DB2 for z/OS Performance

Road show edition
April / May 2008

Information Management software

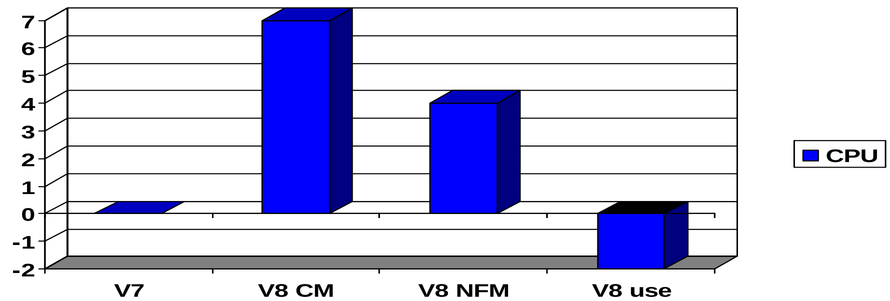
Abstract: DB2 for z/OS Performance:

- This session covers application performance topics for DB2 for z/OS V8 & 9 including:
  - Query performance enhancements such as materialized query table and non-index column distribution statistics
  - SQL performance enhancement such as more indexable predicates and multi-row Fetch, Update, Delete, Insert
  - Index enhancement such as variable length index keys
  - Other application performance enhancement such as trigger and lock avoidance
- This presentation provides information on DB2 for z/OS V8 & 9 performance. Please note that some product changes may result in changes.

Acknowledgment and Disclaimer

- Measurement data included in this presentation are obtained by the members of the DB2 performance department at the IBM Silicon Valley Laboratory. Akira Shibamiya is the primary source.
- The materials in this presentation are subject to
  - enhancements at some future date,
  - a new release of DB2, or
  - a Programming Temporary Fix
- The information contained in this presentation has not been submitted to any formal IBM review and is distributed on an "As Is" basis without any warranty either expressed or implied. The use of this information is a customer responsibility.

V8 best practice performance plan example scenario



Data sharing Better statistics
REBIND
PGFIX(YES)
zIIP
zparms

DB design adjustments
Cluster, index
application changes
multirow fetch & insert
SQL adjustments

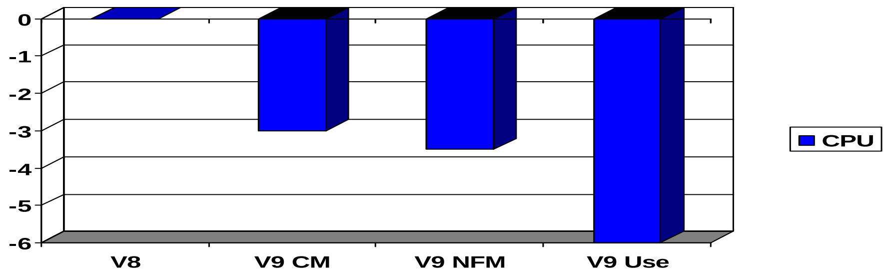
Your situation will vary. Less CPU is better.

Your situation and mileage will vary, but this is a common shape for a V8 performance plan, starting with zero for the V7 base line. When you move to V8, CPU time generally increases from 5% to 10%, shown here as 7. Start with long term page fix for buffer pools with high numbers of pages read and written. Reorg and collect improved statistics for non-uniform distribution of data on non-indexed columns. The V8 CM performance plan REBINDs the primary packages, and adjusts DSNZPARMs. The CM REBIND process provides most of the improved access paths. Data sharing batching helps in CM. During CM, a zIIP is added if your peak work load includes DRDA SQL, parallel query or LOAD, REORG and REBUILD.

In moving to NFM, some additional DSNZPARMS are adjusted and REBIND all plans and packages. Database designs start taking advantage of new clustering & indexing options, such as NOT PADDED for large varchar indexed columns. After making the design changes, REORG the data; REORG or REBUILD the indexes; get improved statistics & REBIND. The data sharing group is quiesced, and protocol 2 locking is used.

