Real-time Analytics Query Performance with DB2 for z/OS

Terry Purcell
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Where does DB2 z fit in the analytics space?

Where does DB2z fit into the Analytics landscape?

Where should each analytics workload reside?

What are the design considerations with Analytics on DB2 for z/OS?

How do I position IDAA or Spark and native DB2 for z/OS?

How to achieve real-time analytics?
Analytics – The changing Landscape

Integrating history/archiving into DB2

Analytics focus in DB2 for z/OS

DB2 for z/OS Tuning Considerations for Analytics
BI/DW and Analytics Landscape with DB2 z

Many customers have “off-platform” BI/DW environments
– Moving DB2 z data regularly to these platforms
– It is estimated that there are “7 copies on average” of OLTP data on other platforms used for analytics or other purposes
  • www.redbooks.ibm.com
  • “Reducing Data Movement Costs in z Systems Environments”
    – Focused on benefit of IDAA in reduced data movements
    – Also applicable to DB2 for z/OS directly
Challenges of Typical ETL Processing with Moving Data

• Processing pattern
  • Move data from original data source(s) through ETL tools or custom transformation programs to target DW/DM
  • Typically, data is stored several times in intermittent staging areas

• Myth: main purpose to transform data (cleansing, merging etc)
• Reality: majority of the ETL processing is generating history after the fact
  • SLA of OLTP data generation workloads
  • Little communication between OLTP and DW teams

• Problems
  • Latency of data typically >1 day, not acceptable any longer
  • Amount of data ever increasing -> prolonging ETL window
Scope of analytics (types)

Excerpts - Blog post by Nin Lei (CTO, IBM Big Data & Analytics for zSystems hardware)

– Strategic analytics
  • Workloads consuming large amount of data, requiring a system architecture with massive parallelism.
    – Year-over-year or month-to-month sales analysis.
    – Data mining to explore how to categorize customers’ behaviors.
    – Fraud detection models to reduce losses.

– Tactical analytics (or in-transaction analytics)
  • More single-customer oriented and thus smaller/targeted data.
    – Identify items purchased by current customer in the past year to recommend the appropriate products for that customer.
    – A phone company call center rep wants to know the customers phone call patterns - to upsell the customer with a more profitable plan.
    – Fraud detection analysis of prior purchase history
Where does Strategic Analytics belong?

Strategic analytics (traditional BI/DW)
– The realm of “shared nothing” or highly parallelized architectures.
  • For DB2 for z/OS – IDAA is an excellent candidate to
    – Reduce data movement (latency) compared with other off-platform solutions
    – Benefit from zSystems quality of service
  • Native DB2 for z/OS requires targeted tuning and parallelism
    – Likely to discourage many customers due to skill/effort, and CPU cost

– IDAA has brought (strategic) analytics back to DB2 for z/OS
  • Accelerating DB2 queries
  • Allowing other data sources to be made accessible to DB2 applications
– Spark opens up new opportunities to the business/application developers
Where does Tactical Analytics belong?

Tactical analytics
   – “In-transaction Analytics”
   – Operational analytics

   – Basically - If the analytics is part of the transaction
     • Then analytics should be performed on or close to the operational data.

   – “Tuned” analytics on DB2 for z/OS can meet transactional concurrency needs
     • IDAA typically better with poorly indexed (tuned) workloads
What is your definition of Real-time Analytics?

Is the Analysis happening in real-time?
– Within the scope of a transaction, or point-of-sale.

Is the data current (the data is in real-time)?
– Or analysis of historical or near real-time data?

Moving data results in latency
– If you copy data from your OLTP system – its not real-time anymore
  • So only the OLTP system can be truly real-time

Not all applications require “real-time” data
– For example, real-time analysis of near real-time data (purchase history during a sale)
How this changes the Analytics Opportunity

Moving analytics to the location of the data, results in:

– Reduced latency required for Analysis of data
  • Real-time or near real-time
– Reduced security risk of multiple copies of enterprise data
– zSystems qualities of service for business critical analytics
– Ability to integrate analytics within the scope of a transaction

Hybrid Transaction Analytics Processing (HTAP) with zSystems

– DB2 for z/OS for OLTP and in-transaction analytics
  • And in-frequent strategic analytics
– IDAA for strategic analytics
  • And ability to converge other data sources into the accelerator (incl competitors DBMSs)
– Apache Spark on z/OS or zLinux
  • Application developer friendly framework for in-place analysis of (potentially) disparate data sources (DB2, IMS, VSAM)
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DB2 for z/OS Tuning Considerations for Analytics
ETL Modernization – History Generation DB2 Temporal

• **DB2 10 delivered Temporal support**

• **Concept of period** (SYSTEM_TIME and BUSINESS_TIME periods)
  o Period is represented by a pair of datetime columns, one column stores start time, the other one stores end time
  o **SYSTEM_TIME period** captures DB2’s creation and deletion of records. DB2 SYSTEM_TIME versioning automatically keeps historical versions of records
  o **BUSINESS_TIME period** allows users to create their own valid period for a given record. Users maintain the valid times for a record.

