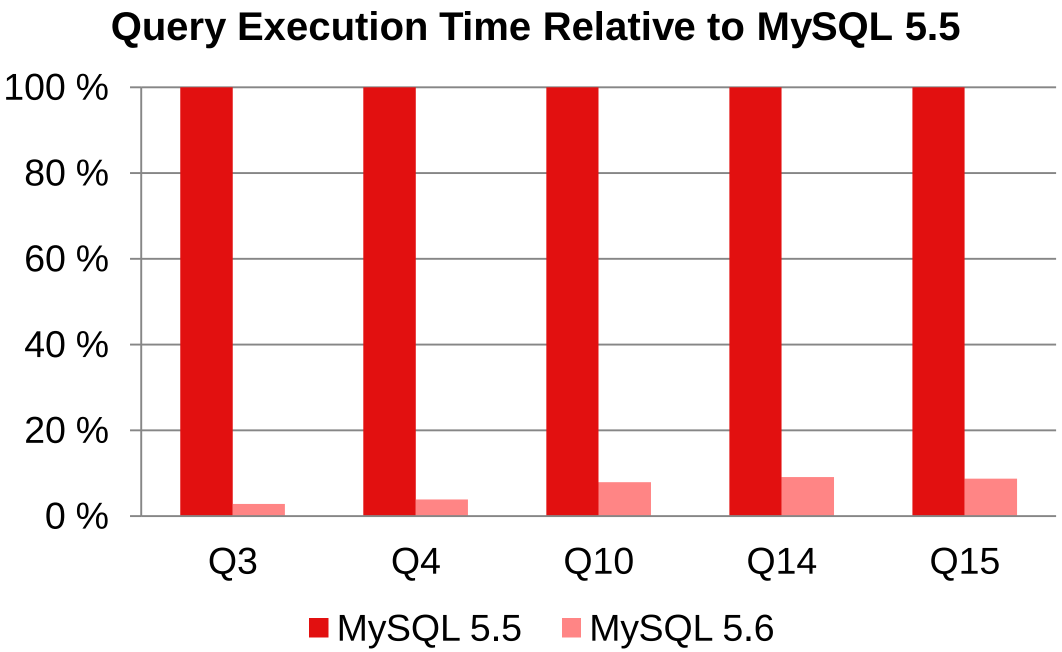


MySQL 5.5 vs MySQL 5.6: DBT-3 Queries using DS-MRR

DBT-3, Scale 10 (23 GB)

innodb_buffer_pool_size= 1 GB (disk-bound)

read_rnd_buffer_size = 4 MB



DS-MRR

Usage

- Default: Cost-based choice for tables larger than
  `innodb_buffer_pool_size` (Otherwise: off)
- Force MRR on:
  ```
  set optimizer_switch = ’mrr_cost_based=off’;
  ```
- Force MRR off:
  ```
  set optimizer_switch = ’mrr=off’;
  ```
- Configurable size for buffer used to sort keys:
  `read_rnd_buffer_size` (Default: 256 kB)

DS-MRR

EXPLAIN

```
mysql> explain select l_suppkey, sum(l_extendedprice * (1 - l_discount))
  from lineitem where l_shipdate >= '1996-07-01' and l_shipdate <
  date_add('1996-07-01', interval '90' day) group by l_suppkey\G
  *************************** 1. row ***************************
             id: 1
    select_type: SIMPLE
          table: lineitem
           type: range
  possible_keys: i_l_shipdate
            key: i_l_shipdate
        key_len: 4
            ref: NULL
           rows: 4354466
          Extra: Using index condition; Using MRR; Using temporary; Using
  filesort
  1 row in set (0.00 sec)
```