V8 use takes more advantage of the V8 performance improvements: MQTs, DPSI, more not-padded indexes, multi-row Fetch, cursor Update, cursor Delete, & Insert. Use other SQL improvements to reduce V8 CPU, less than V7. The work may grow, but some of the growth uses the zIIP.

DB2 9 z10, z9, z890 & z990 performance plan example scenario



Utilities	DB design adjustments
Histogram statistics	Index improvements
REBIND	application changes
DSNZPARMS	native SQL procedures
	SQL adjustments

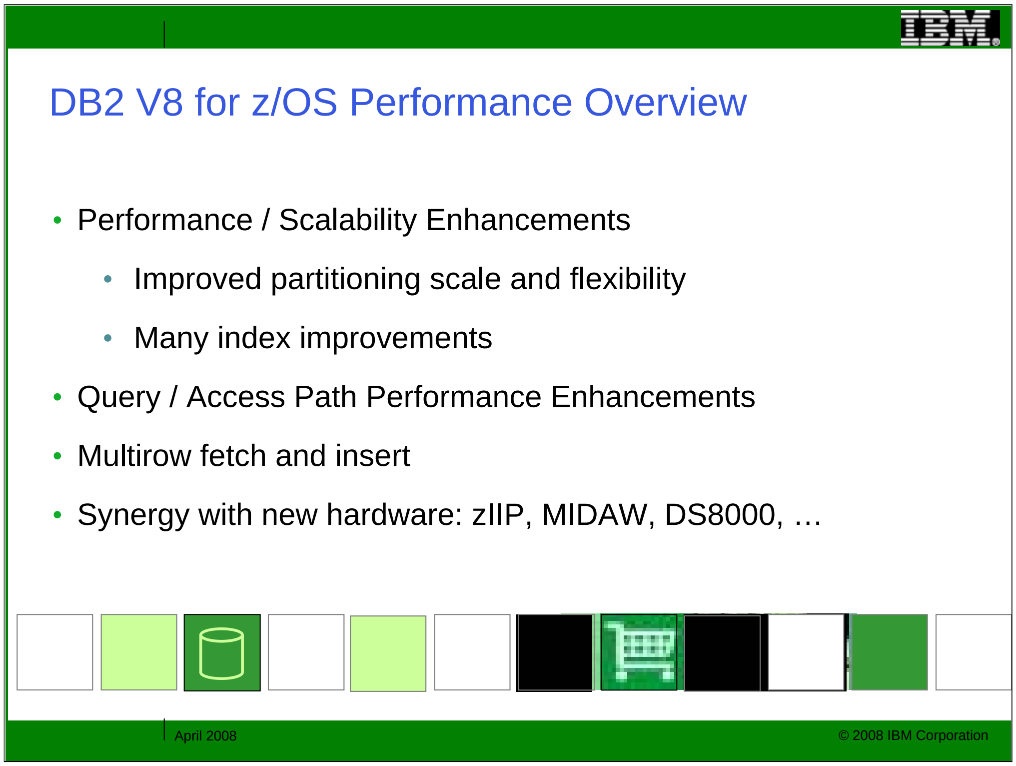
Your situation will vary. Less CPU is better.

z800 and z900 expect +5% to +10% CPU

If you have a z10, z9, z990 or z890, this is expected to be a common shape for a DB2 9 performance plan, starting with zero for the V8 baseline. When you first move to DB2 9, total DB2 CPU time generally decreases from 0% to 5% for z9, z890 and z990 customers, shown here as a first step -3%. Utility CPU reductions help immediately. Some work will be about the same (+/-3%). Start with reorgs and collect improved histogram statistics when useful. The DB2 9 CM performance plan REBINDs the primary packages and adjusts DSNZPARMs. The REBINDs provide most of the improved access paths. On z800 or z900 the initial CPU expectation is +5 to +10% regression, more if there are many columns, so making adjustments is more important.

