Avoiding Performance SRs

Adrian Burke
DB2 SWAT Team SVL
agburke@us.ibm.com
Agenda

- Premise
- Overview of RMF and the Spreadsheet Reporter
  - As a means of visualizing z/OS performance problems
- CPU and WLM Concerns
- I/O and DASD Subsystem
- MEMU2 – Real and Virtual Storage Analysis
- Buffer pools
- Access Path Issues
- Resources
Premise

- Holistic approach → top down = RMF → SMF → Traces/Dumps
  - If SWAT team or L2 performance team is involved this is where we start
  - Get the big picture then drive to root cause
  - Often problems are fleeting and require an understanding of the entire environment
- If there is a perceived DB2 subsystem, or data sharing group performance issue
  - Rule out Sysplex/ CF/ CEC/ LPAR constraints first
- If there is a workload or period of the day suffering
  - WLM/ CPU constraint / Storage / DB2 internals
- If there is a single job, or group of transactions suffering
  - Object contention
  - Access path or DB2 component
  - Storage subsystem
RMF Spreadsheet Reporter

- ... A tool to create, post-process and analyze RMF (Resource Measurement Facility) reports in the form of Excel Spreadsheets: a graph is worth a 1,000 words, especially if it has Red in it
- SMF (System Management Facility) records you need: reports can be run from tool, or MVS then pulled down and post-processed
  - 70-1: % CPU, zIIP busy, weightings, number of MSU’s consumed, WLM capping, physical and logical busy
  - 70-2: crypto HW busy
  - 71: paging activity
  - 72-3: workload activity
  - 73: channel path activity
  - 74-1: device activity
  - 74-4: coupling facility
  - 74-5: cache activity
  - 74-8: disc systems
  - 75: page data sets
  - 78-2: virtual storage
  - 78-3: I/O Queueing

No Charge!

Tools

On this page the RMF development group provides a number of tools to complement the RMF product. If you have trouble downloading the tools directly from this page, follow the instructions to do a direct FTP download.

Page last updated: September 01, 2011
- General download and installation instructions
- RMF Postprocessor XML Toolkit Version 1 for Windows
- RMF Spreadsheet Reporter Version 5 for Windows
- RMF PM Java Technology Edition to monitor z/OS sysplexes
- RMF PM Java Technology Edition with additional support to monitor Linux® enterprise servers
RMF Reports - CPU

- LPAR Trend report
  - REPORTS(CPU)
- Can see stacked picture of single LPAR (GP/zIIP/IFL)
  - This is useful to get an idea of the CEC utilization across processors
- Look at CEC’s CPU trend over the time period with GP and specialty engines
  - You can superimpose the max CPU % the LPAR will achieve based on weightings (previous slide)
  - Also see entire CEC saturation
RMF Reports - WLM

- WLM activity report
  - `SYSRPTS(WLMGL(PO LICY,WGROUP,SCLA SS,SCPER,RCLASS,R CPER,SYSNAM(SWCI N))))`

- Look at all service classes during a certain interval or 1 class over the course of several intervals
  - Yellow missed its goal, Red is a PI of >2

- See reason for delays across all service classes in an interval
  - I/O, CPU, zIIP
Look for potential zIIP offload that landed on a GP
- AAPL% IIPCP
- Red line
  - See what % (not normalized) of a processor the workload consumed

Response times can be seen and charted as well
- Actual average execution time
Overview Records

- This will show all the workloads and the CPU Utilization that contributed to it during the intervals, and the records are small enough you can run the report for days at a time
  - It can show you when certain workloads collide and who is driving the CPU % through the roof
  - By using RMF Spreadsheet reporter you can generate the Overview Records
- Then create and run the Overview Report from your desktop
FTP down your WLM policy in .txt format

Import the WLM policy into a spreadsheet to analyze and filter

Overview of total classes, periods, resource groups

Policy itself can be filtered
  - So why do we have 9 Imp 1 Velocity 60 service classes?
  - This is redundant work for WLM to monitor and manage these identical classes

Easy to search through rules to determine what work is in what service class
RMF Reports - DASD

- DASD Activity Report
  - REPORTS(DEVICE (DASD))
- Gives you overview of top 5 Logical Control Units
  - See what volumes are on there, and what DB2 data is on those volumes
- LCU Top10 Shows top 10 volumes based on criteria you specify and you can manipulate graphs
RMF Summary Report