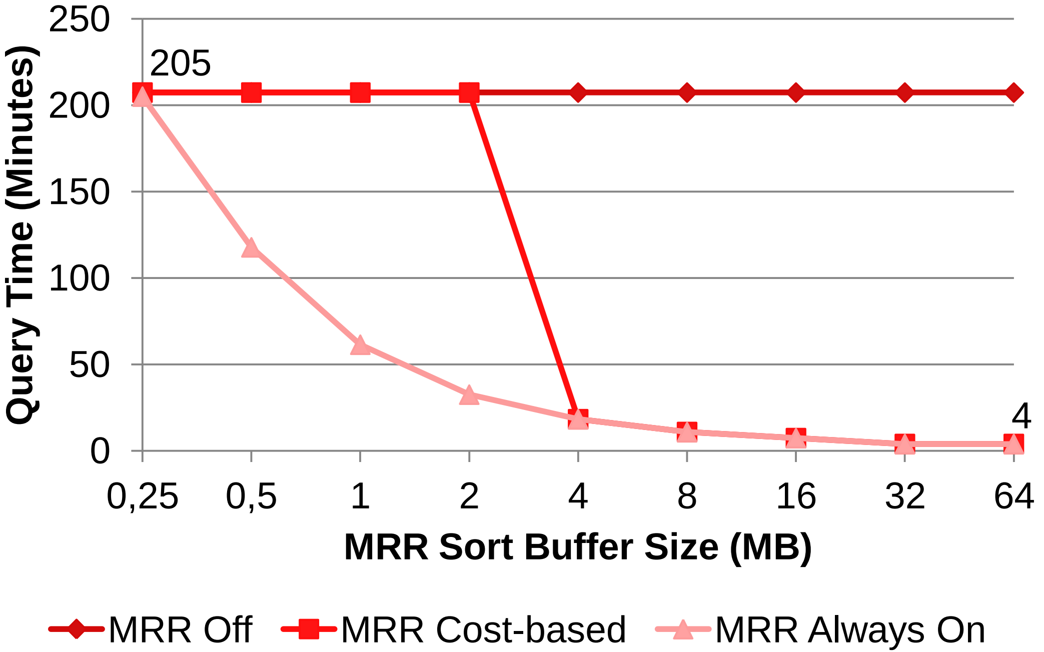
DS-MRR: Sort Buffer Size Matters

DBT-3, Query 15
Scale 10 (23 GB)

innodb_buffer_pool_size= 1 GB (disk-bound)

