DB2 10 for z/OS Performance and Scalability Improvements

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Performance Disclaimer

This document contains performance information based on measurements done in a controlled environment. The actual throughput or performance that any user will experience will vary depending upon considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration, and the workload processed. Therefore, no assurance can be given that an individual user will achieve throughput or performance improvements equivalent to the numbers stated here.

Objective

This session offers what we have done in DB2 9 and 10 to improve the performance and provides a little more detail than “it depends..” for expected improvement

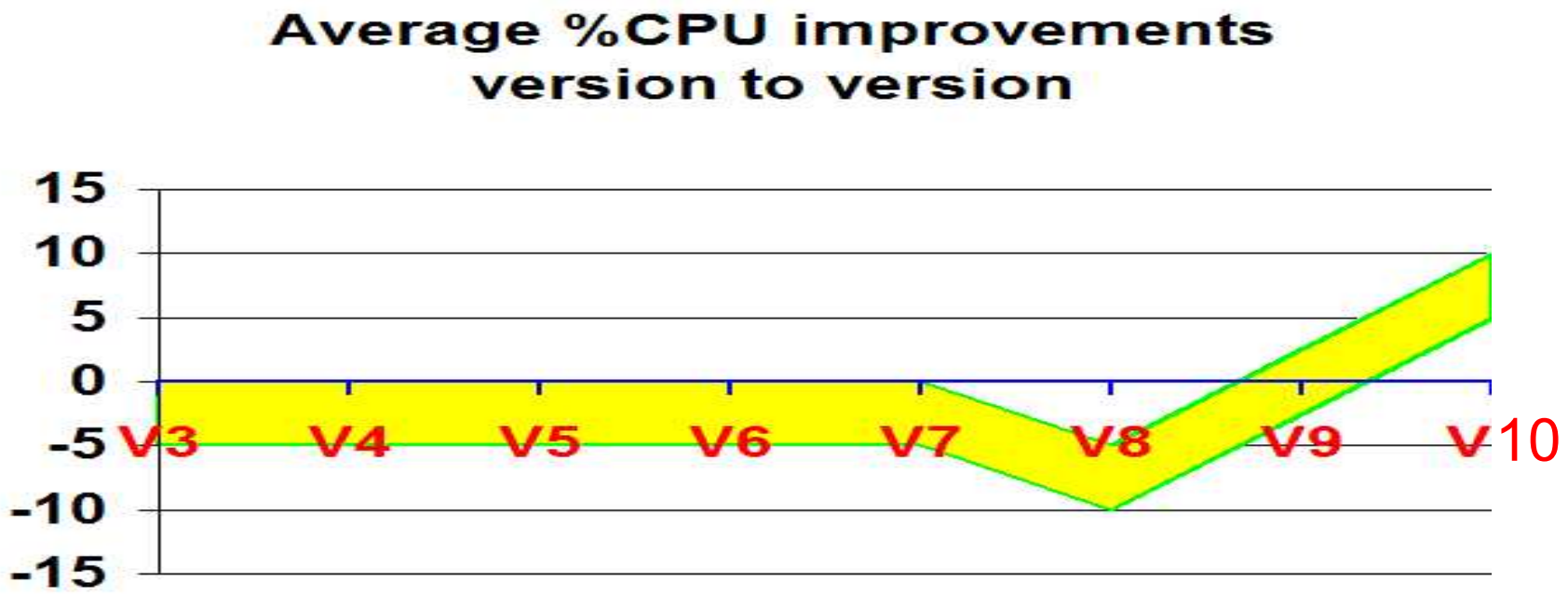
Agenda : Why you may see improvement ?

1. System level performance without changing schema or applications
2. Application level performance
   - Without changing applications nor schema
   - With schema or application change
3. Monitoring improvement
4. Summary

DB2 10 Performance

Constant Cost Pressures

- Performance improvements in key workloads: Transactions, Batch, Insert, …
- Lower CPU usage for large & small DB2 subsystems
- DB2 10 Most customers 5% - 10% CPU reduction out of the box with rebind
- Some workloads and customer situations can reduce CPU time up to 20%



