IBM System z Technology Summit

# Gain insight into DB2 9 and DB2 10 for z/OS performance updates and save costs

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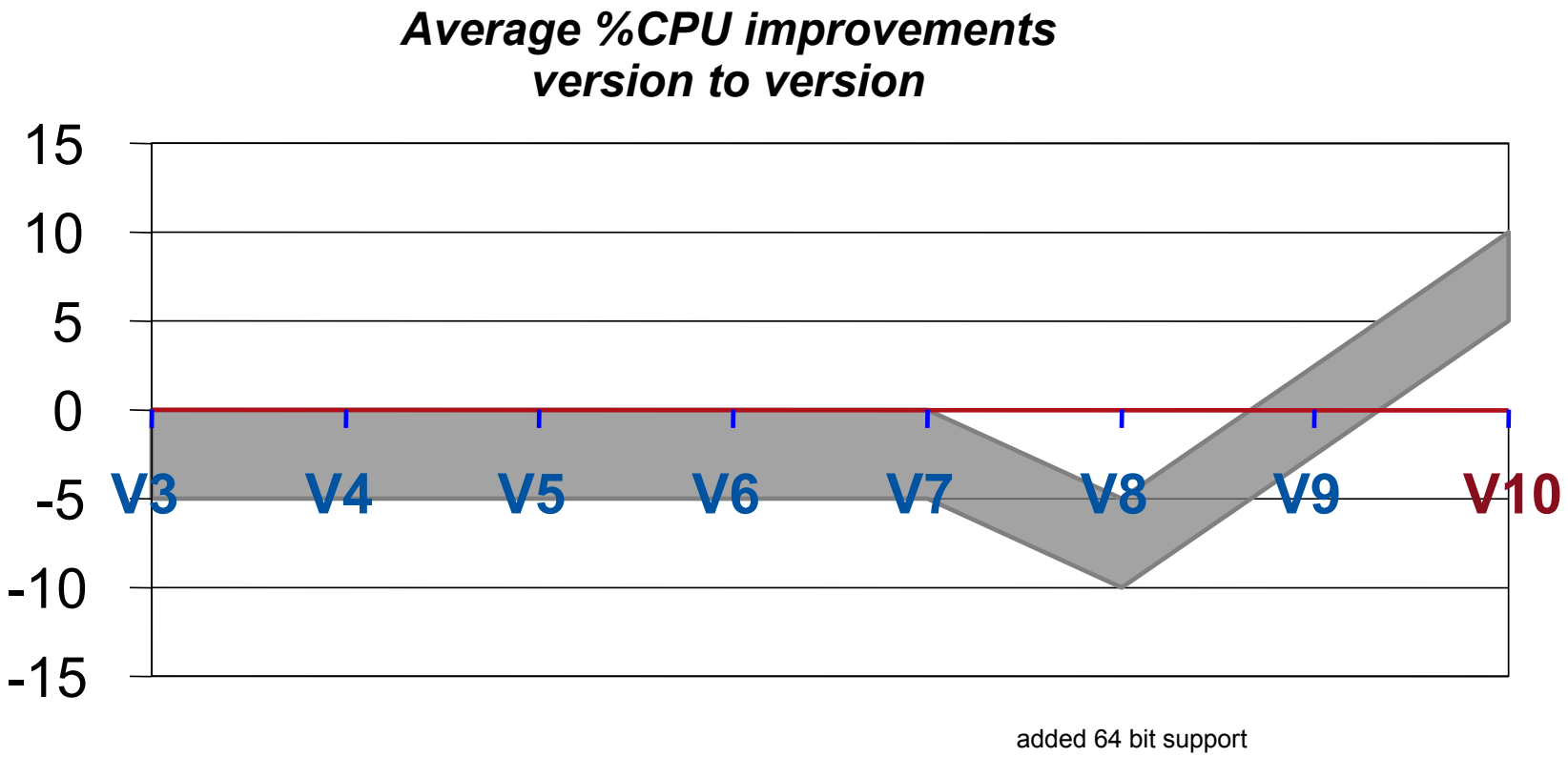
*This document contains performance information based on measurements done in a controlled environment. The actual throughput or performance that any user will experience will vary depending upon considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the 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.*

# DB2 10 Performance Preview

- **Abstract**
  - This session offers a look at performance impact of DB2 9 and DB2 10 for z/OS with particular emphasis on the DB2 10 improvements
- **Agenda**
  - DB2 10 for z/OS performance goals and expectations
  - Scalability and buffer pool enhancements
  - INSERT improvement
  - FETCH/SELECT improvement
  - JDBC and DDF performance
  - LOB, XML, and SQL procedure performance
  - Monitoring enhancements

# DB2 10 Performance Objective

Historical goal of <5% version-to-version performance regression
Goal of 5% -10% performance improvement for DB2 10



