

May 6-10, 2007  
 San Jose Convention Center  
 San Jose, California, USA

Session: I05, H12

## Accelerate Your DB2 Business On Demand Autonomically!

IDUG<sup>®</sup> 2007  
 North America

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May 08, 2007 09:20 a.m. – 10:20 a.m. (I05)  
 May 10, 2007 09:20 a.m. – 10:20 a.m. (H12)

Platform: DB2 for Linux, UNIX, Windows

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## Agenda

- A bit of history
- What does DB2 automatically tune?
- What is left for a DBA to do?
  - Are we headed for unemployment lines?



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## Autonomic History

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Past performance may not be a valid indicator of future results – however, history is valuable for predicting trends.

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## Automated DB2 Tuning – History 101

- 1999 – Database-GUYS (DGI) Wise-GUY™ and Pool-GUY™
- DB2 V5 – Self-Tuning LOAD
- DB2 V6 – Index Advisor, Hash Joins, LOAD
- DB2 V8 ...

Ability to change CFG parameters online!

Autoconfigure (Configuration Advisor)

Auto\_Runstats (Automatic Statistics Collection and Profiling)

db2advise (Design Advisor)

Health Monitor

Automatic Storage

Self Tuning BACKUP

UTIL\_IMPACT\_LIMIT Adaptive Utility Throttling

Automatic REORG

Self Tuning LOAD

Automatic BACKUP

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## What does DB2 9 Autonomically Tune?

It slices, it dices, and makes tuning a snap – yours now for only \$9.95 if you call within the next 3 minutes...

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## AUTOMATIC Summary –

db2 "connect to DBNAME"

db2 "get db cfg for DBNAME show detail" | grep -E "AUTOMATIC|SELF\_TUNING\_MEM|DATABASE\_MEMORY|LOCKLIST|MAXLOCKS|PCKCACHESZ|SHEAPTHRES\_SHR|SORTHEAP"; db2 "select substr(bpname,1,58) as bpname, npages from syscat.bufferpools"

If NPAGES = -2, then automatic memory for that pool is enabled.

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### Autoconfigure

- Enabled by default for new databases
  - "2 second tuning" better than none / defaults
- Caution – Auto Configure is not multiple instance aware
  - Assumes host is purely database server with one instance
- Addresses many, but not all, inadequate default values
  - Locktimeout still -1 (unlimited)
  - MAXFILOP 64
  - LOGBUFZ should be at least 128

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### NUM\_IOCLEANERS

- Automatic by default
  - Cannot be changed online
- Based on number of CPUs and partitions
- While better than the V8 default value of "1", beware of aggressive page cleaning causing spikes in transaction elapsed times.
  - Formula "(#CPUs / #Partitions) – 1" may be better, but not less than 1.

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### NUM\_IOSERVERS

- Automatic by default
  - Much better than V8 default value of 3
  - Cannot be changed online
  - Benefits Prefetching – Appropriate for data warehouse but not OLTP!
- Calculated based on parallelism settings of all tablespaces
  - May be too aggressive
    - 1,000 tablespaces with 3X parallelism across 60 spindles = 3,000 IOSERVERS?
      - And default MAXFILOP is 64?
  - Try # spindles + 10% as alternate for DW, -50% if OLTP
    - Monitor Time Waited on Prefetch
    - Monitor Asynchronous Pages Read per Request (APPR)

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### Attendee Notes - Asynchronous Pages read Per Request (APPR)

- Compute for Database, Bufferpools, and Tablespaces
- $APPR = \frac{\text{Asynchronous pool data page reads} + \text{Asynchronous pool index page reads}}{\text{Asynchronous data read requests} + \text{Asynchronous index read requests}}$
- Your Value? \_\_\_\_\_
- Measure of Prefetch Efficiency, generally should be greater than 10, preferably higher.