1. System Level Performance and Scalability

   Migration performance without changing schema, applications

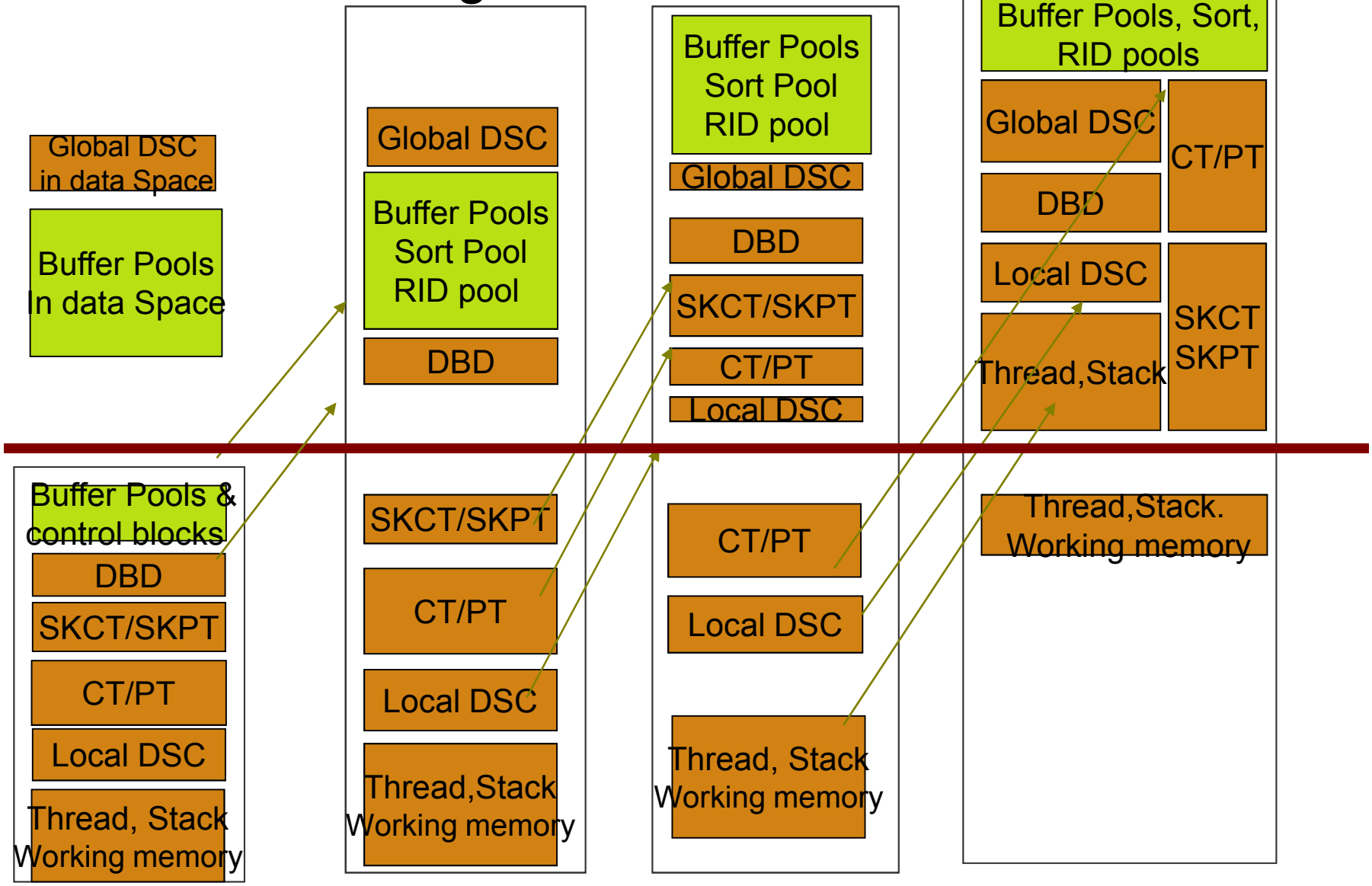
   - Virtual Storage Constraint Relief
   - Reduce CPU by utilizing more real storage
   - Latch Reduction
   - System z Synergy and Buffer Pool
   - Migration Story
   - Utilities and zIIP support

2. Application Level Performance

3. Monitoring Support

4. Summary

DBM1 Virtual Storage Constraint Relief



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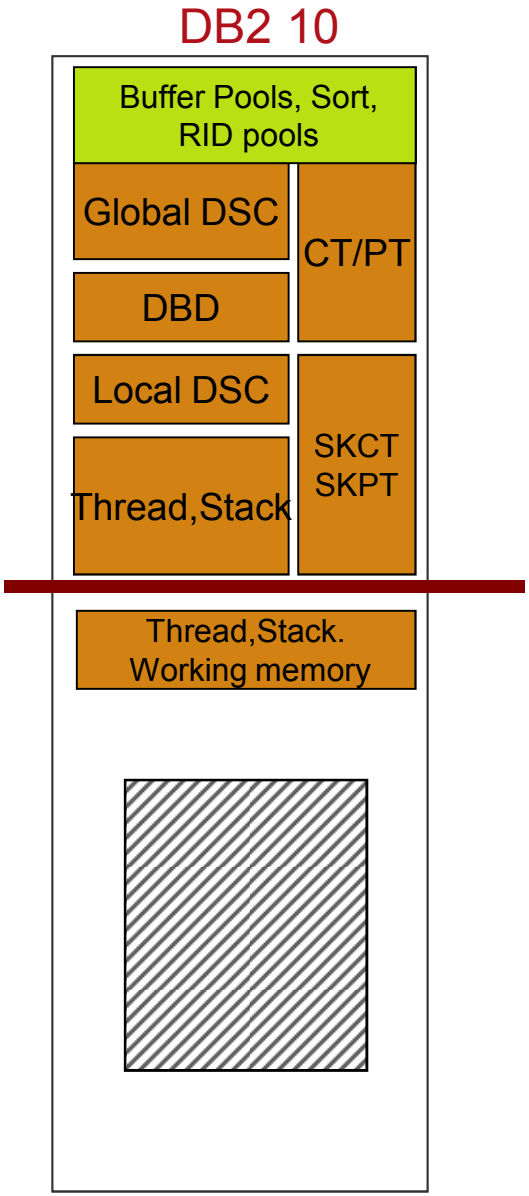


Relief in DBM1 Below The Bar

- **DBM1 below 2GB**
  - EDM storage - All above
  - Thread + Stack - 70-90% less usage in DB2 10 compared to DB2 9
    - xPROC (SPROC, IPROC, UPROC, etc) loaded in below the 2GB bar
    - Built in BIND time, shared at runtime
- **More number of threads**
- **Reduce CPU time by expense of storage**
  - More thread reuse to avoid allocate/deallocate
  - Wider usage for bind option RELEASE(DEALLOCATE)
  - High Performance DBATs
  - Larger MAXKEEPD values for KEEPDYNAMIC=YES users to avoid short prepare

