Locks and Latches

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IRLM

- In V8, 64bit IRLM is supported
  - PC=YES is forced
  - Reduced requirement for ECSA
- Make sure of high IRLM dispatching priority
  - Use WLM service class SYSSTC
- IRLM trace can add up to 25%
  - Can also increase IRLM latch contention
- **MODIFY irlmproc,SET,DEADLOK= or TIMEOUT=** to dynamically change deadlock and timeout frequency

<table>
<thead>
<tr>
<th></th>
<th>TIMEOUT</th>
<th>DEADLOK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range allowed</td>
<td>1 to 3600 sec</td>
<td>0.1 to 5 sec</td>
</tr>
<tr>
<td>Default</td>
<td>60 sec</td>
<td>1 sec</td>
</tr>
<tr>
<td>Recommendation</td>
<td>30 sec</td>
<td>0.5 sec</td>
</tr>
</tbody>
</table>
Lock Avoidance

- Combination of techniques to prevent retrieval of uncommitted data
  - (1) Page latching (and page p-lock in data sharing) controlled by DB2 to ensure physical consistency of the page
  - (2) Commit log sequence number (CLSN) – at the page level
    - DB2 tracks "time" of last update to page (on page) (A)
    - DB2 tracks "time" of oldest uncommitted activity on every pageset/partition (B)
      - Non Data Sharing
        - CLSN = lowest uncommitted RBA for all active transactions for a given pageset
      - Data Sharing
        - For non-GBP-dependent page sets, each member uses a local CLSN = lowest uncommitted LRSN for all active transactions for a given pageset
        - For GBP-dependent page sets, a Global CLSN value is maintained for the entire data sharing group = lowest CLSN value across all members across all page sets (GBP-dependent or not)
      - If (A) < (B) everything on the page is guaranteed to be committed
      - Else, check Possibly UNCommitted bits (PUNC bits)
Lock Avoidance …

- Combination of techniques to prevent retrieval of uncommitted data …
  - (3) Possibly UNCommitted bits (PUNC bits) – at the row level
    - On each row, a PUNC bit is set when the row is updated
      - PUNC bits are periodically reset
        - If successful CLSN check and more than 25% of the rows have the PUNC bit ON
        - RR scanner
        - REORG TABLESPACE
    - If the PUNC bit is not ON, the row/key is guaranteed to be committed
Lock Avoidance …

- Benefits of lock avoidance
  - Increase in concurrency
  - Decrease in lock and unlock activity requests, with an associated decrease in CPU resource consumption and data sharing overhead
- Plans and packages have a better chance for lock avoidance if they are bound with ISOLATION(CS) and CURRENTDATA(NO)
- V8 improvements
  - Lock avoidance for non-cursor ‘singleton’ SELECT
    - In V7, ISO(CS) CD(YES) acquires S page/row lock on the qualified row
    - In V8, DB2 will no longer acquire and hold S page/row lock on the qualified row for ISO(CS) CD(YES or NO)
  - Overflow lock avoidance when the update of a variable length row in a data page results in a new row that cannot fit in that page
    - In V7, no lock avoidance on both pointer and overflow
    - In V8, lock on pointer only
Lock Avoidance …

- BIND option ISOLATION(CS) with CURRENTDATA(NO) could reduce # Lock/Unlock requests dramatically
- High Unlock requests/commit could also be possible from
  - Large number of relocated rows after update of compressed or VL row
    - Lock/Unlock of pointer record (or page)
  - Large number of pseudo-deleted entries in unique indexes
    - Lock/Unlock of data (page or row) in insert to unique index when pseudo-deleted entries exist
  - Both can be eliminated by REORG

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
<th>LOCKING ACTIVITY</th>
<th>QUANTITY / SECOND</th>
<th>THREAD</th>
<th>COMMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>QTXALOCK</td>
<td>LOCK REQUESTS</td>
<td></td>
<td>521.0M</td>
<td>24.2K</td>
<td>3134.34</td>
</tr>
<tr>
<td>QTXAUNLK</td>
<td>UNLOCK REQUESTS</td>
<td></td>
<td>478.1M</td>
<td>22.2K</td>
<td>2876.06</td>
</tr>
</tbody>
</table>

Lock avoidance may not be working effectively if Unlock requests/commit is high, e.g. >5
Lock Avoidance …