In moving to NFM, some additional DSNZPARMS are adjusted and all plans and packages are rebound. The DB2 9 use line takes wider advantage of DB2 9 performance improvements. Database designs start taking advantage of new indexing options, such as compression, index on expression and larger pages. After making the design changes, REORG the data and REORG or REBUILD the indexes, get the improved statistics and REBIND. Native SQL procedures, added use of zIIP, and improved SQL continue the improvements in this phase.

Scenario: Customer mix of DB2 CPU time is 30% in utilities, 70% in SQL access. With 10% improvement for the utilities, we get a -3% net, assuming that SQL is the same as before. With optimization improvements, another -½% improvement shows up in DB2 9 NFM. Then as design adjustments, reorgs and rebinds are performed, we get improvements from varchar improvements, native SQL procedures and improved SQL, another -3%.



The key performance improvements in DB2 9 are reduced CPU time in many utilities, deep synergy with System z hardware and z/OS software, improved performance and scalability, especially for insert, update and delete, better LOB performance and scalability, improved optimization for SQL, zIIP processing for remote native SQL procedures, index compression, reduced CPU time for data with varying lengths and better sequential access. This version also improves virtual storage use below the 2 GB bar.

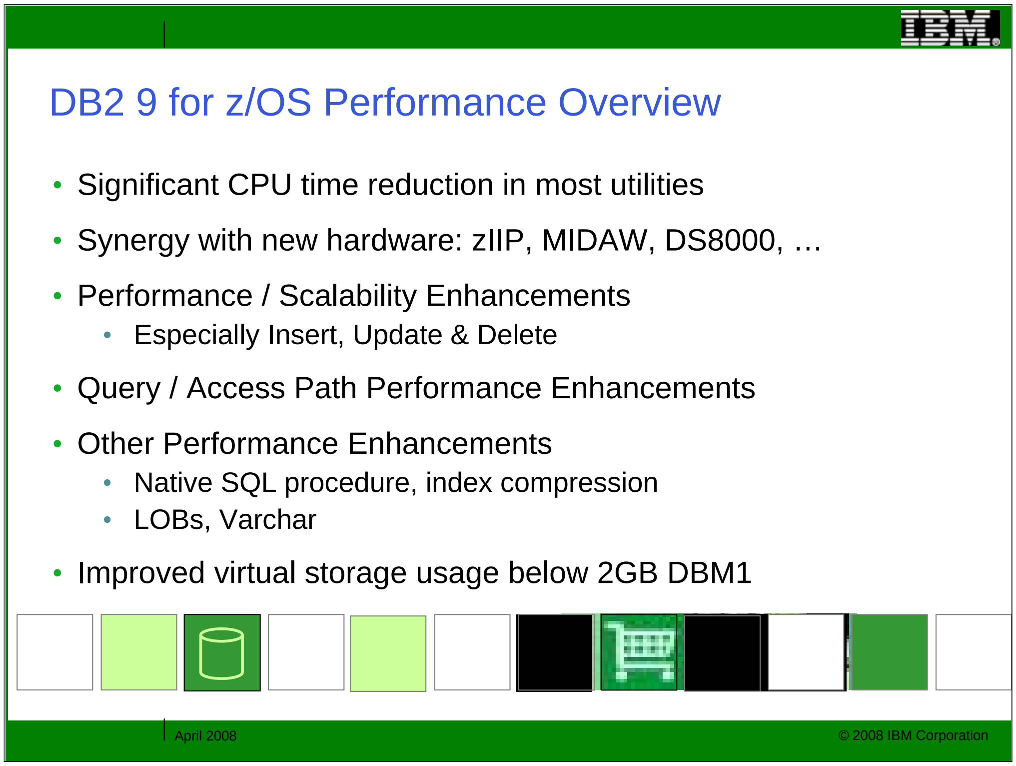
The optimization improvements include more function to optimize, improved information for optimization, better optimization techniques and a new approach to providing information for tuning. V8 SQL procedures were not eligible to run on the zIIP, but changing to use the native SQL Procedure Language on DB2 9 will make the work eligible for zIIP processing. Varying length data can improve substantially if there are large numbers of varying length columns. Several improvements in disk access can reduce the time for sequential disk access and improve data rates.