- RMF post processor
  - Look at CPU Busy (remember this is usually a 15 minute interval though)
  - DASD response taking into account the rate, a very low rate could show increased response time due to missing cache, etc.
  - Demand paging
    - Now-a-days we don’t want to see paging at all as storage gets cheaper and the price paid by the online applications in response time not proportional to the ‘paging rate’

```
RMF SUMMARY REPORT
1
SYSTEM ID 2D11 START 09/25/2012-11.59.00 INTERVAL 00.09.59
CONVERTED TO z/OS V1R13 RMF END 09/25/2012-16.59.00 CYCLE 1.000 SECONDS
1
TOTAL LENGTH OF INTERVALS 04.59.44
CPU DASD DASD TAPE JOB JOB TSO TSO STC STC ASCH ASCH OMVS OMVS SWAP DEMAND
BUSY RESP RATE RATE MAX AVE MAX AVE MAX AVE MAX AVE MAX AVE RATE PAGING
58.3 1.7 1848 124.0 75 72 6 6 181 178 0 0 5 5 0.00 0.05
55.5 1.8 1589 27.1 73 71 6 6 180 178 0 0 5 5 0.00 0.02
```
CPU constraints (1)

- These 2 LPARs LP11 and LP15 are consuming every MIP on the box, borrowing back and forth
  - This was meant to be a load test, and you can see where the test LPAR (Green) ran out of steam as the production LPAR took the CPU cycles
- In internal benchmarks maximum throughput is achieved between 92-94% - root cause almost impossible at 100%, no consistency
CPU Constraints (2)

- LP11 and LP15 saturate the **2 out of 2 CPs** during the day, trading off resources while at the same time Portal is driving **2.5 out of 5 IFLs**
  - The CEC on the previous slide is already fully utilized, and the Portal workload here has 50% of its capacity so it appears DB2 is the bottleneck
  - But it is the CPU capacity...and...
WLM

- ROT: DB2 threads should not end up in a service class which uses WLM resource group capping
  - Resource group capping will ensure that this workload does not get over ‘x’ Service Units a second, and this includes all the DB2 subsystems in the plex,
  - Blocked workload support cannot help these capped transactions, so if there is a serious CPU constraint all DDF work could be starved, and could be suspended while holding important DB2 locks/latches

- In general we suggest avoiding resource group capping in favor of lowering the priority of the work

- The CAP delay is the % of delays due to resource group capping

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>RESPONSE TIME</th>
<th>TIME EX</th>
<th>PERF</th>
<th>AVG</th>
<th>--EXEC USING%--</th>
<th>EXEC DELAYS%</th>
</tr>
</thead>
<tbody>
<tr>
<td>*ALL</td>
<td>000.00.00.027</td>
<td>15.4</td>
<td>0.0</td>
<td>10.6</td>
<td>4.9 N/A</td>
<td>1.3 0.1 0.1</td>
</tr>
<tr>
<td>1E10</td>
<td>000.00.00.015</td>
<td>25.3</td>
<td>0.0</td>
<td>4.0</td>
<td>9.3 N/A</td>
<td>15 3.4 0.0 0</td>
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<tr>
<td>2D11</td>
<td>000.00.00.169</td>
<td>7.6</td>
<td>0.0</td>
<td>6.6</td>
<td>2.2 N/A N/A</td>
<td>34 25 9.0 0 0.2 0.1</td>
</tr>
</tbody>
</table>
Response time goals... too loose

- We do not want the goals to be too loose: if >90% of transactions complete in less than \( \frac{1}{2} \) of their goal, the goal should be adjusted to be tighter, 'cuz WLM doesn't acknowledge a PI<0.5 for response time goals
  - The goal here is 10 seconds for a Portal application that must render its page in 3 seconds, and the transactions are finishing in 4 milliseconds
- The WLM goals should align with the business goals/ SLAs
  - Make the goal around 20 milliseconds so the service level can be maintained

