DB2 for i
Monitoring, Analysis and Tuning

Mike Cain
IBM DB2 for i Center of Excellence
Rochester, MN USA
mcain@us.ibm.com
Even though DB2 for i is:

✓ Self managing
✓ Self tuning
✓ Easy to use
✓ Easy to maintain

SQL monitoring and analysis is advantageous
Review of Query Optimization and Execution
## Components of Work - Database Request

<table>
<thead>
<tr>
<th>RunTime</th>
<th>Output Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Journaling</td>
<td></td>
</tr>
<tr>
<td>Index Maintenance</td>
<td></td>
</tr>
<tr>
<td>Constraint Enforcement</td>
<td></td>
</tr>
<tr>
<td>Locking</td>
<td></td>
</tr>
<tr>
<td>Trigger Processing</td>
<td></td>
</tr>
<tr>
<td>Disk Operations</td>
<td></td>
</tr>
<tr>
<td>CPU Operations</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Open Processing</th>
<th>ODP Creation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database</td>
<td>Authentication</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Optimization</th>
<th>Access Plan Creation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Index Estimates</td>
</tr>
</tbody>
</table>

**Key to optimum SQL performance…**

- Identify
- Minimize
- Eliminate bottlenecks in these areas

---

© 2009 IBM Corporation

---

The New Power Equation

---
Query Optimization

Cost Based Query Optimization

• The DB2 for i Optimizer performs "cost based" optimization

• "Cost" is defined as the estimated time it takes to run the request

• "Costing" various plans refers to the comparison of a given set of algorithms and methods in an attempt to identify the "fastest" plan

• One goal of the optimizer is to eliminate I/O as early as possible by identifying the best path to and through the data

  • The optimizer has the ability and freedom to "rewrite" the query
  • Very sophisticated query strategies and methods are used
Query optimization takes into account...

The Plan

- System configuration
- System attributes
- OS VRM Level
- SMP, DB parallelism
- Database design
- Table sizes, number of rows
- Views and Indexes (Radix, EVI)
- Work management
- Static
- Dynamic
- Extended Dynamic Interfaces
- Job, Query attributes
- SQL Request
- System performance

© 2009 IBM Corporation
SQL Query Processing – New Request

SQL request → Optimize → Open → Run → DB2 for i

The New Power Equation

© 2009 IBM Corporation
(Query) Access Plans

The output of query optimization

Contents

- A control structure that contains information on the actions necessary to satisfy each SQL request
- These contents include:
  - Access Method
  - Info on associated tables and indexes
  - Any applicable program and/or environment information
Access Plan to ODP

Internal Structures

ACCESS PLAN

CREATE

OPEN DATA PATH (ODP)

Executable code for all requested I/O operations

- Create process is EXPENSIVE
  - Longer execution time the first time an SQL statement is executed
- Emphasizes the need of REUSABLE ODPs

© 2009 IBM Corporation
Query Plan Execution

DB Engine
Executable code for I/O operations and processing

• Data Access

• Data Processing

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Size</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item1</td>
<td>150</td>
<td>XL</td>
<td>Red</td>
</tr>
<tr>
<td>Item2</td>
<td>525</td>
<td>S</td>
<td>Blue</td>
</tr>
<tr>
<td>Item3</td>
<td>310</td>
<td>XXL</td>
<td>Yellow</td>
</tr>
<tr>
<td>Item4</td>
<td>90</td>
<td>M</td>
<td>Green</td>
</tr>
</tbody>
</table>
Query Optimization and Execution Phases

Query processing can be roughly divided into four phases:

- **Query Validation**
  - Validate the query request
  - Validate any existing plan(s)
  - Build the internal query structures
- **Query Dispatcher**
  - Determine which query engine can complete the processing
- **Query Optimization**
  - Choose the most efficient access and processing methods
  - Build the access plan
- **Query Execution**
  - Build the structures needed for query cursor
  - Build the structures for any temporary structures (if needed)
  - Build and activate query cursor
  - **Generate information**
  - DB Engine executes the query plan
SQL Monitoring and Analysis Mechanisms
Query Optimization and Execution Information

- Indexes Advised – System wide V5R4 and 6.1 only
- SQE Plan Cache V5R4 and 6.1 only
- SQE Plan Cache Snapshots V5R4 and 6.1 only
- Detailed Database Monitor Data – SQL trace V5R4 and 6.1 enhanced
- Visual Explain V5R4 and 6.1 enhanced

- PRTSQLINF Messages
- Summarized Database Monitor Data
- Debug Job Log Messages
Index Advised – System wide

