Platform: DB2 UDB for z/OS

What's New in DB2 UDB for z/OS Locking and Concurrency

Session: C9

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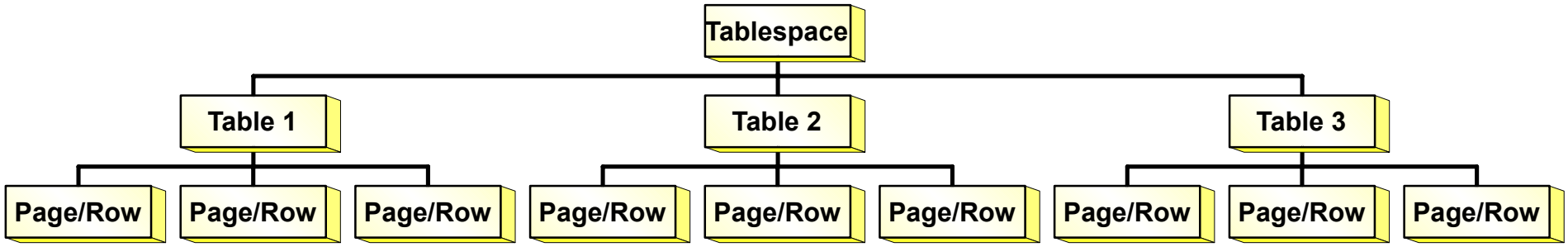
Agenda

- Locking - the basics
- Optimistic Locking for Static Scrollable Cursor
- ZPARM Knobs for Locking
- LOB locks
- Locking Enhancements in V8
  - Deadlock Avoidance between REORG and SQL
  - Data Sharing Locking Enhancement
  - ...

Terminology

- CF - Coupling Facility
- ISO - Lock isolation level
  - RR - Repeatable Read
  - RS - Read Stability
  - CS - Cursor Stability
  - UR - Uncommitted Read
- PI - Partitioned Index
- NFM - V8 New Function Mode
- NPI - Non-Partitioned Index
- XES - z/OS System Lock Manager
- WLM - z/OS Workload Manager

DB2 Locking Hierarchy



DB2 allows 4 levels of locking

High Performance

Tablespace

Partition (for partitioned table spaces)

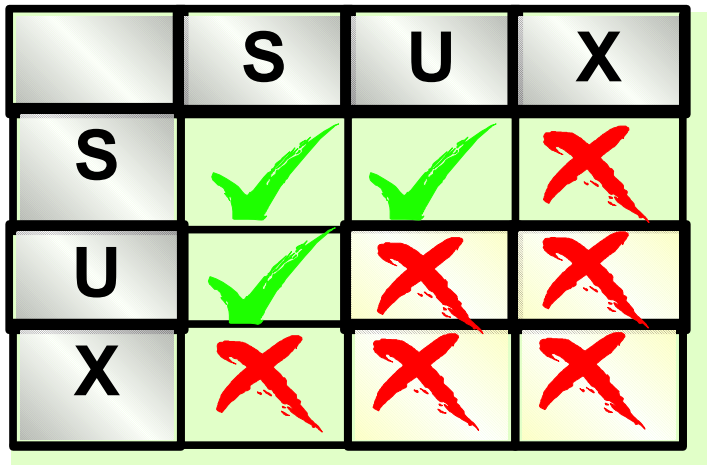
Table (for segmented table spaces)