V8 Queries and data warehouses

- Optimization Improvements
  - Improved techniques
  - Enhanced data
  - Visual Explain
- Enhanced index options
- Materialized Query Tables
- New Partitioning options
- QMF improvements
- SQL enhancements

April 2008

Queries and data warehousing are improved a lot in V8. Optimization improvements provide a performance boost and make the job simpler. Improved optimization techniques like ability to use indexes more, star join and scale improvements allow reduced work for computers and for people. Enhanced data helps get the best access path. Visual Explain improves the ability to analyze and resolve any problems.
The many improvements for indexes, materialized query tables and partitioning can save space and add new options for improved performance and availability, even while simplifying the process. Not padded, clustering, longer and backward scans help indexes. Being able to add, rotate and rebalance partitions improve partitioning options. QMF enhancements build upon these strengths and add new function to reporting, dash boards, and a new platform in WebSphere. SQL enhancements on this page and the next improve portability of the SQL, improve the ability to express queries, and help with performance.



The key performance improvements in DB2 9 are reduced CPU time in many utilities, deep synergy with System z hardware and z/OS software, improved performance and scalability, especially for insert, update and delete, better LOB performance and scalability, improved optimization for SQL, zIIP processing for remote native SQL procedures, index compression, reduced CPU time for data with varying lengths and better sequential access. This version also improves virtual storage use below the 2 GB bar.

The optimization improvements include more function to optimize, improved information for optimization, better optimization techniques and a new approach to providing information for tuning. V8 SQL procedures were not eligible to run on the zIIP, but changing to use the native SQL Procedure Language on DB2 9 will make the work eligible for zIIP processing. Varying length data can improve substantially if there are large numbers of varying length columns. Several improvements in disk access can reduce the time for sequential disk access and improve data rates.

DB2 9 Query Enhancements

- SQL enhancements: INTERSECT, EXCEPT, cultural sort, caseless comparisons, FETCH FIRST in fullselect, OLAP specifications: RANK, ROW_NUMBER, …
- pureXML integration and text improvements
- Index improvements
  - Index on expression   Larger index pages
  - Index compression   Improved page split
- Improved Optimization statistics: Histogram
- Optimization techniques & REOPT(AUTO)
  - Cross query block optimization
  - Generalize sparse index & in-memory data cache method
  - Dynamic Index ANDing for Star Schema
- Analysis: instrumentation & Optimization Service Center

Query enhancements improve data warehousing and reporting. Today's complex applications include both transactions and reporting, so performing both well is imperative. More queries can be expressed in SQL with new SQL enhancements. The set operators INTERSECT and EXCEPT clauses make SQL easier to write. OLAP extensions for RANK, DENSE_RANK and ROW_NUMBER add new capabilities. Other SQL statements improve consistency with the DBMS industry. DB2 9 continues the progress in SQL, with many new functions, statements and clauses. The biggest changes are in XML. New SQL data manipulation statements are MERGE and TRUNCATE. New data types with DECIMAL FLOAT, BIGINT, BINARY and VARBINARY. Improvements in LOBs provide new function, more consistent handling and improved performance. Security is improved with network trusted context and roles. Data definition consistency and usability are improved. DB2 9 is another big step in DB2 family consistency and in the ability to port applications to DB2 for z/OS.

Indexes have many improvements in DB2 9. The key items are the ability to have an index on an expression instead of on a column, compression to save disk space, larger index pages and an improved page split to improve the insert rate.

