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

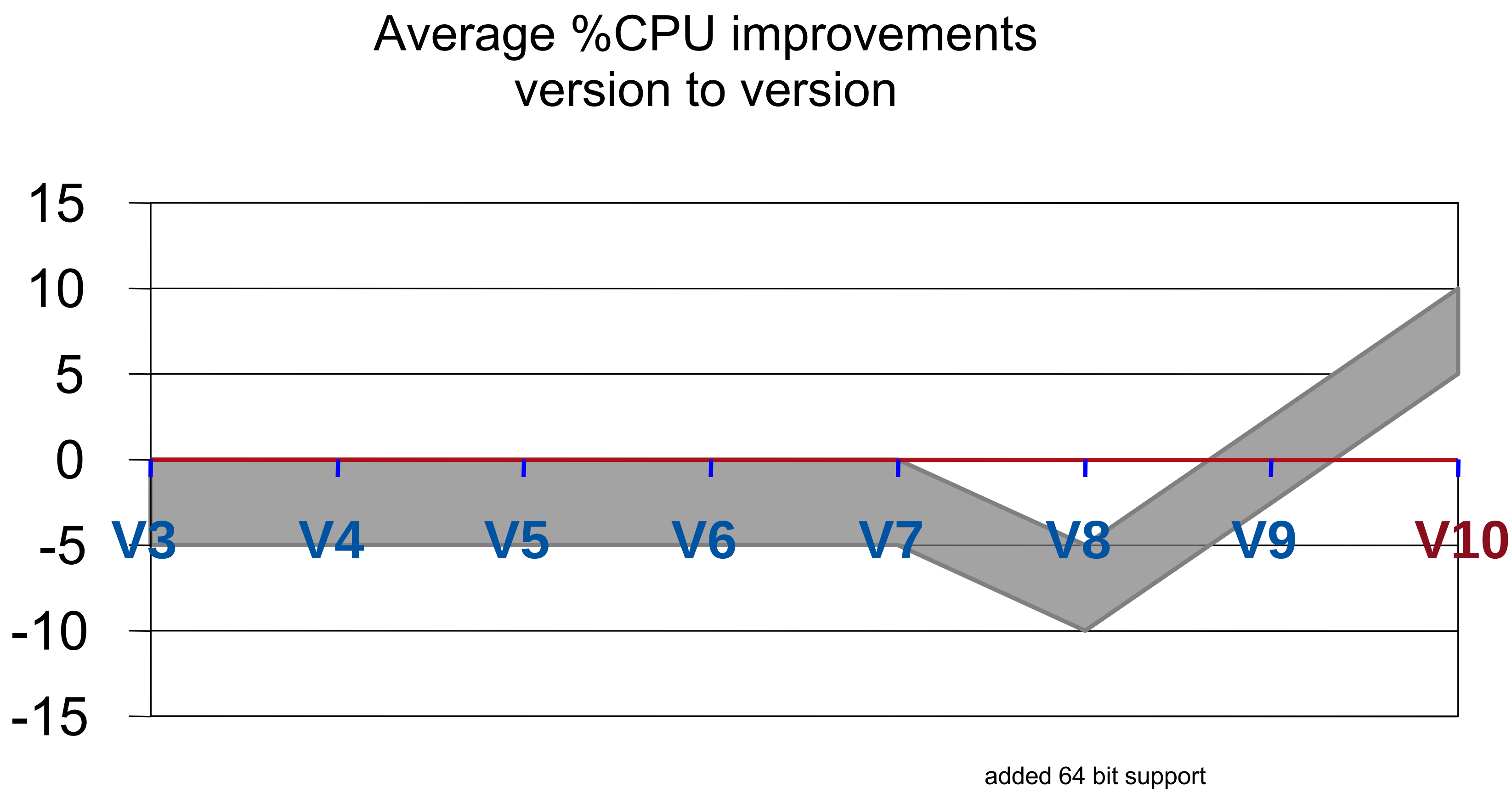
- **Abstract**

  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
  - LOB, XML, and SQL procedure performance
  - JDBC and DDF performance