# DB2 10 Performance Expectation

## Most of workloads…

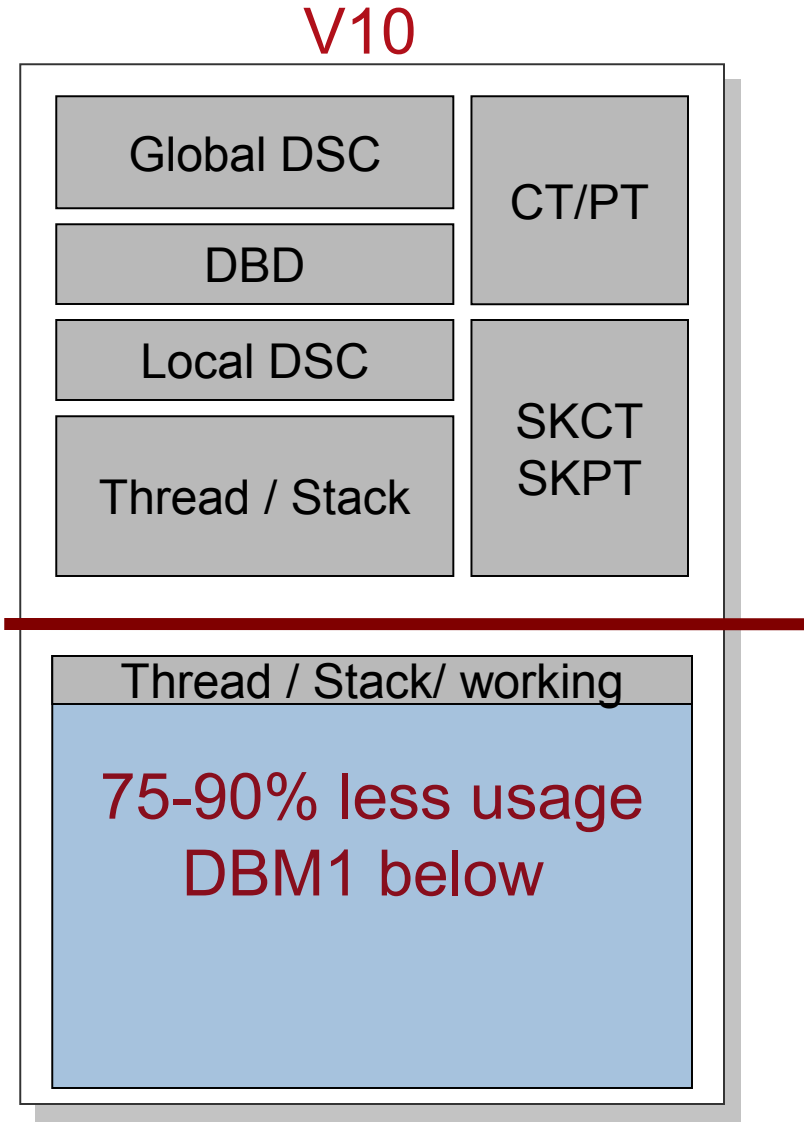
- Up to 10% CPU reduction after REBIND packages
- Higher improvement with workload with scalability issues in V8/V9 or accessed thru DRDA

## Sweet Spots…

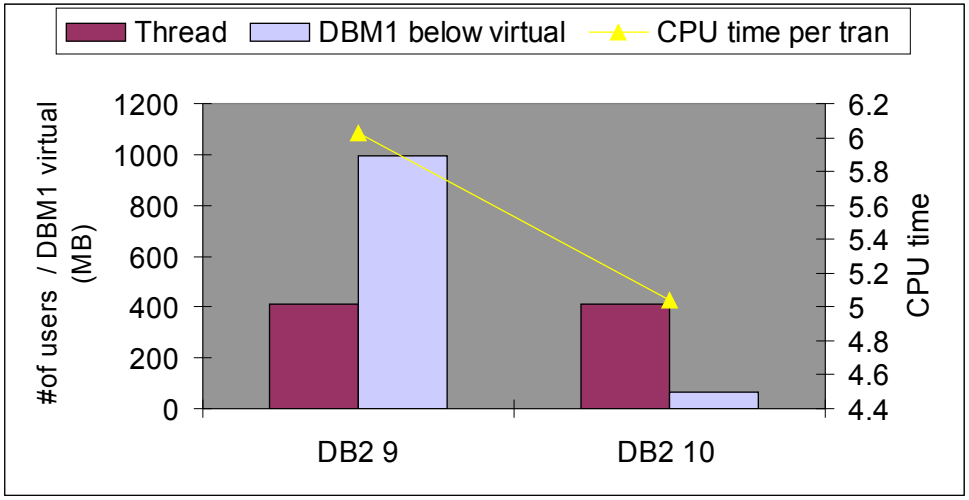
- Workload using native SQL procedures: up to 20% CPU reduction after DROP/CREATE or REGENERATE the procedures
- Query workload with positive access path changes
- Workload with frequent access on small LOB (NFM with Inline LOB)
- Workload with random, singleton select/update (NFM with Hash access)

# DBM1 Virtual Storage Constraint Relief

- **DBM1 below 2GB**
  - 75-90% less usage in V10 compared to V9
  - Some of working storage (stack, xproc storage) stays below 2GB
- **Larger number of threads**
  - Possible data sharing member consolidation
- **Improve CPU with storage**
  - More thread reuse
  - More release deallocate
  - High performance DBATs
  - Larger MAXKEEPD values for KEEPDYNAMIC=YES



# Virtual Storage Reduction from SAP Workload




- **412 concurrent threads**
- **Virtual storage below the bar**
  - 997 MB with DB2 9
  - 63 MB in DB2 10
- **No significant increase in real storage**