Data sizes continue to increase while the SQL grows more complex. The SQL enhancements provide more opportunities for optimization, and DB2 9 adds optimization enhancements to improve query and reporting performance and ease of use. Improved data is provided for the optimizer, with improved algorithms and a rewritten approach to handling performance exceptions. Histogram statistics provide better information about non-uniform distributions of data when there are many values skewed, rather than just a few. Improved algorithms widen the scope for optimization. When exceptions occur, guidance and support are made easier with improved instrumentation, the Optimization Service Center and the Optimization Expert.

IBM

DB2 9 Scalability

- Insert performance APPEND INDEX LOG
  - INDEX on expression, 8K, 16K, 32K, split
  - Randomized index key, larger preformat
  - Log Latch contention & spin relief, archiving
  - Not logged table space
- Partitioned table with segmented space
- Memory improvements 64 bit address space

April 2008

Insert performance increases substantially, through a wide range of improvements. Logging performance is improved with latching improvements and striped archiving. The newer disk and channel changes (DS8000 Turbo, 4 Gb per second channels, MIDAW), improve the data rates substantially. Indexes are improved, with larger page sizes to reduce the number of page splits and also a better page split. Where performance should be optimized for inserts, rather than for later retrieval, the append option can be used. If the data need to be randomized to avoid insert hot spots, the new randomized index key is useful.

The segmented space structure is more efficient in many situations, so adding that space structure for the large partitioned table spaces helps DB2 scale more efficiently.

Memory improvements continue the work from V8, with memory shared above the bar between the DDF and DBM1 address spaces. The shared memory can be used to avoid moving data from one address space to the other. More data structures from the EDMPOOL and dynamic statement cache are moved above the bar.

V8 Performance Highlights

- 10 to 1000 times improvement possible from
  - Materialized Query Table
  - Stage 1 and indexable predicate for unlike data types
  - Distribution statistics on non-indexed columns
  - Other access path selection enhancements

Underlined features require rebind

Performance Highlight - continued

- 2 to 5 times improvement possible from
  - <u>Star Join with work file index and in-memory work file</u>
  - <u>Partition Load/Reorg/Rebuild with DPSI</u>
  - DBM1 virtual storage constraint relief

- Up to 2 times (more in distributed environment) improvement possible from
  - <u>Multi-row Fetch, cursor Update, cursor Delete, Insert</u>

➡ <u>Underlined features require rebind</u>

Materialized Query Table

- Pre-selected and/or pre-computed results from large table(s) saved in much smaller MQT for fast subsequent access
  - Example: Avg Income, Height, NetAssetValue, ... of 300 million US residents grouped by 50 states
  - 10 to 1000 times faster possible for some queries
- Automatic query rewrite for dynamic SQL to take advantage of relevant MQT
  - Summary table can be used directly by both static and dynamic SQL

Materialized Query Table - continued

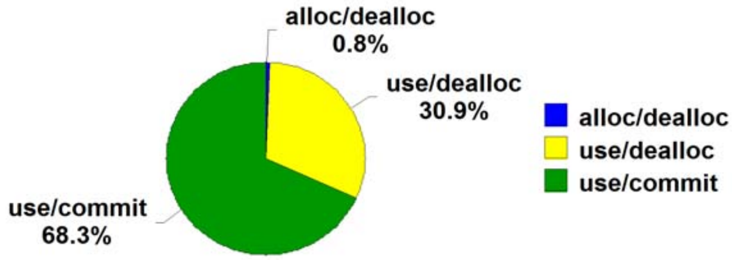
- Performance considerations for maximum use
  - For large MQT,
    - Use segmented table space because of almost instantaneous mass delete in REFRESH TABLE
    - Runstats after REFRESH for good access path selection
      - especially useful in join involving MQT
  - Zparm SPRMMQT for threshold to prevent unnecessary additional bind overhead for short-running SQL

Distribution stats on single and multiple columns

- Top N highest, and/or lowest, frequency of values and cardinality

Bind option

Acquire / release example



SELECT FROM A, SYSIBM.SYSPLAN B WHERE B.ACQUIRE='A' AND B.RELEASE='D' ...