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### Autonomic Memory Tuning – STMM (Self Tuning Memory Manager)

- DB2's scheme for dynamically adjusting memory between:
  1. Locklist & Maxlocks
  2. Package Cache (pckcachesz)
  3. Sortheap & sheapthresh\_shr
  4. Bufferpools
- At least 2 of the 4 memory resources above must be set to automatic --- DB2 robs from Peter to pay Paul




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### STMM -Considerations & Recommendations for OLTP

- OLTP (Transactional Databases)
  - Start with LOCKLIST & PCKCACHESZ automatic
  - Ensure that physical design (indexes, MQTs, MDC) is optimized and free of defects
    - Use multiple bufferpools to separate random (synchronous) I/O from sequential (asynchronous prefetch) I/O.
      - Investigate, and cure if possible, causes of sequential I/O
      - CATLGBP, TEMPSPCBP, USERSYNCPB, USERASYNCPB
  - Enable AUTOMATIC for SORT and Bufferpools to achieve optimum "fine tuning", then lock down sizes.
  - Monitor Carefully: TX Rates & Elapsed times, CPU Busy, changes in I/O behavior (Sync, Async, Times)
  - *If you thought dynamic SQL introduced unpredictability to your environment, what will STMM do?*




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### STMM - Considerations & Recommendations for DW

- Data Warehouse Databases
  - Start with LOCKLIST, PCKCACHESZ, SORT and Bufferpool all automatic
  - Optimize physical design (indexes, MQTs, MDC)
    - Use one large bufferpool
      - Possibly use 2<sup>nd</sup> bufferpool for "hot" lookup tables
      - IBMDEFAULTBP and HOTBP
  - Monitor Carefully: Query Throughput & Elapsed times, CPU Busy, changes in I/O behavior (Sync, Async, APPR, Read/Write Times)




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### STMM - Considerations & Recommendations for DPF

- Data Warehouse Databases - DPF
  - The bufferpool(s) must not have any entries in sysibm.sysbufferpoolnodes
  - One partition is the tuning "king" and dictates tuning for all partitions.
    - db2 "call sysproc.admin\_cmd ('get stmm tuning dbpartitionnum')" [Returns Current Ruling Partition]
    - db2 "call sysproc.admin\_cmd ('update stmm tuning dbpartitionnum N') [Changes Ruling Partition to "N"]
  - Use ACTIVATE DATABASE command – all partitions must be active for STMM




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### STMM – Implementation Details

- DATABASE\_MEMORY is AUTOMATIC by default on Windows and AIX, COMPUTED for Linux, Sun, HP
- db2 update db cfg for DBNAME using self\_tuning\_mem ON (Use OFF to lock current values)
- db2 update db cfg for DBNAME using LOCKLIST AUTOMATIC
- db2 update db cfg for DBNAME using MAXLOCKS AUTOMATIC
- db2 update db cfg for DBNAME using PCKCACHESZ AUTOMATIC
- db2 update db cfg for DBNAME using SORTHEAP AUTOMATIC SHEAPTHRES\_SHR AUTOMATIC
- db2 alter bufferpool **IBMDEFAULTBP** size AUTOMATIC
- "MANUAL" locks in current sizes and disables automation for that component – Alternatively, Integer values disable automatic tuning and will cause change to the specified value




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### STMM - Monitoring

- db2 "get db cfg for DBNAME show detail"
  - Shows current and pending sizes
- db2 "get snapshot for database on DBNAME"
  - Shows current, configured, and high water mark memory heap sizes
- db2 "get snapshot for bufferpools on DBNAME"
  - Node number = 0
  - Tablespaces using bufferpool = 3
  - Alter bufferpool information:
  - Pages left to remove = 0
  - Current size = 1008
  - Post-alter size = 1008
- Be sure to try the new SYSIBMADM.SNAP\* administrative views



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## What's Left for the DBA to do?

Plenty. You still have a job.

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## In an ideal DB2 9 World...

Where will a DBA's time go?