# 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 workloads…**

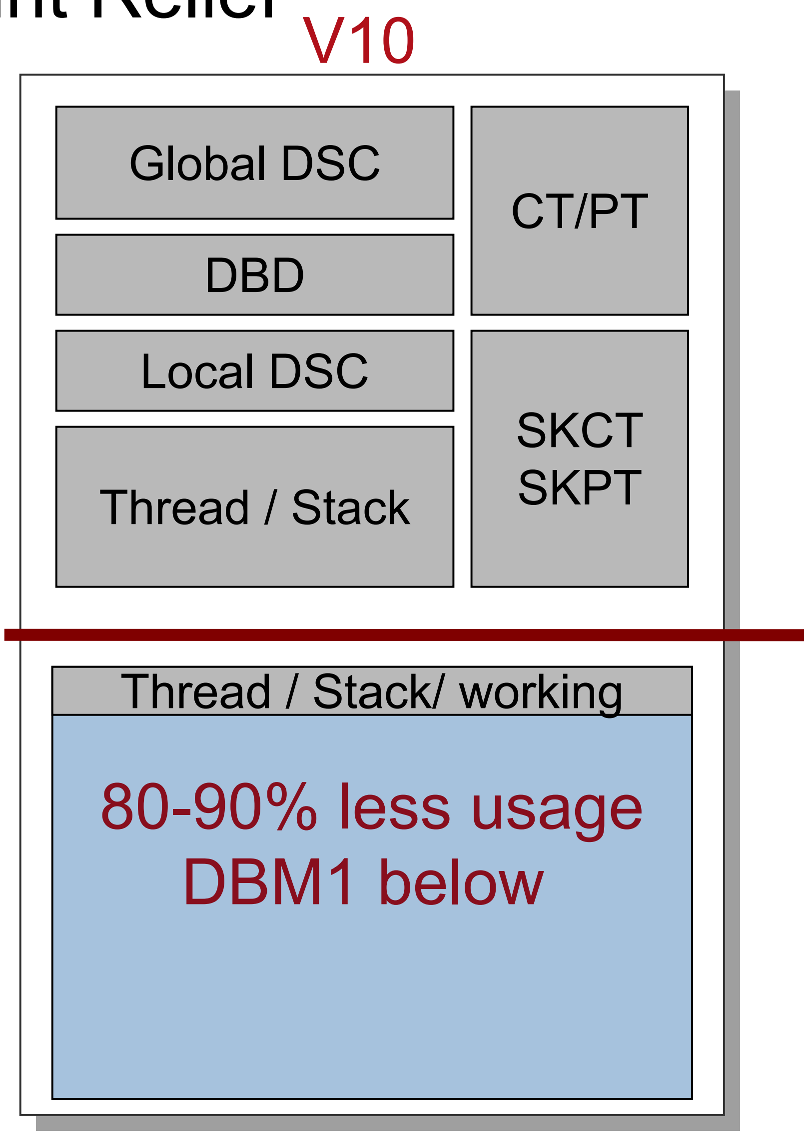
- Up to 10% CPU reduction after REBIND packages
- Higher improvement with workload with scalability issues in V8/V9 or accessed thru DRDA