→ **Better join sequence from more precise filter factor estimation of combined predicates**

Distribution statistics ...

- DSTATS (Distribution stats for DB2 for z/OS)
  - A down-loadable tool available prior to V8
  - http://www.ibm.com/support/docview.wss?uid=swg24001598

- Fixes the most typical access path selection problems encountered today
  - Optimizer unable to come up with the best access path because of a lack of distribution stats on non-indexed columns which are referenced in predicates
    - ➔Can cause performance degradation due to access path change in a new release or after access-path-related maintenance

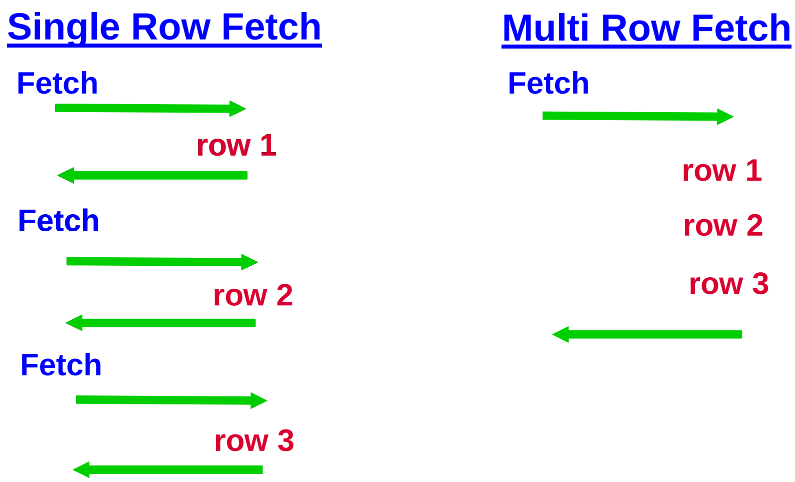
More Indexable Predicates

- For column comp-op value with unlike type or length
  - 4 byte char column = 8 byte host variable
  - Integer column = decimal host variable
  - Stage 2 and non indexable in V7
  - Stage 1 and indexable in V8
    - So index on char or integer column here can be used in V8 but not in V7
  - Also useful where a programming language does not support SQL data types. For example,
    - No decimal type by C/C++, no fixed-length char by Java

NOTES

- Stage 1 and indexable predicate in
  - V6: Column comp-op non column expression such as SELECT FROM A WHERE a1=x+y
    - also char/varchar of different size in equi-join such as SELECT FROM A,B WHERE 10byte char a1=20byte varchar b1
  - V7: Column comp-op column expression in join such as SELECT FROM A,B WHERE a1=b1+x, if table B joined to A
- But generally only if left side column has equal or bigger size and precision
- V8 removed this restriction for both local and join predicates

Multi-row Fetch



Multi-row Fetch - continued

- FETCH NEXT ROWSET FROM cursor FOR N ROWS INTO hva1, hva2, hva3
- Up to 50% CPU time reduction by avoiding API (Application Programming Interface) overhead for each row fetch (100 rows)
  - % improvement lower if more columns and/or fewer rows fetched per call
    - Higher improvement if accounting class 2 on, CICS without OTE, many rows, few columns
  - See later foils for distributed

Multi-row Insert

- INSERT INTO TABLE FOR N ROWS VALUES(:hva1,:hva2,...)
- Up to 40% CPU time reduction by avoiding API overhead for each row insert
  - % improvement lower if more indexes, more columns, and/or fewer rows inserted per call
- Similar improvement for multi-row cursor Update and Delete