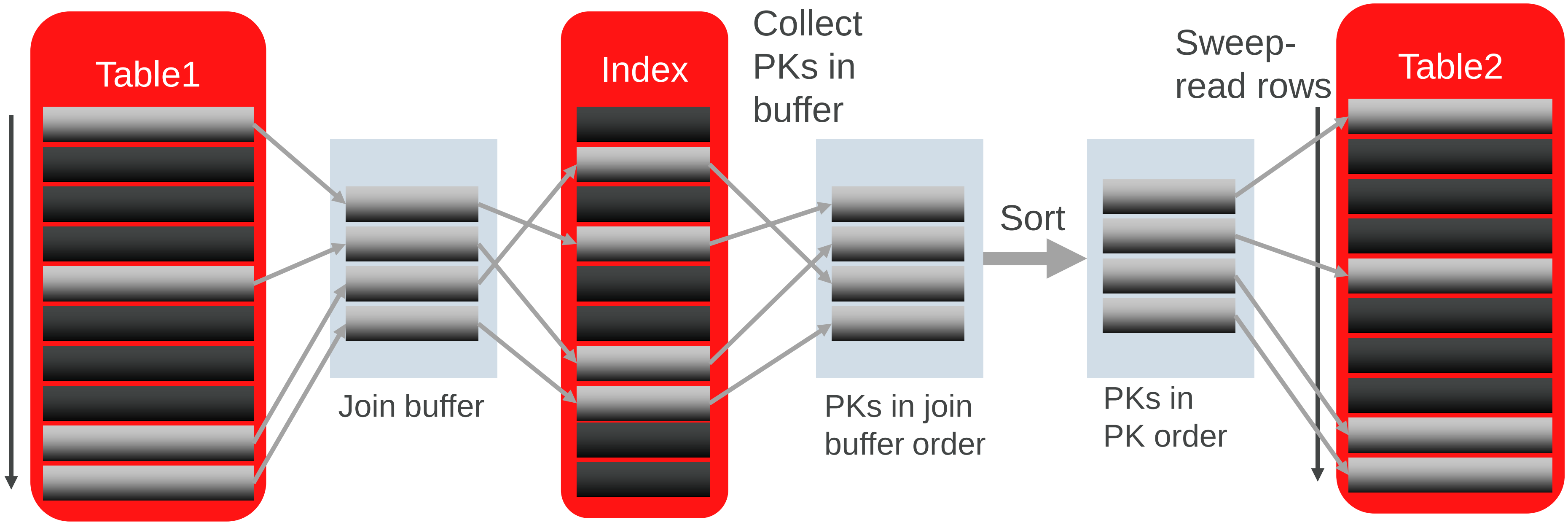
Varying read_rnd_buffer_size

optimizer_switch settings:
MRR Off:
    mrr=off
MRR Cost-based:
    mrr=on,mrr_cost_based=on
MRR Always on:
    mrr=on,mrr_cost_based=off



MySQL 5.6: Batched Key Access (BKA)

DS-MRR Applied to Join Buffering



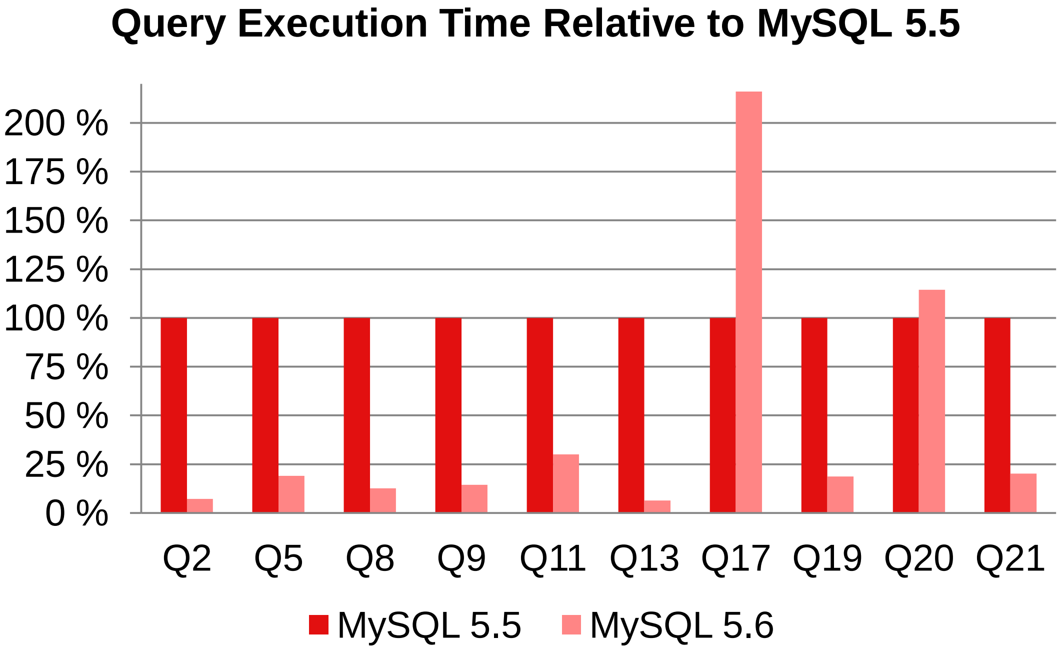
MySQL 5.5 vs MySQL 5.6: Queries using BKA

DBT-3, Scale 10 (23 GB)

innodb_buffer_pool_size= 1 GB (disk-bound)

join_buffer_size = 4 MB

optimizer_switch = ’batched_key_access=on, mrr_cost_based=off’



Batched Key Access

Usage

- Default: Off
- Force BKA on:

```
set optimizer_switch =
  ’batched_key_access=on,mrr_cost_based=off’;
```

- Configurable size for buffering keys to sort:

  `join_buffer_size` (Default: 256 kB)