**Sweet Spots…**

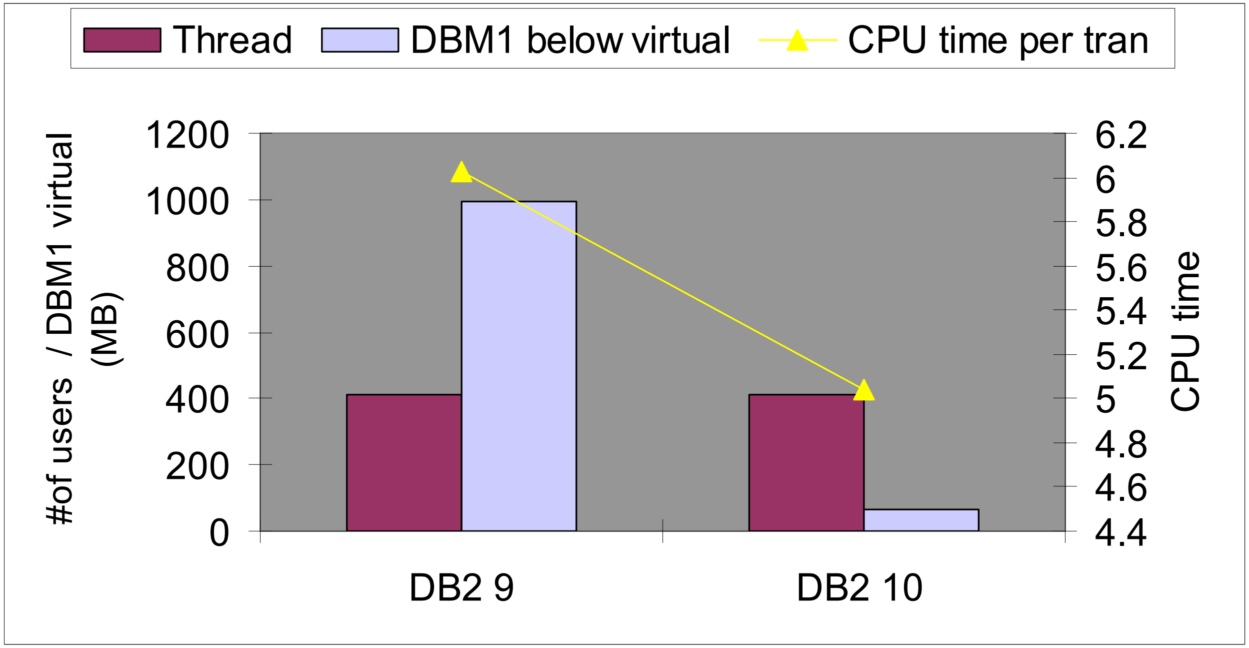
- Workload using native SQL procedures: up to 20% CPU reduction after DROP/CREATE or REGENERATE the procedures
- Query workload with positive access path changes
- Workload with frequent access on small LOB (NFM with Inline LOB)
- Workload with random, singleton select/update (NFM with Hash access)

# DBM1 Virtual Storage Constraint Relief

- **DBM1 below 2GB**
  - 80-90% 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 release deallocate
  - 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 SYSLGRNG (NFM)

# Performance Scalability - H/W synergy

**Exploitation of z10 features**

- CPU improvement using z10 prefetch instructions
- Large fixed page frames for buffer pool
  - 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 commit process
- 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)