• New V5R4 feature, enhanced in 6.1
• System wide index advice
  – Data is placed into a DB2 table (QSYS2/SYSIXADV)
  – Autonomic
  – No overhead
• CQE and SQE support
  – CQE only provides basic advice based on local selection predicates
  – SQE provides complex advice based on all parts of the query
• GUI interface via iSeries Navigator
  – Advice by System, or Schema, or Table
• System only adds rows, user must manage the data
  – Options to clear or prune
• Can create indexes directly from GUI
  – New in 6.1: Multiple index creation
  – Additional indexing analysis might be required
• New in 6.1: Condensed advice
Index Advised – System wide

The New Power Equation
Index Advised – System wide

The New Power Equation | © 2009 IBM Corporation
# Index Advised – System wide

![Index Advisor - Lp18ut14.rchland.ibm.com](index-advisor.png)

<table>
<thead>
<tr>
<th>Table for Which Index was Advised</th>
<th>Schema</th>
<th>Short Name</th>
<th>Keys Advised</th>
<th>Leading Keys Order Indecendant</th>
<th>Index Type Advised</th>
<th>Last Advised for Query Use</th>
<th>Times Advised for Query Use</th>
<th>MTI Used</th>
<th>Estimated Index Creation</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>BATCH_MONITOR</td>
<td>QSMART</td>
<td>BATCH00001</td>
<td>RUN_STARTTIMEMANIFEST, RUN_STARTTIMEMANIFEST</td>
<td>Binary Radix</td>
<td>1/11/08 3:19:20 PM</td>
<td>135492</td>
<td>5272</td>
<td>0</td>
<td>00:00:01</td>
<td>Row sale</td>
</tr>
<tr>
<td>IGNORE_SQLCODES</td>
<td>QSMART</td>
<td>IGNOR00001</td>
<td>SQLCODE, IGNOR00001, SQLCODE</td>
<td>Binary Radix</td>
<td>1/11/08 3:19:20 PM</td>
<td>62858</td>
<td>0</td>
<td>0</td>
<td>00:00:01</td>
<td>Row sale</td>
</tr>
<tr>
<td>QQLDPFP002</td>
<td>SMUDFDPP</td>
<td>QQLDPFP002</td>
<td>EMPNUMC, EMPNUMC</td>
<td>Binary Radix</td>
<td>1/10/08 5:16:00 PM</td>
<td>36784</td>
<td>0</td>
<td>0</td>
<td>00:00:01</td>
<td>Row sale</td>
</tr>
<tr>
<td>QQLDFP003</td>
<td>SMUDFDPP</td>
<td>QQLDFP003</td>
<td>EMPNUMC, EMPNUMC</td>
<td>Binary Radix</td>
<td>1/10/08 5:16:00 PM</td>
<td>35483</td>
<td>0</td>
<td>0</td>
<td>00:00:01</td>
<td>Row sale</td>
</tr>
<tr>
<td>QQLDFP001</td>
<td>SMUDFDPP</td>
<td>QQLDFP001</td>
<td>EMPNUMC, EMPNUMC</td>
<td>Binary Radix</td>
<td>1/10/08 5:16:00 PM</td>
<td>35483</td>
<td>0</td>
<td>0</td>
<td>00:00:01</td>
<td>Row sale</td>
</tr>
<tr>
<td>QQLDFP002</td>
<td>SMUDFDPP</td>
<td>QQLDFP002</td>
<td>EMPNUMC, EMPNUMC</td>
<td>Binary Radix</td>
<td>1/10/08 5:16:00 PM</td>
<td>35483</td>
<td>0</td>
<td>0</td>
<td>00:00:01</td>
<td>Row sale</td>
</tr>
<tr>
<td>BASE1</td>
<td>SMUDFSRVT</td>
<td>BASE00001</td>
<td>C1, C1</td>
<td>Binary Radix</td>
<td>10/29/07 12:14:04 PM</td>
<td>13607</td>
<td>196</td>
<td>0</td>
<td>00:00:01</td>
<td>Row sale</td>
</tr>
<tr>
<td>ALTERNATEVALIDITIES</td>
<td>ALTRNCHASE</td>
<td>ALTRN00001</td>
<td>SEQVALUE, TESTNAME, SEQVALUE, TESTNAME</td>
<td>Binary Radix</td>
<td>1/10/08 5:10:06 PM</td>
<td>5234</td>
<td>15</td>
<td>0</td>
<td>00:00:01</td>
<td>Row sale</td>
</tr>
<tr>
<td>ALTYPEP</td>
<td>DONOTALTER</td>
<td>ALLTYPES</td>
<td>DINTL</td>
<td>Encoded vector...</td>
<td>1/10/08 5:10:06 PM</td>
<td>4304</td>
<td>0</td>
<td>0</td>
<td>00:00:01</td>
<td>Ordering</td>
</tr>
<tr>
<td>CURRENT,TEST Phần B</td>
<td>CURRBTM</td>
<td>CURR00001</td>