<table>
<thead>
<tr>
<th>GOAL: RESPONSE TIME 000.00.10.000 AVG</th>
</tr>
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<tbody>
<tr>
<td>RESPONSE TIME EX PERF AVG</td>
</tr>
<tr>
<td>SYSTEM</td>
</tr>
<tr>
<td>ALL</td>
</tr>
<tr>
<td>1E10</td>
</tr>
<tr>
<td>2D11</td>
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<table>
<thead>
<tr>
<th>RESPONSE TIME DISTRIBUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>HH.MM.SS.TTT</td>
</tr>
<tr>
<td>&lt; 00.00.05.000</td>
</tr>
<tr>
<td>&lt;= 00.00.06.000</td>
</tr>
<tr>
<td>&lt;= 00.00.07.000</td>
</tr>
<tr>
<td>&lt;= 00.00.08.000</td>
</tr>
<tr>
<td>&lt;= 00.00.09.000</td>
</tr>
<tr>
<td>&lt;= 00.00.10.000</td>
</tr>
</tbody>
</table>
Response time goals... too stringent

- The goals need to be reasonable, i.e. attainable by the workload
  - WLM cannot shorten the response time to something lower than the CPU time needed for the transaction to complete
  - With a performance index of 5 all day long this workload would be skip clocked (ignored) if there were CPU constraints
WLM Buckets

- Look at the response time buckets in WLM activity report to gauge reality
- No amount of CPU could bring these transactions back in line with the others
  - The goal is 95%, but only 90% complete in time, so take these outlying trans and break them out into another service class
Response time goals vs. velocity goals

- For transactions and most business processes a Response time goal is much more effective/predictable during times of CPU constraint than velocity goals.

- When determining a good response time goal you need to trend it out:
  - Determine where the business goal is in relevance to what it is achieving.
  - z/OS 1.13 includes average response time info even for velocity goals.
  - In this example the average response time is almost 7 milliseconds.
zIIP Shortages

• **What if I have lots of not accounted for time?**
  - OMPE accounting report
• RMF Spreadsheet Reporter Response delay report
  - Part of WLM activity trend report
• SYS1.PARMLIB (IEAOPTxx) setting
  - IIPHONORPRIORITY = NO
    - Meaning all zIIP eligible work will queue waiting for a zIIP
    - **Important in v10 and v11 and if you have zAAP on zIIP**
    - V10 includes prefetch, deferred writes,
    - V11 includes GBP writes, castout/notify, log prefetch/write

<table>
<thead>
<tr>
<th>CLASS 2 TIME DISTRIBUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
</tr>
<tr>
<td>SECPU</td>
</tr>
<tr>
<td>NOTACC</td>
</tr>
<tr>
<td>SUSP</td>
</tr>
</tbody>
</table>

*CPU delay at about 33%, and the zIIP delay is at 34%.*
Prefetch

- What happens if Prefetch Engines are starved of zIIP?
  - Other Read I/O events and time per event will increase
  - PREF. DISABLED – NO READ ENG could increase
- Customers have seen batch programs miss their window
- Even if prefetch is not used, DB2 may try to schedule it, and app still sees delays with BP hit and no I/Os
  - Increased elapsed time
DASD response time

- Sometimes you need the entire picture when going after response time issues
  - New migration to DB2 10 and applications were experiencing ‘good’ and ‘bad’ days
  - Some access path regressions... but was this related?
- Here are two top 5 logical control unit report from the same time each day
  - Activity rate is quite close (same work going on)
  - Where does the increase in response time come from? – DISC (disconnect time)
  - Synchronous remote copy (Metro Mirror) where the target cannot keep up, and asynchronous copy with write pacing (XRC) can cause high DISC time

<table>
<thead>
<tr>
<th>LCU Summary</th>
<th>LCU</th>
<th>I/O Intens</th>
<th>ST Intens</th>
<th>Path Int</th>
<th>Act. Rt</th>
<th>Resp. Tm</th>
<th>Serv. Tm</th>
<th>IOSQ Tm</th>
<th>Pend. Tm</th>
<th>Disc. Tm</th>
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<tr>
<td>Top 5</td>
<td>004C</td>
<td>1135.07</td>
<td>1005.99</td>
<td>206.60</td>
<td>346.06</td>
<td>3.28</td>
<td>2.91</td>
<td>0.11</td>
<td>0.27</td>
<td>2.31</td>
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<tr>
<td></td>
<td>004E</td>
<td>442.14</td>
<td>399.44</td>
<td>100.49</td>
<td>83.74</td>
<td>5.28</td>
<td>4.77</td>
<td>0.16</td>
<td>0.35</td>
<td>3.57</td>
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<th>ST Intens</th>
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<th>Resp. Tm</th>
<th>Serv. Tm</th>
<th>IOSQ Tm</th>
<th>Pend. Tm</th>
<th>Disc. Tm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top 5</td>
<td>004C</td>
<td>11383.20</td>
<td>9407.79</td>
<td>446.53</td>
<td>305.85</td>
<td>38.74</td>
<td>30.76</td>
<td>7.51</td>
<td>0.44</td>
<td>29.30</td>
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<tr>
<td></td>
<td>0078</td>
<td>4055.60</td>
<td>1636.81</td>
<td>276.85</td>
<td>242.85</td>
<td>16.69</td>
<td>6.74</td>
<td>9.52</td>
<td>0.43</td>
<td>5.60</td>
</tr>
</tbody>
</table>
DB2 Storage