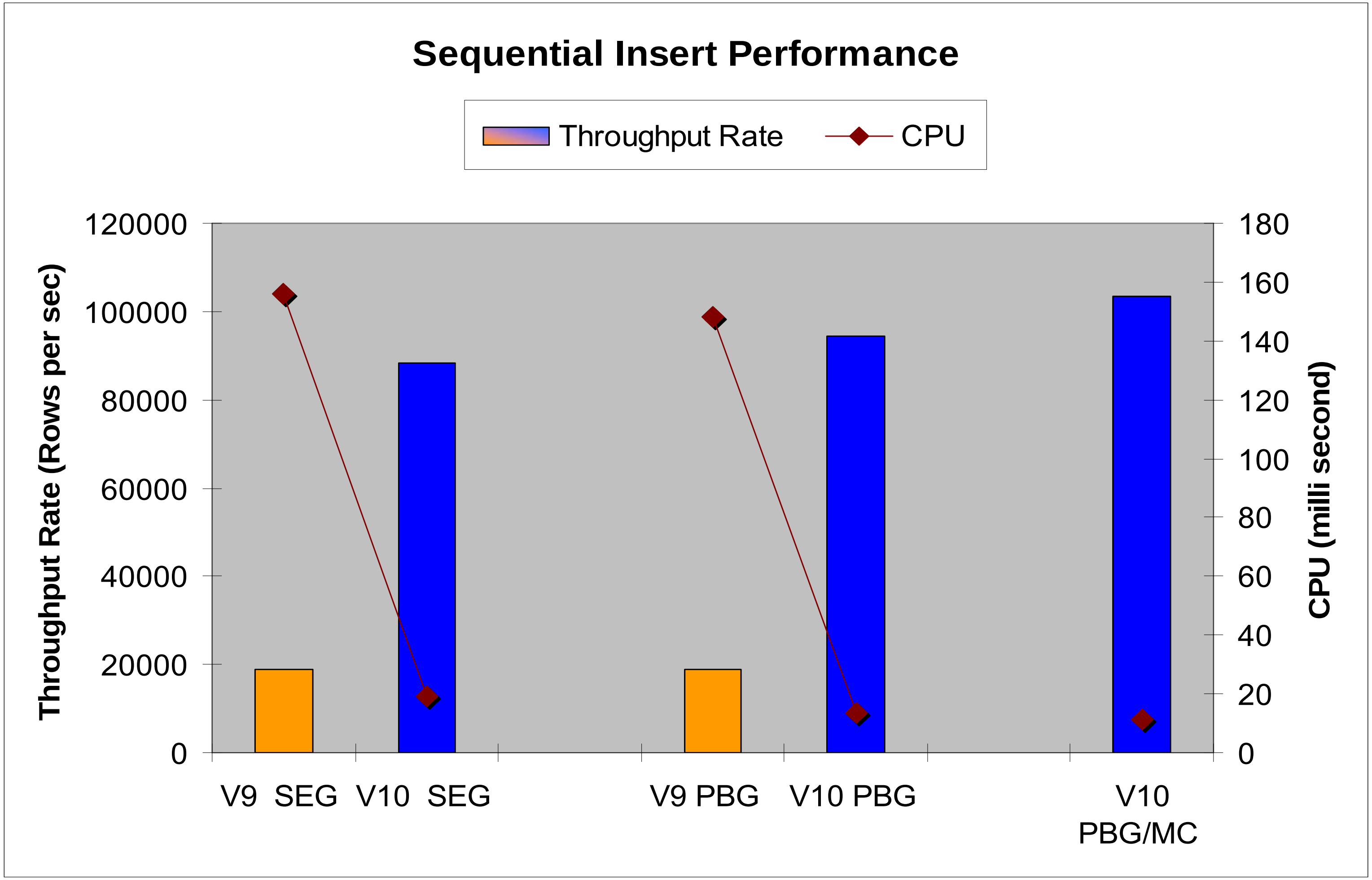
- **Member Cluster option in create table space**
  - Assigns a set of pages and associated space map page to each member
  - Remove the “hot spots” in concurrent sequential insert in data sharing
  - It does not maintain data cluster during the INSERT
  - Data cluster needs to be restored via REORG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

- Still one processing task. No improvement if all indexes are in the buffer pools
- Effective to reduce I/O wait for large indexes which cannot fit in the buffer pools.
- New zparm INDEX_IO_PARALLELISM with default YES
- Classic Partitioned TS and UTS (both PBG/PBR) but not for segmented TS

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

| | |
|---|---|
| **V9** | **Multiple indexes per table**<br>An index is used to enforce uniqueness constraint.  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 an unique indexes**<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 UNIQUE INDEX i2 ON t1(c1,c2,c3,c4,c5)