Page

Row

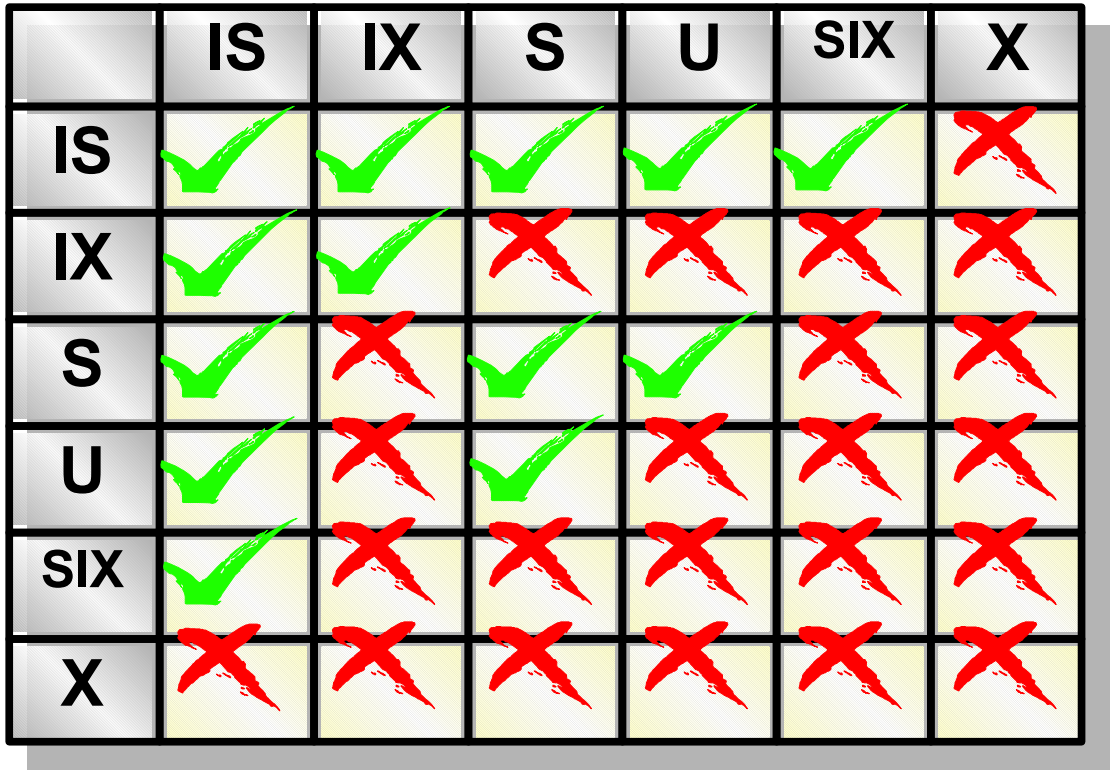
High Concurrency

What makes locking work ?