- In the IFCID 225 record we show the amount of real attributed to DB2 as well as AUX storage attributed to it.
- We also show the amount of real available on the LPAR, and the total AUX storage used.
- We can use this to help determine if there is a real storage shortage.
- Compare this to RMF Monitor 1 to see what address space is paging.
  - And if the customer can look in the SYSLOG they can see who pushed us out to AUX.
- Impact customers have seen from being short on REAL storage:
  - Transaction times begin to climb, customers see sub-second trans take 10’s of seconds (buffer pool hit might require a page-in from AUX).
  - # of concurrent threads in DB2 begin to climb, CTHREAD/MAXDBAT might be hit.
  - SYSPROG and DBA perception is of a system slowdown.
- If SVCDUMP occurs (SDUMP,Q) workload may become non-dispatchable until dump finishes.
DB2 Storage

- In the graphic we can see DB2 storage goes out from REAL to AUX when the real available drops to ‘0’ on the LPAR

- Worst case in this example to get those pages back in:
  - 700 MB – sync I/O time ~3ms = 0.003*179,200 = 537 seconds
  - If those pages were taken out of our buffer pools then we need to spend the I/Os to get the pages back in central storage

- Imagine a 10GB SVCDUMP occurring here!!
Real storage and Sort products

- By default DFSORT and other sort products usually take as much storage as they can get, to help performance... but what about everyone else?
- DFSORT parameters affecting storage use (II13495 ) means to protect DB2
  - These can be dynamically changed for workloads using ICEPRMxx member
    - EXPOLD = % of storage allowed to be pushed to AUX → 0
    - EXPRES= % of storage to preserve, maybe in case of DUMPSPACE/ MAXSPACE → 16GB min in V10
    - EXPMAX= % of storage for memory object and hyperspace sorting, somewhat depends on EXPOLD and EXPRES → how much can you spare

This shows EXPMAX = 25GB, effectively capping what DFSORT can consume.
Buffer Pool sizing considerations

- Starting in DB2 10 the root pages of the indexes are ‘fixed’ in the buffer pool
  - How many indexes do you have in your index buffer pool?
- This would affect DWQT threshold
  - 10,000 buffers, DWQT of 30%
    - With 1,000 indexes you have basically made the DWQT threshold 20%
    - Watch for DWQT being hit multiple times per second and LC23 being elevated
      - Customer saw DWQT threshold being hit 80 times a second and LC23 at 40,000 a second
      - Application response times were significantly impacted due to being I/O bound, elapsed times increased 2-3x
- Regarding 1MB frames and buffer pools
  - Without APAR PI12512, you need a minimum of 6,656 (26MB) buffers before 1MB frames would be used
PCLOSEN/PCLOSESET and Synch I/O

- The default in DB2 10 is PCLOSEN=5, PCLOSESET=10
  - The customer saw a 20% increase in Synch I/O after migration
  - They had moved from PCLOSESET=30 → PCLOSESET=10 so every 10 minutes objects without inter R/W interest would pseudo close
  - When the objects moved out of GBP dependency the local buffers would be cross invalidated
    - Next execution of the application would require entire index be read in

<table>
<thead>
<tr>
<th>OPEN/CLOSE ACTIVITY</th>
<th>QUANTITY /SECOND</th>
<th>/THREAD</th>
<th>/COMMIT</th>
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</thead>
<tbody>
<tr>
<td>DSETS CONVERTED R/W -&gt; R/O</td>
<td>9010.00</td>
<td>0.67</td>
<td>0.03</td>
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<tr>
<td>DSETS CONVERTED R/W -&gt; R/O</td>
<td>24721.00</td>
<td>1.72</td>
<td>0.07</td>
</tr>
</tbody>
</table>
Synch I/O

