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Key Metrics for DB2 for z/OS Subsystem and Application Performance Monitoring (Part 1)

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The genesis of this presentation

- Mainframe DB2 people have an abundance of data fields they can look at for performance monitoring purposes
  - In DB2 monitor displays and reports
  - In z/OS monitor displays and reports
  - In various DB2 -DISPLAY commands
  - In CICS (DSNC) DISPLAY STATISTICS command output
- With all of these numbers staring back at you, you could:
  - Freeze up (sometimes referred to as “analysis paralysis”)
  - Try to analyze everything, all the time (maybe OK if you have a LOT of free time on your hands)
  - Focus too much on “FYI” and “level 2” numbers (the latter being fields that you should check if a “level 1” number is not what it should be), and overlook what’s really important

My goal

- Through this presentation, I want to help you to be more effective and efficient in monitoring DB2 subsystem and application performance
- How?
  - By spotlighting the relatively small set of metrics that are your most important indicators of good (or not) performance

Agenda

- Part 1
  - DB2 monitor-generated reports versus online displays
  - Application performance: DB2 monitor accounting reports (and displays)
- Part 2
  - Subsystem performance: DB2 monitor statistics reports (and displays)
  - The best bits in DB2 and CICS DISPLAY command output
  - Important DB2-related stuff in z/OS monitor reports and displays

DB2 monitor-generated reports versus online displays

Ongoing tuning versus putting out fires

- Many sites use their DB2 for z/OS monitor exclusively in online mode
  - Online monitoring is valuable, especially when you need to see what's happening right now in order to diagnose a performance problem
  - For in-depth, ongoing analysis of the performance "health" of a DB2 for z/OS subsystem and associated applications, I prefer to use DB2 monitor-generated reports
    - If you've only used your DB2 monitor in online mode, look into the product's batch reporting capabilities
    - In this presentation, I'll show a lot of information excerpted from DB2 monitor-generated reports – you should be able to find most of this information in online displays, as well

Generating reports with your DB2 monitor

- Usually involves executing a batch job that includes a DD statement pointing to a data set containing DB2 trace records (these records are usually written to SMF)
  - Batch job has a control statement in SYSIN, in which you specify things such as:
    - "From" and "to" dates/times
    - Report type (e.g., ACCOUNTING LONG)
    - Filtering criteria (e.g., include or exclude a DB2 plan name)
    - Report data organization options (e.g., order by connection type)

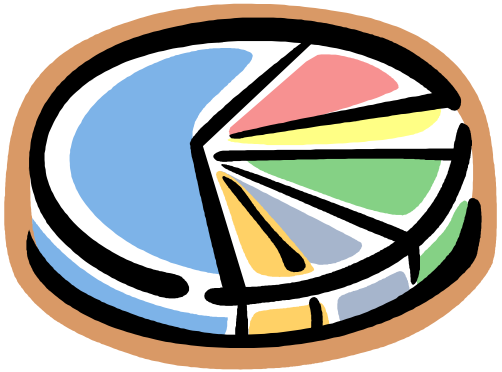
The two most useful DB2 monitor reports

- Accounting long (aka “accounting detail”), with:
  - “From” and “to” times encompassing either a busy 1- or 2-hour time period, or a 24-hour time period
  - Data ordered by (or “grouped by”) connection type
    - Gives you a detailed report for each DB2 connection type: CICS, IMS, DRDA, TSO, call attach, utility, etc.
    - If you need more granularity, can get data at correlation-name level (e.g., CICS transaction ID or batch job name), primary auth ID level, etc.
- Statistics long (aka “statistics detail”), with:
  - Same “from” and “to” times as accounting reports (see above)
- In addition to providing very useful information, these two reports are pretty inexpensive (records on which the reports are based are generated by low-overhead DB2 traces)

Application performance: DB2 monitor accounting reports (and displays)

Understanding your DB2 application workload

- What's the biggest component of your DB2 workload?
  - Seems simple enough, but I've found that plenty of DB2 people cannot readily answer this question as it pertains to their site
- "Biggest" – biggest in terms of aggregate class 2 CPU time
  - Information comes from DB2 accounting trace class 2
  - Also known as "in-DB2" CPU time
  - Indicates the CPU cost of SQL statement execution
- "Component" – connection type (e.g., CICS, batch, DRDA, etc.)