High Performance DBATs

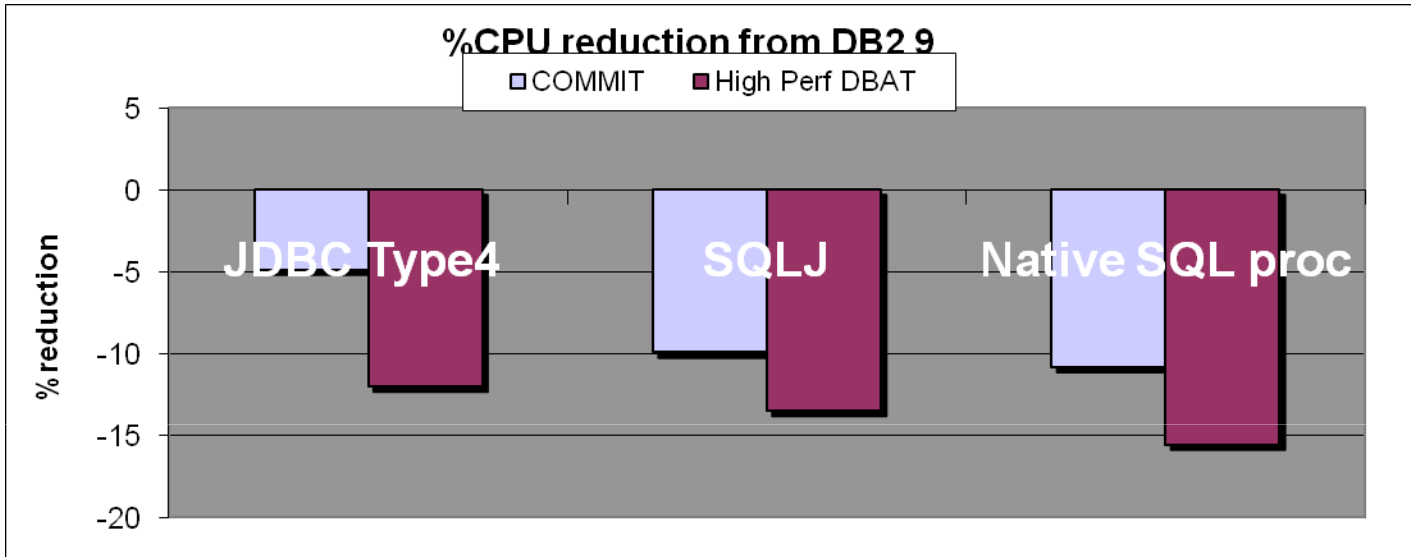
- **Re-introducing RELEASE(DEALLOCATE) in distributed packages**
  - Could not break in to do system maintenance - Utility or DDL
  - V6 PQ63185 to disable RELEASE(DEALLOACTE) on DRDA DBATs
- **High Performance DBATs reduce CPU consumption by**
  - RELEASE(DEALLOCATE) to avoid repeated package allocation/deallocation
  - Avoids processing to go inactive and then back to active
  - Bigger CPU reduction for short transactions commit often
- **Using High Performance DBATs**
  - Stay active if there is at least one RELEASE(DEALLOCATE) package exists
  - Connections will turn inactive after 200 commits to free up resources
  - Normal idle thread time-out detection will be applied to these DBATs
  - No benefit and not support for ACTIVE threads (CMSTATS=ACTIVE)
  - No benefit for KEEPDYNAMIC YES users

Enable High Performance DBATs

- **Two steps to enable High Performance DBAT**
  1. REBIND with RELEASE(DEALLOCATE)
     - Default BIND option in DB2 client driver will be RELEASE (DEALLOCATE) for the client matching with DB2 10 (DB2 connect and JCC 9.7 FP3a)
  2. Then command –MODIFY DDF PKGREL (BNDOPT)
     - No more support on PKGREL(DEALLOC) which was available early beta code
     - -DISPLAY DDF shows the option currently used
- **To disable,**
  - -MODIFY DDF PKGREL (COMMIT) to overlaid BNDOPT option
- **To monitor,**
  - Statistics GLOBAL DDF activity report

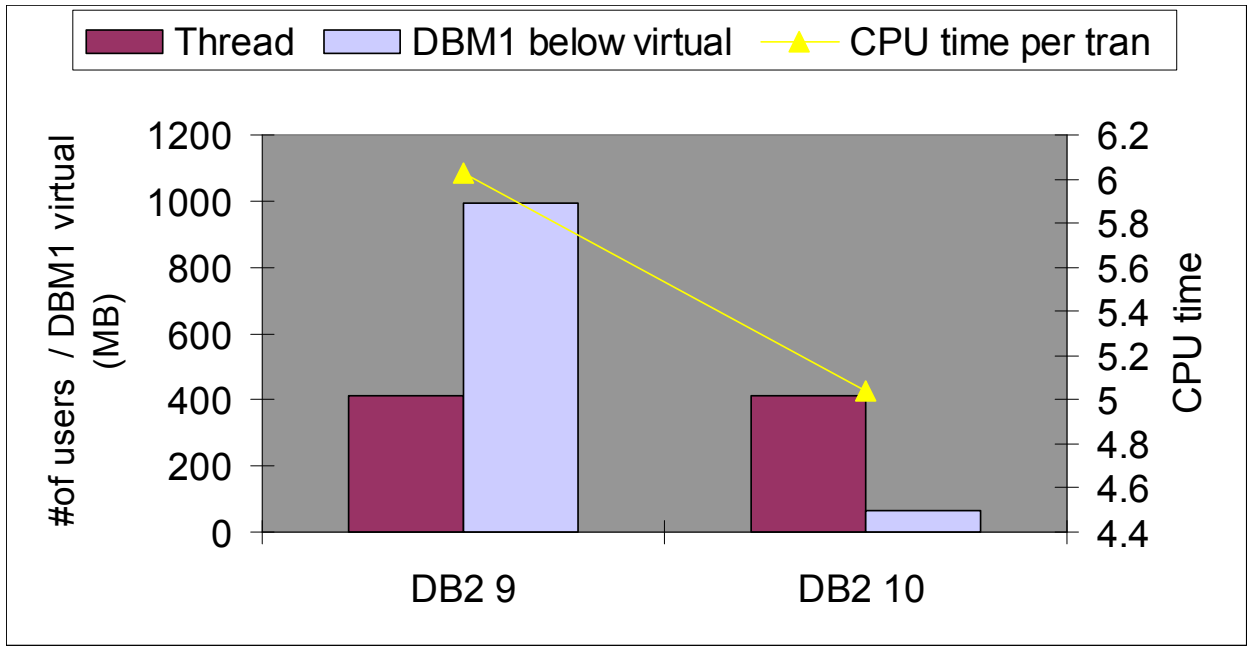
```
GLOBAL DDF ACTIVITY                QUANTITY
-------------------------          ---------
CUR ACTIVE DBATS-BND DEALLC            5.39
HWM ACTIVE DBATS-BND DEALLC           10.00
```