Batched Key Access

EXPLAIN

```
mysql> explain select sum(l_extendedprice* (1 - l_discount)) as revenue from
  lineitem, part where p_partkey = l_partkey and p_brand = 'Brand#22' and
  l_quantity >= 6 and p_size between 1 and 5;
  +----+-------------+----------+------+---------------------------------+--
  | id | select_type | table    | type | possible_keys                   |
  key                 | key_len | ref                    | rows   |
  Extra                                                   |
  +----+-------------+----------+------+---------------------------------+--
  |  1 | SIMPLE      | part     | ALL  | PRIMARY                         |
  NULL                | NULL    | NULL                   | 200000 | Using
  where                                             |
  |  1 | SIMPLE      | lineitem | ref  | i_l_suppkey_partkey,i_l_partkey |
  i_l_suppkey_partkey | 5       | dbt3.part.p_partkey |     15 | Using where;
  Using join buffer (Batched Key Access) |
  +----+-------------+----------+------+---------------------------------+--
  2 rows in set (0.00 sec)
```

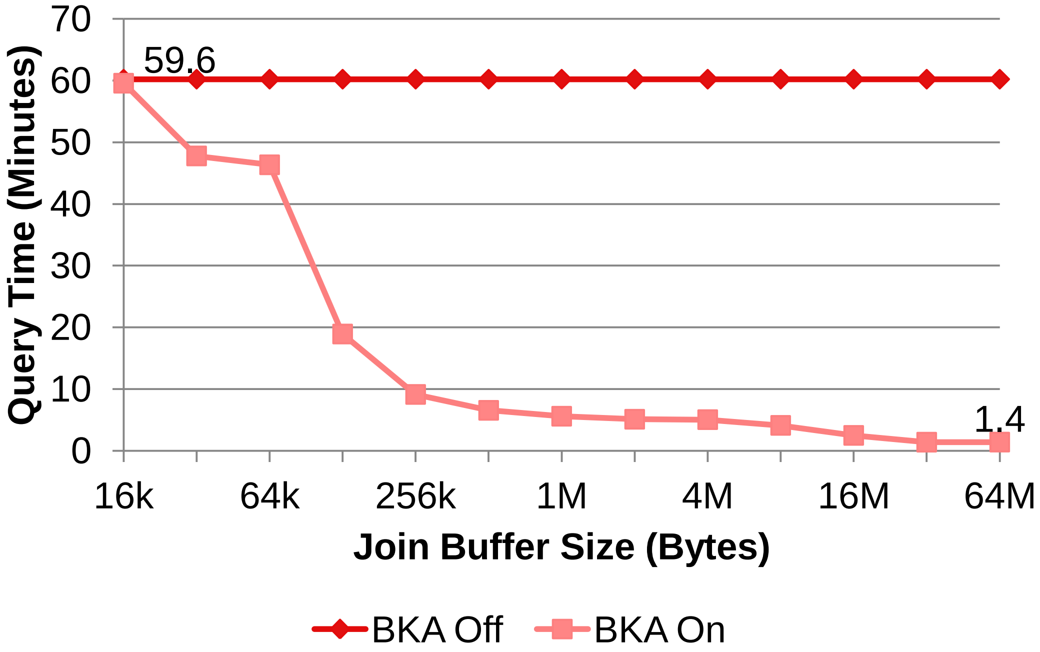
Batched Key Access: Buffer Size Matters

DBT-3, Query 2
Scale 10 (23 GB)

innodb_buffer_pool_size= 1 GB (disk-bound)

Varying join_buffer_size

optimizer_switch = ’batched_key_access=on, mrr_cost_based=off’



MySQL 5.6: Subquery Improvements

Optimize IN subqueries

```
select o_orderdate, o_totalprice
from orders
where o_orderkey in (select l_orderkey
                     from lineitem
                     where l_quantity > 49);
```

- New optimizations in MySQL 5.6:
  - Subquery Materialization
  - Semi-join

Subquery Materialization

1. Execute subquery and store result in a temporary table with unique index (For quick look-up and duplicate removal.)
2. Execute outer query and check for matches in temporary table.

```
select o_orderdate, o_totalprice
from orders
where o_orderkey in (select l_orderkey
                     from lineitem
                     group by l_orderkey
                     having sum(l_quantity) > 313);
```