# DBM1 VSCR Monitoring

- **More focus on**
  - Real storage usage (PM24723)
  - Common storage (ECSA and ESQA) usage
- **New statistics in IFCID 225 reports**
  - DBM1 and DIST address space: virtual below and above, real, and aux
  - Common and Shared storage usage (z/OS APAR OA33106 SRB ESQA reduction)

```
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
```

# Performance Scalability - DB2 Latches (CM)

- **Most of DB2 latches from 64 cp scalability evaluation will have a relief**
  - 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
  - IRLM : IRLM hash contention
  - CML : z/OS Cross Memory Local suspend lock
  - UTSERIAL : Utility serialization lock for SYSUTILX (NFM)

# Performance Scalability - H/W synergy

- **Exploitation of z10 and z196 features**
  - CPU improvement using z10 and z196 prefetch instructions
  - Large fixed page frames for buffer pools
    - Buffer pools with PGFIX=YES
    - Define IEASYSxx LFAREA  1MB page frames
    - Reduction of hit miss in TLB (translation lookaside buffer)
  - Observed 1-4% CPU reduction
- **In-memory buffer pool with large real**
  - DB2 managed in-memory buffer pool
    - PGSTEAL = NONE
    - Pre-load the data at the first open or at ALTER BPOOL
    - Avoid unnecessary prefetch request
    - Avoid LRU maintenance → no LRU latch (LC14)

# INSERT Performance Improvement

## DB2 9

- Large index pages
- Asymmetric index split
- Data sharing Log latch contention and LRSN spin loop reduction
- More index look aside
- Support APPEND option
- RTS LASTUSED support

## DB2 10 CM

- Space search improvement
- Index I/O parallelism
- Log latch contention reduction and faster log I/O during commit
- Additional index look aside

## DB2 10 NFM

- INCLUDE index
- Support Member Cluster in UTS
- Complete LRSN spin avoidance

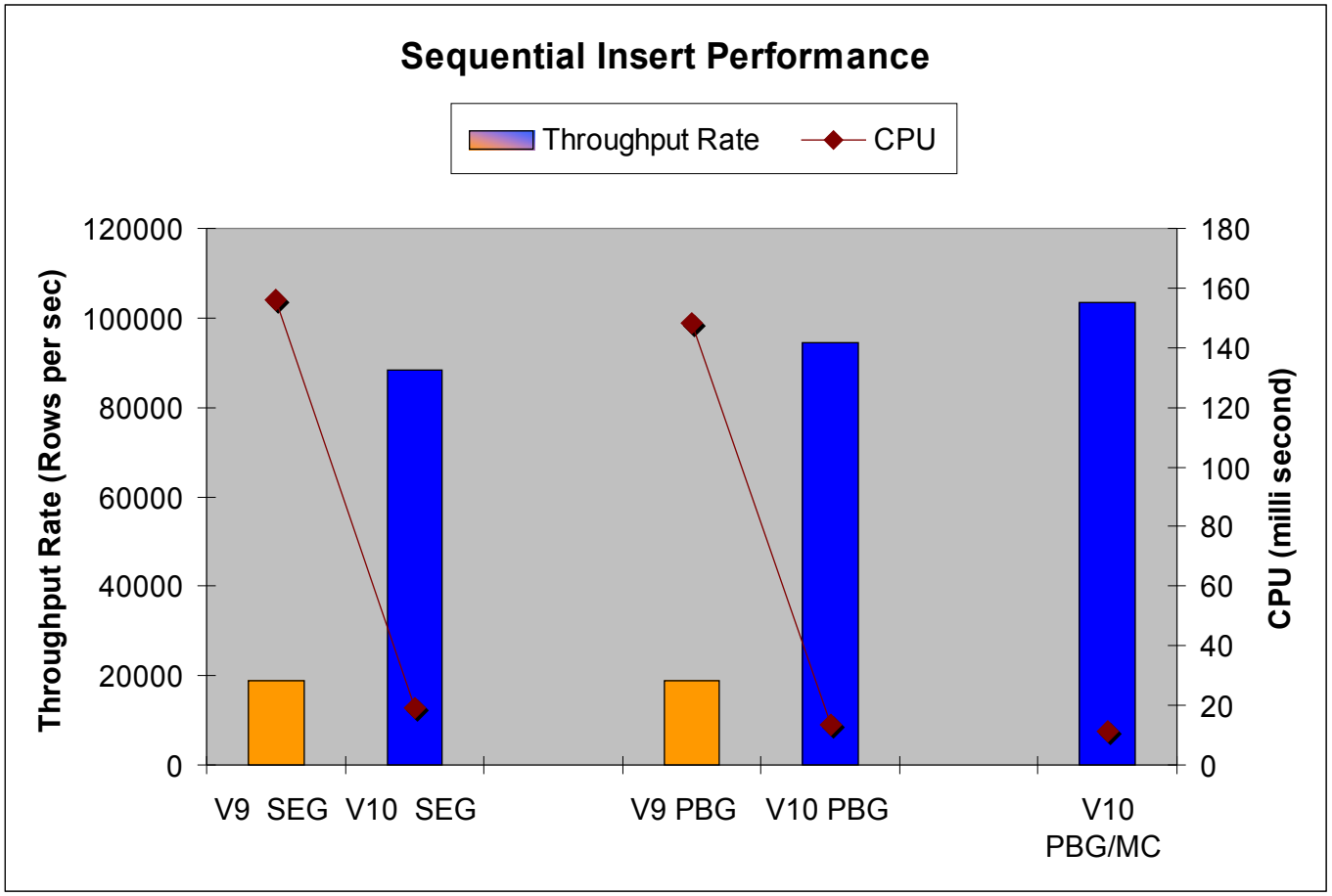
# Universal Table Space (UTS) – Member Cluster (NFM)

