ISAO – IBM Smart Analytics Optimizer

Accelerating DB2 for z/OS

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Challenges: Performance, Scalability, TCO

• Modern BI/DW requirements such as orders of magnitude faster query execution call for new approaches

• DB2 for z/OS has the first class QoS characteristics, however, it is ‘only’ a relational DBMS
  • RDBMSs are the most widely used sophisticated data repositories with huge ecosystems of applications built on top of them, however, they are not the ultimate answer for everything
  • Deficiencies come from the way the data is stored and managed
    • optimizing for limited cache
    • supporting limited CPU parallelism
  • RDBMSs attempt to address performance and scalability challenges with their standard tools of the trade: indexing, prebuilt aggregates, MQTs, …
    • Requires very sophisticated tools and top DBA expertize which significantly drives up TCO
    • Increasingly not good enough due to ad-hoc, unpredictable nature of the DW/BI requests
Smart Analytics Optimizer:

Accelerating DB2 for z/OS OLAP Workloads
SAO – Platform View from a System HW perspective
(extension to the system z Specialty engines)

Price-Performance

Better

Worse

Less

More...

Application Inventory

Z

Shared Memory

zIIP & zAAP

Partitioned Z Engines for Linux

IFL

Z Frames

System Z Blade Extension

SAO – Platform View from a System HW perspective
(extension to the system z Specialty engines)
IBM Smart Analytics Optimizer

What is it?

✓ A high performance, appliance-like add-on delivering order-of-magnitude faster, predictable, analytic query responses transparently to all users.

How is it different

• Performance: through implementing leading technology trends: hybrid row/column store, predicate evaluation on compressed data, multi-core and vector optimized algorithms

• Integration: the data continues to be managed and secured by the most reliable database platform - DB2 for z/OS

• Self-managed workloads: queries are executed in most efficient way irrespective of their type (OLTP vs. OLAP)

• Transparency: applications connect to DB2 and are entirely unaware of ISAO presence

• Simplified administration: appliance form factor and hands-free everyday operations, reduced need for complex query tuning
Smart Analytics Optimizer (SAO) – Platform View

- Applications
- DBA Tools, z/OS Console, ...

Application Interfaces (standard SQL dialects)
Operation Interfaces (e.g. DB2 Commands)

- Data Manager
- Buffer Manager
- IRLM
- Log Manager
- Smart Analytics Optimizer

DB2

z/OS

Price/Performance optimized Hardware
SAO Features

• A special purpose, network attached blades system
  • Offload typical DW queries from traditional database server to the accelerator
  • Based on IBM research prototype – defining new frontiers in performance and scalability

• No changes to the applications
  • Applications continue to attach to DB2.
  • DB2 transparently to the applications exploits the accelerator when applicable query needs to be executed
  • Full fencing and protection of DB2 against possible accelerator failures

• Improving performance of typical DW queries by orders of magnitude

• Achieving linear scaling with the number of CPUs

• Reducing need for tedious tuning of DB2 (MQTs, indexes, etc.)

• Significantly improved price/performance and TCO as a combined effect of:
  • Offloading very CPU intensive operations from System z
  • Using price/performance optimized hardware
  • Orders of magnitude performance improvement for offloaded queries
  • Reduced DBA effort for tuning offloaded queries

• Appliance-like form-factor
  • User/reference guide assisted installation, initial configuration
  • Hands free operations
Adding the Accelerator without changing the environment

- Remote DB2 Applications
- Local DB2 Applications
- Monitoring

System z

SAO

Storage
Defining which data to accelerate

- A MART is a logical collection of tables which are related to each other. For example all tables of a single star schema would belong to the same MART.

- The administrator uses a rich client interface to define the tables which belong to a MART together with the information about their relationships.

- DB2 for z/OS creates definitions for these MARTs in its own catalog. The related data is read from the DB2 tables and transferred to the InfoSphere Warehouse Accelerator.