• **DML syntax** allow query/update/delete data for periods of time
  o `SELECT ... FROM STT/BTT FOR SYSTEM_TIME AS OF exp/FROM exp1 TO exp2/BETWEEN exp1 AND exp2 ...;`
ETL Modernization - History Generation
DB2 System Temporal...

Current SQL Application

Audit History

Current

History Generation

Auditing SQL Application Using ASOF

Transparent/automatic Access to satisfy ASOF Queries

Jul 2008
Aug 2008
Sep 2008

Sep 2008
Aug 2008
Jul 2008
Temporal Auditing Support

- DB2 system versioning feature provides an auditing solution to track
  - WHEN the data is modified.

- To meet regulatory compliance requirements, it is quite common and mandatory to audit and track
  - WHO modified the data, and
  - WHAT action (SQL statement) caused the data modification.

- New syntax to define non-deterministic generated expression columns.

- ON DELETE ADD EXTRA ROW clause is also added
  - Intended to be used when the system-period temporal table contains a non-deterministic generated expression column.
ETL Modernization - History Generation
DB2 Archive Transparency

- Querying and managing tables that contain a large data is a common problem
  - Performance of maintaining large table is a key customer pain point

- One known solution is to archive inactive/cold data to a different environment
  - Challenges on the ease of use and performance:
    - How to provide easy access to both current and archived data within single query
    - How to make data archiving and access “transparent” with minimum application changes
DB2 11 Archive Transparency -- archive data
... from OLTP current table to DB2 archive table

```
SET SYSIBMADM.MOVE_TO_ARCHIVE = 'Y';
*** INSERT/UPDATE disabled ***
OR
SET SYSIBMADM.MOVE_TO_ARCHIVE = 'E';
*** INSERT/UPDATE enabled ***
DELETE FROM PROJECT_AET
WHERE STATUS = 'C' OR STATUS = 'F';
```

```sql
current data
```

```
Finished Project B
Finished Project D
```

```
archive data
```
What is DB2 Archive Transparency -- retrieve data ... from OLTP current table and DB2 archive table

**PROJECT_AET**

<table>
<thead>
<tr>
<th>ID</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1001</td>
<td>A</td>
</tr>
<tr>
<td>1003</td>
<td>A</td>
</tr>
<tr>
<td>1006</td>
<td>C</td>
</tr>
</tbody>
</table>

**PROJECT_ARC**

<table>
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<th>STATUS</th>
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</thead>
<tbody>
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<td>F</td>
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<tr>
<td>1004</td>
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<tr>
<td>1005</td>
<td>F</td>
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</tbody>
</table>

**EMPLOYEE_AET**

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<th>PROJ</th>
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<td>1003</td>
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<td>E5</td>
<td>1006</td>
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</tbody>
</table>

**EMPLOYEE_ARC**

<table>
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<th>PROJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>1002</td>
</tr>
<tr>
<td>C2</td>
<td>1005</td>
</tr>
</tbody>
</table>

---

UDF (proj_id) ... return (SELECT COUNT(*) FROM EMPLOYEE_AET WHERE PROJ = proj_id)

SELECT UDF (ID) AS EMP_COUNT, ID AS PROJ_ID FROM PROJECT_AET WHERE STATUS <> 'C';

SET SYSIBMADM.GET_ARCHIVE = 'Y';  
*** employee & project ***  
*** current & archive table ***

SET SYSIBMADM.GET_ARCHIVE = 'N';  
*** employee & project ***  
*** current table only ***
History Generation in DB2 for z/OS

Goal is to integrate history generation into the operational system
– With minimal impact to the Operational System
  • Assuming history data is not retrieved within that OLTP system
  • Potentially improve OLTP performance by moving data out of “active” tables

– System/business Temporal, Temporal auditing, and Transparent archive
  • Each solving a complementary business problem

• IDAA also has tight integration with each history generation solution, including
  – High Performance Storage Saver (empty partition in DB2, partition exists in IDAA)
  – Accelerator Only Tables (AoTs – Proxy table in DB2, data only appears in IDAA)
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DB2 for z/OS Tuning Considerations for Analytics
Analytics Queries on DB2z - What do they look like?