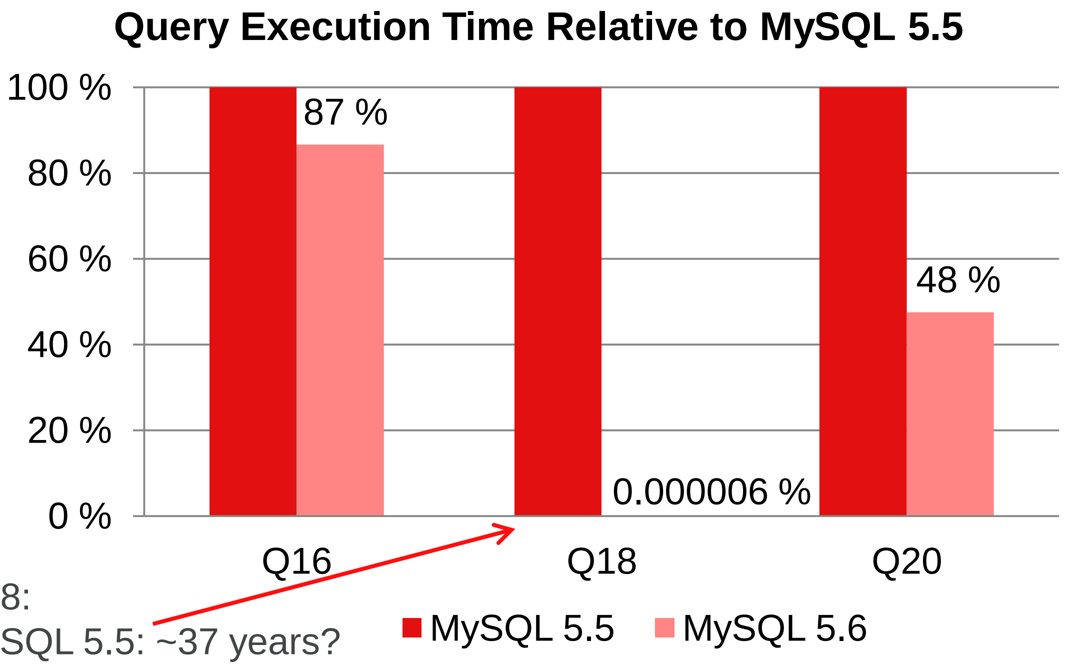
Materialize

MySQL 5.5 vs MySQL 5.6: Subquery Materialization

DBT-3, Scale 10 (23 GB)

innodb_buffer_pool_size= 24 GB (CPU-bound)

For Q20:
optimizer_switch = ’semijoin=off; subquery_materialization_cost_based=off’



Q18:
MySQL 5.5: ~37 years?
MySQL 5.6: 69 seconds

MySQL 5.6: Semi-join

- Convert subquery to inner join, BUT
  - Need some way to remove duplicates
- Different strategies for duplicate removal:
  - FirstMatch (equivalent to traditional subquery execution)
  - LooseScan (index scan, skip duplicates)
  - Materialization: MatLookup (like subquery materialization),
    MatScan (materialized table is first in join order)
  - Duplicate WeedOut (insert result rows of semi-join query into temporary table with unique index; duplicate rows will be rejected. Any join order.)
- If duplicate removal is not necessary:
  - Table pull-out

Semi-join, cont.

- Main advantage:
  - Opens up for more optimal ”join orders”.
  - Example:

```
select o_orderdate, o_totalprice
from orders
where o_orderkey in (select l_orderkey
                     from lineitem
                     where l_shipDate=’1996-09-30’);
```

