DB2 BLU inside out

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"Super analytics made super easy."
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Overview
Key ideas

- **Dynamic In-Memory**
  In-memory columnar processing with dynamic movement of data from storage data

- **Actionable Compression**
  Patented compression technique that preserves order so that the data can be used without decompressing

- **Parallel Vector Processing**
  Multi-core and SIMD parallelism (Single Instruction Multiple Data)

- **Data Skipping**
  Skips unnecessary processing of irrelevant data

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**Super Fast, Super Easy — Create, Load and Go!**
No Indexes, No Aggregates, No Tuning, No SQL changes, No schema changes
BLU Acceleration: 10TB Query, Seconds or Less

SELECT COUNT(*) from MYTABLE where YEAR = '2010'

- 32 cores
- 1TB memory
- 10TB table
- 100 columns
- 10 years data

Actionable Compression reduces to 1TB

In-memory Massive Parallel Processing

32MB linear scan on each core

Column Processing reduces to 10GB

Vector Processing
Scans as fast as 8MB through POWER7 Accelerated SIMD

Data Skipping reduces to 1GB

Result in seconds or less

10TB data

10TB table

10 years data

2010 data
Seamless Integration into DB2

• **Built seamlessly into DB2 – integration and coexistence**
  – Column-organized tables can coexist with existing, traditional, tables
    - Same schema, same storage, same memory

• **Same SQL, language interfaces, administration**
  – Column-organized tables or combinations of column-organized and row-organized tables can be accessed within the same SQL statement
Creating a column-organized table

- Example:

```
CREATE TABLE sales_col (  
  c1 INTEGER NOT NULL,  
  c2 INTEGER,  
...  
  PRIMARY KEY (c1) ) ORGANIZE BY COLUMN;
```

- If `dft_table_org = COLUMN` (e.g. `DB2_WORKLOAD= ANALYTICS`):
  - `ORGANIZE BY COLUMN` is the default and can be omitted
  - Use `ORGANIZE BY ROW` to create row-organized tables
Data Layout
# Columnar storage in DB2 (conceptual)

- Separate set of extents and pages for each column

<table>
<thead>
<tr>
<th>TSN</th>
<th>Name</th>
<th>Address</th>
<th>City</th>
<th>State</th>
<th>Zip</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>John Picone</td>
<td>18 Main Street</td>
<td>Springfield</td>
<td>MA</td>
<td>01111</td>
</tr>
<tr>
<td>1</td>
<td>Susan Nakagawa</td>
<td>455 N. 1st St.</td>
<td>San Jose</td>
<td>CA</td>
<td>95113</td>
</tr>
<tr>
<td>2</td>
<td>Sam Gerstner</td>
<td>911 Elm St.</td>
<td>Toledo</td>
<td>OH</td>
<td>43601</td>
</tr>
<tr>
<td>3</td>
<td>Chou Zhang</td>
<td>300 Grand Ave</td>
<td>Los Angeles</td>
<td>CA</td>
<td>90047</td>
</tr>
<tr>
<td>4</td>
<td>Mike Hernandez</td>
<td>404 Escuela St.</td>
<td>Los Angeles</td>
<td>CA</td>
<td>90033</td>
</tr>
<tr>
<td>5</td>
<td>Pamela Funk</td>
<td>166 Elk Road #47</td>
<td>Beaverton</td>
<td>OR</td>
<td>97075</td>
</tr>
<tr>
<td>6</td>
<td>Rick Washington</td>
<td>5661 Bloom St.</td>
<td>Raleigh</td>
<td>NC</td>
<td>27605</td>
</tr>
<tr>
<td>7</td>
<td>Ernesto Fry</td>
<td>8883 Longhorn Dr.</td>
<td>Tucson</td>
<td>AZ</td>
<td>85701</td>
</tr>
<tr>
<td>8</td>
<td>Whitney Samuels</td>
<td>14 California Blvd.</td>
<td>Pasadena</td>
<td>CA</td>
<td>91117</td>
</tr>
<tr>
<td>9</td>
<td>Carol Whitehead</td>
<td>1114 Apple Lane</td>
<td>Cupertino</td>
<td>CA</td>
<td>95014</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TSN = Tuple Sequence Number

Page locations for tuples: John Picone (TSN 0, address 18 Main Street), Susan Nakagawa (TSN 1, address 455 N. 1st St.), Sam Gerstner (TSN 2, address 911 Elm St.), Chou Zhang (TSN 3, address 300 Grand Ave.), Mike Hernandez (TSN 4, address 404 Escuela St.), Pamela Funk (TSN 5, address 166 Elk Road #47), Rick Washington (TSN 6, address 5661 Bloom St.), Ernesto Fry (TSN 7, address 8883 Longhorn Dr.), Whitney Samuels (TSN 8, address 14 California Blvd.), Carol Whitehead (TSN 9, address 1114 Apple Lane).
Reclaiming Space in the Table

- **Objective:** Find empty storage extents and return pages to table space for re-use

- **Option 1:** If DB2_WORKLOAD=ANALYTICS, automatic space reclamation is active for all column-organized tables

```
update db cfg using auto_maint ON auto_tbl_maint ON auto_reorg ON;
```

- **Option 3:** Use REORG TABLE explicitly
  - Can use RECLAIMABLE_SPACE from ADMINTABINFO/ADMIN_GET_TAB_INFO to
    - ALLOW WRITE ACCESS--.
    - REORG-TABLE--table-name--RECLAIM EXTENTS--+
    - ALLOW READ ACCESS+++ 
    'ALLOW NO ACCESS----'

What you see in the DB2 catalog: TABLEORG

Which tables are column-organized?