What are the attributes of an Analytics Query?
– Analytics queries often involve
  • More tables in a query – joins, subqueries, table expressions etc
  • More complex expressions (in WHERE clause or select list)
  • More rows being processed when compared with OLTP
  • More rows joined, sorted etc
  • Views that contain joins or UNION ALL
    – Views may contain more columns/tables than query requires

NOTE: Avoiding ETL results in transformations occurring within the SQL

Today’s OLTP workloads have similar complexity
– CICS/COBOL applications were written with efficiency as part of the design
– Today’s workloads are developed for speed of deployment, not performance
DB2 Analytics Enhancements

Recent DB2 releases have significant functional and performance focus on Analytics

- DB2 9 through 12
  - DB2 12 major focus due to HTAP and also new SAP analytics workloads

From DB2 9 thru 12 OLAP SQL function

- Rank/Dense rank/Row number
- Moving sum/average
- Grouping sets, ROLLUP/CUBE
- Median, Lag, Lead, Percentile
DB2 11 for z/OS Analytics Performance

DB2 11 Internal Workload measurements

* NOTE: IBM results were obtained in isolated testing for internal measurement purposes only
  * Customer results cannot be predicted due to variability of workloads
DB2 12 (High Level) Performance

Query focus based upon new(er) workloads

– Complex views or table UDFs
  • UNION ALL
  • Outer joins
  • Join predicates with (stage 2) expressions
  • CASE expressions, CAST functions, scalar functions

– Query - General Bottlenecks
  • Sort/workfile reductions
  • Reducing prepare cost and frequency
  • I/O performance
  • Reduce unnecessary prefetch scheduling

– OLTP (engine) focus
  • Index tree traversal
  • Reduced getpage cost for pinned objects (PGSTEAL(NONE))
  • Reduced latch contentions, remove scalability limitations
DB2 12 for z/OS Analytics Performance

Initial performance measurements showing promising results
- 2-3 times acceleration for new analytics or poorly clustered workloads
- Up to 25% CPU saving for traditional query workloads
- Minor improvement for IDAA targeted (scan based) workloads

- NOTE: IBM results were obtained in isolated testing for internal measurement purposes only
  - Customer results cannot be predicted due to variability of workloads
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Tuning for Analytics on DB2 for z/OS

Strategic (traditional BI/DW) Analytics
– If near-real time is sufficient (as it generally is)
  • Perfect candidate for DB2 z with IDAA
– For real-time
  • DB2 z requires sufficient resources (CPU, memory, WF space/DASD)
  • Targeted tuning
    – Partitioning, clustering, indexing (out of scope for this presentation)
    – Potentially MQTs (although DB2 z does not support incremental update)

Tactical (transactional) Analytics
– Since analytics is against the scope of the transaction
  • Existing OLTP indexing may suffice
Tuning for Analytics on DB2 for z/OS

Many recent DB2 performance enhancements may require minimal degree of tuning to:
- Ensure optimal performance
- Minimize analytics impact on OLTP workloads

Some configuration discussed
- Sparse index
- DPSIs
- Parallelism
- Compression
- Sort/Workfile (incl RID overflow, DRDA impact)
- Optimizer statistics recommendations
IMDC/Sparse index – Performance considerations

DB2 11 provides simple accounting/statistics data for sparse index
- Sparse IX disabled – If > 0
  - Suggest reducing MXDTCACH or allocating more memory to the system
- Sparse IX built WF – If > 0
  - Increase MXDTCACH (if above counter is = 0) or reduce WF BP VPSEQT (if high sync I/O)

Memory considerations for sparse index
- Default DB2 setting for MXDTCACH is conservative
- Customers generally undersize WF BP (compared to data BPs)
  - And often set VPSEQT too high (close to 100) for sort BP

- If sync I/O seen in WF BP or PF requests & issues with PF engines
  - Consider increasing MXDTCACH given sufficient system memory
  - Consider increasing WF BP size and setting VPSEQT=90
Recent DPSI performance enhancements

A “partitioned” index means excellent utility performance
- But historically there was one sweet spot ONLY for DPSIs
  - When local predicates in the query could limit partitions to be accessed
- Outside of the DPSI sweet spot – performance often suffers compared with NPIs