- The InfoSphere Warehouse Accelerator transforms the data into a highly compressed, scan optimized format which is kept locally (in memory) on the Accelerator.
4b. Zoom In: Size Estimates and Fact table property
SAO Load creates In-Memory Replica of Data

• A highly compressed, version of all data of the MARTs is kept in the memory of the InfoSphere Warehouse Accelerator.

• The data in memory is a snapshot of the original data which is still stored within DB2.

• Data changes on the original data need to be captured on the DB2 side and applied on the memory structures of the InfoSphere Warehouse Accelerator.
  
  • Planned latency between data change capture and applying the changes might cause different versions of the data to be queried.
  
  • Queries see snapshot data (for some time in the past) as in MQT approach – if a mart is enabled for acceleration queries will be eligible to be routed to the snapshot.

Support for SET CURRENT REFRESH AGE
IDUG study on update frequency – periodic update is OK

- 90% populate their warehouse once a day or less frequently

Figure 10: How frequently is the data in your data warehouse/data marts refreshed?

- Once a day: 49.58%
- Once a week: 19.92%
- Once a month: 13.98%
- Twice a month: 5.51%
- Real time (less than one hour): 7.2%
- Twice a day: 1.27%
- Hourly: 2.54%
Data Maintenance (SAO Currency)

- In the initial release, we concentrate on DWH specific population methods:
  - LOAD RESUME
  - Roll In/Out of Ranges/Partitions
  - Delete complete Ranges/Partitions
  - Reload a complete Range/Partition
  - Based on the DB2 UNLOAD utility

- **LOG based data change capture under evaluation**
  - Have a stored procedure which reads the LOG and delivers all SAO relevant changes to the appliance
  - Might be useful for minor updates and/or INSERT based table population

- **Other data maintenance scenarios which are not covered by partitioned LOAD or incremental updates cause a full reload of a MART.**
Target Market: Business Intelligence (BI)

- Characterized by:
  - “Star” or “snowflake” schema:
  - Complex, ad hoc queries that typically
    - Look for trends, exceptions to make actionable business decisions
    - Touch large subset of the database (unlike OLTP)
    - Involve aggregation functions (e.g., COUNT, SUM, AVG,...)
    - The “Sweet Spot” for SAO!
What the Accelerator is designed for

- Fast scans over large (fact) tables
- OLAP-style queries over large fact tables in relational star schema with grouping and aggregations

```sql
SELECT PRODUCT_DEPARTMENT, REGION, SUM(REVENUE)
FROM FACT_SALES F
  INNER JOIN DIM_PRODUCT P ON F.FKP = P.PK
  INNER JOIN DIM_REGION R ON F.FKR = R.PK
  LEFT OUTER JOIN DIM_TIME T ON F.FKT = T.PK
WHERE T.YEAR = 2007
GROUP BY PRODUCT_DEPARTMENT, REGION
```
Matching of queries for SAO support

- DB2 for z/OS will reuse partial MQT functionality to find out which queries are eligible for SAO offload and which are not.
- This implies that a subset of the MQT restrictions is inherited (at least for release 1 of SAO)
  - Only a single query block at a time can be routed to SAO (Queries which consist of several Query Blocks, are not seen as whole query by the accelerator but only as single, independent blocks)
  - The results of subqueries can not be used by SAO in the outer query (DB2 would need to pass a subselect result to SAO)
The following queries run in DB2 and not accelerated

- DB2 matches one query block at a time and routes a single query block to SAO
  - Queries which consist of several Query Blocks, are not seen as whole query by the accelerator but only as single, independent blocks
- Outer query block containing inner query blocks is not routed
  - The results of subselects can not be used by SAO in the outer query (DB2 would need to pass a subselect result to SAO)
- The following SQL may generate multiple query blocks
  - subselects and common table expressions
    - subselects in quantitative predicates (SOME, ANY, ALL)
    - EXISTS or IN predicate with subselects
  - UNION, INTERSECT, EXCEPT
  - UNION ALL views -> can only route inner query blocks
- Only inner join and Fact left outer join Dimension (no full, right outer join)
- Most DB2 built in functions are supported except
  - mathematical functions like sin, cos, tan, exp, correlation
  - User defined functions
  - Advanced string functions like locate, left, like, overlay, position
  - Advanced OLAP functions like rank, dense_rank, row_number, rollup, cube
Supported schemas

- A MART consists of a set of tables together with their referential constraints.
  - Fact tables are considered to be the tables which have the highest join depth.