- **Possible V10 definition**

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

  ALTER INDEX i1 ADD INCLUDE (c4)
  ALTER INDEX i1 ADD INCLUDE (c5) and REBUILD INDEX

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

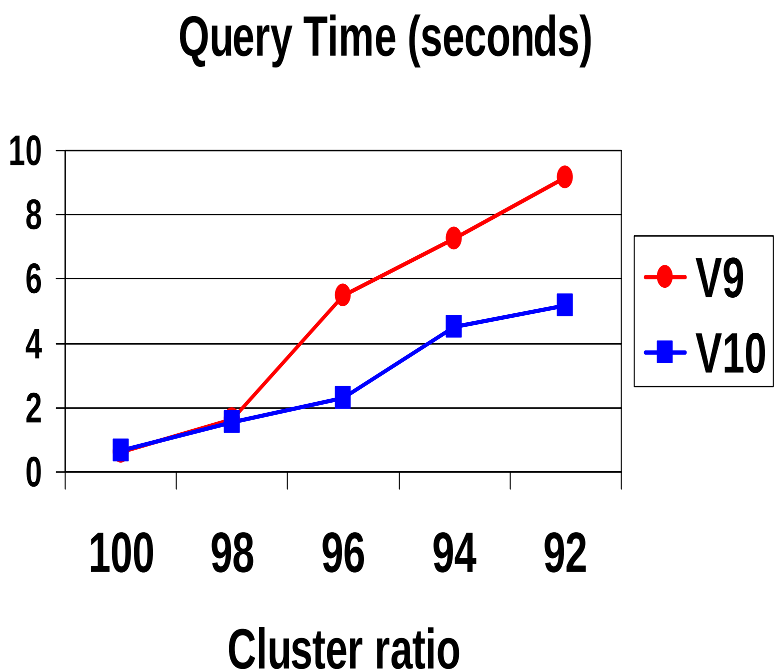
# Row Level Sequential Detection (CM)

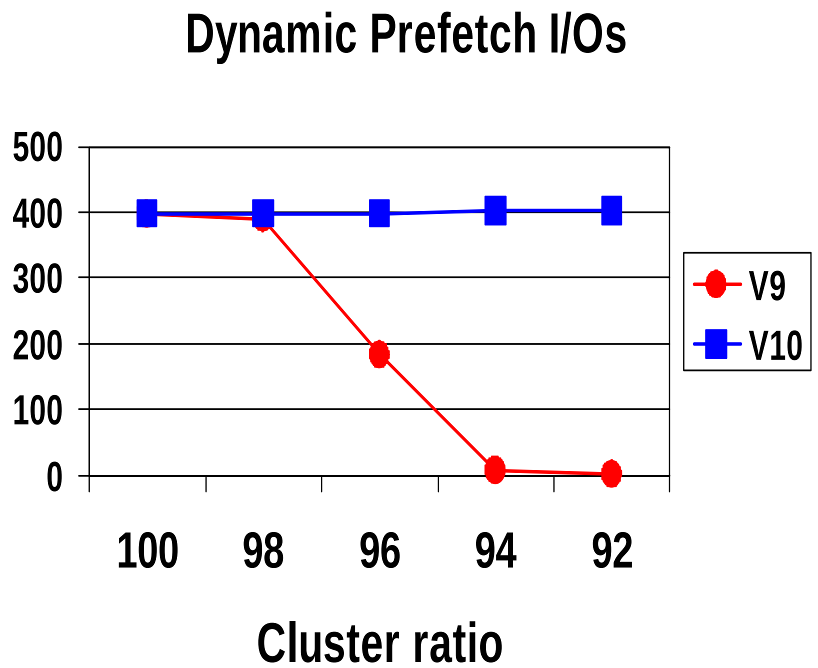
- **Problem:**
  Dynamic prefetch sequential works poorly when the number of rows per page is large.