Will process less rows if starting with `lineitem` instead of `orders`

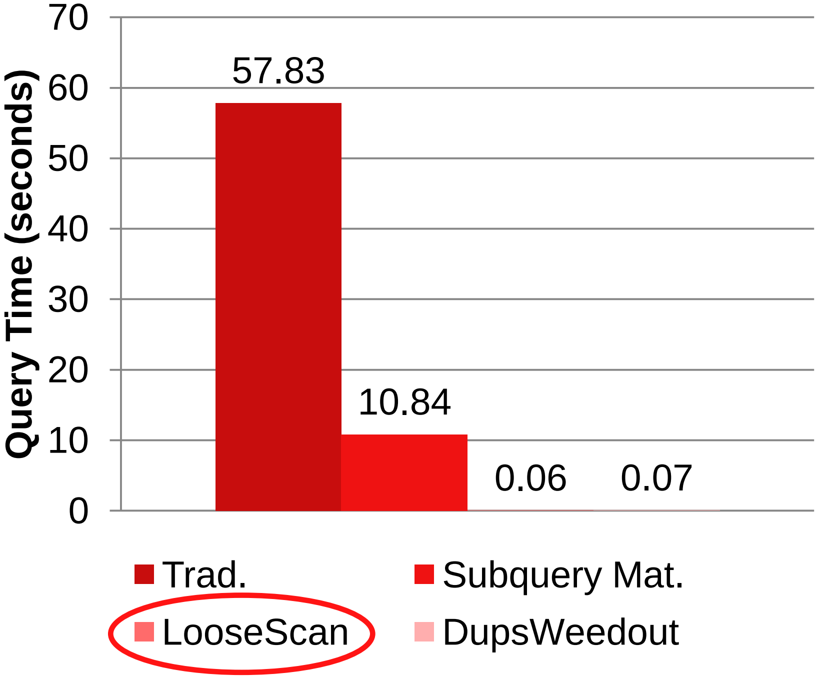
- Restriction:
  - Cannot use semi-join if subquery contains union or aggregation

MySQL 5.6: Semi-join: Example 1

```
select o_totalprice
from orders
where o_orderkey in
(select l_orderkey
 from lineitem
 where l_shipdate =
      '1996-09-30');
```

DBT-3, Scale 10 (23 GB)

innodb_buffer_pool_size= 24 GB (CPU-bound)

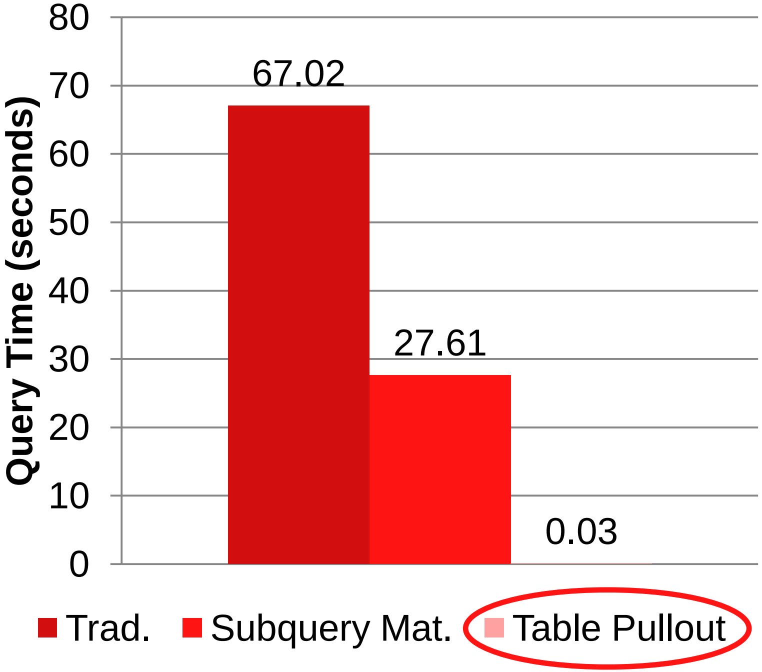


MySQL 5.6: Semi-join: Example 2

```
select
 sum(l_quantity*
    l_extendedprice)
from lineitem
where l_orderkey in
(select o_orderkey
 from orders
 where o_orderdate =
      '1996-09-30');
```

DBT-3, Scale 10 (23 GB)

innodb_buffer_pool_size= 24 GB (CPU-bound)