- New column in syscat.tables: TABLEORG

```
SELECT tabname, tableorg, compression
FROM   syscat.tables
WHERE  tabname like 'SALES%';
```

<table>
<thead>
<tr>
<th>TABNAME</th>
<th>TABLEORG</th>
<th>COMPRESSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>SALES_COL</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>SALES_ROW</td>
<td>R</td>
<td>N</td>
</tr>
</tbody>
</table>

2 record(s) selected.

For column-organized tables, COMPRESSION is always blank because you cannot enable/disable compression.
What you see in the DB2 catalog: Synopsis Tables

- For each columnar table there is a corresponding synopsis table, automatically created and maintained.

SELECT tabschema, tabname, tableorg FROM syscat.tables WHERE tableorg = 'C';

<table>
<thead>
<tr>
<th>TABSCHEMA</th>
<th>TABNAME</th>
<th>TABLEORG</th>
</tr>
</thead>
<tbody>
<tr>
<td>MNICOLA</td>
<td>SALES_COL</td>
<td>C</td>
</tr>
<tr>
<td>SYSIBM</td>
<td>SYN130330165216275152_SALES_COL</td>
<td>C</td>
</tr>
</tbody>
</table>

2 record(s) selected.

- Size of the synopsis table: ~0.1% of the user table
- 1 row for every 1024 rows in the user table
## Synopsis Table

- Meta-data that describes which *ranges* of values exist in which parts of the user table

<table>
<thead>
<tr>
<th>TSNMIN</th>
<th>TSNMAX</th>
<th>S_DATEMIN</th>
<th>S_DATEMAX</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1023</td>
<td>2005-03-01</td>
<td>2006-10-17</td>
<td>...</td>
</tr>
<tr>
<td>1024</td>
<td>2047</td>
<td>2006-08-25</td>
<td>2007-09-15</td>
<td>...</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TSN = Tuple Sequence Number

- Enables DB2 to skip portions of columns when scanning data during query
- Predicate WHERE S_DATE = 2007-01-01 would skip first range
- Predicate WHERE S_DATE = 2006-09-12 would scan both ranges
What you see in the DB2 catalog: Page Map Index

- Automatically created and maintained
- Used internally to locate column data in the storage object
- Maps columns and TSNs to pages

```
SELECT indschema, indname, colnames, indextype
FROM syscat.indexes
WHERE tabname = 'SALES_COL';
```

<table>
<thead>
<tr>
<th>INDSHEMA</th>
<th>INDNAME</th>
<th>COLNAMES</th>
<th>INDEXTYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSIBM</td>
<td>SQL130330165215840</td>
<td>+ID</td>
<td>REG</td>
</tr>
<tr>
<td>SYSIBM</td>
<td>SQL130330165216790</td>
<td>+COLGID+STARTTSN</td>
<td>CPMA</td>
</tr>
</tbody>
</table>

2 record(s) selected.
Compression
BLU uses Multiple Compression Techniques

- Approximate Huffman-Encoding ("frequency-based compression"), prefix compression, and offset compression
- Frequency-based compression: Most common values use fewest bits

Example showing 3 different code lengths. Code lengths vary depending on the data values.

<table>
<thead>
<tr>
<th>Code</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>California</td>
</tr>
<tr>
<td>1</td>
<td>NewYork</td>
</tr>
<tr>
<td>00</td>
<td>Arizona</td>
</tr>
<tr>
<td>001</td>
<td>Colorado</td>
</tr>
<tr>
<td>010</td>
<td>Kentucky</td>
</tr>
<tr>
<td>011</td>
<td>Illinois</td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
<tr>
<td>111</td>
<td>Washington</td>
</tr>
<tr>
<td>000000</td>
<td>Alaska</td>
</tr>
<tr>
<td>000001</td>
<td>Rhode Island</td>
</tr>
</tbody>
</table>

- 2 High Frequency States (1 bit covers 2 entries)
- 8 Medium Frequency States (3 bits cover 8 entries)
- 40 Low Frequency States (6 bits cover 64 entries)
Compression Dictionaries for Column-Organized Tables

- Column-level dictionaries: *Always one per column*
  - Dictionary populated during load replace, load insert into empty table
  - Automatic Dictionary Creation during Insert
- Page-level dictionaries: *May also be created*
  - If space savings outweighs cost of storing page-level dictionaries
  - Exploit local data clustering at page level to further compress data
Actionable Compression

- Evaluating SQL predicates directly on compressed data
  - No decompression required for comparisons like BETWEEN, <, >, <=, =
  - Many values can be compared with few instructions (SIMD processing)
Query Processing
Sample Query

SELECT c.trading_name
FROM f, c, dt
WHERE f.client_dim_key = c.client_dim_key
    AND f.trade_dt = dt.dt_dim_key
    AND f.is_cancelled = 0
GROUP BY c.trading_name, dt.year
ORDER BY c.trading_name

Let’s review the execution plan of this query....
Sample Execution Plan

Operators above CTQ use DB2’s regular row-based processing

Operators below CTQ are optimized for column-organized tables

Here: All table scans, hash joins, and grouping are performed in columnar query runtime. (Good.)
Summary

- **What does BLU provide?**
  - Columnar engine integrated into a traditional database providing excellent performance for analytics workload

- **What are key differentiators?**
  - Actionable compression
  - Not bound to memory limits, but memory optimized
  - Well integrated into traditional database, which still can be used for high performant OLTP processing.

- **What’s new?**
  - SAP has announced support for DB2 BLU Acceleration