DB2 11 improves join performance for DPSIs
- By page range screening for join predicates (when join by partitioning columns)
- By exploiting parallelism when partitioned by non-join columns
Parallelism to alleviate DPSI query performance

Outside of sweet spot(s) - Parallelism can improve DPSI performance
  – You must have fewer (larger) partitions – rather than many smaller partitions
  – Think 12 partitions or less – rather than 100s
    • Parallelism cannot save DPSI performance with 100s of partitions
      – Unless your CPU resources can support 100s of parallel degrees
    • This may seem counterintuitive for utility performance
      – Except……if larger/fewer parts mean DPSIs rather than NPIs – net is utility improvement
  • DPSI part-level join parallelism controlled by zparm PARAMDEG_DPSI
Parallelism considerations

Number of degrees
– Default PARAMDEG=0 which equals 2 * # of total CPs
  • Can be too high if few zIIPs
  • Conservative recommendation is 2 * # of zIIPs
  • Very conservative – set PARAMDEG=2 & PARA_EFF=100

Parallelism requires sufficient resources
– Specifically – zIIP processors
  • Since 80% of child tasks are zIIP eligible
  • Parallelism may increase CPU consumption up to 20%

– NOTE: DB2 12 increases parallel child task offload to 100%
DRDA performance implications

Isolation level has an impact on performance
- Default isolation level is CS(2).
  - Dynamic SQL's will use SYS*200 packages for default isolation level(CS).
  - Other isolations will use different packages (Eg:SYS*300 for RS)
  - In CLI, application can set isolation level using connection attribute, db2cli.ini or db2dsdriver.cfg file.


  - Best performance (of course) is ISOLATION UR

Disable default of CURSOR HOLD used by ODBC/JDBC
- As WITH HOLD disables DB2 in-memory sorts
- Can be changed by setting CURSORHOLD=0 in db2cli.ini file
Sort / Workfile Recommendations

In-memory (from V9 to 11) is avoided if CURSOR WITH HOLD
  – See previous slide

FETCH FIRST n ROWS
  – Recommended to use if less than FULL result set required
    • Better to tell DB2 you will only fetch a maximum of 500 rows
  – If FETCH FIRST value is < FULL result set
    • Will reduce sort workfile usage
Sort / Workfile Recommendations

Ensure adequate WF BP, VPSEQT & datasets

- Sort requirements can increase with Analytics
  - Goal is to minimize impact Analytics has on OLTP work
- Set VPSEQT=90 for sort (due to sparse index, tag sort and/or DGTTs)
  - Evaluate sync I/Os in WF BP
    - may indicate sparse index spilling to WF
    - Or, usage of tag sort (row length > 4k)

- Provide multiple physical workfiles placed on different DASD volumes
  - To avoid WF spacemap contention
  - Sort workfile placement example
    » 4-way Data Sharing Group
    » Assume 24 volumes are available
    » Each member should have 24 workfile tablespaces on separate volumes
    » All members should share all 24 volumes (i.e. 4 workfiles on each volume)
Sort and the VARCHAR curse

Benefit of VARCHAR is flexibility in column length

– Allowing ONLY the required length to be stored without the need to store trailing blanks
  • Saving space in indexes and data (without need for compression)

– For sort however, columns that are part of the sort key are padded to full length for the sort
  • Example where 100 bytes is stored in VARCHAR 128 vs 512 length

```sql
SELECT DISTINCT VARCHAR128COL FROM TABLE
vs
SELECT DISTINCT VARCHAR512COL FROM TABLE
```

Varchar 512 is 4 times the sort key size of 128
DB2 Optimizer and the Statistics Challenge

DB2 cost-based optimizer relies on statistics about tables & indexes
– Customers often gather only standard or default statistics
  • E.g. RUNSTATS TABLE(ALL) INDEX(ALL) KEYCARD

Queries would often perform better if DB2 optimizer could exploit more complete statistics
– What to collect?
  • May be less critical for simple OLTP queries
  • Becomes more important as statement complexity or number of objects increase
– DB2 11 added externalization of missing statistics by the optimizer
– DB2 12 completes the integration with statistics profile
Optimizer externalization of missing statistics

- **Bind**
- **Rebind**
- **Prepare**

Optimizer:

- **Optimize**
- **Statistics in Catalog Tables**
- **New in V11**
  - Missing stats?
  - Conflicting stats?
  - **Statsin**
  - **DSNZPARM - minutes**
  - In memory recommendations
- **Statistics Profiles**
  - **Added in V12**
  - **SYSSTATFEEDBACK**
  - Automatically used by **RUNSTATS USE PROFILE**
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