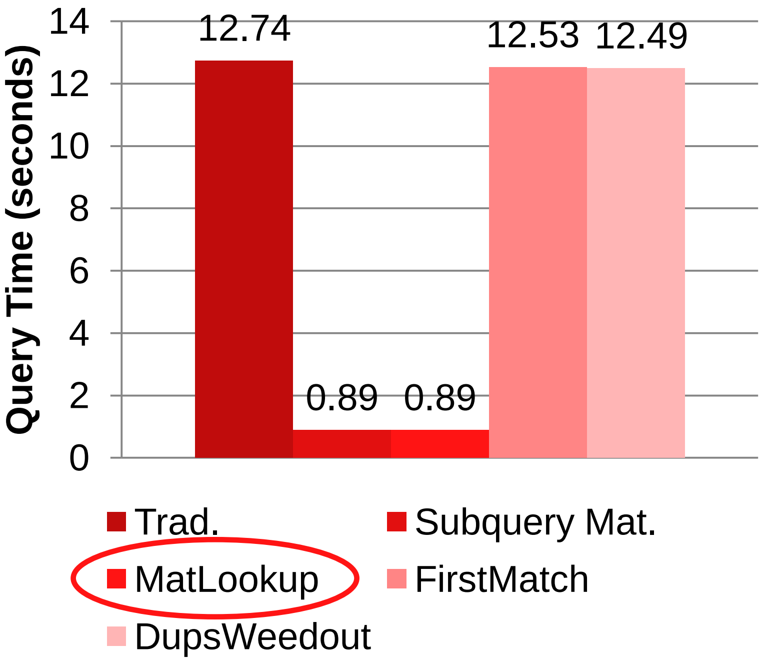


MySQL 5.6: Semi-join: Example 3

```
select s_name, s_address
from supplier
where s_suppkey in
(select ps_suppkey
 from partsupp, part
 where ps_partkey=p_partkey
   and p_name like 'grey%`
   and ps_availqty > 9990);
```

DBT-3, Scale 10 (23 GB)

innodb_buffer_pool_size= 24 GB (CPU-bound)



Semi-join

Usage

- Default: All IN sub-queries that do not contain aggreation or union are converted to semi-join
- Disable semi-join conversion:

```
set optimizer_switch = ’semijoin=off’;
```

- Disable individual semi-join strategies:

```
set optimizer_switch = ’firstmatch=off’;
set optimizer_switch = ’loosescan=off’;
set optimizer_switch = ’materialization=off’;
```

- Force traditional IN-to-EXIST evaluation:

```
set optimizer_switch = ’semijoin=off,materialization=off’;
```

MySQL 5.6: Index Condition Pushdown (ICP)

DBT3 Query 6: Forecasting Revenue Change Query

Need force index to get ICP for this query

```
select sum(l_extendedprice * l_discount) as revenue
from lineitem force index(j_l_shipdate_discount_quantity)
where l_shipdate >= '1994-01-01'
  and l_shipdate < date_add('1994-01-01’,interval '1' year)
  and l_discount between 0.09 - 0.01 and 0.09 + 0.01
  and l_quantity < 24;
```