High Performance DBATs and CPU Reduction



- **Workload: distributed IRWW workloads with different interfaces show 4-7% further CPU reduction using High Performance DBATs**
- **37% CPU reduction with simple transactions with AutoCommit ON**

Virtual Storage Reduction from SAP Workload



- **Same 412 concurrent threads**
- **Virtual storage below the bar 997 MB with DB2 9 -> 63 MB in DB2 10**
- **No significant increase in real storage**
- **16% CPU time reduction**

DBM1 VSCR Monitoring

- **More focus on**
  - **Real storage usage**
  - **Common storage (ECSA and ESQA) usage**
- **New statistics in IFCID 225 reports**
  - **DBM1 address space : virtual below and above, real, #of user threads**
  - DIST address space : virtual below and above, real
  - Common and storage usage

```
DBM1 AND MVS STORAGE BELOW 2 GB                    QUANTITY
-----------------------------------------  ------------------
TOTAL NUMBER OF ACTIVE USER THREADS                  2694.28
  NUMBER OF ALLIED THREADS                            386.00
  NUMBER OF ACTIVE DBATS                             2275.06
  NUMBER OF POOLED DBATS                               33.21

REAL AND AUXILIARY STORAGE FOR DBM1                QUANTITY
 ----------------------------------------  ------------------
 REAL STORAGE IN USE                    (MB)         5396.07
   31 BIT IN USE                        (MB)          289.45
   64 BIT IN USE                        (MB)         5106.62
 HWM 64 BIT REAL STORAGE IN USE         (MB)         5106.64
```

Common Storage and Real Storage Usage

- **DB2 usage for ESQA**
  - SRB process
    - z/OS APAR OA33106 Reduction of suspend SRB process
- **DB2 usage for ECSA**
  - Common control blocks and distributed threads
    - Many are moved to HCSA or private storage above
  - Continue to monitor using IFCID225
    - QW0225GC + FC + VC
- **DB2 usage for Real Storage**
    - Private and shared storage
      - Buffer pool is 64 bit private storage
      - Majority of thread / stack storage is in 64 bit shared storage
  - Currently real storage usage for 64 bit shared storage is not reported accurately
    - New IFCID 225 counters to measure real storage value with z/OS support (APAR PM24723 and z/OS APAR OA35885)

Performance Scalability - DB2 Latches (CM)