- **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 (as today).
    - Also applies to indexes

# Index → Data Range Scan

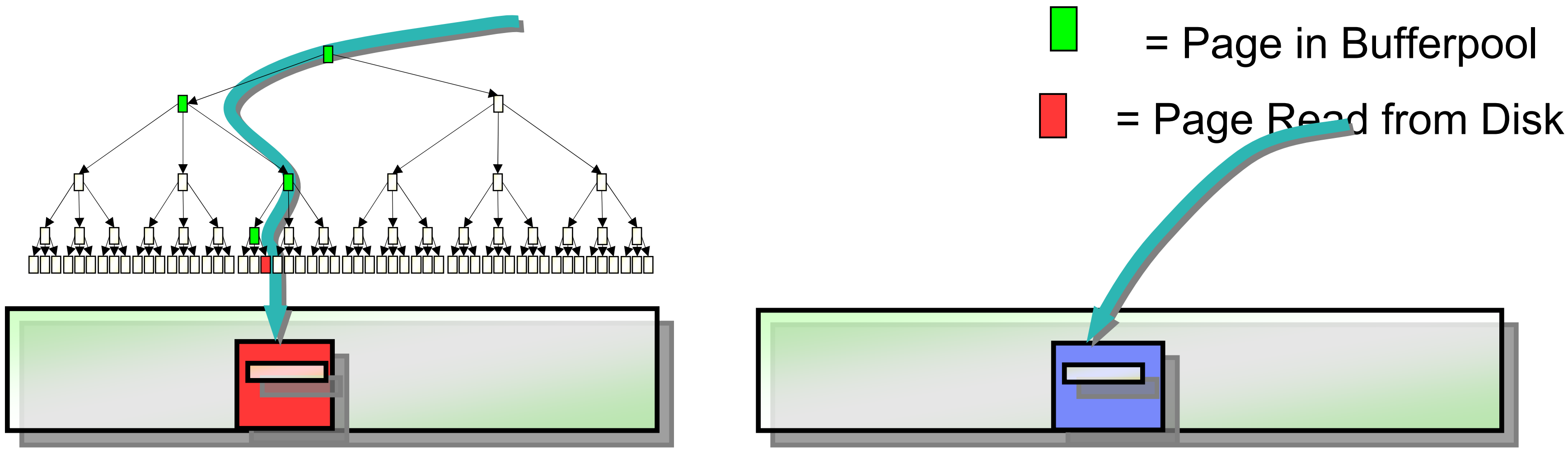
**Row size = 49 bytes, page size = 4K (81 rows per page)**
**Read 10% of the rows in key sequential order**



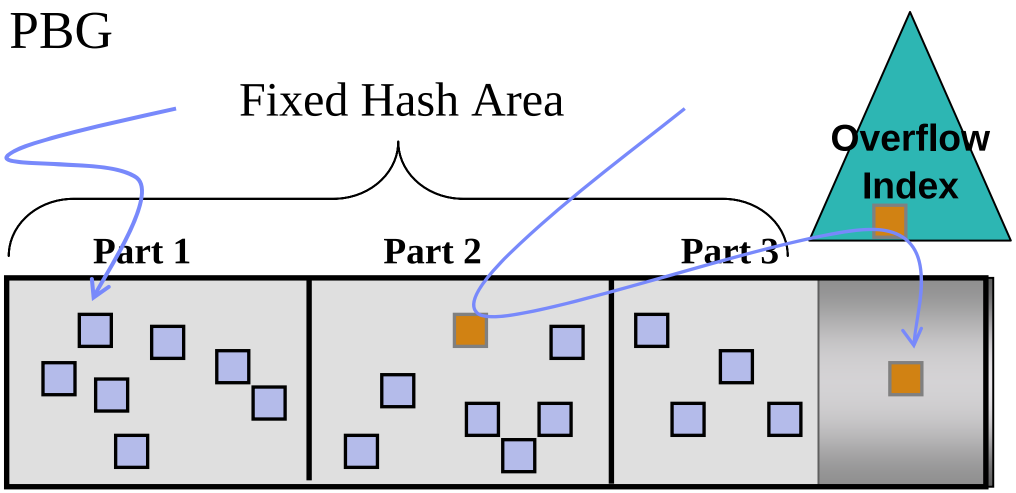

- Row level sequential detection (RLSD) preserves good sequential performance for the clustered pages