Answering the "biggest component" question

- Accounting long report, with data ordered by connection type
- For each connection type, perform a simple calculation (referring to sample report output on following slide):
  - (average class 2 CPU time) X (number of occurrences)
  - "Number of occurrences" = number of trace records
    - Usually one per transaction for online, one per job for batch
    - DB2 can "roll up" accounting records for DRDA transactions (ACCUMACC – default is 10 – and ACCUMUID parameters in ZPARM)
  - Reports generated by different monitors can look a little different
    - Samples in this presentation are from reports generated by IBM's Tivoli OMEGAMON XE for DB2 Performance Expert on z/OS
    - Fields in reports can usually be found in online monitor displays
  - Note: I'm leaving out some report lines and columns because putting all on a slide would require a too-small font size

Sample report output (2-hour time period)

```
CONNTYPE: DRDA

AVERAGE          DB2  (CL.2)      HIGHLIGHTS
-----------      ----------      ------------------------
CP CPU TIME        0.003614      #OCCURRENCES   :   3087344

SE CPU TIME        0.003348
```

Don't forget this! (SE = "specialty engine," which usually means zIIP)

(avg CL 2 CPU) X (# of occurrences) = 0.006962 X 3,087,344

= 21,494 seconds

In a DB2 data sharing environment, do this for each member of the group to get TOTAL DRDA SQL cost, TOTAL CICS-DB2 SQL cost, etc.

The DRDA part of the overall DB2 workload

- Often, DRDA-related activity is the fastest-growing component of an organization's DB2 for z/OS workload
- At some sites, DRDA-related activity is the largest component of the DB2 for z/OS workload – bigger than CICS-DB2, bigger than batch-DB2
  - Again, "largest" refers to total class 2 CPU time
- I have found that people – even mainframe DB2 people – are often unaware of this
  - Not uncommon for senior IT managers to think of the mainframe as just the server where the "legacy" applications run
  - In fact, the mainframe DB2 platform is evolving to become a "super-sized" (and super-available, super-secure) data server for multi-tier apps

Another important workload characteristic

- Is the DB2 workload CPU-constrained?
- A good place to check: “not accounted for” time in the DB2 monitor Accounting Long report
  - What it is: in-DB2 (i.e., class 2) elapsed time that is not CPU time, not suspension time (the latter being class 3, or “waiting for” time)
  - Basically DB2 saying, “this was time, related to SQL statement execution, that I can’t account for”
  - In my experience, usually associated with DB2 wait-for-dispatch time
    - In other words, DB2 (vs. application) tasks are not being readily dispatched
  - DB2 address spaces usually have a high priority in the system, so if not-accounted-for time is relatively high for a transactional workload, it could be that you’ve hit a processing capacity wall

DB2 not-accounted-for time (1)

```
CONNTYPE: CICS

CLASS 2 TIME DISTRIBUTION
-----------------------------------------
CPU     |================> 30%
SECPU   |
NOTACC  |==> 5%
SUSP    |================================> 65%
```

- I get concerned if not-accounted-for time is greater than 10% for a high-priority transactional workload such as CICS-DB2 (or, often, DRDA)
  - Not so concerned if this time exceeds 10% for batch DB2 workload – that's not uncommon

DB2 not-accounted-for time (2)

```
CONNTYPE: CICS

AVERAGE          DB2  (CL.2)
-------------    ----------
ELAPSED TIME       0.085225 (A)

CP CPU TIME        0.025313 (B)

SE CPU TIME        0.000000 (C)

SUSPEND TIME       0.055708 (D)

NOT ACCOUNT.       0.004204
```

- If your monitor report does not have the “bar chart” elapsed time breakdown shown on the preceding slide, it will likely have a “not accounted for” field in the “class 2” time column (in red at left)
- If “not accounted for” time is not provided, calculate it yourself:
- A – (B + C + D)

What if not-accounted-for time is high?