<td>STARTTIME</td>
<td>Encoded vector...</td>
<td>10/29/07 3:33:48 PM</td>
<td>3765</td>
<td>0</td>
<td>0</td>
<td>00:00:01</td>
<td>Ordering</td>
</tr>
<tr>
<td>CURRENT,TEST Phần B</td>
<td>CURRBTM</td>
<td>CURR00001</td>
<td>INTERFACE, TESTNAME, INTERFACE, TESTNAME</td>
<td>Binary Radix</td>
<td>10/29/07 3:33:48 PM</td>
<td>3765</td>
<td>0</td>
<td>0</td>
<td>00:00:01</td>
<td>Ordering</td>
</tr>
<tr>
<td>FASTPATH07</td>
<td>SNSFSPTH</td>
<td>FASTPATH07</td>
<td>DATEFND</td>
<td>Binary Radix</td>
<td>10/29/07 2:33:32 PM</td>
<td>3092</td>
<td>0</td>
<td>0</td>
<td>00:00:01</td>
<td>Row sale</td>
</tr>
<tr>
<td>ALTYPEP</td>
<td>DONOTALTER</td>
<td>ALLTYPES</td>
<td>DINTS</td>
<td>Binary Radix</td>
<td>1/10/08 5:10:06 PM</td>
<td>2672</td>
<td>8</td>
<td>0</td>
<td>00:00:01</td>
<td>Ordering</td>
</tr>
<tr>
<td>ALTERNATEVALIDITIES</td>
<td>ALTRNCHASE</td>
<td>ALTRN00001</td>
<td>SEQVALUE, TESTNAME, SEQVALUE, TESTNAME</td>
<td>Binary Radix</td>
<td>10/25/07 11:42:25 AM</td>
<td>2505</td>
<td>77</td>
<td>0</td>
<td>00:00:01</td>
<td>Ordering</td>
</tr>
<tr>
<td>CSTHOR</td>
<td>DONOTALTER</td>
<td>CSTHOR</td>
<td>CUSTED</td>
<td>Binary Radix</td>
<td>1/10/08 5:50:42 AM</td>
<td>2500</td>
<td>173</td>
<td>0</td>
<td>00:00:01</td>
<td>Row sale</td>
</tr>
<tr>
<td>ALTYPEP</td>
<td>DONOTALTER</td>
<td>ALLTYPES</td>
<td>DINTL</td>
<td>Binary Radix</td>
<td>1/10/08 5:10:06 PM</td>
<td>2332</td>
<td>8</td>
<td>0</td>
<td>00:00:01</td>
<td>Ordering</td>
</tr>
<tr>
<td>ALTYPEP</td>
<td>DONOTALTER</td>
<td>ALLTYPES</td>
<td>DINTS</td>
<td>Encoded vector...</td>
<td>1/10/08 4:51:07 PM</td>
<td>2304</td>
<td>0</td>
<td>0</td>
<td>00:00:01</td>
<td>Ordering</td>
</tr>
<tr>
<td>ALAIIN</td>
<td>DONOTALTER</td>
<td>ALLIONS</td>
<td>DCHARF</td>
<td>Binary Radix</td>
<td>1/10/08 4:50:08 PM</td>
<td>2288</td>
<td>0</td>
<td>0</td>
<td>00:00:01</td>
<td>Row sale</td>
</tr>
<tr>
<td>FASTPATH07</td>
<td>SNSFSPTH</td>
<td>FASTPATH01</td>
<td>CHARFLD, CHARFLD</td>
<td>Binary Radix</td>
<td>10/29/07 2:33:30 PM</td>
<td>2266</td>
<td>0</td>
<td>0</td>
<td>00:00:01</td>
<td>Row sale</td>
</tr>
</tbody>
</table>

© 2009 IBM Corporation

---

*The New Power Equation*
SQE Plan Cache

New V5R4 feature, enhanced in 6.1
• System wide information from the SQE Plan Cache
  – Automatic
  – No overhead
• SQE support only
• GUI interface via iSeries Navigator
  – Access
  – Filtering
  – Analysis by time, user, job, statement, etc.
  – Visual Explain
• Data is volatile
  – Information in the SQE Plan Cache is “live” and changing
  – SQE Plan Cache is cleared at IPL
  – New in 6.1: Event monitor to capture plans that are pruned
• SQE Plan Cache is always available
  – No need to “start and stop” a tool or utility

SQE Plan Cache
SQE stores all query plans in a centralized system wide plan cache.
Along with the plans, SQE keeps meta data and runtime information for the plans (i.e. queries).
The plan cache is considered temporary storage.
SQE Plan Cache

Example: filter on top 10 and current user

✓ Get the plan ids for the top 10 queries
✓ Get the plan ids of all queries the current user ran
✓ “AND” the plan id lists together
✓ Return those plans to the user

If the current user ran one or more of the top 10 plans, those particular plans will be returned.