	S	U	X
S	✓	✓	✗
U	✓	✗	✗
X	✗	✗	✗

Page/Row locks

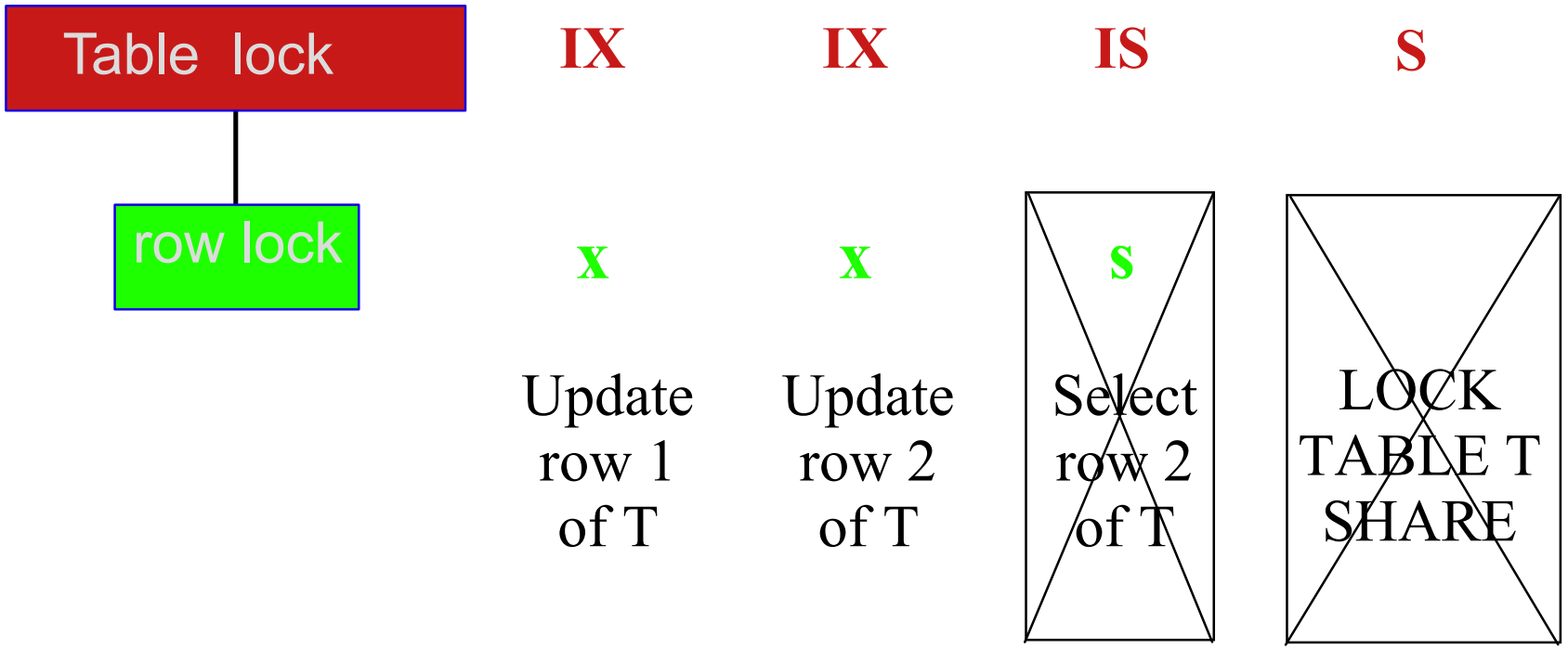


	IS	IX	S	U	SIX	X
IS	✓	✓	✓	✓	✓	✗
IX	✓	✓	✗	✗	✗	✗
S	✓	✗	✓	✓	✗	✗
U	✓	✗	✓	✗	✗	✗
SIX	✓	✗	✗	✗	✗	✗
X	✗	✗	✗	✗	✗	✗

Tablespace/Table/Partition locks

Example

- *CREATE TABLESPACE **TS1** ... LOCKSIZE(ROW)*
- *CREATE TABLE **T** IN **TS1***



What is Drain/Claim ?

- *Drains/Claims are used to serialize between Utilities and SQL*
- A CLAIM registers an SQL agent's use of an object
  - Claim can be acquired on individual partitions
  - Acquired at first access to data or an index
  - CLAIMs are released at commit (except for held cursor)
  - Supports 3 claim classes: RR, CS, and WRITE
- Utilities detect claimers are present and wait
- **Drain Write** waits for all write claims to be released
- **Drain All** waits for claims on all classes to be released
- SHRLEVEL(CHANGE) Utilities are CLAIMers

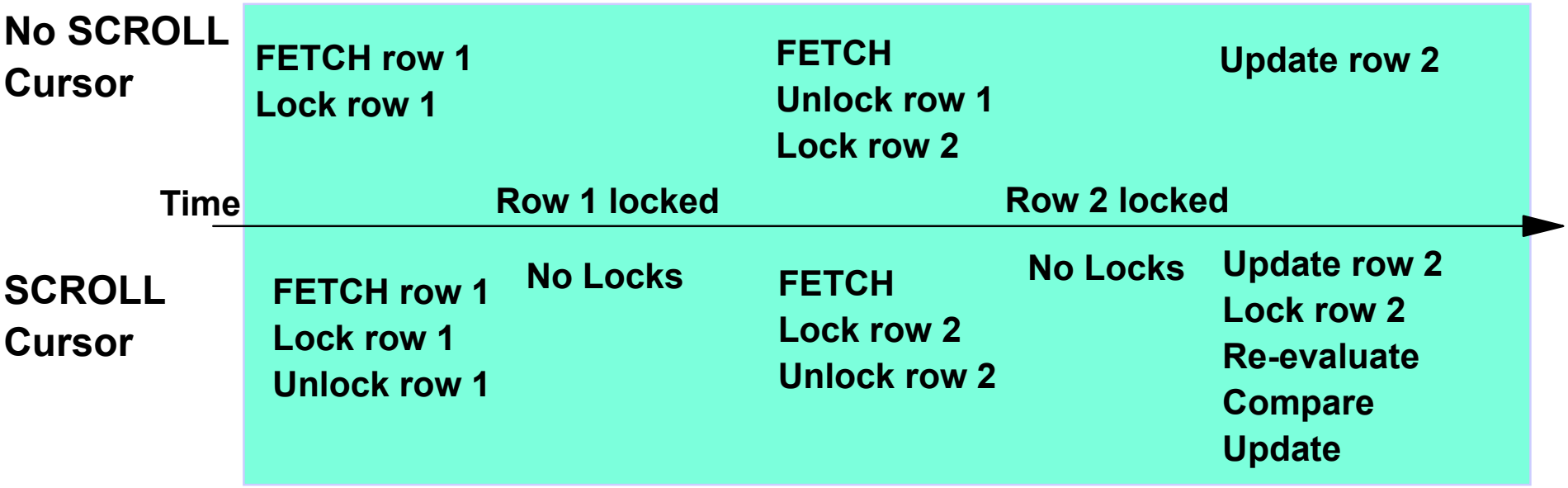
Optimistic Locking for Static Scrollable Cursor