- Effective lock avoidance is very important in data sharing
  - Long-running URs can reduce the effectiveness of lock avoidance by stopping the Global CLSN value from moving forward
  - Recommendation: Aggressively monitor long-running URs
    - 'First cut' ROTs:
      - URs running for a long time without committing: zparm URCHKTH<=5
        - Message DSNR035I
      - URs performing massive update activity without committing: zparm URLGWTH=10(K)
        - Message DSNJ031I
    - Need Management ownership and process for getting rogue applications fixed up so that they commit frequently based on
      - Elapsed time and/or
      - CPU time (no. of SQL update statements)
Lock Tuning

- As a general rule, start with LOCKSIZE PAGE as design default
  - If high deadlock or timeout, consider LOCKSIZE ROW
  - Not much difference between one row lock and one page lock request
  - However, the number of IRLM requests issued can be quite different
    - No difference in a random access
    - In a sequential scan,
      - No difference if 1 row per page (MAXROWS=1) or ISOLATION(UR)
      - Negligible difference if ISO(CS) with CURRENTDATA(NO)
      - Bigger difference if ISO(RR|RS), or sequential Insert, Update, Delete
      - Biggest difference if ISO(CS) with CURRENTDATA(YES) and many rows per page
  - In data sharing, additional data page P-locks are acquired when LOCKSIZE ROW is used
Lock Tuning …

- MAX PG/ROW LOCKS HELD from Accounting trace is a useful indicator of commit frequency
  - Page or row locks only
  - AVERAGE is for average of MAX, TOTAL is for max of MAX (of Accounting records)
    - So if transaction A had max. locks of 10 and transaction B had 20, then
      - AVERAGE (avg. of max.) = 15
      - TOTAL (max. of max.) = 20
  - In general, try to issue Commit to keep max. locks held below 100

<table>
<thead>
<tr>
<th>LOCKING</th>
<th>AVERAGE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ti Meouts</td>
<td>0.00</td>
<td>1</td>
</tr>
<tr>
<td>Deadlocks</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>Escal. (Shared)</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>Escal. (Exclus)</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>Max Pg/Row Locks Held</td>
<td>2.43</td>
<td>350</td>
</tr>
<tr>
<td>Lock Request</td>
<td>78.61</td>
<td>24637270</td>
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<tr>
<td>Unlock Request</td>
<td>26.91</td>
<td>8433176</td>
</tr>
<tr>
<td>Query Request</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>Change Request</td>
<td>1.72</td>
<td>539607</td>
</tr>
<tr>
<td>Other Request</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>Total Suspensions</td>
<td>0.20</td>
<td>63617</td>
</tr>
<tr>
<td>Lock Suspensions</td>
<td>0.00</td>
<td>1518</td>
</tr>
<tr>
<td>I RLM Latch Suspens.</td>
<td>0.20</td>
<td>62091</td>
</tr>
<tr>
<td>Other Suspens.</td>
<td>0.00</td>
<td>8</td>
</tr>
</tbody>
</table>
Lock Tuning …

- **ZPARMS**
  - **RRULOCK** – U-lock on SELECT FOR UPDATE for ISOLATION(RR|RS)
    - NO – Acquires S-locks on FETCH (default)
    - YES – Acquires U-locks on FETCH
      - If no update, U is demoted to S on next fetch
      - If update, U is promoted to X in COMMIT duration
  - **XLKUPDLT** – X-lock for searched UPDATE/DELETE
    - Take X-lock immediately on qualifying rows/pages instead of S|U-lock
    - Good if most accessed objects are changed
    - V8 PQ98172 introduces a new option: TARGET
      - X-lock only for the specific table that is targeted by UPDATE or DELETE
      - S- or U-lock when scanning for rows/pages of other tables referenced by the query
  - **SKIPUNCI** – Skip uncommitted inserts for ISOLATION(CS|RS)
    - New parameter in V8 and restricted to row level locking only
DDL and DML Concurrency

- DBD is locked
  - X by SQL DDL like CREATE/DROP/ALTER (TS, TBL, IX) and some utilities
    - Prevents parallel SQL DDLs against the same database
  - S by BIND, DB2 utility, dynamic SQL without caching

- How to improve DDL concurrency?
  - Reduce the number of objects within a database
    - Smaller DBDs also helps to reduce the DBD Pool Size and logging volume
      - Example: Create Index with 1000 page DBD results in 2000 pages logged
    - Group all SQL DDLs within the same database in the same commit scope
      - Only one delete/insert of DBD rather than one per SQL DDL
      - Avoid mixing DDLs and DMLs within the same COMMIT
      - Don’t delay commit after DDLs
DDL and DML Concurrency …

- How to improve DDL and DML concurrency?
  - Dynamic SQL will not acquire S DBD locks if ZPARM CACHEDYN = YES
    - Unless dynamic statement caching use has been prohibited for another reason e.g. REOPT(VARS), or DDL was performed in the same unit of work