If the user did not run any of the top 10 plans, nothing is returned.

The top 10 plans for current user is not necessarily returned.

Filters are "ANDed" together and represent an "intersection"
List is initially empty to allow for user filtering.
### SQL Statement Longest Runs - Lp18ut14.rchland.ibm.com(Lp18ut14)

```sql
SELECT ALL CUSTOMER,
      AL5 MONTHNAME,
      AL5 YEAR,
      SUM(AL2 QUANTITY) quantity
FROM ITEM_FACT AL2,
     CUST_DIM AL1,
     TIME_DIM AL5
WHERE (AL2.CUSTKEY=AL1.CUSTKEY
       AND AL5.DATEKEY=AL2.SHIPDATE)
AND (AL5.YEAR=?)
AND (AL5.MONTH=?)
```

<table>
<thead>
<tr>
<th>Time Run</th>
<th>Processing Time (sec)</th>
<th>Records Selected</th>
<th>User Name</th>
<th>Job Name</th>
<th>Job User</th>
<th>Job Number</th>
<th>CPU Time (sec)</th>
<th>Synchronous Database Rn</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/26/09 3:00:16 PM</td>
<td>3.7470</td>
<td>121</td>
<td>COBBG</td>
<td>USER</td>
<td>172125</td>
<td>1.1234</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/26/09 3:00:27 PM</td>
<td>0.0001</td>
<td>121</td>
<td>COBBG</td>
<td>USER</td>
<td>172125</td>
<td>0.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/26/09 3:00:41 PM</td>
<td>0.0001</td>
<td>121</td>
<td>COBBG</td>
<td>USER</td>
<td>172125</td>
<td>0.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/26/09 3:00:46 PM</td>
<td>0.0001</td>
<td>121</td>
<td>COBBG</td>
<td>USER</td>
<td>172125</td>
<td>0.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/26/09 3:00:53 PM</td>
<td>0.0001</td>
<td>121</td>
<td>COBBG</td>
<td>QZD4SOINT</td>
<td>USER</td>
<td>172125</td>
<td>0.0000</td>
<td></td>
</tr>
</tbody>
</table>

**Status COMPLETE**

The New Power Equation
The New Power Equation
### Active Query Summary

- **Number of Currently Active Queries**: 22
- **Number of Queries Run Since Start**: 3423
- **Number of Query Full Opens Since Start**: 1466

### Plan Usage Summary

- **Current Number of Plans in Cache**: 396
- **Current Plan Cache Size**: 56 MB
- **Plan Cache Size Threshold**: 512 MB

![SQL Plan Cache Properties](image)
To limit the amount of data collected, specify which filters to use. When filters are provided, only statements that match the specified filter values will be captured.

- Minimum runtime for the longest execution of the statement:
  - [ ] 0 Seconds
- Statements that ran on or after this date and time:
  - [ ] 2/12/08 12:58:22 PM
- Statements the following user has ever run:
  - [ ]
- Statements that are currently active:
  - [ ]
- Statements for which an index has been advised:
  - [ ]
- Statements for which statistics have been advised:
  - [ ]
- Include statements initiated by the operating system:
  - [ ]
- Statements that reference the following objects:
  - [ ]

The New Power Equation
SQE Plan Cache Snapshots

• New V5R4 feature, enhanced in 6.1
• System wide information materialized from the SQE Plan Cache
  – No overhead – data capture is part of normal query optimization and execution
  – Pre-filtering
  – Data is placed into a single DB2 table
• SQE support only
• SQL interface (CALL QSYS2/DUMP_PLAN_CACHE)
  – MC Press Tech Tip - Automatically Generate an SQE Plan Cache Snapshot
  – New in 6.1: SQE Plan Cache Snapshots are automatically registered
• GUI interface via iSeries Navigator
  – Access
  – Filtering
  – Analysis by time, user, job, statement, etc.
  – Visual Explain
• Data is not volatile
  – Information from the SQE Plan Cache is “captured” at a point in time
• SQE Plan Cache is always available
  – No need to “start and stop” a tool or utility
• Additional analysis methods available like “before and after” comparisons
• New in 6.1: Copy to spreadsheet