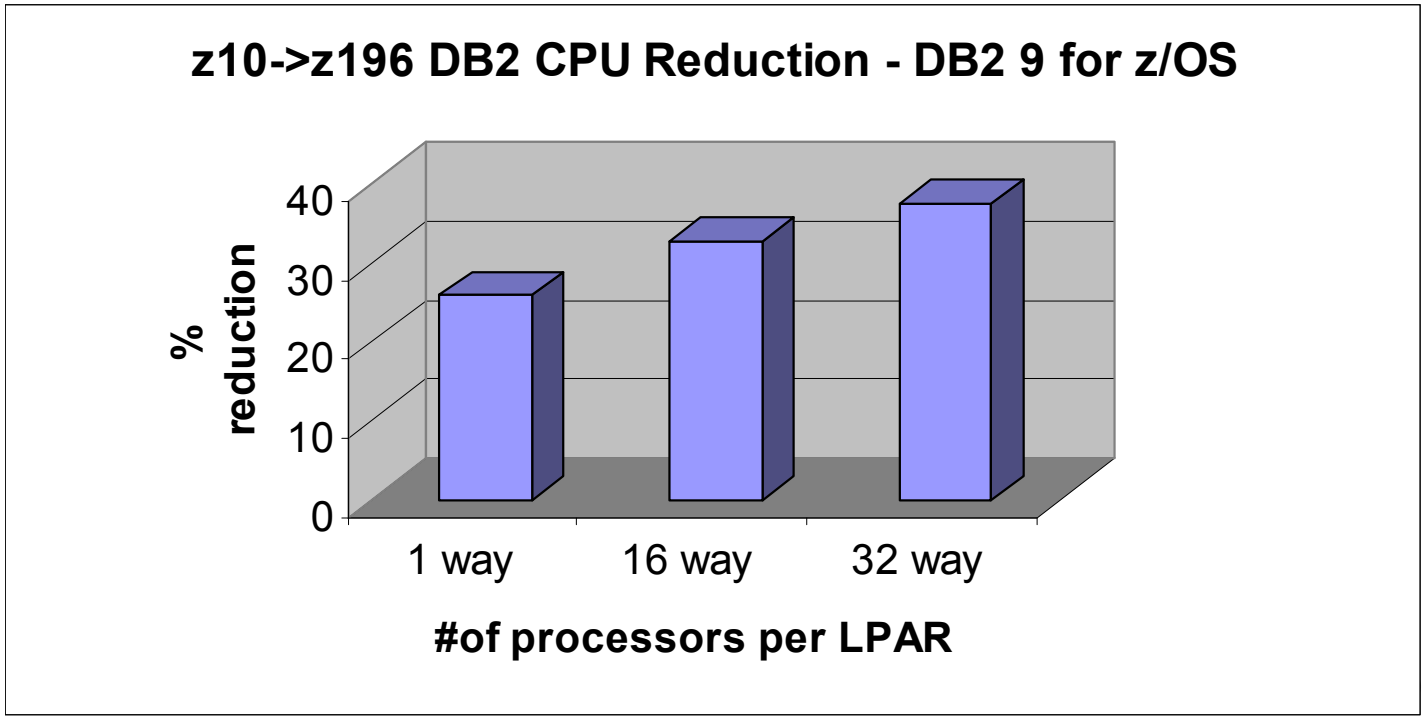
- **Faster process on latch suspend/resume**
- **Most of known DB2 latches are addressed in DB2 10**
  - LC12 : Global Transaction ID serialization
  - LC14 : Buffer Manager serialization
  - LC19 : Log write in both data sharing and non data sharing
  - LC24 : EDM thread storage serialization (Latch 24)
  - LC24 : Buffer Manager serialization (Latch 56)
  - LC25 : EDM hash serialization
  - LC27 : WLM serialization latch for stored proc/UDF
  - LC32 : Storage Manager serialization
- **Internal contention relief**
  - IRLM : IRLM hash contention
  - CML : z/OS Cross Memory Local suspend lock
  - UTSERIAL : Utility serialization lock for SYSLGRNG (*NFM)
  - Concurrent RE/BIND and most of DDL (*NFM)

Exploitation of system z Hardware

- **z10 and zEnterprise 196 prefetch instruction**
- **Large page frame size (1MB page frame) for buffer pools**
  - Why Large pages?
    - Significant reduction of hit miss in TLB (translation lookaside buffer)
  - z10 and z196
  - IEASYSXX LFAREA=(xx%| xxM | xxG| xxT) and RE-IPL
    - Backed by 256 contiguous 4K real frames and not page-able.
  - 1MB page is fixed, 64bit private pool
  - Buffer pools with long term page fix (**PGFIX=YES**)
    - If 1MB page frames are available, DB2 will request 1MB first
  - Long Term Page Fix from DB2 V8 to reduce CPU cost for I/O operations even without 1MB
  - 1MB page frames to reduce CPU cost during get pages and release pages
    - Buffer pools with large variations of getpage activities
  - Observed 1-4% CPU reduction in workload level by using 1MB page frames

DB2 and zEnterprise 196

- **Available in Sept 2010**
  - Larger processor cache (1.5MB L2 per core, 24MB L3 per chip, 129MB L4)
  - DB2 9 OLTP, Insert, Utility and query workloads observing 20% to 40% DB2 CPU reduction compared to **z10** processors. Typical range is 25 to 35 %.
  - Higher DB2 CPU reduction can be achieved as #of processors per LPAR increases → Best fit with DB2 10 scalability
  - More than 20% improvement with **DB2 10** compared to DB2 9 on z196 64 way



Buffer Pool Related Enhancements

- **Large real and DB2 managed in memory buffer pool**
  - z196 supports up to 3TB memory
  - PGSTEAL = NONE
    - Pre-load the data at the first open or at ALTER BPOOL
    - Avoid unnecessary prefetch request (similar to VPSEQT=0)
    - Avoid LRU maintenance -> no LRU latch
- **Buffer pools allocation as needed**
  - No more penalty for BP over-sizing
    - In DB2 9, an entire buffer pool is allocated when first used
    - If a defined size is bigger than actual used size and using PGFIX=YES
- **Table space buffer pools are no longer allocated when index-only access**

Migration Story..

- DB2 9 NFM REBIND with PLANMGMT
- Migrate to DB2 10 CM without REBIND
- Enable 1MB page usage for key buffer pools
  - 1-4% CPU reduction
- Rebind step by step under DB2 10 CM
  - Virtual storage reduction
  - CPU reduction from avoiding “conversion” of packages, SPROC re-enablement
- Rebind selective applications with Release Deallocate
  - Key online transactions frequently executed, DDF applications
- Enable DB2 10 NFM
- Enable DB2 10 performance feature

Migration Performance - Early Experience

- **Skip Migration Performance**
- **Catalog tables are replaced with UTS and LOB in NFM**
  - Performance of ENFM process
- **Concurrent REBIND/BIND/DDL in NFM**
  - CPU/Elapsed increase in single bind, utilize parallel bind jobs
    - Plan management is turned on as default
    - Inline LOB is used for SPT01
  - Limitation on concurrent DROP database
- **Workload with very short running transactions**
  - May not see improvement
  - Good candidates for Release Deallocate or High performance DBATs
- **REBIND**
  - Virtual storage usage
  - Re-enable SPROC (Fast column processing)
    - IFCID 224 records the package with migrated SPROC
  - Packages with CPU Parallelism IFCID 360
    - IFCID360 records the migrated packages with CPU parallelism which causes incremental bind