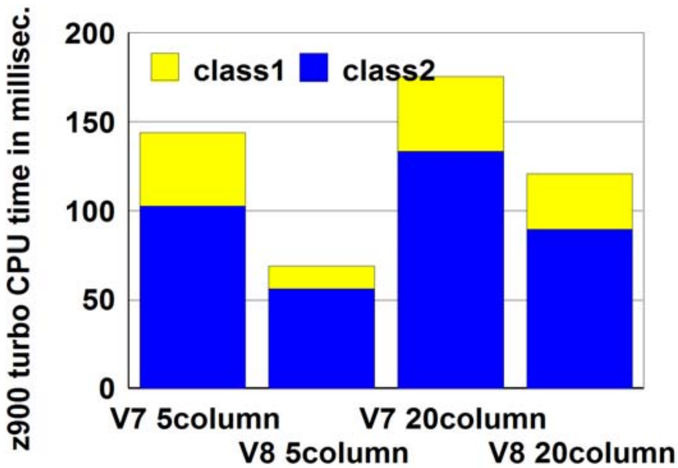
Multi-row in distributed environment

- Fetch, insert, update & delete
- Dramatic reduction in network traffic and response time possible
  - by avoiding message send/receive for each row in
    - Fetch when not [read-only or (CURRENTDATA NO and ambiguous cursor)]
    - Update and/or Delete with cursor
    - Insert
  - Up to 8 times elapsed time reduction observed (up to 4 times CPU time reduction)

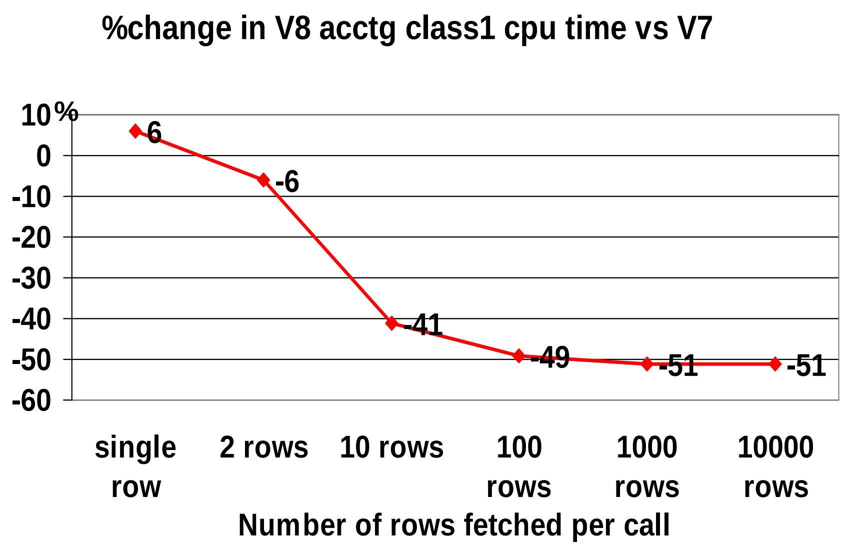
Distributed multi-row ...

- If Fetch with read-only or [CURRENTDATA NO and ambiguous cursor], multi-row Fetch is automatically enabled, resulting in
  - CPU time saving of up to 50%
  - But no significant difference in message traffic compared to V7 with Block Fetch
    - Note that multi-row Fetch is unblocked; i.e. if 10 Fetch calls are issued for 10 rows each, 10 blocks are sent, compared to 1 block if multi-row Fetch is not explicitly used.
    - V7 PQ49458 8/2003
      - OPTIMIZE FOR for access path and network blocking
      - FETCH FIRST for access path but not network blocking when no OPTIMIZE FOR clause