- To minimise lock contention on DB2 Catalog/Directory pages and DBD
  - Assign unique authid and a private database to each user
    - Each Catalog page contains only one value for dbid or authid
  - Be careful about user query on Catalog tables
    - e.g. SQL LOCK TABLE or ISOLATION(RR)
IRLM Latch Contention

IRLM latch contention should be less than 1-5% of Total IRLM Requests

IRLM Latch Contention = SUSPENSIONS (IRLM LATCH) (A)
Total IRLM Requests = LOCK + UNLOCK + QUERY + CHANGE REQUESTS (B)
IRLM Latch Contention Rate (%) = (A)/(B)*100

High number of IRLM latch suspensions could be caused by
- IRLM Trace on
- Low IRLM dispatching priority
- Frequent IRLM Query requests (e.g. DISPLAY DATABASE LOCKS, or MODIFY irlmproc, STATUS)
- Very low deadlock detection cycle time and very high locking rates
## Data Sharing Lock Tuning

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>QTGSLSLM</td>
<td>SYNCH.XES - LOCK REQUESTS</td>
</tr>
<tr>
<td>QTGSCSLM</td>
<td>SYNCH.XES - CHANGE REQUESTS</td>
</tr>
<tr>
<td>QTGSUSLM</td>
<td>SYNCH.XES - UNLOCK REQUESTS</td>
</tr>
<tr>
<td>QTGSIGLO</td>
<td>SUSPENDS - IRLM GLOBAL CONT</td>
</tr>
<tr>
<td>QTGSSGLO</td>
<td>SUSPENDS - XES GLOBAL CONT</td>
</tr>
<tr>
<td>QTGSFLMG</td>
<td>SUSPENDS - FALSE CONTENTION</td>
</tr>
</tbody>
</table>

### Global Contention

Global Contention should be less than 3-5% of XES IRLM Requests

\[
\text{Global Contention} = \text{SUSPENDS} - \text{IRLM} + \text{XES} + \text{FALSE} \quad (A)
\]

\[
\text{XES IRLM Requests} = (\text{SYNCH. XES} - \text{LOCK} + \text{CHANGE} + \text{UNLOCK}) + (\text{SUSPENDS} - \text{IRLM} + \text{XES} + \text{FALSE}) \quad (B)
\]

Global Contention Rate (%) = \(\frac{(A)}{(B)} \times 100\)

### False Contention

False Contention should be less than 1-3% of XES IRLM Requests

\[
\text{False Contention} = \text{SUSPENDS} - \text{FALSE} \quad (C)
\]

\[
\text{XES IRLM Requests} = (\text{SYNCH. XES} - \text{LOCK} + \text{CHANGE} + \text{UNLOCK}) + (\text{SUSPENDS} - \text{IRLM} + \text{XES} + \text{FALSE}) \quad (B)
\]

False Contention Rate (%) = \(\frac{(C)}{(B)} \times 100\)
Data Sharing Lock Tuning …

- **Notes**
  - **IRLM Cont.** = IRLM resource contention
  - **XES Cont.** = XES-level resource cont. as XES only understands S|X mode
    - e.g. member 1 asking for IX and member 2 for IS
    - Big relief with Locking Protocol 2 when enabled after entry to V8 (NFM) but increased overhead for pageset/partitions opened for RO on certain members, e.g.
      - -START DATABASE(....) SPACENAM(...) ACCESS(RO)
      - SQL LOCK TABLE statement
      - LOCKSIZE TABLESPACE or LOCKSIZE TABLE for segmented tablespace
      - Table scan with Repeatable Read isolation level
      - Lock escalation occurs
  - **False Cont.** = false contention on lock table hash anchor point
    - Could be minimised by increasing the number of Lock entries in the CF Lock Table
    - Note: the counter is maintained on a per-LPAR basis
      - Will over-report false contentions in cases where multiple members from the same data sharing group run on the same z/OS image
## Data Sharing Lock Tuning …