Utility Performance

- **Significant improvement in DB2 9 and service stream**
- **Equivalent performance from DB2 9 in most of utilities**
- **Elimination of Utility serialization (UTSERIAL) in NFM**
- **Dataset Level Flashcopy support**
- **RUNSTATS**
  - Collect KEYCARD information as default
    - RUNSTATS / INLINE STATISTICS correlation-stats
    - Key cardinality statistics will always be collected with INDEX keyword
  - zIIP eligible for portion of RUNSTATS
    - Not for INLINE statistics
  - AUTO Sampling
    - Better sampling using page sampling based on Real Time Stats
    - Significant CPU & ET savings
    - TABLESAMPLE SYSTEM AUTO

Migration Performance – zIIP usage

- **More zIIP support for TCO improvement**
  - Portion of RUNSTATS utility (Class 1 CPU)
    - Redirection rate varies depends on the RUNSTATS option
  - Parsing process of XML Schema validation (Class 2 CPU)
    - 100% of new validation parser is eligible
      - Can be zIIP, zAAP, or zAAP on zIIP
      - Retro fit into DB2 9 via PK90032 (preconditioning), PK90040 (enabling)
  - Portion of DBM1 processes
    - Prefetch I/Os (DBM1 SRB)
    - Deferred write I/Os (DBM1 SRB)

Beta Customers' Feedback – Workload level

Workload	Results
CICS online transactions	Approx. 7% CPU reduction in DB2 10 CM after REBIND, 4% additional reduction when 50MB of 1MB page frames are used for selective buffer pools
CICS online transactions	Approx 12% CPU reduction
CICS online transactions	Approx 5% CPU reduction from DB2 8
CICS online transactions	No CPU reduction - Candidate of release deallocate usage
Distributed Concurrent Insert	50% DB2 elapsed time reduction, 15% chargeable CPU reduction **after enabling high perf DBAT**
Data sharing heavy concurrent insert	38% CPU reduction
Queries	Average CPU reduction 28% from V8 to DB2 10 NFM
Batch	Overall 20-25% CPU reduction after rebind packages

1. System Level Performance and Scalability

2. Application Level Performance
   - Migration performance without changing DDLs, applications
   - Improvement with DDL or application changes
     - **SQL Procedure Improvement**
     - **Insert, Update and Delete Performance**
     - **Fetch, SELECT performance**
     - **DDF , T2 access and dynamic SQL**
     - **Hash Access**
     - **LOB and XML**

3. Monitoring Support
4. Summary

SQL Procedure Performance (CM)

DB 9

Introduced native SQL Procedure

- Improvement by executing procedures in DBM1 instead of WLM address space
- Produce less SQL statements

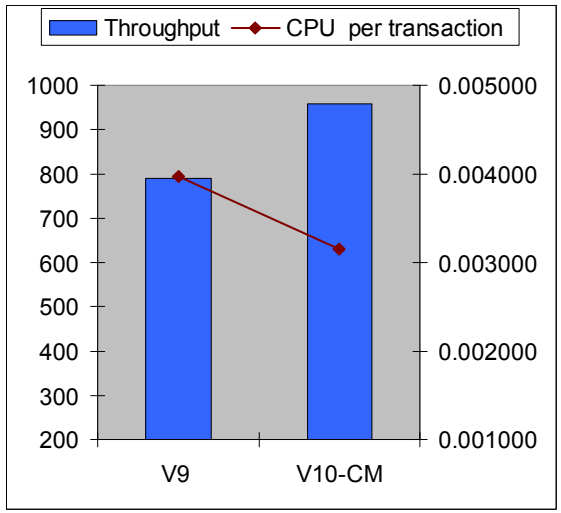
DB2 10

- Performance optimization for common path
- Specific CPU reduction in commonly used application logic
- SELECT values FROM SYSIBM.SYSDUMMY1
- Chained SET statement support (NFM)

Note: Improvement for SELECT values FROM SYSIBM.SYSDUMMY1

- Applies any applications
- CPU reduction by not calling DM modules

Comparing Native SQLPL Workload DB2 9 vs. DB2 10 CM



- **OLTP using SQLPL**
  - 20% CPU reduction with DB2 10 CM
  - 89% DBM1 Below the Bar usage reduction
  - 5% resp time improvement due to latch contention relief
    - Faster latch resolution
    - LC27 reduction

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Insert Performance Improvement

DB2 9

- Large index pages
- Asymmetric index split
- More index look aside
- Data sharing
  - Log latch contention
  - LRSN spin loop reduction
  - Remove log force write at new page (Seg,UTS) via PK83735/PK94122
- Support APPEND option
- RTS LASTUSED support

DB2 10 CM

- Space search improvement
- Index I/O parallelism for non-Seg TS
- Log latch contention reduction and faster log I/O during commit
- Additional index look aside
- Log Buffer to pagefix

DB2 10 NFM

- INCLUDE index
- Support Member Cluster in UTS
- Further LRSN spin avoidance for tables.