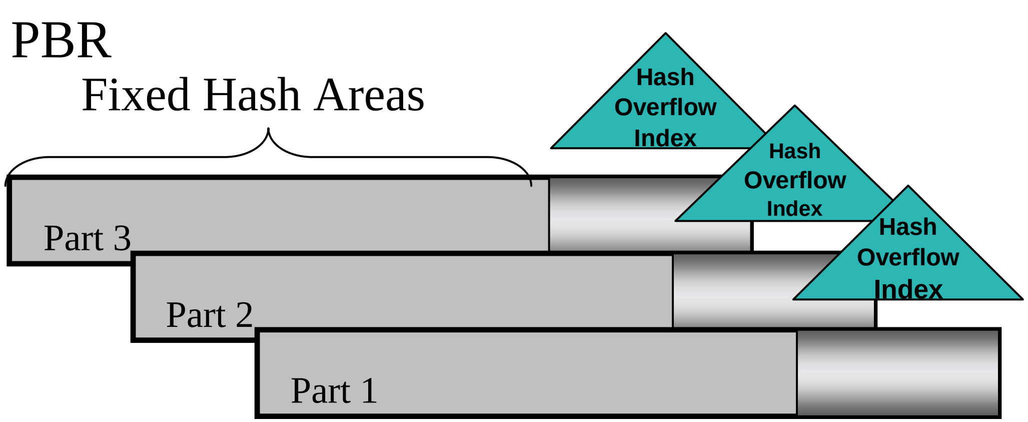
# Index to Data Access Path vs. Hash Access




- 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

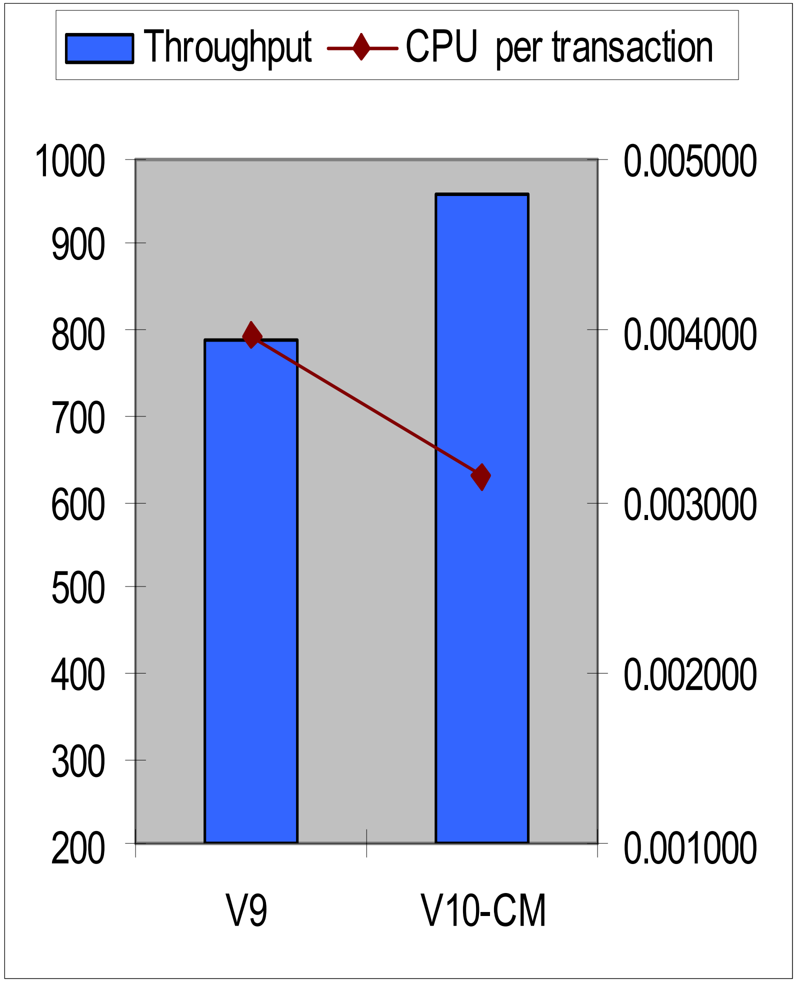
- **Performance benefit :**
  - Up to 30% DB2 CPU reduction with random access
    - Higher improvement with large table with small rows
    - Savings in index maintenance once you remove the clustering index
  - Possible reduction in Hotspots
    - Rows are randomly distributed