RR - lock every page/row as it is read
RS - lock every row that qualifies stage 1 predicate
CS - lock each row fetched(currentdata(YES))
- lock only if cursor FOR UPDATE OF if (currentdata(NO))
- no rows remain locked after OPEN
UR - No rows locked

Optimistic Locking Mechanism
If not RR/RS, rows are not locked at the end of OPEN
When positioned updates/deletes requested,
-DB2 locks the row,
-Re-evaluates the predicate and
-Compares by Column Value (cols in SELECT list)
to determine if the update/delete can be allowed

Optimistic Locking for Static Scrollable Cursor ...

- Release locks after fetch
- Because we are optimistic that no positioned update or delete will occur
- Even if it does, we are optimistic that the pertinent values will not have changed
- So we compare by value under a new lock to ensure data integrity



ZPARM Knobs for Locking

- *EVALUNC - Applies to ISO(CS or RS)*
  - YES - Defer locking until after predicate evaluation
  - NO - If lock avoidance fails, lock row before predicate evaluation (default)
- RRULOCK - Applies to ISO(RS or RR) on SELECT FOR UPDATE
  - 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
  - NO - Acquires S locks on FETCH (default)
- XLKUPDLT - Applies to searched UPDATE or DELETE
  - YES/TARGET - Acquires X locks on qualified rows based on stage-1 predicates (PQ98172 introduces the TARGET option)
  - NO - Acquires S/U first, then promote from S/U to X (default)

ZPARM Knobs for Locking ...

- *RELCURHL - Applies to Cursor Hold*
  - YES - Release row/page lock on the positioned row (default)
  - NO - Keep lock on row/page of position (if any) across commit
    - Only need for this would come from some application dependency
- SKIPUNCI (V8) - Applies to ISO(CS or RS)
  - YES - Skip uncommitted insert
  - NO - Wait until uncommitted insert commits or rolls back (default)

LOB Locks

- *Used to determine whether space can be reused for deleted LOBs*
  - Not for concurrency control
- Locks are held until commit
  - Insert/Update - X LOB lock
  - Select/Delete - S LOB lock
    - No lock avoidance
    - ISO UR skips uncommitted inserts
      - If acquired, will keep S locks until commit
  - Held across commit for held cursor or held locator
- Increase LOCKMAX value to avoid lock escalation
- Frequent commits, free locators and release held cursors to reduce number of held LOB locks

DDL and DML Concurrency

- Unable to support parallel DDLs against the same database due to X-DBD lock
- How to improve DDL concurrency ?
  - Reducing the number of objects within a database
    - Also helps to reduce the EDM Pool Size and
    - Logging volume
  - Avoid mixing DDLs and DMLs within the same COMMIT
  - Group all DDLs within the same database in the same commit scope
    - The deletion and re-insertion of DBD will be done once, instead of each DDL statement
  - Don't delay commit after DDLs
- How to improve DDL and DML concurrency ?
  - Dynamic SQL will not acquire S DBD locks if ZPARM CACHEDYN = YES

Agenda

- Locking - the basics
- Optimistic Locking for Static Scrollable Cursor
- ZPARM Knobs for Locking
- LOB locks
- **Locking Enhancements in V8**
  - **Deadlock Avoidance between REORG and SQL**
  - **Data Sharing Locking Enhancement**
  - **...**

Deadlock Avoidance between Utilities and SQL

- *Problem: Drain/Claim deadlocks between REORG and SQL*
  - Draining/claiming data/indexes in opposite order
  - Draining/claiming partitions in opposite order
  - Drainng/claiming writers and readers in opposite order
  - Could also happen for QUIESCE, RECOVER, CHECK INDEX, LOAD, COPY, ...
  - Deadlocks will not be detected by IRLM
    - Typically, application gets a -911 lock time-out SQL code
    - Utilities could end with RC = 8 and reason code = 00C200EA