Improvement Applies to all TS types

1. **Candidate selection in Sequential Insert for all TS types**
   - Optimize when index manager picks the candidate RID during sequential insert
     - Result: Higher chance to find the space and avoiding a space search
   - Significant improvement in high concurrent insert for all types of Table Spaces with sequential or skip sequential input

2. **Log latch reduction in both data sharing and non data sharing**
   - DB2 9 Log latch reduction in data sharing
   - DB2 10 reduction in both non data sharing and data sharing
   - More LRSN spin avoidance in NFM
     - Avoid LRSN spins when same data/index pages are updates
     - Typical case : MRI

Improvement Applies to all TS types.. Continued

3. Parallel log I/Os for dual logging

- Shorter LOG write I/O wait as I/O requests are done parallel for LOGCOPY1 and LOGCOPY2

4. Long Term Page Fix for output log buffers

- Reduce MSTR SRB time during log I/Os

5. Referential integrity check performance

- Avoid RI check for each insert of a child under the same parent
- Sequential detection and index look aside for RI

Focus on UTS

- **Wider adaption of Universal Table Spaces**
  - Catalog Tables
  - New Functions : Hash Access, Inline LOB, Access Currently Committed
  - Alter Table Space types

1. **Segmented and UTS space search and CPU reduction**

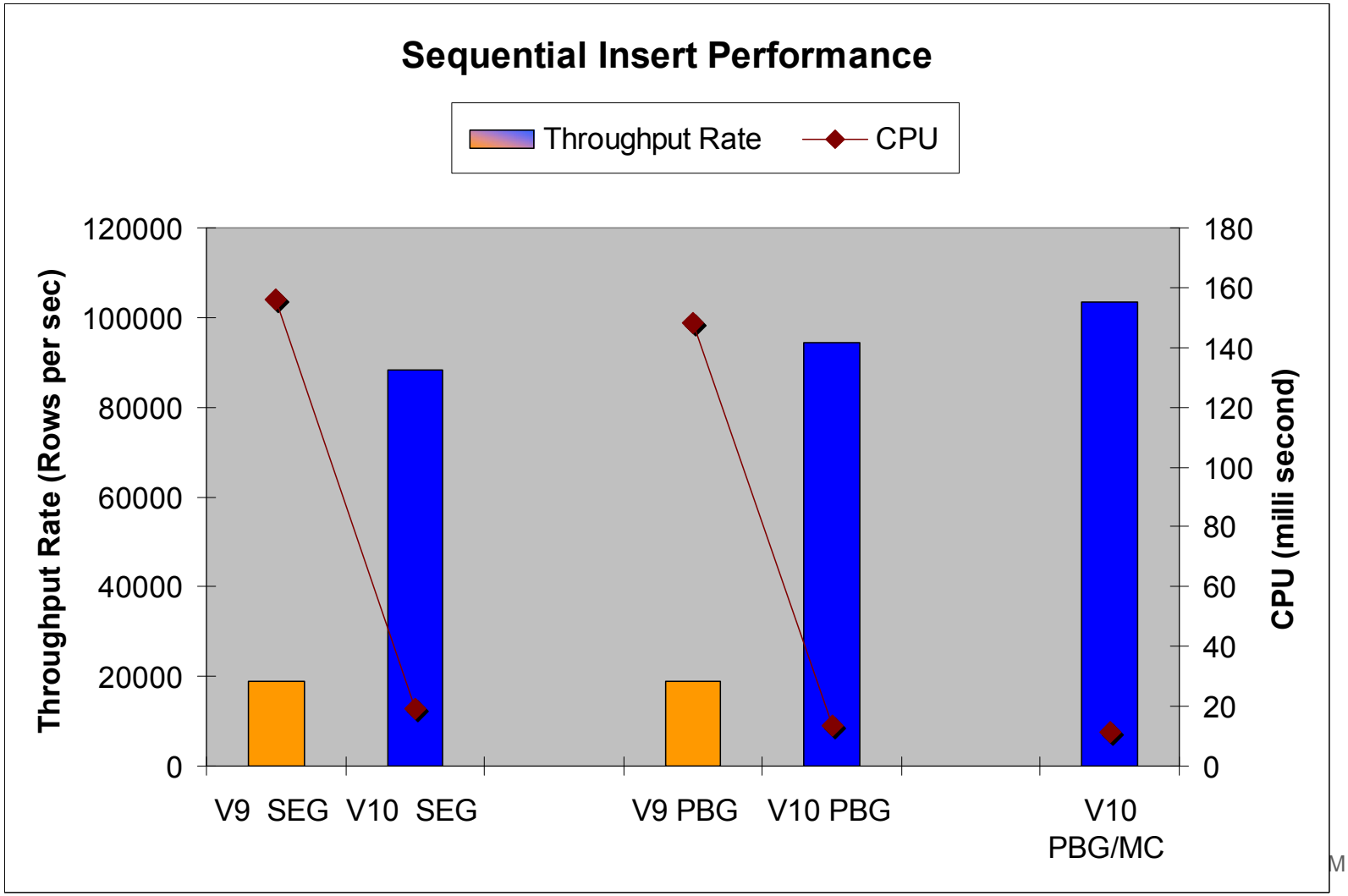
2. **Segmented and UTS space map page latch reduction**
   - Reduce the time held for space map latch

3. **Mass Delete Lock avoidance**

4. **UTS with MEMBER CLUSTER option (NFM)**
   - MEMBER CLUSTER does not maintain the clustering -> quicker space search in insert and remove the hot space map/data page in concurrent insert in data sharing
   - Same consequence during query due to loss of clustering

Insert Performance Improvement

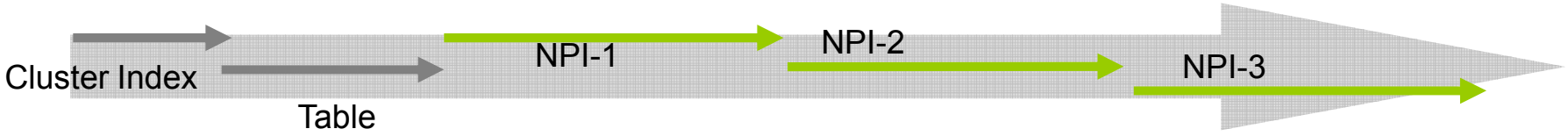
- **Sequential key insert into 3 tables from JDBC 240 clients in two way data sharing members. Using Muti Row Insert (batch size 100). Each member resides on LPARs with z10 8CPs.**



