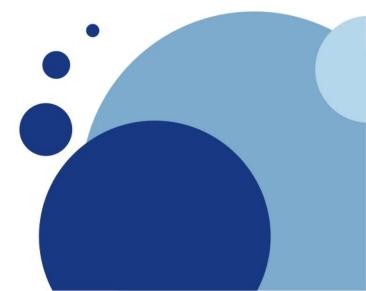
Columnar RDBMS

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Column-oriented storage systems versus roworiented storage systems

Bill

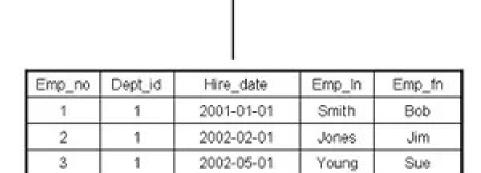
Jack

Laura

Stemle

Aurora

Jung



2003-02-01

1999-06-15

2000-08-15

4

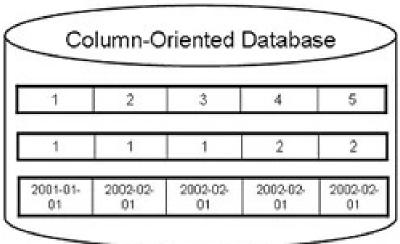
5

6

2

3

| | | ow-Oriented | Databas | | |
|-----|---|-------------|---------|-----|--|
| 1 1 | | 2001-01-01 | Smith | Bob | |
| 2 | 1 | 2002-02-01 | Jones | Jim | |
| 3 | 1 | 2002-05-01 | Young | Sue | |



Benchmarking Data Servers: Columnoriented vs row-oriented storage systems

- Columnar Storage Systems
 - High IO performance: less data moving from hard drives to memory
 - Efficient Memory Management: load only required data into memory
 - Reduced Storage: columns with low cardinality are compressed
 - Efficient Schema Modifying Techniques: adding new columns will not induce a file storage re-organization
- Types
 - Binary Association Tables
 - Each column is stored in a separate (surrogate key, value) table, e.g. RDBMS: MonetDB, C-Store, ...
 - Family of columns
 - Vertical partitioning for DB design

Perf. Results (TPC-H*d, sf=10) with *MonetDB* **COMAD'2013, BICOD'2017**

MonetDB DBMS (column-oriented)

100.92

36.74

435.8

0.11

1.5

2.43

2.16

MvSQL DBMS (row-oriented)

578.09

68.74

2.40

511.54

855.46

402.16

Q21

Q22

| | | | | Transfer and an artifact for the state of th | | | | |
|-----------------|---|---|---|--|--|--|--|--|
| SQL Workload | | | | SQL Workload | MDX Workload (sec) Query Cube-then-Query | | | |
| MySQ | <u>L</u> | | | MonetDB | | | | |
| 2,778 | sec | | | 30 sec | | | | |
| Java h | neap spa | ace Er | ror | 758 sec | | | | |
| 2,558 | sec | | | 2,536 sec | | | | |
| Mondr | rian Erro | or: Siz | ze of c | ross join exceeded limit | | | | |
| 4.00 | 2,558.21 | 3,020.27 | 1,604.10 | 0.17 | 2,536.28 | 2,834.2 | 1,313.5 | |
| 144.36 | 456.81 | 735.67 | 123.43 | 2.91 | 42.78 | 54.64 | 23.36 | |
| 38.68 | n/a^{*2} | n/a^{*2} | _ | 3.53 | n/a^{-2} | n/a^{*2} | _ | |
| 122.11 | 391.06 | 946.16 | 0.06 | 0.19 | 4.6 | 18.01 | 0.09 | |
| 90.97 | 13,005.27 | 32,064.90 | 12,413.74 | 2.9 | 18.4 | 532.35 | 5.4 | |
| 47.92 | 414.82 | 461.90 | 4.62 | 1.36 | 18.08 | 64.94 | 0.99 | |
| 4.22 | 1,131.37 | 5,711.14 | 2.03 | 2.06 | 8.76 | 47.48 | 0.82 | |
| 905.16 | | n/a^{*1} | 9 17 | 1.68 | | n/a^{*1} | | |
| 1.56 | 598.9 | | 37.57 | 0.8 | 57.22 | | 0.12 | |
| 1.55 | 14,662.53 | n/a^{*3} | - | 0.58 | 423.9 | n/a^{*2} | | |
| | SQL Workload MySC 2,778 Java h 2,558 Mondr 4.00 144.36 38.68 122.11 90.97 47.92 4.22 905.16 1.56 | SQL Workload Query MySQL 2,778 sec Java heap spa 2,558 sec Mondrian Erro 4.00 2,558.21 144.36 456.81 38.68 n/a*2 122.11 391.06 90.97 13,005.27 47.92 414.82 4.22 1,131.37 905.16 n/a*2 1.56 598.9 | SQL Workload (Query Cube-thes) MySQL 2,778 sec Java heap space End 2,558 sec Mondrian Error: Siz 4.00 2,558.21 3,020.27 144.36 456.81 735.67 38.68 n/a*2 n/a*2 122.11 391.06 946.16 90.97 13,005.27 32,064.90 47.92 414.82 461.90 4.22 1,131.37 5,711.14 905.16 n/a*2 n/a*1 1.56 598.9 727.72 | Workload Query Cube-then-Query MySQL 2,778 sec Java heap space Error 2,558 sec Mondrian Error: Size of c 4.00 2,558.21 3,020.27 1,604.10 144.36 456.81 735.67 123.43 38.68 n/a*2 n/a*2 - 122.11 391.06 946.16 0.06 90.97 13,005.27 32,064.90 12,413.74 47.92 414.82 461.90 4.62 4.22 1,131.37 5,711.14 2.03 905.16 n/a*2 n/a*1 - 1.56 598.9 727.72 37.57 | $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$ | $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$ | $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$ | |

0.15

39.33