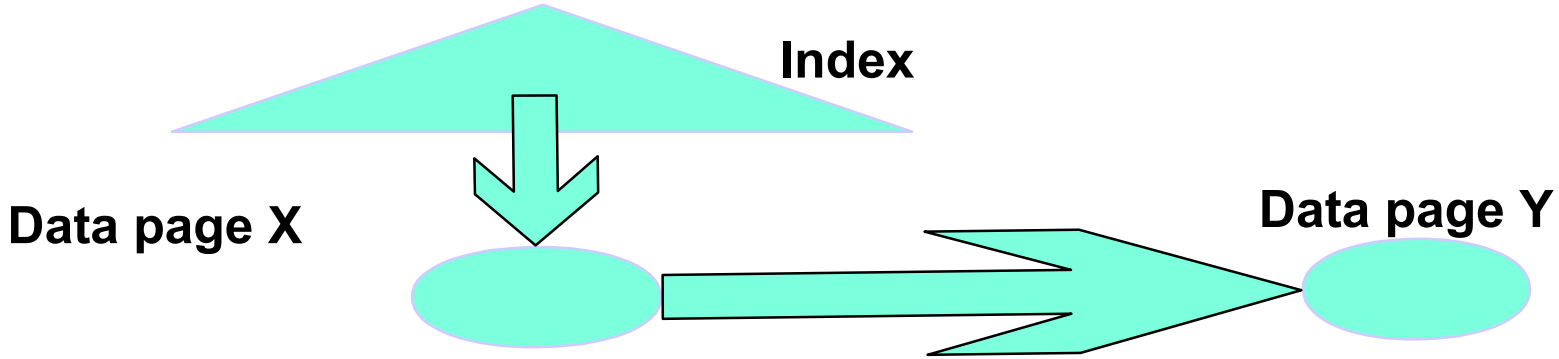
Deadlock Avoidance between Utilities and SQL ...

- Solution:
  - SQL will always claim data first before claiming indexes
  - For Partitioned Tables
    - Introduces an extra claim at the table space level
    - Claim table space first before claiming partition(s)
    - Drain table space first before draining partition(s) for a table space level utility
  - DISPLAY DATABASE ... will show table space level claims and drain locks
  - For Online REORG, could use DRAIN ALL to alleviate drain/claim writers and readers in opposite order
    - But, may impact availability to R/O applications during the last log apply phase
  - Available in V7 via PQ96628 with ZPARM CLAIMDTA=YES

Partitioning Key Update Enhancement

- *Problem in V7: When a row is updated to move across partition boundary (e.g. from PART 2 to Part 6)*
  - Needs to quiesce applications from accessing data between Part 2 and Part 6
    - Drain table and PI from partitions 2 through 6
    - Drain all NPIs
  - Not usable because deadlock/timeout
  - Disable by setting ZPARM PARTKEYU = NO or SAME
- V8 will no longer need to quiesce applications when moving rows across partition boundary
  - Will only need to acquire S page/row lock on the parent row until commit if the update is done against a dependent table in Referential Integrity relationship

Overflow Lock Avoidance



- When an update of variable length row in data page X results in new row which can not fit in that page,
  - New row stored in a different page Y
  - Its pointer stored in old page X to avoid index update
  - If updating later with small row, it can be put back on home page X, again without index update.
- Problem: Potential doubling of data I/O and Getpage and more lock/unlock requests

Overflow Lock Avoidance ...

- V7: no lock avoidance on both pointer and overflow
- V8: lock on pointer only

Isolation CS CD NO or YES	V7	V8
Lock/Unlock for pointer	Yes	Yes
Lock/Unlock for overflow	Yes	No

➡ All locks/unlocks here disappear after REORG
- Consider Reorg when (FAR+NEARINDREF) exceeds 5 to 10% range

Increase Lock Holder WLM priority

- *Problem: A high WLM priority application needs to access/update a row that was X locked by a low priority job*
  - Needs to wait until the low priority job issues a commit
- V8 will temporary increase the lock holders priority using the waiter's priority to reduce the lock wait time
  - Invokes WLM to raise the holder's priority when the waiter exceeds 1/2 of the lock time-out value
  - limited to lock holders on the same DB2 member
  - Resume lock holder's original WLM service class when lock is released
  - Prereq z/OS 1.4 (WLM Enqueue Management)