- **Member Cluster option in create table space**
  - Assigns a set of pages and associated space map page to each member
  - Remove the “hot spots” in concurrent sequential insert in data sharing
  - It does not maintain data cluster during the INSERT
  - Data cluster needs to be restored via REORG
  - Each space map contains 10 segments
- **Altering to MEMBER CLUSTER**

```
ALTER TABLESPACE MyTableSp
    MEMBER CLUSTER YES/NO;
```

  - REORG to materialize the pending alter

# INSERT Performance Improvement




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

# I/O Parallelism for Index Updates (CM)

| | |
|---|---|
| **V9** | During insert, DB2 executes index updates sequentially<br>Tables with many non-clustering indexes may suffer high synchronous read I/O wait |
| **V10** | I/O parallelism by prefetching index pages to overlap the I/Os against non-clustering indexes |

- **New zparm INDEX_IO_PARALLELISM (default YES)**
  - Parallel read I/Os for additional indexes by using prefetch
  - Enabled only when there are index I/Os (buffer pool miss)
  - Applicable with all table space types except segmented table space
  - Enabled with 3 or more indexes
- **Elapsed time reduction**
  - Effective to reduce I/O wait for large indexes that cannot fit in the buffer pools

# Additional Non-key Columns in a Unique Index (NFM)

| | |
|---|---|
| **V9** | **Multiple indexes per table**<br>An index is used to enforce uniqueness constraint<br>Additional indexes are necessary to achieve index-only access on columns not part of the unique constraint during queries<br>Higher Insert / Delete CPU time, increased storage requirements |
| **V10** | **Additional Non-key Columns in a unique index**<br>Reduce index maintenance cost during insert, DASD space savings |

# Additional Non-Key Columns in a Unique Index

- **V9 definition**

```
CREATE UNIQUE INDEX i1 ON t1(c1,c2,c3)
CREATE INDEX i2 ON t1(c1,c2,c3,c4,c5)
```

- **Possible V10 definition**

```
CREATE UNIQUE INDEX i1 ON t1(c1,c2,c3) INCLUDE (c4,c5)
          or
ALTER INDEX i1 ADD INCLUDE (c4,c5) and DROP INDEX i2
```

- **The following restrictions will apply:**
  - INCLUDE columns are not allowed in non-unique indexes
  - Indexes on Expression will not support INCLUDE columns
  - Indexes with INCLUDEd columns can not have additional unique columns ALTER ADDed to the index

# SELECT/FETCH Performance Improvement

| | |
|---|---|
| **V9** | Plan Stability for static SQL statements<br>Sort performance improvement, in memory workfile/sparse index<br>Index on Expression<br>Many access path related improvements<br>Histogram stats, etc. |
| **V10** | CPU reduction on index predicate evaluation<br>Better performance using a disorganized index<br>Row Level Sequential Detection<br>Group by using Hash, More in memory workfile usage<br>Dynamic statement cache support for literal constants<br>Many access path related enhancements<br>-Parallelism improvement<br>-IN list access improvement<br>-Auto stats…and more |

# CPU reduction in Predicate Evaluation (CM)

- **Optimize in index predicate evaluation process**
  - Applicable in any workload but query with many predicates shows higher improvement
- **Performance improvement**
  - Average improvement shows average 20% CPU reduction from generic 150 queries
  - Individual queries show between 1 and 70% improvement

# Improvement in using Disorganized Index (CM)

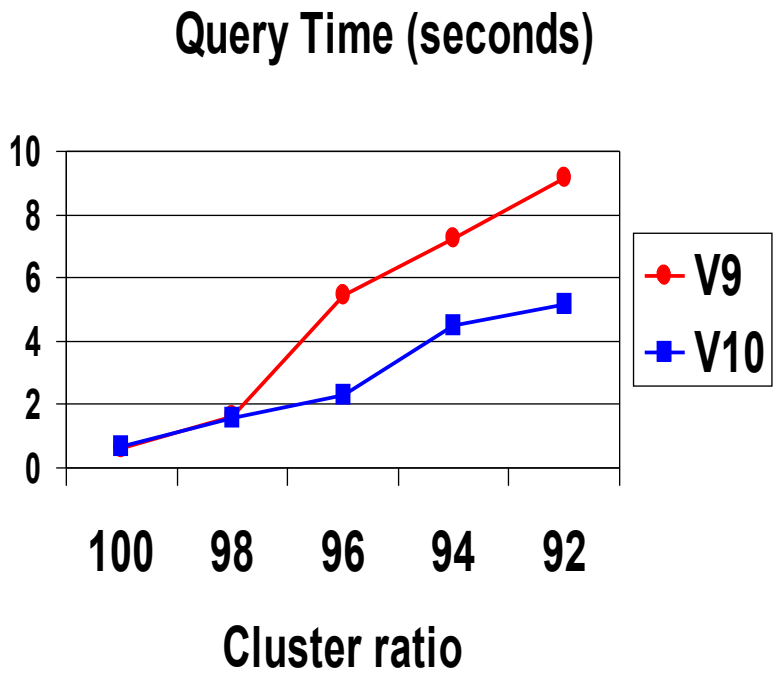
- **Index scan using disorganized index causes high sync I/O wait**
- **Disorganized index detection at execution**
- **Use List Prefetch on index leaf pages with range scan**
  - Reduce Synchronous I/O waits for queries accessing disorganized indexes
  - Reduce the need of REORG Index
  - Throughput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