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>QTGSPPPE</td>
<td>PSET/PART P-LOCK NEGOTIATION</td>
</tr>
<tr>
<td>QTGSPGPE</td>
<td>PAGE P-LOCK NEGOTIATION</td>
</tr>
<tr>
<td>QTGSOTPE</td>
<td>OTHER P-LOCK NEGOTIATION</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DATA SHARING LOCKING</th>
<th>QUANTITY / SECOND</th>
<th>/ THREAD</th>
<th>/ COMMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYNCH. XES - LOCK REQUESTS</td>
<td>227.5M</td>
<td>10.6K</td>
<td>1368.75</td>
</tr>
<tr>
<td>SYNCH. XES - CHANGE REQUESTS</td>
<td>1340.7K</td>
<td>62.24</td>
<td>8.07</td>
</tr>
<tr>
<td>SYNCH. XES - UNLOCK REQUESTS</td>
<td>225.8M</td>
<td>10.5K</td>
<td>1358.14</td>
</tr>
<tr>
<td>ASYNCH. XES - RESOURCES</td>
<td>1315.00</td>
<td>0.06</td>
<td>0.01</td>
</tr>
<tr>
<td>PSET/ PART P-LOCK NEGOTIATION ON</td>
<td>18037.00</td>
<td>0.84</td>
<td>0.11</td>
</tr>
<tr>
<td>PAGE P-LOCK NEGOTIATION ON</td>
<td>2863.00</td>
<td>0.13</td>
<td>0.02</td>
</tr>
<tr>
<td>OTHER P-LOCK NEGOTIATION ON</td>
<td>9067.00</td>
<td>0.42</td>
<td>0.05</td>
</tr>
<tr>
<td>P-LOCK CHANGE DURING NEG.</td>
<td>15991.00</td>
<td>0.74</td>
<td>0.10</td>
</tr>
</tbody>
</table>

- P-lock contention and negotiation can cause IRLM latch contention, page latch contention, asynchronous GBP write, active log write, GBP read

![ROT]

**P-lock Negotiation should be less than 3-5% of XES IRLM requests**

P-lock Negotiation = P-LOCK NEGOTIATION – PSET/PART + PAGE + OTHER (A)

XES IRLM Requests = (SYNCH. XES – LOCK + CHANGE + UNLOCK) + (SUSPENDS – IRLM + XES + FALSE) (B)

P-lock Negotiation Rate ( % ) = (A)/(B)*100
Data Sharing Lock Tuning …

Notes

- Other P-lock negotiation for
  - Index tree P-lock (See LC06 contention in Latch section)
  - Castout P-lock
  - SKCT/SKPT P-lock

- Breakdown by page P-lock type in GBP statistics

<table>
<thead>
<tr>
<th>GROUP TOTAL CONTINUED QUANTITY / SECOND / THREAD / COMMIT</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PAGE P-LOCK LOCK REQ</td>
<td>877.4K</td>
</tr>
<tr>
<td>SPACE MAP PAGES</td>
<td>83552.00</td>
</tr>
<tr>
<td>DATA PAGES</td>
<td>10663.00</td>
</tr>
<tr>
<td>INDEX LEAF PAGES</td>
<td>783.2K</td>
</tr>
<tr>
<td>PAGE P-LOCK UNLOCK REQ</td>
<td>926.8K</td>
</tr>
<tr>
<td>SPACE MAP PAGES</td>
<td>593.00</td>
</tr>
<tr>
<td>DATA PAGES</td>
<td>143.00</td>
</tr>
<tr>
<td>INDEX LEAF PAGES</td>
<td>8231.00</td>
</tr>
<tr>
<td>PAGE P-LOCK LOCK SUSP</td>
<td>8967.00</td>
</tr>
<tr>
<td>SPACE MAP PAGES</td>
<td>593.00</td>
</tr>
<tr>
<td>DATA PAGES</td>
<td>143.00</td>
</tr>
<tr>
<td>INDEX LEAF PAGES</td>
<td>8231.00</td>
</tr>
<tr>
<td>PAGE P-LOCK LOCK NEG</td>
<td>10285.00</td>
</tr>
<tr>
<td>SPACE MAP PAGES</td>
<td>8.00</td>
</tr>
<tr>
<td>DATA PAGES</td>
<td>10.00</td>
</tr>
<tr>
<td>INDEX LEAF PAGES</td>
<td>10267.00</td>
</tr>
</tbody>
</table>
Data Sharing Lock Tuning …

➢ To reduce page p-lock and page latch contention on space map pages during heavy inserts into GBP-dependent tablespace

   ▪ TRACKMOD NO

   ▪ MEMBER CLUSTER
     – Option only available for partitioned tablespace
       – Switching to partitioned will likely result in extra getpages for true varying length rows and fixed length compressed
       – Increases the number of space map pages
         – 199 data pages per space map instead of 10K per space map

   ▪ When MEMBER CLUSTER is used, LOCKSIZE ROW has the potential to provide additional relief for insert intensive workloads
     – Reduced page P-lock and page latch contention on data pages
     – Better space use
     – Reduced working set of pages in buffer pool
Data Sharing Lock Tuning …