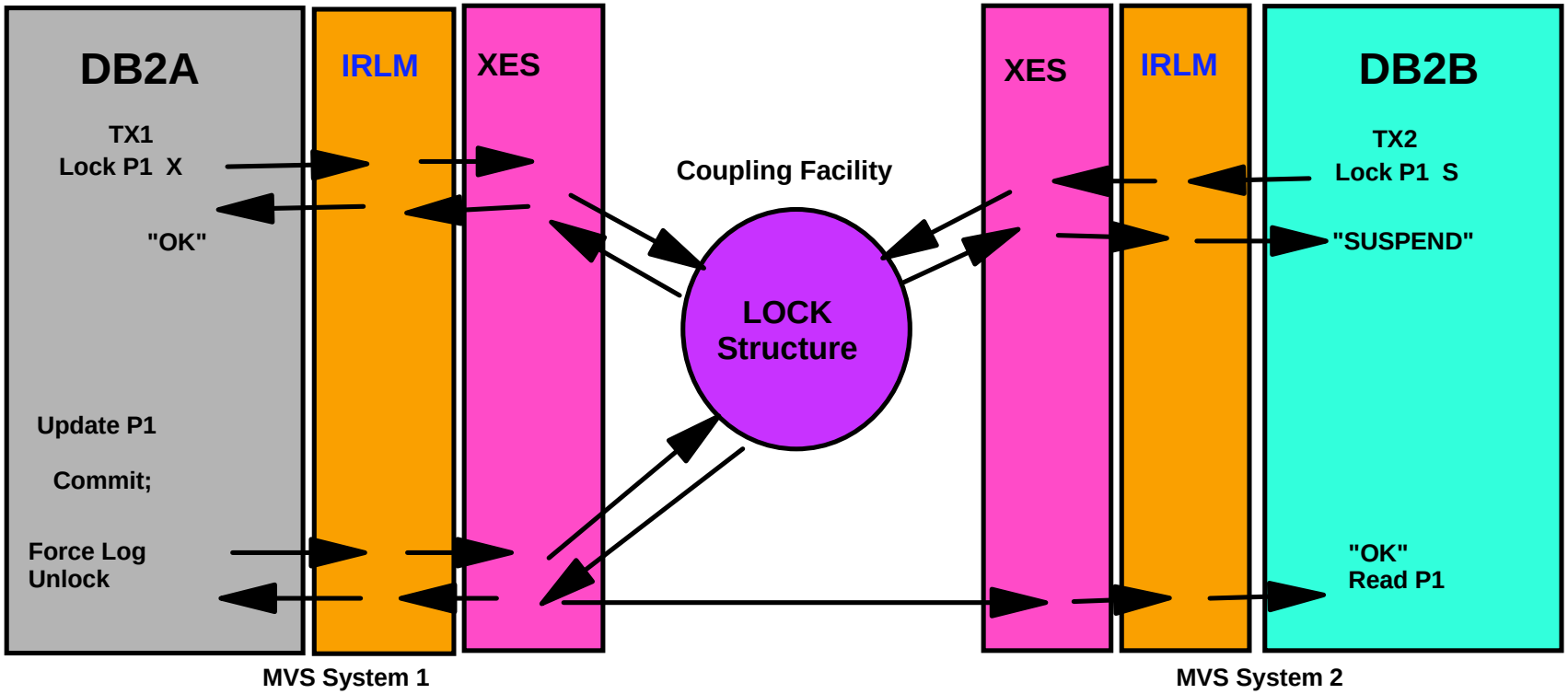
Miscellaneous Enhancements

- *Lock avoidance for 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)
    - Internal cursor is closed after the singleton SELECT is processed
- V8 writes IFCID 337 record when lock escalation occurs
  - Allows performance monitors to report on lock escalation
  - Need to enable statistics trace class 3 or performance trace class 6
  - The DSNI031I message will continue to be written when lock escalation occurs

Miscellaneous Enhancements ...

- *CLI "release locks at close cursor" attribute*
  - *Release S/U row/page locks at close cursor*
  - *Applicable only to ISO (RR or RS)*
  - *In V7, locks are held until commit*
- *SELECT ...WITH ISO(RR or RS) USE AND KEEP(EXCLUSIVE) LOCKS*
  - Acquires X locks on FETCH
- *SELECT ...WITH ISO(RR or RS) USE AND KEEP(SHARE/UPDATE) LOCKS*
  - Acquires S/U locks on FETCH
- SELECT ... KEEP UPDATE LOCKS (V7 syntax)
  - Acquires X locks on FETCH
- Timeout message (DSNT318I) for P locks (PQ87877)