© 2009 IBM Corporation
SQE Plan Cache Snapshots
Detailed Database Monitor – SQL Trace

- Enhanced in V5R4 and 6.1
- Detailed information collected by the SQL “tracing” facility
  - Data is placed into a single DB2 table
  - Potentially high overhead
- CQE and SQE support
- Command interface – STRDBMON / ENDDBMON
- Connection attributes interface
- GUI interface via iSeries Navigator
  - Access
  - Pre-filtering and Post-filtering
    - New in 6.1: port number and Query Governor
  - Analysis by time, user, job, statement, etc.
  - Summary information via “dashboard”
  - Visual Explain
- Data is not volatile
  - Information from the optimizer and engine is “captured” at a point in time
- Additional analysis methods available like “before and after” comparisons
- New in 6.1: Copy to spreadsheet
Welcome to the System i Navigator SQL Performance Monitor wizard. This wizard will take you through the steps needed to start an SQL performance monitor.

Please specify the following:

Name: New SQL Performance Monitor
Type: Detailed
Schema for data: COBBG
Storage limit (MB): No maximum
Detailed Database Monitor – SQL Trace

SQL Performance Monitor Wizard - Lp18ut14.rchland.ibm.com(Lp18u...

To limit the amount of data collected, specify which filters to use. When filters are provided, only statements that match the specified filter values will be captured.

If you would like to limit the amount of data collected, specify which filters to use:

- Minimum estimated query runtime:
  - Value: 0

- Minimum estimated temporary storage:
  - Value: 0

- Job name:
  - Value: OZDASOINIT

- Job user:
  - Value: USER

- Current user:
  - Value: COSB6G

- Client location:
  - Value: 9.10.74.79

- Local port:
  - Value: 0

- Query Governor limits:
  - Value: Always collect information when exceeded

- Statements that access these objects:
  - Conditional collection of information when exceeded

Activity to monitor:

- Only collect monitor output for user activity
- Collect monitor output for user and system activity
Detailed Database Monitor – SQL Trace
The New Power Equation
Visual Explain

- Enhanced in V5R4, enhanced in 6.1
- Graphical representation of query plan
  - Representation of the DB objects and data structures
  - Representation of the methods and strategy
  - Associated environmental information
  - Advice on indexes and column statistics
  - Highlighting of specific query rewrites
  - Highlighting of expensive methods
- CQE and SQE support
- GUI interface via iSeries Navigator
- Based on detailed optimizer information
  - SQE Plan Cache
  - SQE Plan Cache Snapshots
  - Detailed Database Monitor Data
- New in 6.1:
  - Explain while running
  - Print attributes for a given node

© 2009 IBM Corporation
Visual Explain

```sql
SELECT COUNT(*)
FROM item_fact F
INNER JOIN time_drm D
ON F.shipdate = D.dateKey
WHERE d.year = 2004 AND d.week = 3;
```

New Snapshot - Hash Group By - Statements - Lp18ut14.rchl...
select count(*)
FROM item_fact F
INNER JOIN time_dim D
ON F.time_key = D.time_key
WHERE F.year = ? and F.year = ?
Visual Explain – Explain while running New in 6.1

The New Power Equation
SQL Details for Job (i.e. Connection)

Requires DB2 for i 6.1

The New Power Equation
Which Feedback Mechanism?

SQL request → Query Optimization → Visual Explain

- Indexes Advised
- SQE Plan Cache
- SQE Plan Cache Snapshots
- Detailed DB Monitor Data
- Summarized DB Monitor Data
- Debug Job Log Messages
- Print SQL Information Messages
Which Method or Mechanism?

• What is the starting point?
• What is the perspective?
  – System
  – Application
  – User
  – Job
  – SQL Request
  – Access method or strategy
• What information is already known, or assumed?
• What is the analysis methodology?
• How big of “net” can you cast?
• How much “help” do you want?
  – Textual information or graphical information
  – Real time information
  – Comparative information
  – General advice or specific advice
• Before and After information needed?

The New Power Equation
What about System Performance Information?

Collection Services
Performance Tools
Job Watcher
iDoctor

DB2 for i

Indexes Advised
SQE Plan Cache
SQE Plan Cache Snapshots
Visual Explain
Detailed DB Monitor Data
Summarized DB Monitor Data
Debug Job Log Messages
Print SQL Information Messages
Query Optimization

SQL request
Questions & Answers

The New Power Equation