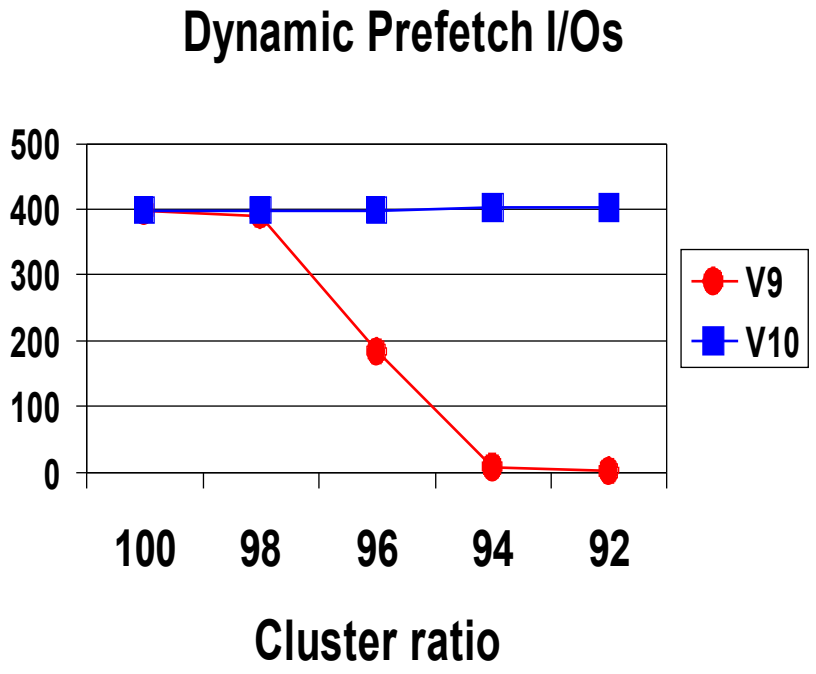
# Row Level Sequential Detection (CM)

- **Problem**
  - Dynamic prefetch sequential works poorly when the number of rows per page is large
- **Solution**
  - Row Level Sequential Detection (RLSD)
  - Count rows, not pages to track the sequential detection
  - Since DB2 10 will trigger prefetch more quickly, it will use progressive prefetch quantity
    - For example, with 4K pages the first prefetch I/O reads 8 pages, then 16 pages, then all subsequent I/Os will prefetch 32 pages (like today)
    - Also applies to indexes

# Index → Data Range Scan

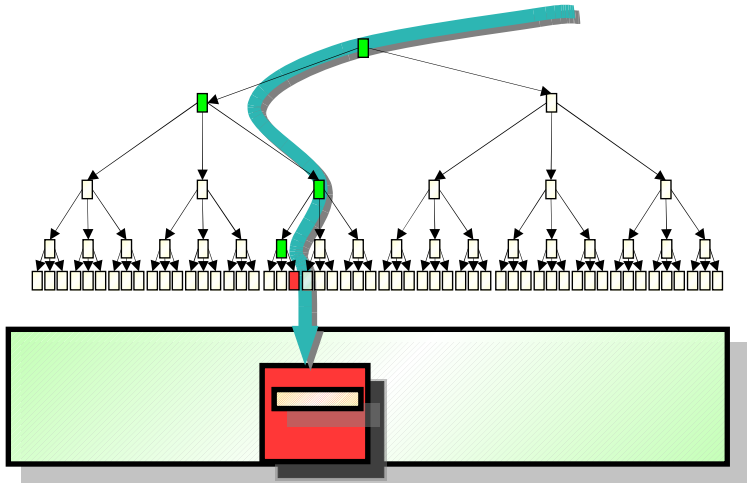
**Row size = 49 bytes, page size = 4K (81 rows per page)**
**Read 10% of the rows in key sequential order**