Data Sharing Locking Overview

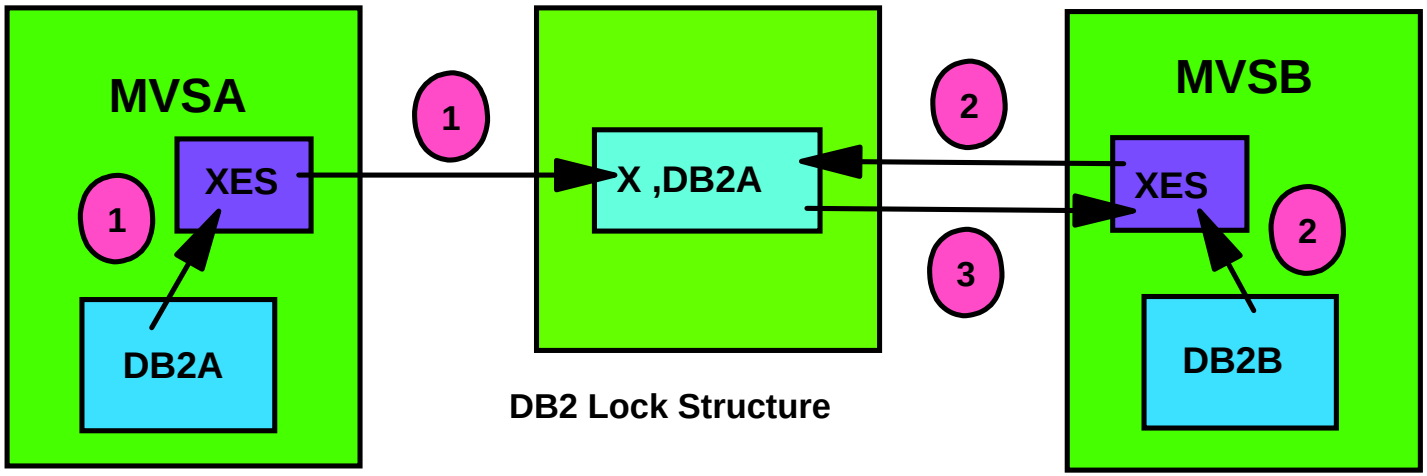


- When "No contention", Global lock granted synchronously for execution of the transaction
- No need to "Suspend" the transaction task (measured in Microseconds)
- "Lock contention" is detected quickly

Data Sharing Global Lock Contention Problem

- *IRLM relies upon the z/OS System Lock Manager (i.e. XES) to handle*
  - Inter-system locking services
- Various IRLM lock levels can ONLY map to one of two XES lock levels
  - IRLM IS and S locks map to XES S lock
  - IRLM U, IX, SIX, and X locks map to XES X lock
- When two members requesting IX lock on the same TS
  - Both IRLM IX locks map to XES X locks - lock conflict
  - XES detects contention and invokes IRLM to perform global contention processing
    - Determine if IX is really compatible with IX
    - Grant lock request

Global L-lock Contention - Example



1. A program on DB2A requests an IX lock on tablespace TS123, and XES propagates this as an X lock on the lock table entry

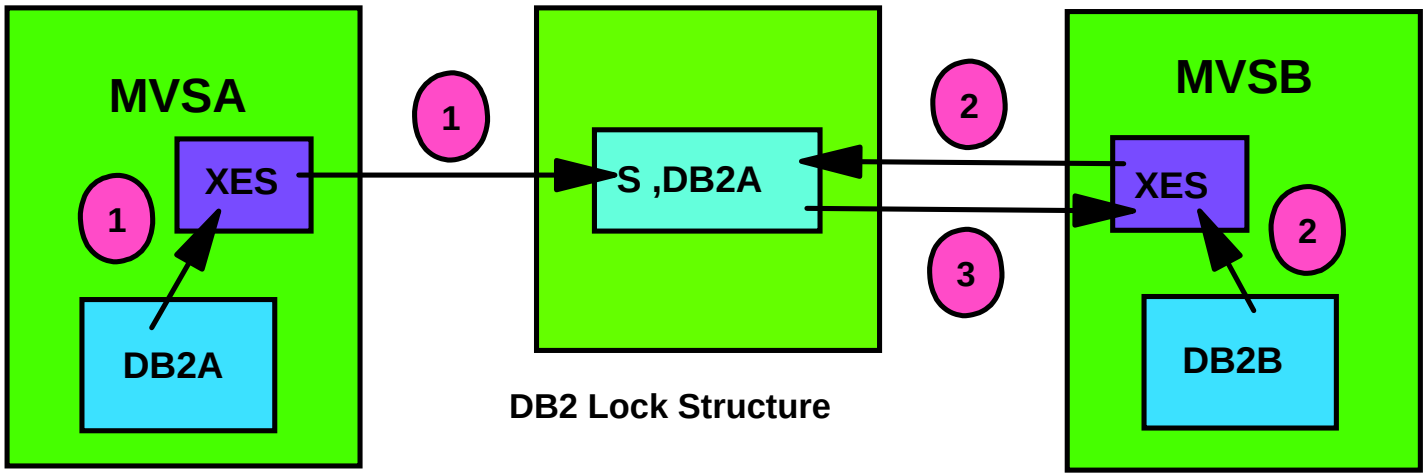
2. A program on DB2B requests an IX lock on tablespace TS123, and XES propagates this as an X lock on the lock table entry