- Only Queries, including at least the fact table, can be routed to SAO (Queries which are only scanning the dimensions have to be handled by DB2)

- Multiple fact tables are allowed within the same MART definition but:
  Queries can not handle table across MART boundaries
Support for data types

- Not supported:
  - Any kind of LOB
  - ROWID
  - XML
  - Binary data
Summary why a query may not be routed

1. Because it uses CURRENT REFRESH AGE = 0
2. Because it contains syntax that is not supported (e.g. Subselect or full outer join)
3. Because the accelerator or AQT is disabled
4. Because it references a table or column that is not in the accelerated mart (may be due to unsupported datatypes)
5. Because the query does not reference a fact table
6. Because the optimizer decides DB2 for zOS can do better (DB2 has a cost-based threshold)
   - E.g. Query with selective predicate on indexed column is executed in DB2
Added Explain Table for Queries are NOT Accelerated

A new EXPLAIN table is added to show

- Whether or not a query block is eligible for automatic query rewrite, and if not eligible show the reason why it's not eligible.

- If eligible for automatic query rewrite, which materialized/accelerated query tables were considered, and for each one that wasn't chosen the reason why it was not chosen.

- The DDL for this new EXPLAIN table is as follows:

  ```sql
  CREATE TABLE DSN_QUERYBLOCKINFO_TABLE(
      QUERYNO INTEGER NOT NULL WITH DEFAULT,
      QBLOCKNO SMALLINT NOT NULL WITH DEFAULT,
      ...
      QB_REASON SMALLINT NOT NULL WITH DEFAULT,
      QB_INFO CLOB(2MB) NOT NULL WITH DEFAULT,
  ) CCSID UNICODE;
  ```

- Column "QB_INFO" contains data in XML format. This column would contain the objects that caused acceleration not to be chosen.
The tested (sub-)schema

**STORE1**
- **PK**: STORE_NUMBER
- **ADDRESS**

**STORE2**
- **PK**: STORE_NUMBER
- **ADDRESS**

**FACT**
- **FK1**: PRODUCTID
- **FK2**: DATEID
- **FK3**: STORE_NUMBER1
- **FK4**: STORE_NUMBER2
- **SALESKEYQUANTITY**
- **INVENTORYCOUNT**
- **CUSTID**
- **RAB**

**PRODUCT**
- **PK**: PRODUCTID
- **COLOR**
- **BRAND**
- **CATEGORYID**
- **MERCHANDISEID**

**DATE_RANGE**
- **PK**: DATEID
- **WEEK_ENDING_DATE**

**CATEGORY**
- **PK**: CATEGORYID
- **MERCHANDISE_ID**
- **PRODUCT_GROUP**

**KEY NUMBERS**
- **1.314.304.366**
- **61.254**
- **7175**
- **7299**
- **470**
- **110**
Average deviations: 5.8s vs. 1520s
Query Execution Times: DB2 with SAO - Speedup

Average 86
Summary

Goal: Constant, short response time for BI queries in DB2 for z/OS without tuning (orders of magnitude improvement)

1. In-memory database – no disk I/O
2. Compression scheme that allows fixed length tuples and predicate evaluation on compressed data
3. Brute-force scans for all queries instead of tuning of indexes using massive parallelisation – scales with number of blades
4. Exploiting multi-core architecture and SIMD instructions of commodity hardware
5. Pre-join dimension tables to fact during load (schema melting)
6. Appliance attached to DB2 to which DB2 will transparently route queries without changing user application
What is available on System z & How to implement
Some key Redbooks