- DB2 10 added a mechanism to avoid local buffer pool scans when objects go from GBP dependent to non-GBP dependent
  - This saves DBM1 CL2 CPU time, and application elapsed time
  - But depending on the amount of pseudo closes you have it can increase synch I/O for some applications that bounce in and out of GBP dependency

<table>
<thead>
<tr>
<th>GROUP BP7</th>
<th>AVERAGE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>GBP-DEPEND GETPAGES</td>
<td>343.4K</td>
<td>16481954</td>
</tr>
<tr>
<td>READ(XI)-DATA RETUR</td>
<td>30.67</td>
<td>1472</td>
</tr>
<tr>
<td>READ(XI)-NO DATA RT</td>
<td>2.50</td>
<td>120</td>
</tr>
<tr>
<td>READ(NF)-DATA RETUR</td>
<td>190.04</td>
<td>9122</td>
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<tr>
<td>READ(NF)-NO DATA RT</td>
<td>12379.02</td>
<td>594193</td>
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<th>GROUP BP12</th>
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<td>GBP-DEPEND GETPAGES</td>
<td>102.9K</td>
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<tr>
<td>READ(XI)-DATA RETUR</td>
<td>36.23</td>
</tr>
<tr>
<td>READ(XI)-NO DATA RT</td>
<td>0.04</td>
</tr>
<tr>
<td>READ(NF)-DATA RETUR</td>
<td>10.52</td>
</tr>
<tr>
<td>READ(NF)-NO DATA RT</td>
<td>1227.54</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>GROUP BP7</th>
<th>AVERAGE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>GBP-DEPEND GETPAGES</td>
<td>320.4K</td>
<td>15380145</td>
</tr>
<tr>
<td>READ(XI)-DATA RETUR</td>
<td>54.67</td>
<td>2624</td>
</tr>
<tr>
<td>READ(XI)-NO DATA RT</td>
<td>16597.00</td>
<td>796656</td>
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<tr>
<td>READ(NF)-DATA RETUR</td>
<td>140.60</td>
<td>6749</td>
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<tr>
<td>READ(NF)-NO DATA RT</td>
<td>16620.69</td>
<td>797793</td>
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<table>
<thead>
<tr>
<th>GROUP BP12</th>
<th>AVERAGE</th>
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<tbody>
<tr>
<td>GBP-DEPEND GETPAGES</td>
<td>91613.63</td>
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<tr>
<td>READ(XI)-DATA RETUR</td>
<td>24.73</td>
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<tr>
<td>READ(XI)-NO DATA RT</td>
<td>24369.05</td>
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<td>READ(NF)-DATA RETUR</td>
<td>0.29</td>
</tr>
<tr>
<td>READ(NF)-NO DATA RT</td>
<td>3086.73</td>
</tr>
</tbody>
</table>
Dynamic Access Path Degradation

- Do you look for trends, application profiles?
  - If something changes how do you know?
    - Monitors
    - Phone call/email complaints
Access Path tracking for dynamic SQL

1. Determine dynamic access path degradation (using parameter markers[?] and REOPT)
   - How?
     - In test using statement cache table / plan table historical values for average elapsed time? – or ranking and browsing them?
       - IFCID 316,317,318 must be started for useful stats and utilize the DSN_STATEMENT_CACHE_TABLE (best practice)
     - Application folks provide a top 10 and do their own testing
     - Query Monitor reports or other monitor reports
       - how do you know who it is? i.e. ‘db2jcc_a’ CORRID
     - Open ticket/phone call from end user
Capturing documentation for IBM for access path regression

- Methods for capturing documentation for all releases is documented here
  - OSC and DB2PLI8 do not support DB2 10
  - SYSPROC.ADMIN_INFO_SQL supports V8 -> V11 *(Required)*
  - Excellent developerWorks article here:
  - It is installed in V10 base and is subject to the installation verification process
    - DB2HLQ.SDSNSAMP(DSNTESR) will create and bind it
    - calling program is DSNADMSB, and sample JCL in DSNTEJ6I
  - Ensure DB2 9 and DB2 10 have APAR PM39871 applied
- Data Studio V4.1 incorporates this procedure into a GUI *(Best Practice)*
  - No charge product, replacement for OSC and Visual Explain
  - Incorporates Statistics Advisor
  - Query Environment Capture used to collect doc.
    - FTP doc directly to DB2 Level 2 in the tool
Access Path tracking for dynamic SQL