3. MVSB gets a contention response from the coupling facility which is an XES lock contention; XES invokes IRLM to resolve that IX - IX is compatible

Avoid Global L-lock Contention

- *IRLM now maps IX L-locks to XES S*
  - Grant IX lock locally when only IS or IX L-locks held on the object
  - Parent S L-lock still sent to CF without XES contention
- How do we ensure that IX remains incompatible with S ?
  - Gross S parent L-lock now maps to XES X
  - XES global lock contention to verify that a S table L-lock is compatible with another S table L-lock
    - Rare
- Majority cases are IS - IS, IS - IX, and IX - IX
  - Hence performance benefits
- IRLM U, SIX, and X L-locks continue maps to XES X

Avoid Global L-lock Contention - Example



1. A program on DB2A requests an IX lock on tablespace TS123, and XES propagates this as an S lock on the lock table entry

2. A program on DB2B requests an IX lock on tablespace TS123, and XES propagates this as an S lock on the lock table entry

3. MVSB gets a OK response from the coupling facility and IX lock on TS123 is granted immediately (in microseconds)

Child Locks Propagation based on Pageset P-lock

- *Child L-lock propagation no longer based on parent L-lock*
- *Now based on cached(held) state of the pageset P-lock*
  - If pageset P-lock negotiated from X to SIX or IX, then child L-locks propagated
  - Reduced volatility
  - If P-lock not held at time of child L-lock request, child lock will be propagated
  - "Index-only" scan (if any locks taken) must open table space
- Parent L-lock no longer need to be held in cached state after DB2 failure
  - A pageset IX L-lock no longer held as a retained X lock
    - Important availability benefit in data sharing

LOCKPART NO is no longer supported

- *The parent L-lock and P-lock for partitioned tables will always be managed at the partition level*
- *LOCKPART NO semantic is no longer supported*
  - Change to LOCKPART YES internally
  - Data sharing and non-data sharing
  - ONLY lock the partitions as we need them
  - May see additional partition locks acquired even if LOCKPART NO is specified
- All data sharing locking enhancements are enabled only in V8 NFM after
  - A group-wide shutdown and restart

Benefits with Data Sharing Locking Enhancement

- *Faster lock processing for IX and IS parent L-locks*
  - *IX - IX, IX - IS, IS - IS*
  - *Parent L-lock still sent to CF Lock Structure*
    - *But, there will never be XES-level lock contention for the above common conditions*
- *Child locks propagated based on pageset P-lock*
  - Less volatility
- Avoids the cost of global lock contention whenever possible
- Improved availability by reducing X "retained lock" on the entire table space following a system failure
- Improved data sharing performance, especially for OLTP
- Reduce the need for RELEASE(DEALLOCATE)

Possible Future Enhancements

- Avoid commit duration LOB locks
- Option to skip locked rows for ISO(CS or RS)
- Avoid child lock propagation during group restart
- Support Postponed URs for Restart Light

Reference

- *IBM RedBook at www.redbooks.ibm.com*
  - DB2 for z/OS and OS/390 V7 Performance Topics SG24-6129
  - DB2 UDB for z/OS Version 8 Performance Topics SG24-6465
- DB2 UDB for OS/390 V7 Administration Guide, SC26-9931
- *DB2 UDB for z/OS V8 Administration Guide, SC18-7413-01*

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International DB2 Users Group