- Enterprise Data Warehousing with DB2 9 for z/OS

- 50 TB Data Warehouse Benchmark on IBM System z
  - This is the draft

- DB2 for z/OS: Data Sharing in a Nutshell

- System Programmer’s Guide To: Workload Manager

- Workload Management for DB2 Data Warehouse, REDP-3927
The IBM Smart Analytics System 9600
IBM Smart Analytics System 9600

Includes -

- **Hardware**
  - Appliance-Like delivery built on System z10 technology
  - DS8000 enterprise class storage
  - Pre-packaged in multiple scale factors to meet any requirement.

- **Software**
  - Optimized software stack
  - Enhance the solution with addition software add-ons

- **Services**
  - Installed and ready to use

- **Maintenance**
  - Up to 5 years hardware maintenance
IBM Smart Analytics System – 9600

Building an end-to-end BI environment on System z

IBM Smart Analytics System -z
Foundation for growth
- Replication Server
- Federation Server/Classic Fed
- IBM Smart Analytics Optimizer

View of Business

System z

InfoSphere Warehouse

Cognos 8.4 BI

DB2 for z/OS

z/OS

LPAR or stand alone

DB2 Warehouse Database

DS8700
IBM Smart Analytics System 9600 Software

Deeply Optimized by IBM Experts… Flexible Growth…

**Powerful Data Warehouse and BI Software**
- DB2 for z/OS Value Unit Edition (primary) V9
- DB2 Utilities Suite V9
- DB2 Connect
- InfoSphere Warehouse on System z V9.5.2
- IBM Cognos 8.4 BI for Linux on System z
- z/OS Operating System Stack V1.11
- z/VM 6.1

**Optional Value Priced Add-ons**
- Tivoli OMEGAMON for DB2 Performance Expert
- Tivoli Directory Server
- InfoSphere Information Server
- InfoSphere Replication Server
  - Q-Rep, CDC and Event Publisher eligible
- InfoSphere Federation Server plus Classic Federation on System z
- Tivoli ITCAM, ITUAM
- Cognos Now! For Linux on System z
Comparing the Smart offerings in System Z:

- **IBM Smart Analytics System:**
  - Complete, end-to-end environment for BI workload
  - Processes ALL queries submitted by end-users
  - **Software:**
    - Includes z/OS, DB2 for z/OS,
    - Linux, InfoSphere Warehouse, Cognos, DB2 Connect
  - **Supports:**
    - Data movement
    - Enduser tools (Cognos)
    - Data Storage (Data warehouse)
  - Runs in z/OS-DB2 LPAR, Linux on Z LPAR for Tooling
  - Is an all purpose environment to deploy any BI workload

- **IBM Smart Analytics Optimizer:**
  - Self-contained, closed system, dedicated to processing select queries
  - MUST connect TO a DB2 for z/OS environment that is running a BI workload
  - **Software:**
    - IBM SAO sofware 56997-AQT that is custom code unique to this offering, ordered as part of the system.
  - **Supports:**
    - Only executes a **SUBSET** of queries that arrive in DB2
  - **Qualifying queries:**
    - Are selected/routed to IBM SAO by DB2 for z/OS
    - Are multidimensional
    - Generally scan the FACT table loaded in memory in the IBM SAO offering
V2 - Query Execution Process Flow

IBV Smart Analytics System - 9600

Application Interface

DB2 Optimizer

IBM SAO Interface

Coordinators

Queries executed with IBM SAO

Worker 1

Worker 2

Worker 3

Worker n-1

Worker n

DB2 Query Execution
Run-time:
for queries that cannot (or should not) be off-loaded to ISAO

IBM SAO

Queries executed without IBM SAO
IBM Smart Analytics System

More Information

To learn more about the IBM Smart Analytics System visit:

Collateral:

IBM Smart Analytics System 9600 Webpage:

System z page:  http://www.ibm.com/systems/zbi

Other Links:


