Information Management

IBM

ISAO – IBM Smart Analytics Optimizer

Accelerating DB2 for z/OS

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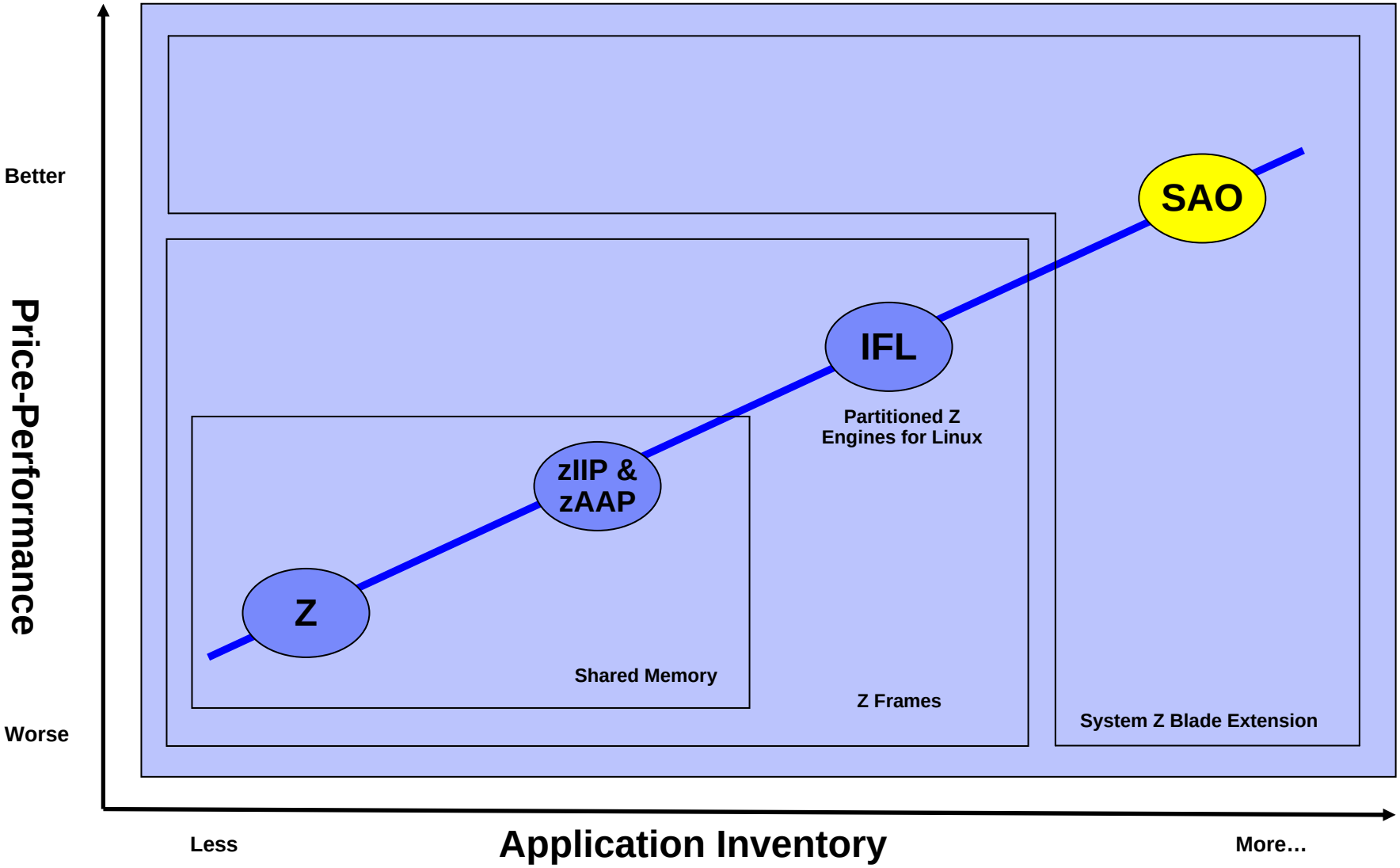
Challenges: Performance, Scalability, TCO

- **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)



IBM Smart Analytics Optimizer

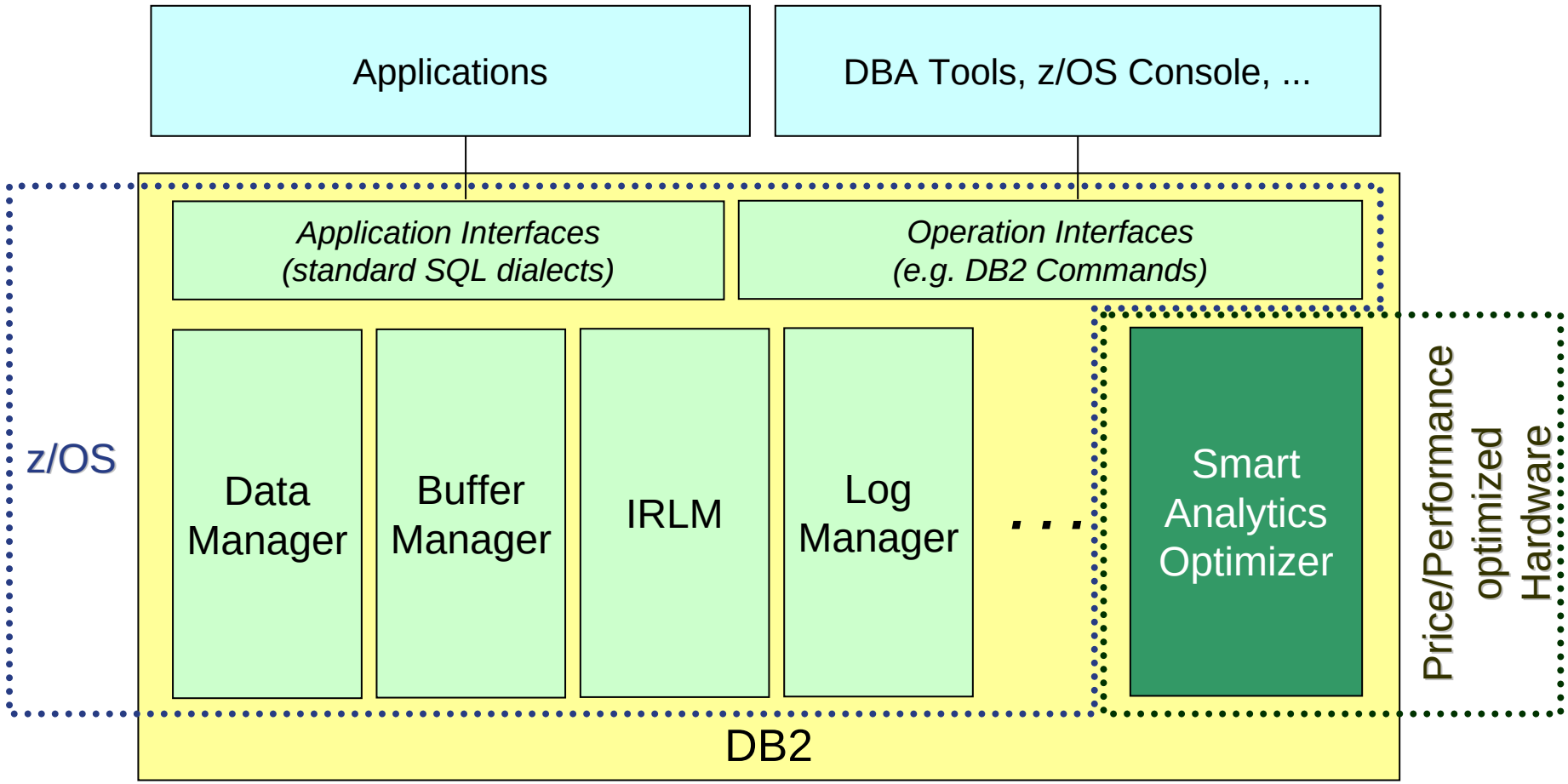
What is it?

- ✓ 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

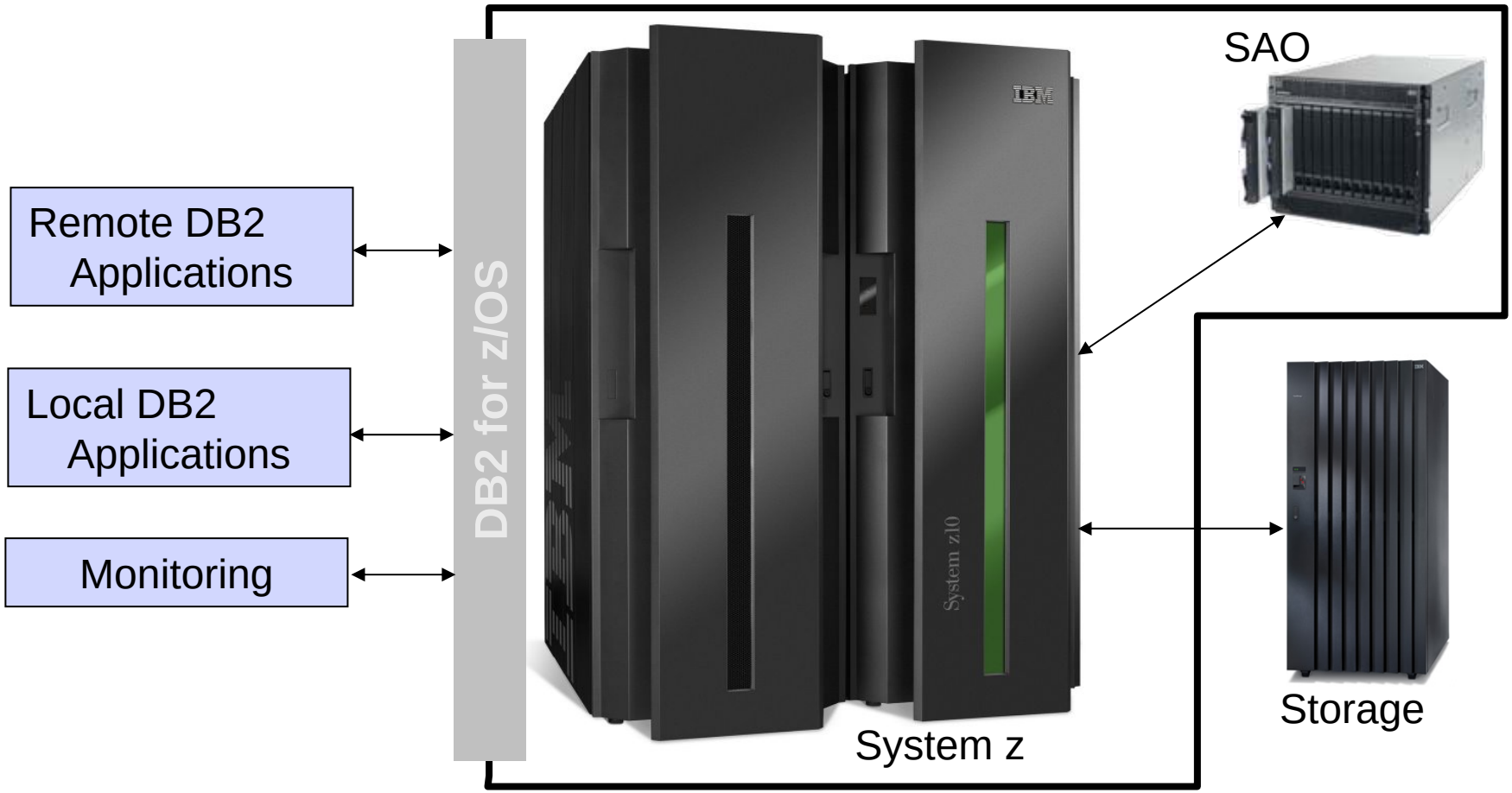
Smart Analytics Optimizer (SAO) – Platform View



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

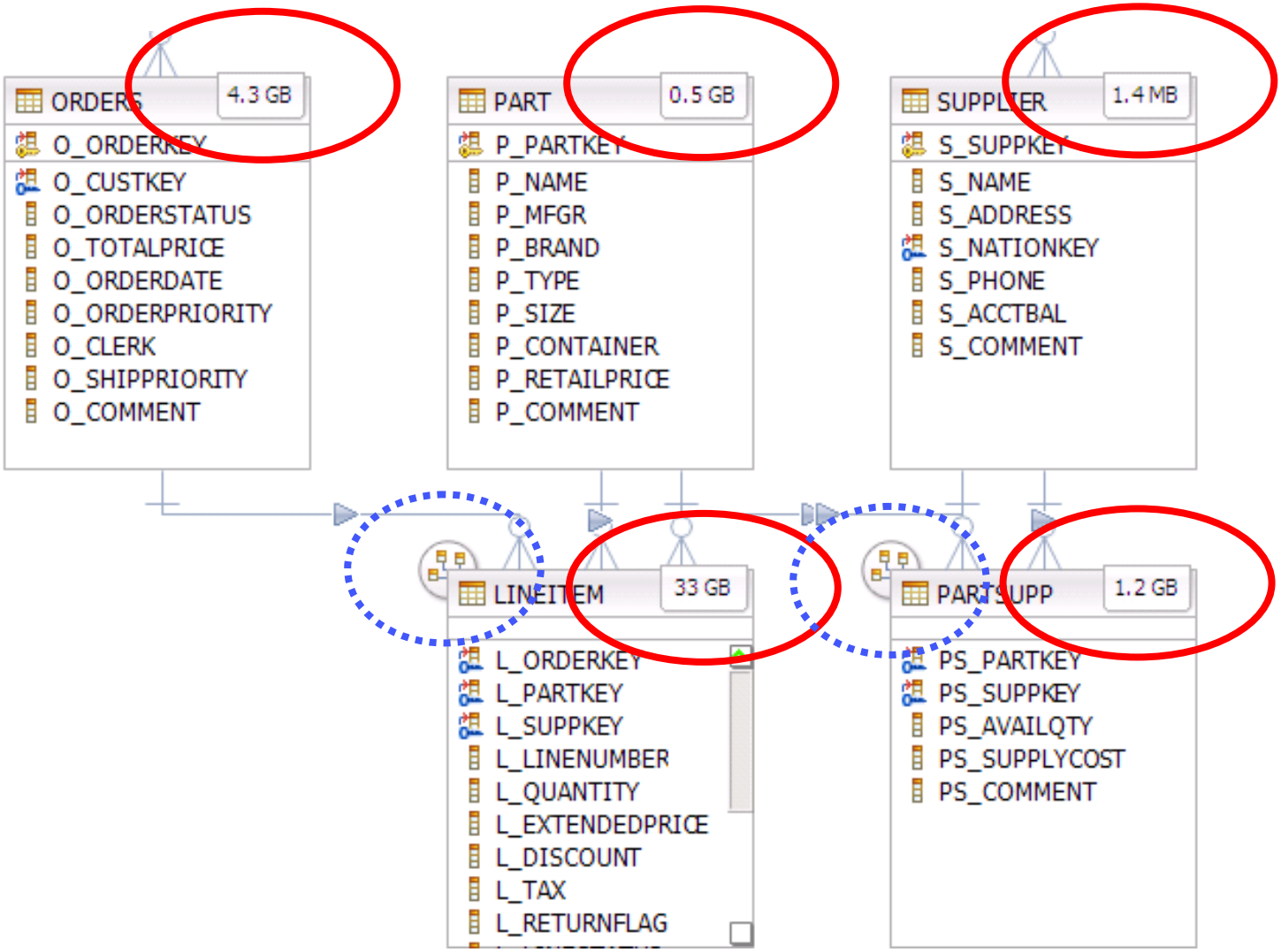
Adding the Accelerator without changing the environment



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 it's 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

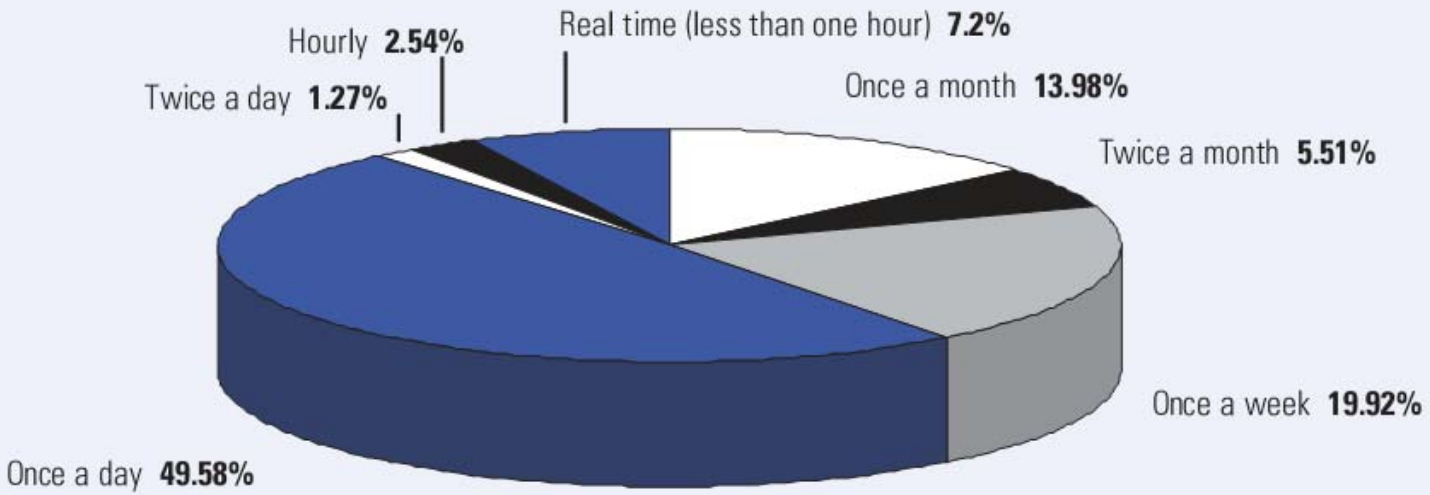
- **A highly compressed, version of all data of the MARTs is kept in the memory of the InfoSphere Warehouse Accelerator**
- **The data in memory is a** snapshot **of the original data which is still stored within DB2.**
- **Data changes on the original data need to be captured on the DB2 side and applied 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?

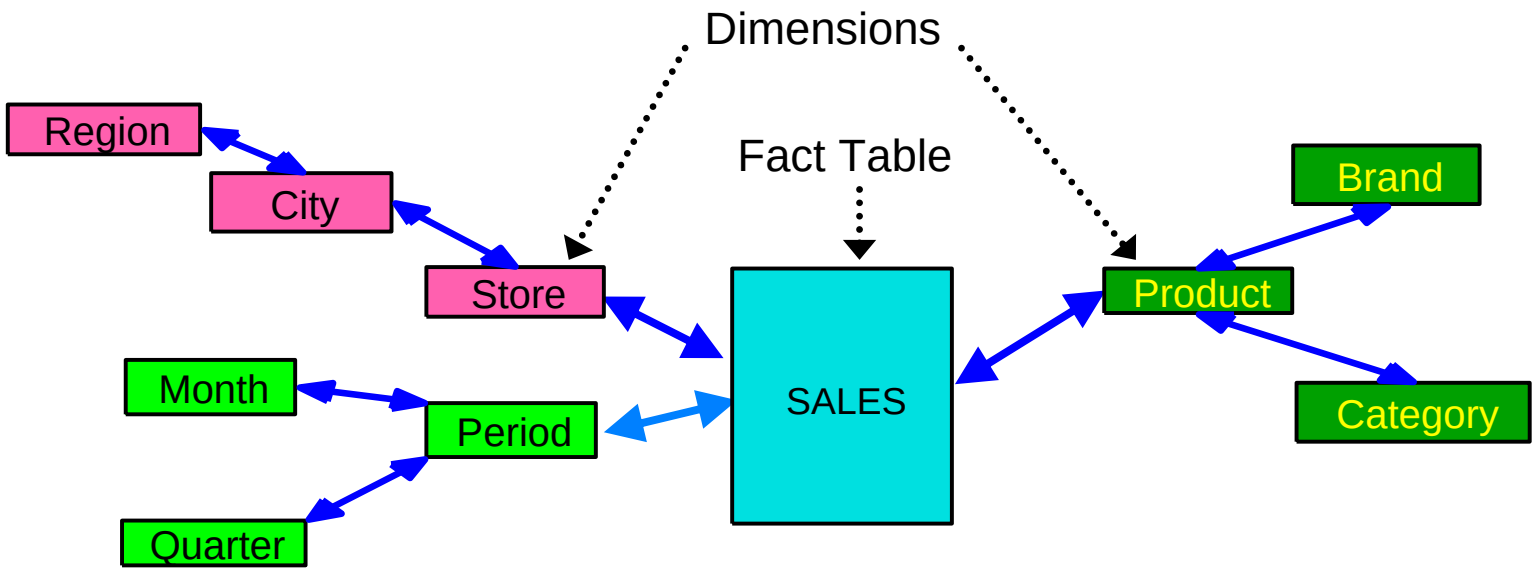


Data Maintenance (SAO Currency)

- **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

```
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

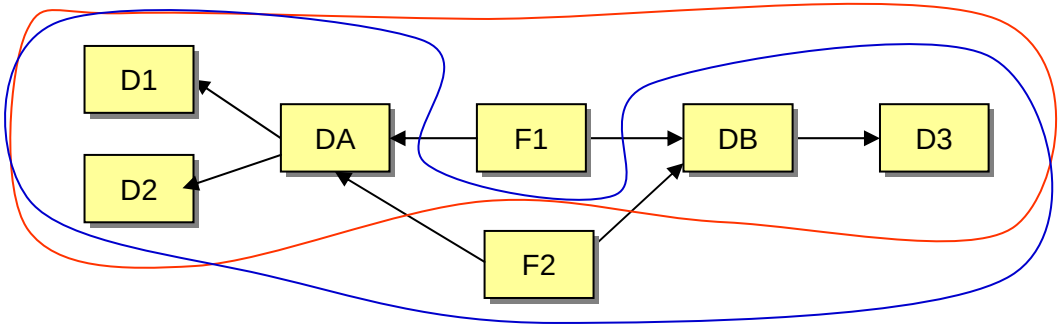
- **DB2 for z/OS will reuse partial MQT functionality to find out which queries are eligible for SAO offload and which are not.**
- **This implies that a subset of the MQT restrictions is inherited (at least for release 1 of SAO)**
  - Only a single query block at a time can be routed to SAO (Queries 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

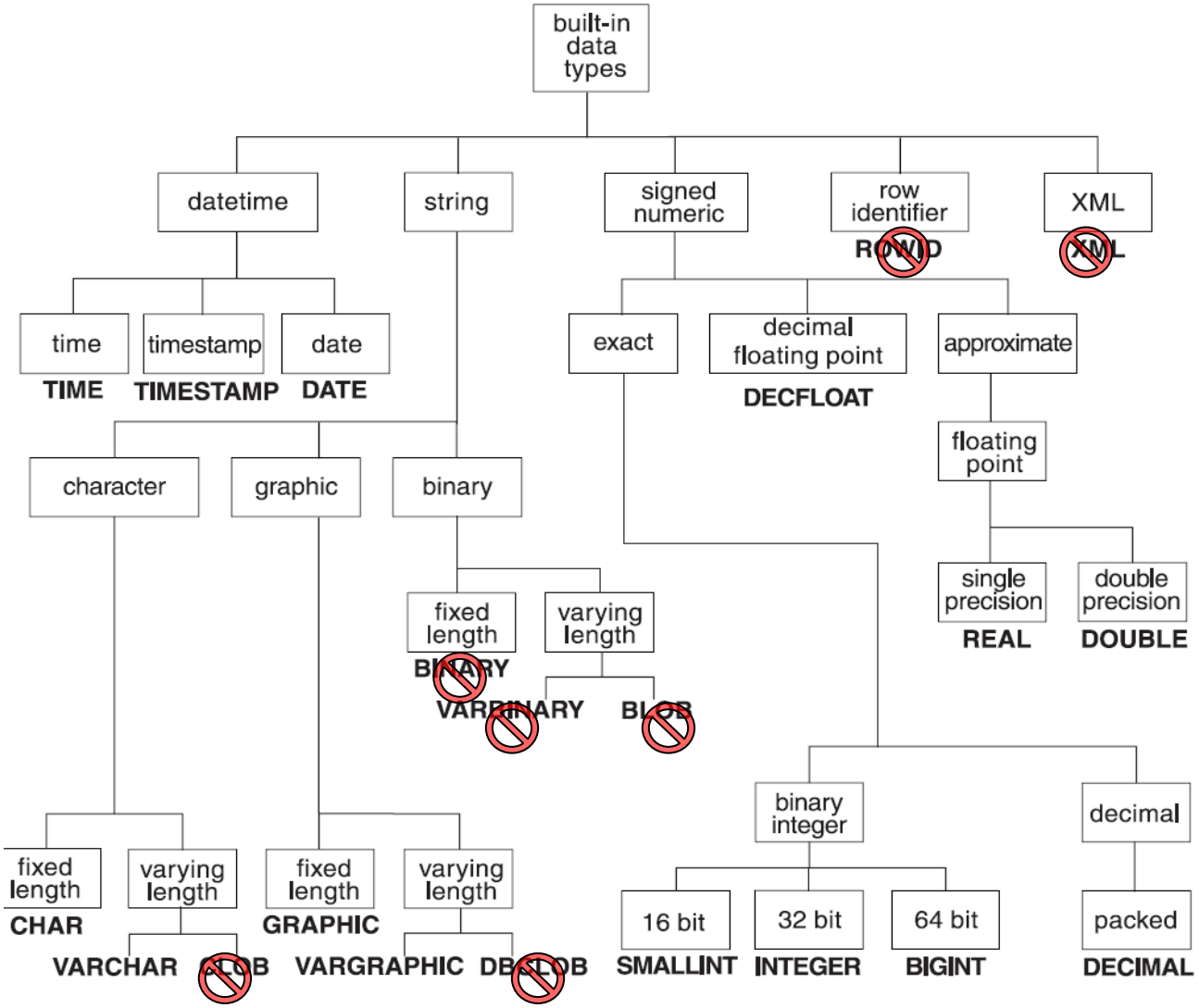
- DB2 matches one query block at a time and routes a single query block to SAO
  ➔ Queries which consist of several Query Blocks, are not seen as whole query by the accelerator but only as single, independent blocks
- Outer query block containing inner query blocks is not routed
  ➔ The results of subselects 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

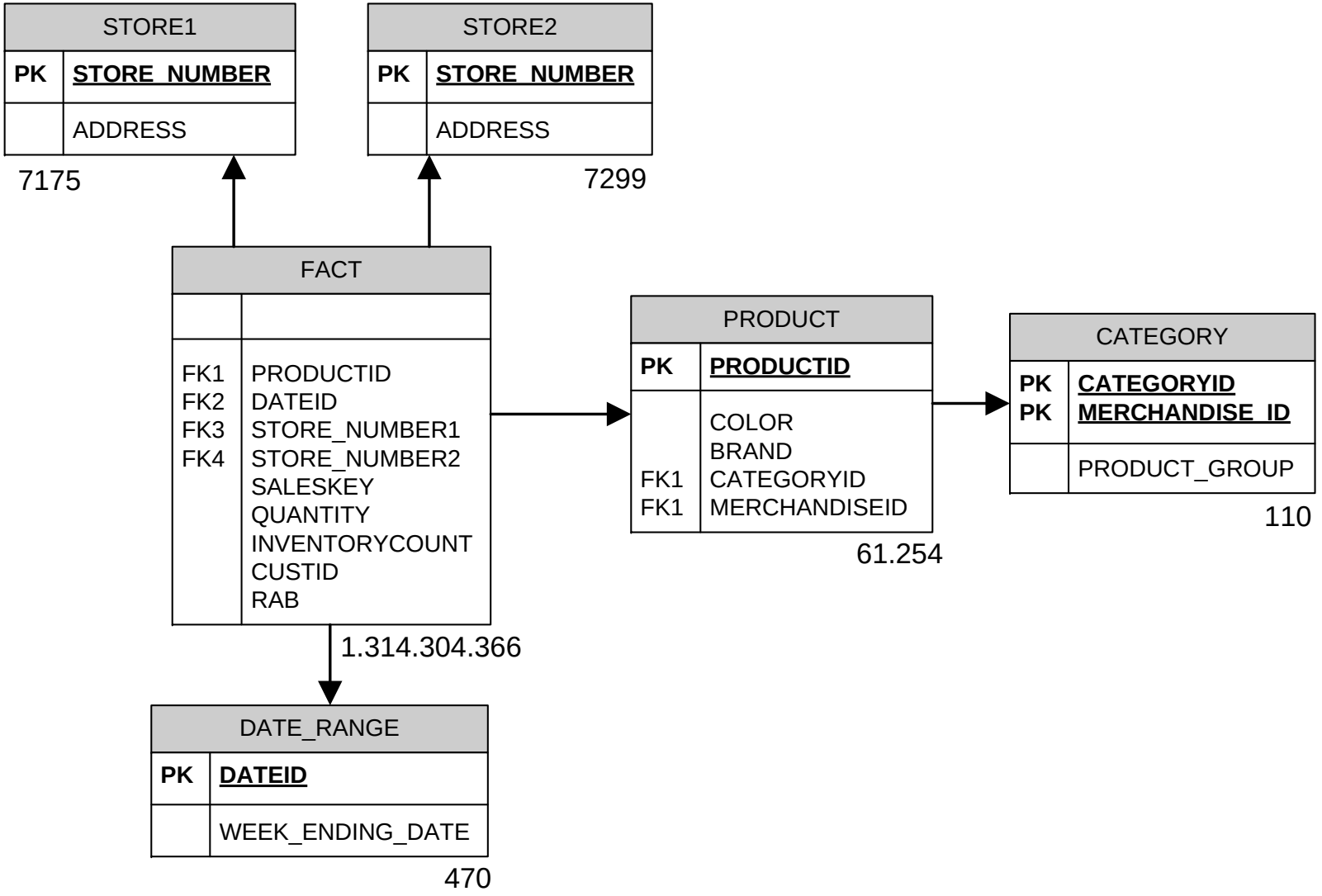
A new EXPLAIN table is added to show

- **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:**

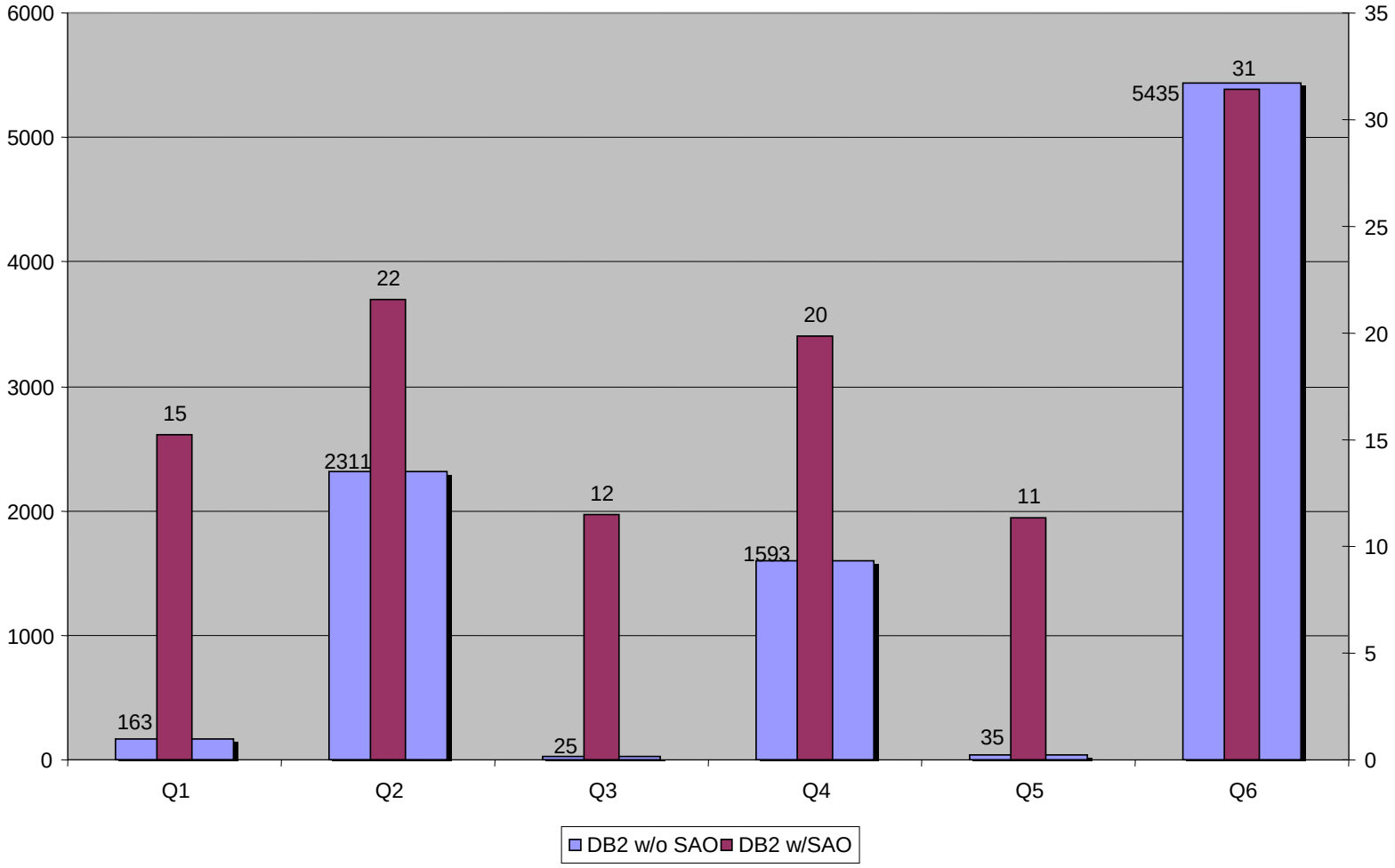
```
CREATE TABLE DSN_QUERYBLOCKINFO_TABLE(
   QUERYNO INTEGER NOT NULL WITH DEFAULT,
   QBLOCKNO SMALLINT NOT NULL WITH DEFAULT,
   ...
   QB_REASON SMALLINT NOT NULL WITH DEFAULT,
   QB_INFO CLOB(2MB) NOT NULL WITH DEFAULT,
) CCSID UNICODE;
```

- **Column "QB_INFO" contains data in XML format. This column would contain the objects that caused acceleration not to be chosen..**

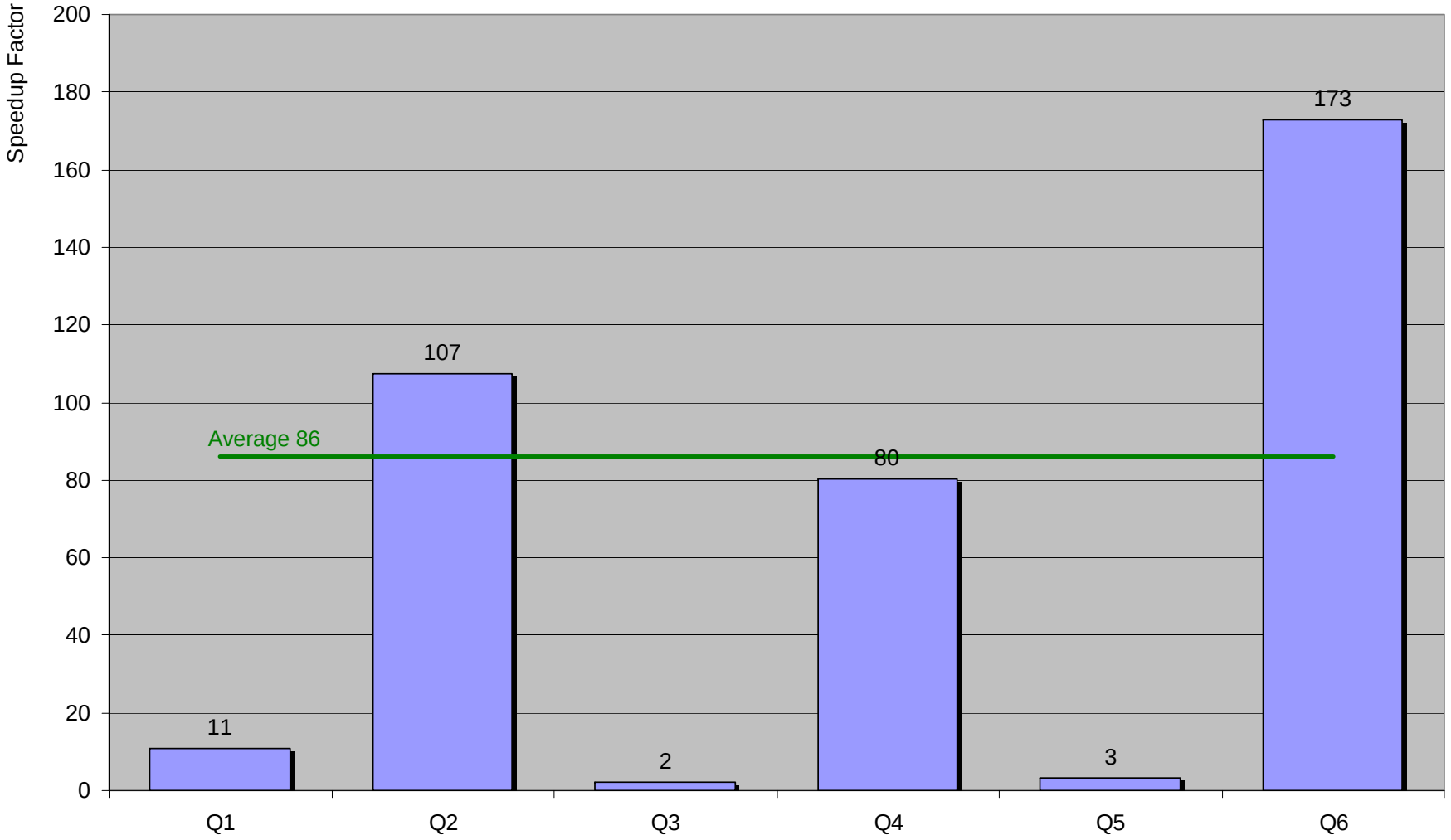
The tested (sub-)schema



Average deviations: 5.8s vs. 1520s



Query Execution Times: DB2 with SAO - Speedup

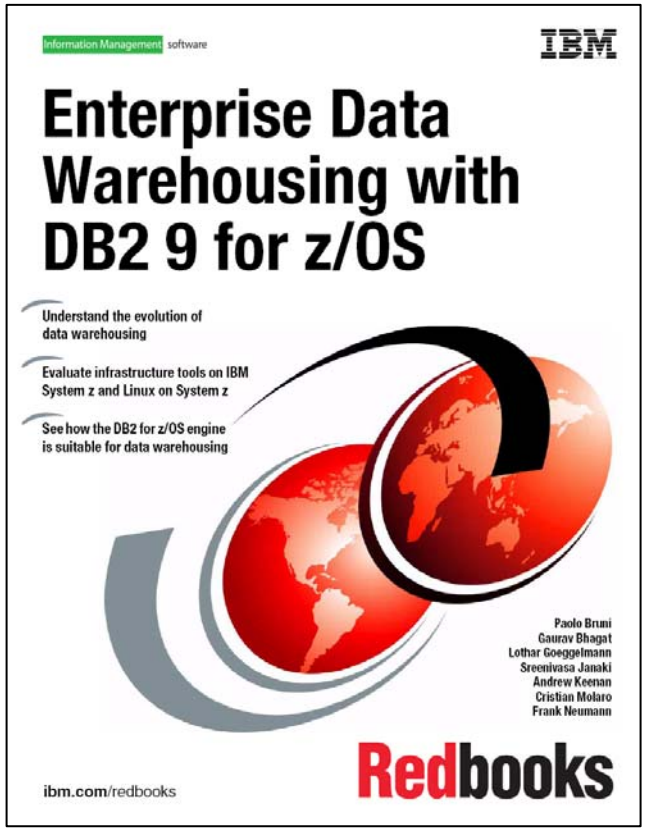


Summary

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**
  - http://www.redbooks.ibm.com/abstracts/sg247637.html
- **50 TB Data Warehouse Benchmark on IBM System z**
  - http://www.redbooks.ibm.com/redbooks.nsf/RedpieceAbstracts/sg247674.html
  - This is the draft
- **DB2 for z/OS: Data Sharing in a Nutshell**