2. run SQL through Data Studio
   - Do the entries in the DSN_STATEMENT_CACHE_TABLE and PLAN_TABLE now match when it was externalized from a ‘good’ execution?
     - Meaning you must have historical records of this, look for index scans, table space scans, if STMTID is unique to QUERYNO in PLAN_TABLE you can see access path, but not WHY that path was chosen without literals
     - Or very intuitive DBA who ‘knows’ what the access path should be
   - YES – why is this execution noticeably worse – 1 set of very skewed literals?
   - NO – obviously statement was invalidated and prepared again, or pushed out of the pool; which should be when the end user noticed the degradation

3. Look at CACHED_TS, is that when it degraded; work with appl. folks to get literal values from that time, or at least some examples of them
   - Use Data Studio RUNSTATs Advisor and Query Environment Capture when needed to duplicate stats in test → Run Explain again
   - Remember that optimizer can only use histogram/DSTATS stats with literals, so RUNSTATS needs to be based on real values (due to REOPT(ONCE)
   - Can indexes be tweaked to stabilize access path?
Access Path tracking for dynamic SQL

- Wouldn’t it be nice if DB2 captured REOPT literals, and access path? – Request for Enhancement

- 4. previous attempts were futile, need to engage level 2 as we believe it is an optimizer issue: send doc to level using SQL Environment Capture

- 5. as a last ditch effort, assisted by level 2 use access path hints in DB2 → determine if BIND(QUERY) is reasonable; Selectivity Override (V11); skew your own stats
  - Determine if the 80/20 rule applies and which access path is acceptable for the majority of the time
  - put it in DSN_USERQUERY, BIND query, then flush user query table
You can export the entire DSN_STATEMENT_CACHE_TABLE contents to a .csv file by submitting it within Data Studio and exporting the result set. This allows you to avoid trying to FTP the result down from z/OS in order to submit it to support, as well as sort the output.
What to do with the Export

- Look for the low hanging fruit – sort on top class 2 CPU consumers, then focus on rows accessed

<table>
<thead>
<tr>
<th>STAT_GPAGB</th>
<th>STMT_TEXT</th>
<th>STAT_SNNRB</th>
<th>STAT_WIRTB</th>
<th>STAT_EROWB</th>
<th>STAT_PROWOB</th>
<th>STAT_SORTB</th>
<th>STAT_INDB</th>
<th>STAT_RSCNB</th>
</tr>
</thead>
<tbody>
<tr>
<td>16063</td>
<td>SELECT COUNT(*) FROM DBA560.GLWTSP1</td>
<td>0</td>
<td>0</td>
<td>1396685</td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>23</td>
</tr>
</tbody>
</table>

- Compare the ratio of rows examined vs. processed
  - STAT_EROW / STAT_PROW
  - A larger quotient means there are rows that can be shed from the access path earlier in the query
  - The exact numbers are not important

<table>
<thead>
<tr>
<th>STAT_GPAGB</th>
<th>STMT_TEXT</th>
<th>STAT_SNNRB</th>
<th>STAT_WIRTB</th>
<th>STAT_EROWB</th>
<th>STAT_PROWOB</th>
<th>STAT_SORTB</th>
<th>STAT_INDB</th>
<th>STAT_RSCNB</th>
</tr>
</thead>
<tbody>
<tr>
<td>14802</td>
<td>SELECT COUNT(*) FROM DBA560.GLWTSP1</td>
<td>375</td>
<td>0</td>
<td>0</td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>23</td>
</tr>
</tbody>
</table>

- By adding an index we can avoid a table space scan and eliminate much of the rows from a relational scan
- Or by adding a missing column to an index you can go from index and data to index only access
References

- RMF spreadsheet reporting tool
  - Link to download
  - InfoCenter link
  - Redbook using RMF and the spreadsheet reporter

- MEMU2 – Brand new version for DB2 10 and DB2 11

- Subsystem and Transaction Monitoring and Tuning with DB2 11 for z/OS SG24-8182
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