- **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”

# SQL Procedure  Performance (CM)

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

# 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

# High Performance DBAT…

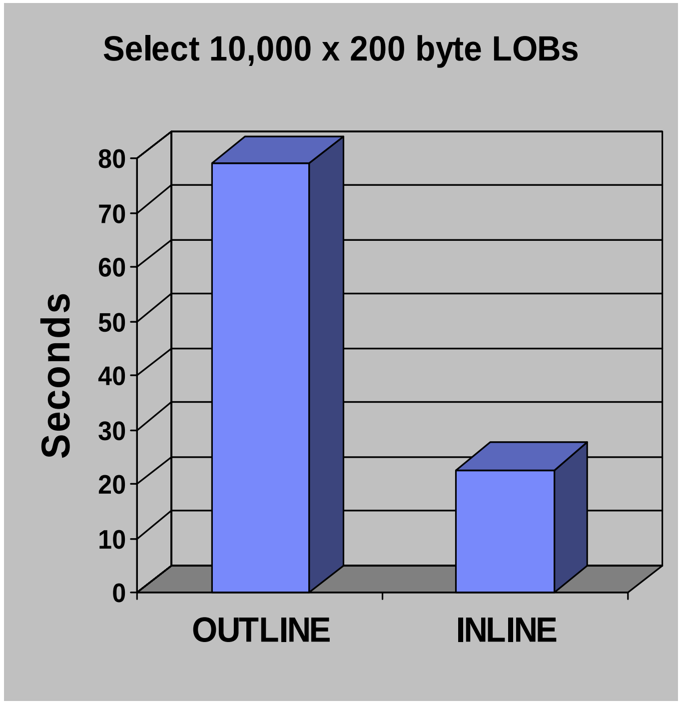
- **New -MODIFY DDF PKGREL command**
  - Options
    - PKGREL(BNDOPT) honors package bind option
    - PKGREL(COMMIT) forces package bind option RELEASE(COMMIT)
      - Same as V9 inactive connection behavior
      - Will allow BIND and DDL to run concurrently with distributed work
    - PKGREL(DEALLOC) forces package bind option RELEASE(DEALLOCATE)
      - Provides better performance behavior
      - BIND and DDL can not break in when concurrent distributed work runs

# 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

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 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

# DB2 10 Monitoring Enhancements and Changes

1. **New Monitor class 29  for statement detail level monitoring**
   IFCID 316/318 for dynamic, 400/401 for static
2. **Record index split with new IFCID 359**
3. **Separate accounting to identify DB2 latch and transaction lock in class3**
4. **Package LASTUSED**
5. **Storage statistics(IFCID225) for DIST address space, shared, and common storage**
6. **Specialty Engines**

   Portion of RUNSTATS utility (redirect rate depends on RUNSTATS parms)

   Prefetch and Deferred Write Engines redirected 100%

# DB2 10 Monitoring Enhancements and Changes

7. **Package accounting information with rollup**

8. **Statistics trace interval**
   Always 1 minute interval in V10 no matter what you use in STATIME for critical statistics records

9. **Compression for DB2 trace data in SMF with a 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 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 |

# 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 !