Task Category	Percentage
Physical Design	50%
Admin Tasks	40%
Config Tasks	10%

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**Taming the Autonomic Beast**

- Configuration Changes, 10-15% Improvement
- Physical Design Changes, 85-90% Improvement
- Administrative Tasks
  - Online REORG
  - Monitoring and Testing Backups
  - HADR
  - Recovery Testing
  - LBAC Configuration
  - Auditing
  - Security Administration
  - Performance Monitoring and Locking Diagnosis
  - Table Compression Analysis & Implementation

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**Configuration Changes**

Autoconfigure is a good start...  
 ... let's explore some more necessary changes.

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**Let's Get Busy – Configuration Changes**

1. db2 "update db cfg for DBNAME using MAXFILOP 512", then monitor DB Snap to ensure Database Files Closed = 0. Changes online at TX boundary.
2. Catalog Cache Size – not an Automatic participant, but can be changed online
  - Monitor Catalog Cache Hit Ratio (from DB Snap) and increase CATALOGCACHE\_SZ until CATHR > 95%
    - $CATHR = 100 - ((Catalog\ cache\ inserts * 100) / Catalog\ cache\ lookups)$
3. Verify appropriate value for NUM\_IOSERVERS
  - DW - #Spindles + 10%
  - OLTP - #Spindles – 50%

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### NUM\_IOCLEANERS + CHNGPGS\_THRESH: Asynchronous Write Percentage (AWP)

- Compute for *Database*, Bufferpools, and Tablespaces
- $AWP = \frac{((\text{Asynchronous pool data page writes} + \text{Asynchronous pool index page writes}) * 100)}{(\text{Buffer pool data writes} + \text{Buffer pool index writes})}$ 
  - Your Value? \_\_\_\_\_ (use DB Snap)
- Should be > 90%, else need to increase num\_iocleaners (up to #CPUs - 1) and/or lower CHNGPGS\_THRESH by 5% decrements

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### Configuration Changes: LOGBUFSZ Online=no AT=no

- Buffers read & write I/O to log files
- **Default size 8 is grossly too small for most of today's databases, autoconfigure will "tune"**
- Set it to 256-512, higher if you do lots of Rollbacks or have high DML activity
- Must be less than DBHEAP size
- $LGRHR (\text{Log Read Hit Ratio}) = 100 - \frac{(\text{Number read log IOs} * 100)}{\text{Log pages read}}$ 
  - Your value? \_\_\_\_\_ (use DB SNAP)
- If LGRHR < 98%, increase LOGBUFSZ further

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### Physical Design Changes

Memory Tuning will be an exercise in futility if the physical design does not support the workload. Memory shell games will only mask real performance problems...

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### Workload Analysis > Well Stated Opportunity

- 80+% of Tuning Benefit comes from complete and accurate understanding of the SQL workload and its costs
- What is the most costly, most harmful, SQL during peak periods? Recent periods? Over time?
  - Highest CPU Consumption
  - Highest Sort Time Consumption
  - Highest average Elapsed times
  - Highest Read I/O (rows read)
- Grouping & Cost Aggregation of similarly structured SQL statements is imperative to "True Cost" determination

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### SQL Equalization & Cost Aggregation

US Patent # 6,772,411

Select c1, c2, c4 from tbl where c5 = '0360' cpu=.1  
100's of SQL statements per second...

SQL Snapshot shows 19 different statements!  
**WRONG ANSWER!**

- How the DBA needs to see the SQL Workload:

SQL Statement	Count	TotCPU	CPU%	Relative Costs
Select c1, c2, c4 from tbl where c5 = '?'	16	1.6	66.6	
Select c1, c2, c4 from tbl where c5 > '?'	2	.6	25.0	
Select c1, c2, c4 from tbl where c8 = '?'	1	.2	8.33	
<b>Totals:</b>	<b>19</b>	<b>2.4</b>	<b>100.00</b>	

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### Solving Problems > Effective Solutions

- Given a costly SQL statement, 3 possible solutions:
  - 1) Physical Design Change (95%)
    - Add an Index
    - Add/modify Cluster Index
      - Most potent weapon against poor application performance
    - Drop Ineffective/Costly Indexes
      - Low Cardinality, Skewed Distributions, Redundant Indexes
    - Generated Columns with new supporting Index
    - MQT/AST/MDC tables
  - 2) Tweak Catalog Statistics to "fool" optimizer (2%)
    - A temporary and difficult to maintain "solution"
  - 3) Re-write/modify SQL (3%)
    - The DB2 Optimizer Re-writes SQL. Isn't re-writing re-written SQL redundant?