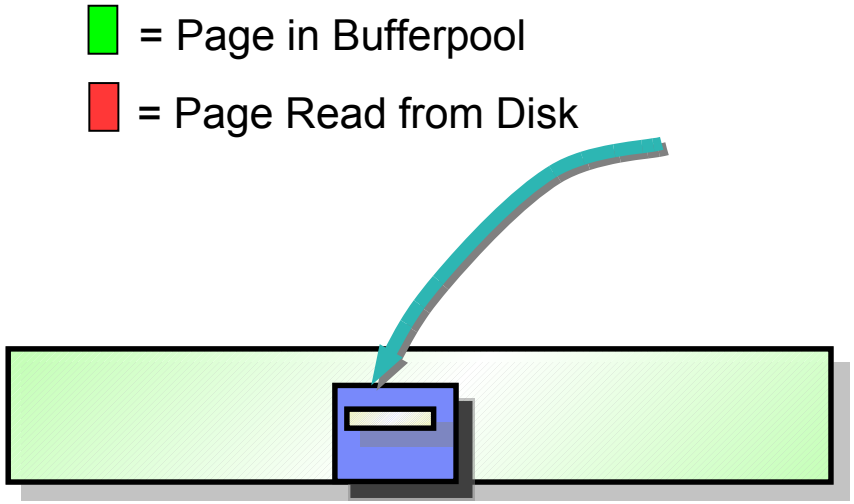



- Row level sequential detection (RLSD) preserves good sequential performance for the clustered pages

# Index to Data Access Path vs. Hash Access

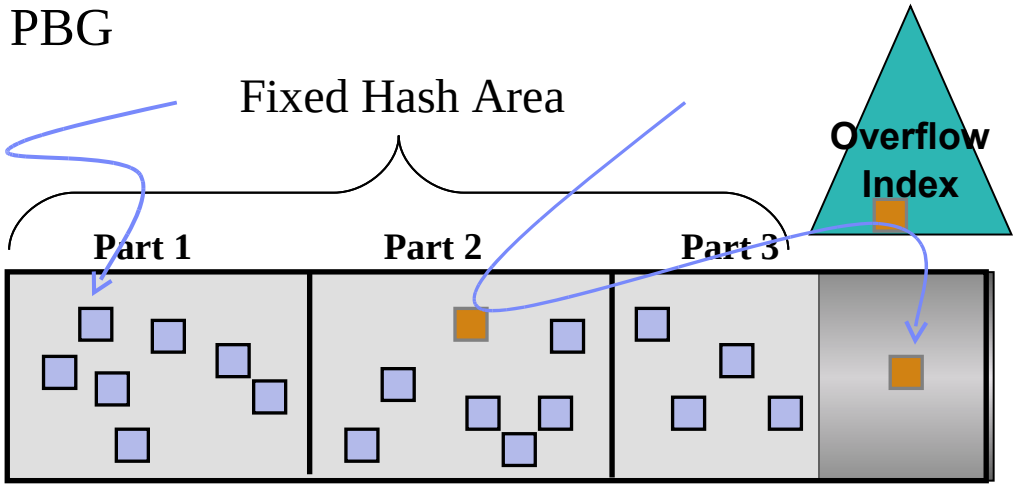


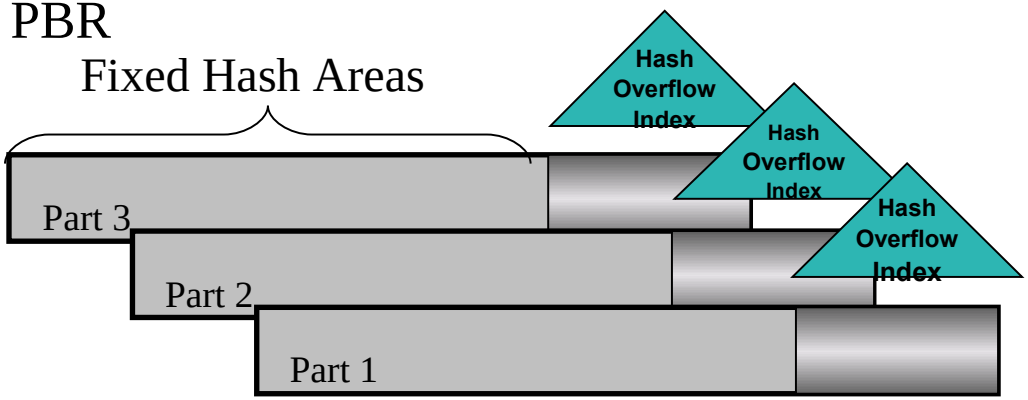



- **Index->Data access**
  - Traverse down Index Tree
  - For a 5 Level Index
    - 6 GETP
    - 2 I/O's
  - 5 index page searches

- **Hash Access**
  - Locate a row without having to use an index
  - Single GETP in most cases
  - 1 Synch I/O in common case
  - Greatly reduced search CPU expense

# Hash Access and Hash Space




- **Optimal to get from fixed area**
  - 1 getpage, 1 I/O
- **Overflow**
  - 3 getpages, 2-3 I/Os
- **Use REORG with AUTOESTSPACE YES unless you know better**
- **Real Time Statistics (RTS)**
  - # of overflow TOTALENTRIES
  - TOTALENTRIES / TOTALROWS < 10%
- **FREEPAGE is not valid for HASH space but PCTFREE is honored**

# Hash Access Summary

- **Performance benefit**
  - Up to 30% DB2 CPU reduction with random access
    - Higher improvement with large table with small rows
    - Savings in index maintenance once you remove the clustering index
  - Possible reduction in Hotspots
    - Rows are randomly distributed