Conditions evaluated during index scan

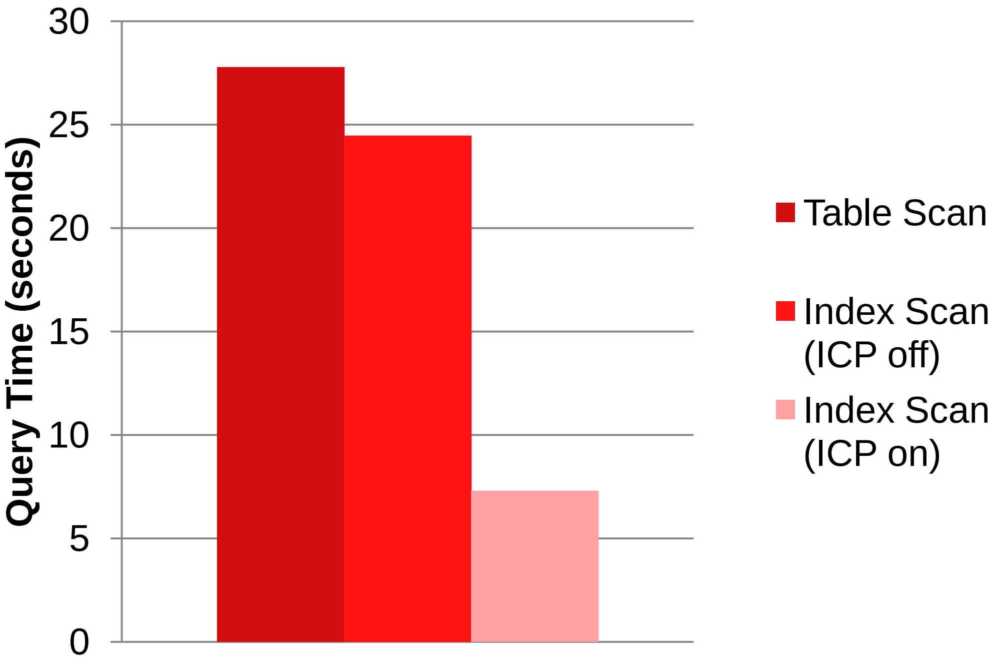
Index range scan criteria

MySQL 5.6: Index Condition Pushdown

DBT-3, Query 6
Scale 10 (23 GB)

innodb_buffer_pool_size= 24 GB
(CPU-bound)

optimizer_switch settings:
index_condition_pushdown = on/off



Index Condition Pushdown

EXPLAIN

```
mysql> explain select sum(l_extendedprice * l_discount) as revenue from
  lineitem force index (i_l_shipdate_discount_quantity) where l_shipdate >=
  '1994-01-01' and l_shipdate < date_add( '1994-01-01' , interval '1' year)
  and l_discount between 0.09 - 0.01 and 0.09 + 0.01 and l_quantity < 2\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: lineitem
         type: range
possible_keys: i_l_shipdate_discount_quantity
          key: i_l_shipdate_discount_quantity
      key_len: 16
          ref: NULL
         rows: 18940908
        Extra: Using index condition
1 row in set (0.00 sec)
```

Index Condition Pushdown

EXPLAIN FORMAT=JSON

```
mysql> explain FORMAT=JSON select sum(l_extendedprice * l_discount) as
  revenue from lineitem force index (i_l_shipdate_discount_quantity) where
  l_shipdate >= '1994-01-01' and l_shipdate < date_add( '1994-01-01' ,
  interval '1' year) and l_discount between 0.09 - 0.01 and 0.09 + 0.01 and
  l_quantity < 24;
| {
  "query_block": {
    "select_id": 1,
    "table": {
      "table_name": "lineitem",
      "access_type": "range",
       ...
      "filtered": 100,
      "index_condition": "((`dbt3`.`lineitem`.`l_shipDATE` >= '1994-01-01')
  and (`dbt3`.`lineitem`.`l_shipDATE` < ('1994-01-01' + interval '1' year))
  and (`dbt3`.`lineitem`.`l_discount` between (0.09 - 0.01) and (0.09 +
  0.01)) and (`dbt3`.`lineitem`.`l_quantity` < 24))"
    }
```

MySQL 5.6: More Optimizer Improvements

- ORDER BY with LIMIT optimization
- Delayed Materialization of Derived Tables
- Extended secondary keys (InnoDB)
- Reduced optimization time for large IN-lists
- Reduced optimization time for many-table joins
- Reduced space usage for large temporary tables with VARCHAR
- Speed-up of information schema queries
- EXPLAIN for INSERT, UPDATE, DELETE
- Structured EXPLAIN (JSON format)
- Optimizer trace

More information

- My blog:
  - http://oysteing.blogspot.com/
- Optimizer team blog:
  - http://mysqloptimizerteam.blogspot.com/
- What’s new in MySQL 5.6:
  - http://dev.mysql.com/tech-resources/articles/whats-new-in-mysql-5.6.html

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