  - http:// www.redbooks.ibm.com/abstracts/sg247322.html
- **System Programmer's Guide To: Workload Manager**
  - http:// www.redbooks.ibm.com/abstracts/sg246472.html
- **Workload Management for DB2 Data Warehouse, REDP-3927**
  - http:// www.redbooks.ibm.com/abstracts/redp3927.html

The IBM Smart Analytics System 9600

IBM Smart Analytics System 9600

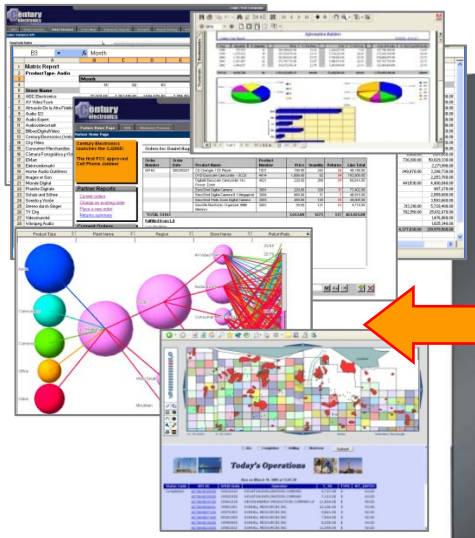
Includes -

- ***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*

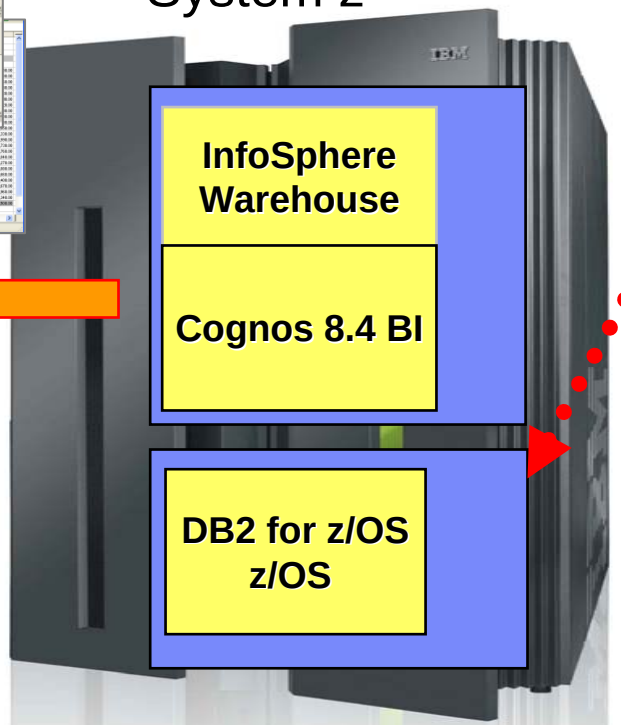
IBM Smart Analytics System – 9600

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

View of Business



System z



LPAR or stand alone

DS8700

IBM Smart Analytics System -z

Foundation for growth

- ***Replication Server***
- ***Federation Server/Classic Fed***
- ***IBM Smart Analytics Optimizer***

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
  Option for MLC
- 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

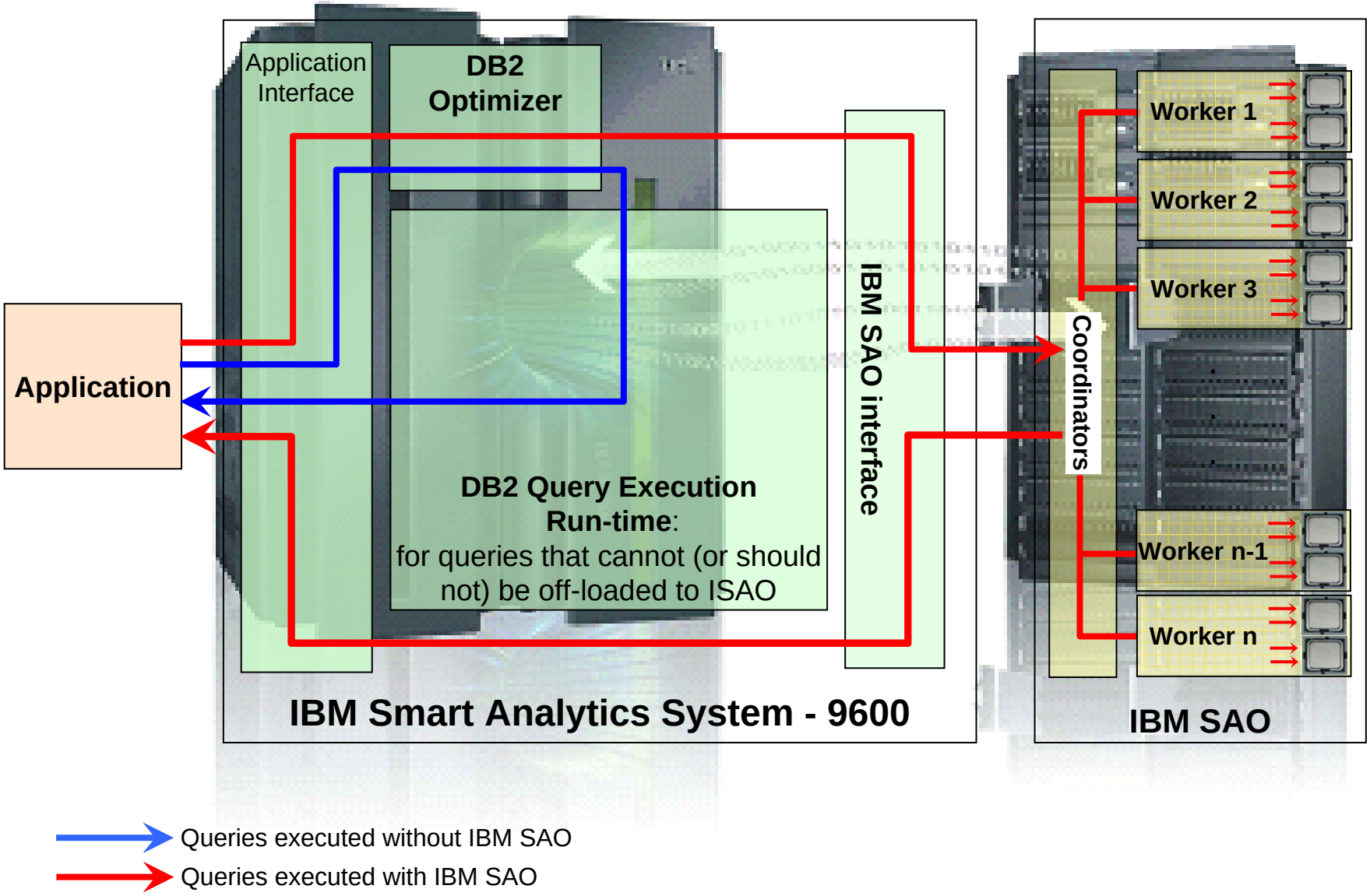
- Tivoli OMEGAMON for DB2 Performance Expert
- Tivoli Directory Server
- InfoSphere Information Server
- InfoSphere Replication Server
  - Q-Rep, CDC and Event Publisher eligible
- InfoSphere Federation Server plus Classic Federation on System z
- Tivoli ITCAM, ITUAM
- Cognos Now! For Linux on System 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



IBM Smart Analytics System

More Information

To learn more about the IBM Smart Analytics System visit:

http://www-01.ibm.com/software/data/infosphere/data-warehousing/

Collateral:

IBM Smart Analytics System 9600 Webpage:

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

Other Links:

- **Data Warehousing and BI on Z -** http://www-2000.ibm.com/software/data/businessintelligence/systemz/
- **Terabyte Club for System z BI customers:** http://www-2000.ibm.com/software/data/businessintelligence/systemz/terabyte-club.html
- **Data Governance on System z:** http://www-2000.ibm.com/software/data/db2imstools/solutions/compliance.html