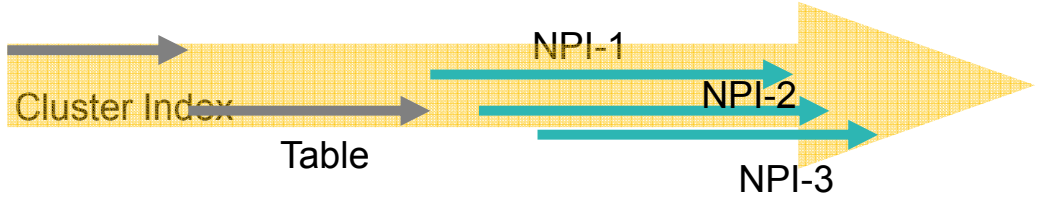
I/O Parallelism for Index Maintenance (CM)

- **zPARM INDEX_IO_PARALLELISM (default ON)**
  - Parallel read I/Os for additional indexes by using prefetch
  - Enabled only when there are index I/Os (buffer pool miss)
  - Applicable with all TS type except segmented TS
  - Enabled at 3rd (or 2nd if MC/APPEND) index update
- **Elapsed time reduction**
- **Class 2 CPU time reduction with additional prefetch cost (DBM1 SRB)**

DB2 9



DB2 10



Parallel I/Os for non Clustering indexes

INCLUDE Indexes (NFM)

- **DB2 9 definition**

  CREATE UNIQUE INDEX i1 ON t1(C1,C2)

  CREATE INDEX i2 ON t1(C1,C2,C3,C4)

- **Possible DB2 10 definition**

  CREATE UNIQUE INDEX i1 ON t1(C1,C2) INCLUDE (C3,C4)

  or

  ALTER INDEX i1 ADD INCLUDE (C3,C4)

  and DROP INDEX i2

- **Note the index becomes REBUILD PENDING status after ALTER**

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Select/Fetch Performance Improvement

DB2 9

Sort performance improvement , In memory workfile/Sparse index

Index on Expression

Many access path related improvements

- Plan Stability for static SQL statements
- Histgram statistics, and more..

DB2 10

CPU reduction on index predicate evaluation

RID Pool enhancement by using workfile

Better performance using a disorganized index

Row Level Sequential Detection

Group by using Hash, More in memory workfile usage

Dynamic statement cache support for literal constants

Many access path related enhancements

- Parallelism improvement
- IN list access improvement
- Auto stats…and more

CPU Reduction in Stage 1 Predicate Evaluation (CM)

```
SELECT name FROM employee
  WHERE  id > :H
AND status IN ('a','b','c','d') ;
```

- **Queries with stage 1 predicates with range, IN list, like**
  - No indication at Access Path Selection
  - Utilize dynamic optimization to evaluate the rows at runtime
  - Applicable in any workloads but higher improvement with queries where many rows are evaluated with multiple predicates
  - Performance improvement
    - Average improvement 20% from generic 150 queries
    - Individual queries shows between 1 and 70% improvement

CPU Reduction in Stage 2 Predicate Evaluation (CM)

SELECT name FROM employee WHERE (salary > 6700)

AND upper(code) =’iod’ ← stage2 predicate

- **DB2 9 Stage2 Predicate => Evaluate in RDS**
- **DB2 10 Stage2 Predicate can be evaluated at Data Manager**
  - Indicated during access path selection in PUSHDOWN column in DSN_FILTER_TABLE
  - Performance Improvement
    - Measured 10- 30% improvement from queries with stage2 predicates pushdown to DM

CPU Reduction in Sort Process (CM)

- **Simple ORDER BY sort**
  - DB2 9 : In memory sort is used if the results fit in 32KB
  - DB2 10 : In memory sort can be used if the results fit in 1MB
- **Internal SQL sort :**
  - Examples: Sort Merge Join, Non-correlated sub query using IN list
  - DB2 9 : workfile was created
  - DB2 10 : In memory workfile can be used
- **GROUP BY sort**
  - DB2 9 : Tournament sort
  - DB2 10: Hash sort for efficient GROUP BY operation

CPU Parallelism Enhancement

- **More Parallelism**
  - Parallelism with Multi Row Fetch with read only cursor
  - Parallelism with reverse index scan
  - Parallelism with workfile created by view, outer join, Tablefunction
- **Effective Parallelism**
  - Dynamic Record Range Partitioning
    - DB2 9 Key range partitioning based on LOW2KEY/HIGH2KEY
    - DB2 10 materialize the intermediate result in a sequence of join process, and divide into ranges with equal number of records
- **Balanced Parallel Tasks**
  - Straw Model
    - Smaller workgroup continues to work as it finishes

Improvement in using Disorganized Index (CM)

- **Index scan using disorganized index causes high sync I/O wait**
- **Disorganized index detection at execution**
- **Use List Prefetch on index leaf pages with range scan**
  - Reduce Synchronous I/O waits for queries accessing disorganized indexes.
  - Reduce the need of REORG Index
  - Throughput improvement in Reorg, Runstats, Check Index
- **Early performance results**
  - 2 to 6 times faster with simple select SQL statements with small key size using list prefetch compared to Sync I/Os
  - 2 times faster using list prefetch for online REORG an disorganized NPI

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