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### Hidden Physical Design Costs – obfuscated by well tuned memory

- A simple SELECT executed with high frequency against a table with only 32 rows consumed 34% of ALL CPU time on an SMP 4-way
- Myth: Small tables don't need indexes
- Realities:
  - Explains don't identify costly SQL against small tables
  - Explains don't consider frequency of execution
  - Only Dynamic SQL Equalization finds high cost SQL
  - Even ONE row tables can benefit from indexes




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### Which tables have highest Rows Read?

- db2 "select tabname, rows\_read from sysibmadm.snaptab order by rows\_read desc fetch first 10 rows only"
- Two Possibilities:
  1. The data is very popular!
    - Consider placing the table in its own tablespace on best performing disks. Can also assign tablespace to its own bufferpool.
  2. Expensive TBSCANS are occurring against the table
    - Use SQL Equalization to identify SQL
    - Use IBM Design Advisor for Physical Design solutions (Indexes, MDC, MQT, partitioning)

**Heads Up: The Design Advisor does NOT recommend XML Indexes**




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### Which Tables have highest rows written? What indexes are defined?

- db2 "get snapshot for tables on DBNAME"
- db2 "select tabname, rows\_written from sysibmadm.snaptab order by rows\_written desc fetch first 10 rows only"
- Back at your office, carefully review all indexes on these Top 10 tables to ensure they conform to best practices guidelines (coming up)
- You can query 'SYSCAT.INDEXES', use the command "db2 describe indexes for table *schema.tablename* show detail", or use a GUI (like Control Centre)




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### Index Design Guidelines

- Indexes with Cardinality = 1 are a performance death sentence. Do not create indexes "just in case"...
- Indexes with Skewed distributions are expensive to maintain on Insert, Update, Delete
- Redundant Indexes are expensive to maintain, consume disk, and provide no value to DB2 – Drop them!
  - IX on C1, C2 <<- Redundant Index
  - IX on C1, C2, C4
- Use composite indexes to replace single column indexes
- For multi-column indexes, place the column that is most frequently known (= predicate) first.
- Use Clustering Indexes to reduce Sort & CPU costs

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### Composite Indexes Accelerate Your Business

- "SELECT \* from TB where C1 = ? And C2 = ? And C3 >= ?" caused an SLA to be missed and service contracts nearly lost
- Myth: Use 3 single column indexes on C1, C2, and C3 individually
- Realities:
  - Index AND-ing can be CPU and I/O expensive
  - A single composite index on columns C1, C2, & C3 is dramatically faster and more efficient
  - The INDEX/Design Advisor favors composite indexes, but identifying the costly SQL is the trick >> SQL EQ!

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### Which Tablespaces have the slowest Read and Write times (ORMS, OWMS)?

- Ensure tablespace best practices implemented
  - Multiple containers
    - Equal Size
    - Different Devices/Paths
    - PREFETCHSIZE is 3-4X EXTENTSIZE
  - Containers not on OS Paging disks or other very busy spindles
  - RAID storage has "db2set DB2\_PARALLEL\_IO=" (or tsid list)" enabled
  - DMS Storage can be 5-10% faster, but more difficult to administrate
  - Use Automatic Storage with multiple paths

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### Attendee Notes - ORMS

- ORMS for the Database Overall:
  - db2 "select (POOL\_READ\_TIME / (POOL\_DATA\_P\_READS + POOL\_INDEX\_P\_READS + 1) as ORMS from sysibmadm.snapdb where db\_name = 'DBNAME'"
- ORMS for the top 10 (read) slowest tablespaces:
  - db2 "select tbsp\_name, (POOL\_READ\_TIME / (POOL\_DATA\_P\_READS + POOL\_INDEX\_P\_READS + 1) as ORMS from sysibmadm.snapdb order by ORMS desc fetch first 10 rows only"
- How do the top 10 TS compare to the database average?