- Add capacity (could just be an LPAR configuration change)
- If that's not feasible…
  - May see what you can do to reduce CPU consumption of the DB2 workload (more on that to come in this presentation)
  - Ensure that dispatching priorities are optimized for throughput in a CPU-constrained environment
    - IRLM should be in the SYSSTC service class (very high priority)
    - DB2 MSTR, DBM1, DIST, and stored procedure address spaces should be assigned to a high-importance service class (my opinion: somewhat higher priority than CICS AORs)
      - If system is really busy, you may need to go with PRIORITY(LOW) for CICS-DB2 transaction TCBs (relative to priority of CICS AOR main task – default is HIGH)
    - Classify DRDA transactions (in WLM policy) so they won't run as "discretionary" work

How is your DB2 I/O performance?

Sample report output

```
CONNTYPE: DB2CALL

                                        (A)          (B)
CLASS 3 SUSPENSIONS    AVERAGE TIME    AV.EVENT
-------------------    ------------    --------
SYNCHRON. I/O              6.520800     6133.32
```

- Average service time for synchronous I/Os = A / B
- Times are getting to be <u>really</u> low (in this case, 1.06 ms)
  - Has much to do with advances in I/O hardware and software: faster channels, parallel access volumes (reduces UCB-level queuing), lots of disk controller cache (and sophisticated management of same)
- A time > 5 ms represents opportunity for improvement
- A time > 10 ms could indicate a performance problem

How CPU-efficient are your DB2 applications?

- Usually, you're aiming to reduce A (referring to sample report below), which is in-DB2 CPU time (CPU cost of SQL statement execution)
  - Note that, sometimes, reducing A can be accomplished by increasing B (recall that "SE" is short for "specialty engine," which usually is a zIIP engine – more on this to come)

Sample accounting report output

```
AVERAGE          DB2  (CL.2)
-----------      ----------
CP CPU TIME       28.311773 A

SE CPU TIME        0.000000 B
```

Average CPU time – per what and for what?

- Depends on scope of information in accounting report (specified by you)
- Could be average:
  - Per transaction/job for connection type (e.g., all DRDA, all call attach)
  - Per transaction for a CICS AOR (an example of a connection ID)
  - For a given batch job or CICS tran (examples of correlation names)
  - Per transaction or job for a given DB2 authorization ID
- Larger scope can be appropriate when planning change of the "rising tide lifts all boats" variety (e.g., page-fixed buffer pool)
  - Largest scope: DB2 subsystem ID

If DRDA accounting records rolled up, number of commits is good indicator of number of transactions

AVERAGE	DB2 (CL.2)
CP CPU TIME	28.311773
SE CPU TIME	0.000000

Information at the program (package) level

Package name

Sample report output

```
M123456B                        TIMES
------------    ------------
CP CPU TIME     13:35.566002

SE CPU TIME           0.000000
```

- Very useful if a batch job or transaction involves execution of multiple programs
- Requires data from DB2 accounting trace classes 7 and 8

- May be LOTS of packages in the report – where do you start?
  - Your monitor may show in the Accounting Long report the top programs by elapsed time (class 7)
  - High elapsed time often points to high CPU time

```
PROGRAM NAME    CLASS 7 CONSUMERS
D789123Y        |=> 3%
M123092G        |=======> 15%
I273459Z        |> 1%
```

Application efficiency: thread reuse

(data in this report sample happens to be for a CICS-DB2 workload)

Thread reused, auth ID changed

Thread not reused

Thread reused, no auth ID change

NORMAL TERM.	AVERAGE
NEW USER	0.79
DEALLOCATION	0.01
RESIGNON	0.20

- Sample above shows a thread reuse rate of 99% -- very good
- Boost CICS-DB2 thread reuse via protected entry threads for high-use trans (PROTECTNUM in DB2ENTRY RDO resource)
  - Non-protected thread usually deallocated after transaction completes
  - Protected thread will stick around for 45 seconds (default) after transaction completes – can be reused by another transaction associated with same DB2ENTRY if plan name doesn't change