- **Performance concern**
  - Not for sequential fetch nor insert
    - Significant Sync I/O increase if accessed in clustering order
    - No Member Cluster support
    - Careful research is necessary on picking the candidate
      - Statement level of monitoring for GetPage and I/Os
  - Significant impact on LOAD utility using input data with clustering order
    - Relief is coming soon
  - Possible INCREASE in I/O or BP space in some cases
    - In case of small ‘active’ working set
    - In case of many “row not found”

# Local JDBC and ODBC Application Performance

- **Local Java and ODBC applications did not always perform faster compared to the same application called remotely**
  - DDF optimized processing with DBM1 that was not available to local ODBC and JDBC application
  - zIIP offload significantly reduced chargeable CP consumption
- **Open support of DDF optimization in DBM1 to local JCC type 2 and ODBC z/OS driver**
  - Limited block fetch
  - LOB progressive streaming
  - Implicit CLOSE
- **Expect significant performance improvement for applications with**
  - Queries that return more than 1 row
  - Queries that return LOBs

# High Performance DBATs

- **Re-introducing RELEASE(DEALLOCATE) in distributed packages**
  - Could not break in to do DDL, BIND
  - 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
- **Using High Performance DBATs**
  - Stay active if there is at least one RELEASE(DEALLOCATE) package exists
  - Connections will turn inactive after 200 times (not changeable) to free up DBAT
  - Normal idle thread time-out detection will be applied to these DBATs
  - Good match with JCC packages
  - Not for KEEPDYNAMIC YES users

# Enable High Performance DBATs

- **Two steps to enable High Performance DBAT**
  - 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)
  - Then command -MODIFY DDF PKGREL (BNDOPT)
    - -DISPLAY DDF shows the option currently used
- **To disable**
  - -MODIFY DDF PKGREL (COMMIT) to overlay BNDOPT option
    - Same as V9 inactive connection behavior
    - Will allow BIND and DDL to run concurrently with distributed work
- **To monitor**
  - GLOBAL DDF activity
    - Statistics report

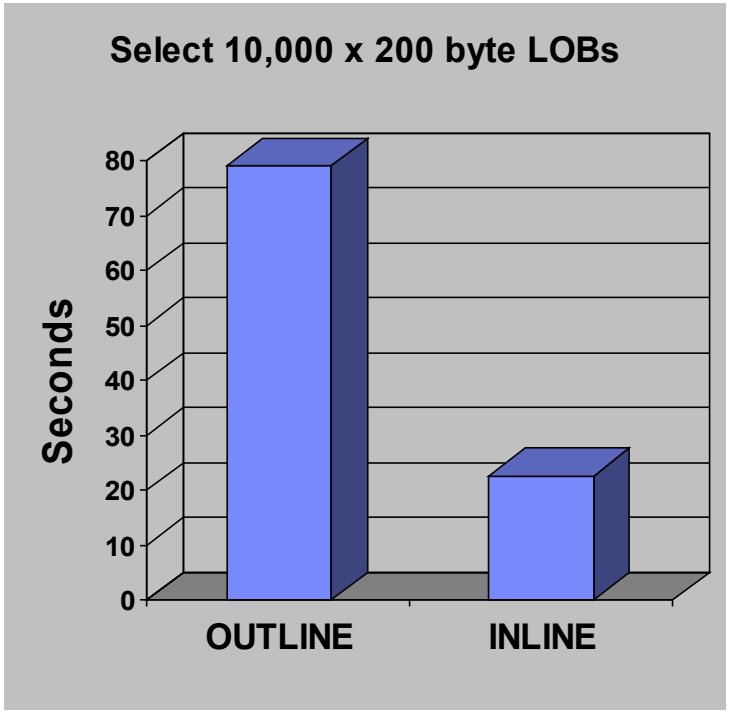
```
GLOBAL DDF ACTIVITY            QUANTITY
-------------------------      ---------
CUR ACTIVE DBATS-BND DEALLC        5.39
HWM ACTIVE DBATS-BND DEALLC       10.00
```

# Inline LOBs (NFM)

- **CREATE or ALTER TABLE INLINE LENGTH on UTS**
  - INLINE to base table up to 32K bytes
- **Completely Inline LOBs**
  - Reduce DASD space
    - No more one LOB per page, Compression
  - CPU and I/O saving
    - Avoid LOB aux indexes overhead
- **Split LOBs**
  - A part of LOB resides in base and other part in LOB TS
  - Incur the cost of both inline and out of line
  - Index on expression can be used for INLINE portion

# Inline LOBs (NFM) …

*Elapsed time in random select*




Very small LOBs select, insert shows Up to 70% elapsed time reduction with INLINE LOBs

- **Inline is good, if**
  - Most of LOBs are small and only a few are large ones
  - Compress well
- **Inline is not good, if**
  - Most of LOBs become “split LOB” unless indexing is important for inlined portion
  - Majority of SQLs do not touch the LOB columns
- **Base table becomes larger with Inline**
  - Buffer hit ratio for base table may decrease
  - Image copy of base table becomes larger