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### Attendee Notes - OWMS

- OWMS for the Database Overall:
  - db2 "select (POOL\_WRITE\_TIME / (POOL\_DATA\_WRITES + POOL\_INDEX\_WRITES + 1) as OWMS from sysibmadm.snapdb where db\_name = 'DBNAME'"
- OWMS for the top 10 (write) slowest tablespaces:
  - db2 "select tbsp\_name, (POOL\_WRITE\_TIME / (POOL\_DATA\_WRITES + POOL\_INDEX\_WRITES + 1) as OWMS from sysibmadm.snapdb order by OWMS desc fetch first 10 rows only"
- How do the top 10 TS compare to the database average?




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### Which Tablespaces are Synchronously Read? Asynchronously Read?

- Tablespaces that are highly Synchronously Read contain tables with good indexes that support queries and avoid costly scans. These tablespaces should be placed into a USER`SYNCBP` Bufferpool.
- Tablespaces with significant Asynchronous reads have tables that are being prefetched – An indexing opportunity may or may not exist. Place these tablespaces into a USER`ASYNCP` Bufferpool. This bufferpool should be large enough to facilitate effective prefetching (APPR), with memory preference given to USER`SYNCBP`.




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### Attendee Notes – Sync Read Percent (SRP)

- For the Database:
  - select 100 - (((pool\_async\_data\_reads + pool\_async\_index\_reads) \* 100) / (pool\_data\_p\_reads + pool\_index\_p\_reads + 1)) as SRP from sysibmadm.snaptb where DB\_NAME = 'DBNAME'
- For Tablespaces:
  - select tbsp\_name, 100 - (((pool\_async\_data\_reads + pool\_async\_index\_reads) \* 100) / (pool\_data\_p\_reads + pool\_index\_p\_reads + 1)) as TSSRP from sysibmadm.snaptbsp order by TSSRP desc
    - Lists tablespaces from most randomly (Synchronously) read to least. SRP should be 70%+ to participate in USERSYNCP.




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### When to REORG online (INPLACE)?

- When Table (Overflows \* 100 / Rows\_Read) > 3% and "significant activity" is present
- db2 "select 'REORG TABLE ' || TABSCHEMA || ' ' || TABNAME || ' INPLACE ALLOW WRITE ACCESS;' from sysibmadm.snaptab where (ROWS\_READ > 999) AND (((OVERFLOW\_ACCESSES \* 100) / (ROWS\_READ + 1) > 3)"
- Reorgchk? Maybe once or twice a year.
- Remember to REORG indexes after table REORG completes




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**In Summary...**

DB2 9 helps automate configuration tuning, but – you still have a job to do!

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## When is your tuning job done?

- **OLTP:**
  - Rows Read/TX/TB < 10
  - DB BP Sync Reads > 90%
  - BP, Pkg Cache, & Catlg Cache hit ratios > 95%
  - There are no bad apples
    - No Slow TS (ORMS, OWMS)
    - No SQL > 10% CPU
    - No SQL > 50% SLA time
    - No SQL w/ Rows Read/Rows Fetched > 100 (IXEFF)
    - No Files Closed
    - No Lock or Token Waits
  - Phone Rage Ends
- **Data Warehouse:**
  - Prefetch is Effective (APPR > 10 for each TS)
  - No Slow TS (ORMS, OWMS)
  - TEMPSPACE defined where data isn't – has 3-6 containers
  - DB BP Sync Reads > 25%
  - Catlg Cache Hit > 95%
  - No Files Closed
  - SQL having Frequency>1 uses
    - MQTs / ASTs
    - MDC tables
    - Effective Indexes
  - Phone Rage Ends

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Thank you  
for attending!

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