➢ BUT…

- Do not use LOCKSIZE ROW without MEMBER CLUSTER for an INSERT-at-the-end intensive workload
  - May result in excessive page p-lock contention on data pages and space map pages, in addition to the extra locking protocol that comes with taking page p-lock

- Do not use LOCKSIZE ROW with or without MEMBER CLUSTER for a mixed INSERT/UPDATE/DELETE workload
  - Consider using LOCKSIZE PAGE MAXROWS 1 to reduce page P-lock and page latch contention on data pages
Data Sharing Lock Tuning …

- 50% of CLAIM_REQ can be used as a very rough estimate of #
tablespace/partition locks acquired when effective thread reuse with
RELEASE(COMMIT), or no thread reuse
  - CLAIM_REQ assumed once for index and once for tablespace/
    partition for a very rough estimation
  - These tablespace/partition locks can be eliminated with effective
    thread reuse with use of RELEASE(DEALLOCATE)
Internal DB2 Latch Contention

Try to keep latch contention rate < 1K-10K per second

- Disabling Acct Class 3 trace can help reduce CPU time when high latch contention
- Typical high latch contention classes highlighted
  - LC06 = Index split latch
  - LC14 = Buffer pool LRU and hash chain latch
  - LC19 = Log latch
  - LC24 = Prefetch latch or EDM LRU chain latch

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
<th>LATCH CNT / SECOND</th>
<th>/ SECOND</th>
<th>/ SECOND</th>
<th>/ SECOND</th>
</tr>
</thead>
<tbody>
<tr>
<td>QVLSLC01 to QVLSLC32</td>
<td>INTERNAL LATCH CONTENTION BY CLASS 1-32</td>
<td>LC01-LC04</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>LC05-LC08</td>
<td>0.00</td>
<td>105.58</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>LC13-LC16</td>
<td>0.01</td>
<td>676.17</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>LC17-LC20</td>
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<td>6.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>LC21-LC24</td>
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<td>4372.87</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>LC25-LC28</td>
<td>0.00</td>
<td>0.57</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>LC29-LC32</td>
<td>0.08</td>
<td>25.46</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Internal DB2 Latch Contention …

- LC06 for index tree P-lock by index split
  - Index split is particularly painful in data sharing
    - Results in two forced physical log writes
      - Index split time can be significantly reduced by using faster active log device
  - Options to reduce index split
    - Distributed freespace tuning
    - Minimum index key size especially if unique index
    - NOT PADDED index for large varchar columns (V8)
    - Large index page size (V9)
    - Asymmetric leaf-page split (V9)
  - A number of index splits in LEAFNEAR/FAR in SYSINDEXPART and RTS REORGLEAFNEAR/FAR
  - X’46’ in IFCID 57 performance trace
  - X’FE’ index tree latch in non data sharing not in Class 6
Internal DB2 Latch Contention …

- LC14 Buffer Pool latch
  - If many tablespaces and indexes, assign to separate buffer pools with an even Getpage frequency
  - If objects bigger than buffer pool, try enlarging buffer pool if possible
  - If high LC14 contention, use buffer pool with at least 3000 buffers
  - Use FIFO rather than LRU buffer steal algorithm if there is no read I/O, i.e. object(s) entirely in buffer pool
    - LRU = Least Recently Used buffer steal algorithm (default)
    - FIFO = First In First Out buffer steal algorithm
      - Eliminates a need to maintain LRU chain which in turn
        - Reduces CPU time for LRU chain maintenance
        - Reduces CPU time for LC14 contention processing
Internal DB2 Latch Contention …

- LC19 Log latch
  - Minimise #log records created via
    - LOAD RESUME/REPLACE with LOG NO instead of massive INSERT/UPDATE/DELETE
    - Segmented or UTS tablespace if mass delete occurs
  - Increase size of output log buffer if non-zero unavailable count
    - When unavailable, first agent waits for log write
    - All subsequent agents wait for LC19
  - Reduce size of output log buffer if non-zero output log buffer paging
    - See Log Statistics section
  - Potential for reduced LC19 Log latch contention in DB2 9 (CM, NFM)
Internal DB2 Latch Contention …

- LC24 latch
  - Sum of two types of latch contention
  - (1) EDM LRU latch – X’18’ in IFCID 57 performance trace
    - Use EDMBFIT zparm of NO
    - Thread reuse with RELEASE DEALLOCATE instead of RELEASE COMMIT for frequently executed packages
  - (2) Prefetch scheduling – X’38’ in IFCID 57 performance trace
    - Higher contention possible with many concurrent prefetches
    - Disable dynamic prefetch if unnecessary by setting VPSEQT=0
    - Use more partitions (one x’38’ latch per data set)