Maximizing performance benefit of thread reuse

- Bind packages executed via reused threads with RELEASE(DEALLOCATE)
  - What that means: table space locks, EDM pool elements retained until thread deallocation, vs. being released at commit (i.e., end of transaction or end of job)
  - If package is executed repeatedly via the same thread, these resources won't have to be repeatedly reacquired – that improves CPU efficiency
- Can reduce CPU consumption by several percentage points
- Considerations:
  - Not good bind option for programs that get exclusive table space locks
  - If using DB2 V8 or DB2 9, keep an eye on EDM pool space
    - RELEASE(DEALLOCATE) will increase amount of non-stealable space
  - Can impact scheduling of utilities, bind operations

DB2 10: a new thread reuse option

- High performance DBATs (database access threads – used for client-server work that comes through DB2 DDF)
  - High performance DBAT is instantiated when a DBAT used to execute a package bound with RELEASE(DEALLOCATE)
    - Prior releases of DB2 treated packages bound with RELEASE(DEALLOCATE) as though they were bound with RELEASE(COMMIT) when executed via DBAT
  - High performance DBAT doesn't go into the pool – it remains dedicated to connection through which it was instantiated
    - Terminated after 200 units of work to free up resources
  - Best used for simple, high-volume DRDA transactions
    - May want to bind IBM Data Server Driver or DB2 Connect packages with RELEASE(DEALLOCATE) – perhaps in a separate collection (e.g., NULLID2), to allow for selective use of high-performance DBATs
  - Monitoring: DB2 monitor Statistics Long report (to be covered)

Application efficiency: GETPAGES

- For my money, the number one determinant of CPU time for a DB2-accessing job or transaction
- Ways to reduce GETPAGE activity:
  - Change query access paths
    - Often involves adding indexes or modifying existing indexes
    - Might involve rewriting the query to get a better-performing access path
  - Re-cluster data
    - ALTER INDEX CLUSTER / NOT CLUSTER
    - Table-controlled partitioning: can have different clustering, partitioning keys
  - Archive/purge “cold” data, so “warm” data not so spread out in table

```
TOTAL BPOOL ACTIVITY     AVERAGE
--------------------     --------
GETPAGES                  359.66
```

Application efficiency: dynamic SQL cache

- Tends to be particularly important for client-server transactions (DRDA workload) – often involve execution of dynamic SQL
  - Recall that when programs issue JDBC or ODBC calls, these are executed as dynamic SQL statements on the DB2 for z/OS server
  - CPU cost of full PREPARE of a statement can be several times the cost of statement execution
- One way to boost statement cache hits: enlarge the dynamic statement cache (it's been above 2 GB "bar" since DB2 V8)
- Also: use parameter markers (vs. literal values) in dynamic SQL statements (cache "hit" requires byte-for-byte match)

DYNAMIC SQL STMT	AVERAGE
NOT FOUND IN CACHE	(A) 0.26
FOUND IN CACHE	(B) 1.05

What you want:
maximize B / (A + B)

DB2 10 and dynamic statement caching

- CONCENTRATE STATEMENTS WITH LITERALS attribute of PREPARE statement (can also be enabled on DB2 client side by specifying keyword in data source or connection property)
  - If match for dynamic statement with literals not found in cache, literals replaced with & and cache is searched to find match for new statement
    - If not found, new statement is prepared and placed in the cache
- Not quite as CPU-efficient as traditional dynamic statement caching and parameterized SQL, but less costly than full prepares of dynamic statements containing literals
  - Note: may WANT optimization using literals for range predicates

DYNAMIC SQL STMT	AVERAGE
CSWL - MATCHES FOUND	0.24

Application efficiency: shifting work to zIIPs

- zIIP offload reduces cost of computing
- Options for increasing zIIP utilization:
  - For DRDA workload, if using traditional DB2 stored procedures, switch to native SQL procedures (introduced with DB2 9 in NFM)
  - If it's a batch workload, consider binding some packages with DEGREE(ANY) to enable query parallelization
    - May want to limit degree of parallelization via PARAMDEG in ZPARM
  - Migrate to DB2 10 (if not there already) – prefetch processing is zIIP-eligible, and so is XML schema validation processing

```
AVERAGE          DB2  (CL.2)
-----------      ----------
CP CPU TIME       28.311773  A

SE CPU TIME        0.000000  B
```

← Aim: reduce A by increasing B

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