# XML Performance Improvement

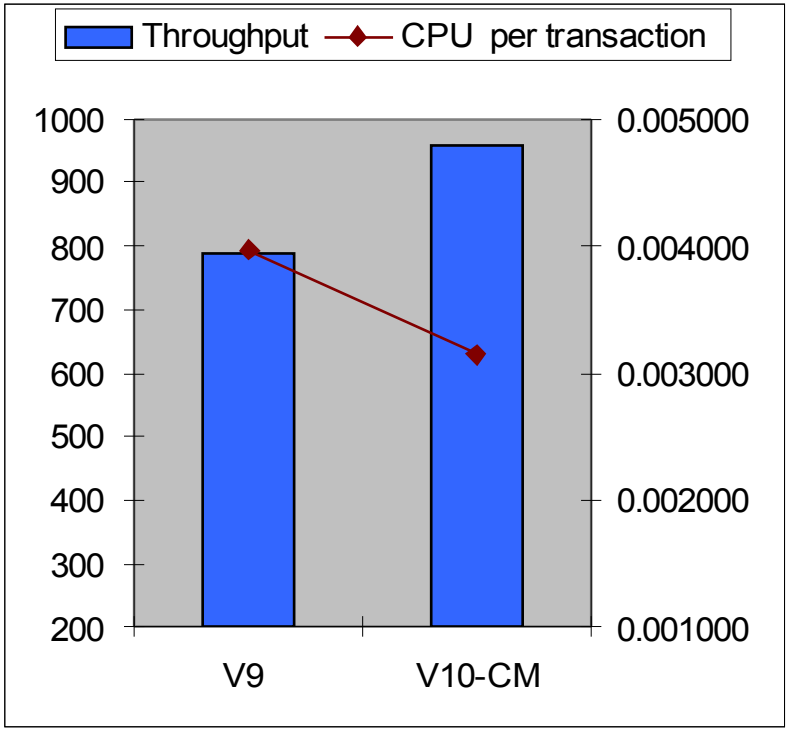
- **Significant Performance improvement in V9 service stream**
- **DB2 10 performance improvement**
  - Binary XML support
    - Avoid the cost of XML parsing during insert
    - Reduce the XML size
    - Measured 10-30% CPU and elapsed time improvement
  - Schema Validation in engine
    - No more UDF call for validation
    - Utilize XML System Service Parser
      - 100% zIIP / zAAP eligible for validation parser cost
  - XML Update
    - No more full document replace

# SQL Procedure Performance (CM)

| | |
|---|---|
| **V9** | **Introduced native SQL Procedure**<br>Improvement by executing procedures in DBM1 instead of WLM address space |
| **V10** | **Further performance optimization for Native SQL Procedures**<br>Specific CPU reduction in commonly used areas<br>-Pathlength reduction in IF statement<br>-Optimization in SELECT x from SYSDUMMY1 |

# Measurements – SQLPL (CM)

- **OLTP using SQLPL**
  - 20% CPU reduction with V10 CM
  - 89% DBM1 Below the Bar usage reduction
  - 5% resp time improvement due to latch contention relief



# DB2 10 Monitoring Enhancements and Changes

- **New Monitor Class 29 for statement detail level monitoring**
  - IFCID 316/318 for dynamic, 400/401 for static
- **Record index split with new IFCID 359**
- **Separate Accounting to identify DB2 latch and transaction lock in Class3**
- **Package LASTUSED**
- **Storage statistics (IFCID225) for DIST address space, shared and common storage**
- **Specialty Engines**
  - Possible redirection value (zIIP SECP) is no longer supported, always zero SE CPU (actual offloaded CPU time) continues to be available
  - Portion of RUNSTATS utility (redirect rate depends on RUNSTATS parms)
  - Parsing process of XML Schema validation
  - Prefetch and Deferred Write Engines redirected 100%

# DB2 10 Monitoring Enhancements and Changes

- **Package accounting information with rollup**
- **Statistics trace interval**
  - Always 1 minute interval in V10 no matter what you use in STATIME for critical statistics records
- **Compression for DB2 trace data in SMF**
  - New zparm SMFCOMP
  - Overhead is minimum (up to 1% measured )
  - Up to 90% SMF data set saving from measurements
  - Trace formatter needs to be modified to call z/OS services to decompress the data

# Beta Customers' Feedback – Workload level

| Workload | Results |
|---|---|
| CICS online transactions | Approx. 7% CPU reduction in DB2 10 CM after REBIND, 4% additional reduction when 1MB page frames are used for selective buffer pools |
| CICS online transactions | Approx 10% CPU reduction from DB2 9 |
| CICS online transactions | Approx 5-10% CPU reduction from DB2 8 |
| CICS online transactions | Approx 10% CPU increase -> investigating<br>Candidate for 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 |

# Beta Customers' Feedback – Line Item Focused

| Workload | Results |
|---|---|
| Multi row insert | 33% CPU reduction from V9, 4x improvement from V8 due to LRSN spin reduction |
| Query with 10 stage 1 predicates | 5 index matching, 1 index screening, range and IN predicates<br>60% CPU reduction with same access path |
| Parallel Index Update | 30-40% Elapsed time improvement with class 2 CPU time reduction |
| Inline LOB | SELECT LOB shows 80% CPU reduction |
| Include Index | 17% CPU reduction in insert after using INCLUDE INDEX |
| Hash Access | 20-30% CPU reduction in random access<br>No improvement or some degradation in CICS workload<br>16% CPU reduction comparing Hash Access and Index-data access<br>5% CPU reduction comparing Hash against Index only access<br>20x elapsed time increase in sequential access |

Thank you !

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