DSNTIAUL fetching 10000 rows with 5 and 20 columns



20 column 100000 row Fetch CPU Time



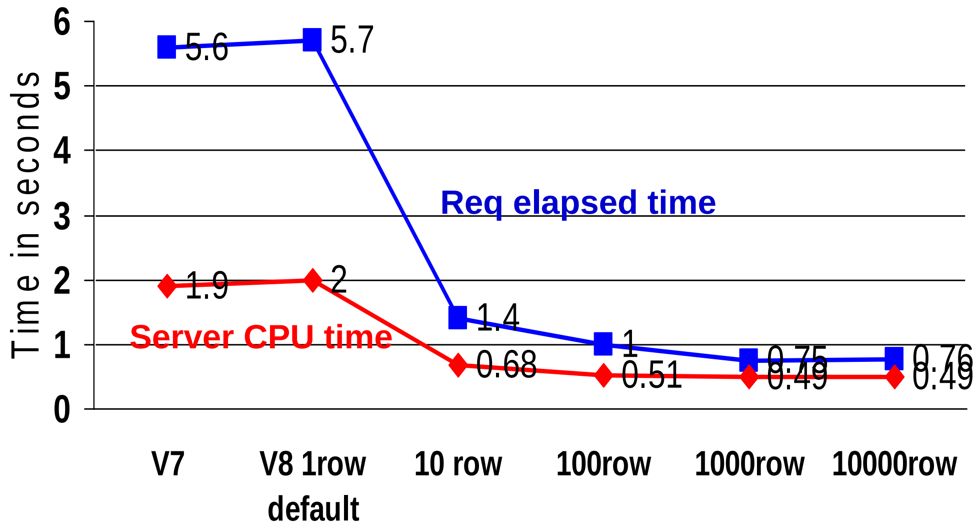
NOTES

- The graph clearly shows that the percentage improvement goes up as more rows are fetched per Fetch call.
  - With 1 row fetch, V8 CPU is 6% higher than V7.
  - However, with 2 row fetch, V8 becomes faster by 6%.
  - Beyond 100 rows, about 50% improvement continues.
  - Similarly for elapsed time and class 2 CPU time.
- The measurement shown is for a very simple fetch via table space scan fetching 20 columns
  - Less %improvement for more complex Fetch involving join, sort, index access, more than 20 column fetch
  - More %improvement for less than 20 column fetch

Multi-row Insert Workstation-to-Host

- **DB2 for z/OS V8 acting as a DRDA application server, accessed from a DB2 Connect Client running on Linux/Unix/Windows as a DRDA application requestor**
- **10000 20-column rows inserted**
- **10 rows / Insert call**
  - **-76% elapsed time and -63% CPU time compared to V7**
  - **-30% elapsed time and -38% CPU time compared to V7 array input**
- **100 rows / Insert call**
  - **-82% elapsed time and -63% CPU time compared to V7**
  - **-33%elapsed time and -49% CPU time compared to V7 array input**

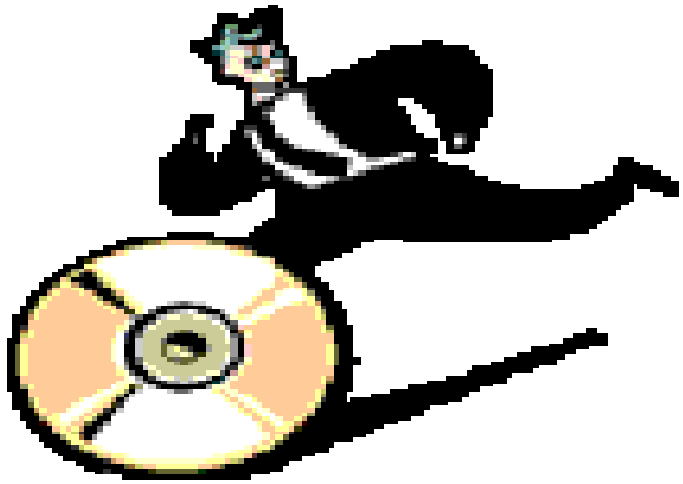
Workstation-to-Host Insert without array input



Automatic use of multi-row Fetch

- DRDA as discussed previously
- DSNTEP4 = DSNTEP2 with automatic multi-row fetch
  - Up to 35% CPU reduction in fetching 10000 rows with 5 and 20 columns
- DSNTIAUL (sample Unload utility)
  - Up to 50% CPU reduction in fetching 10000 rows with 5 and 20 columns
- QMF with APAR

Elapsed Time Analysis



NOTES

- **<u>Accounting report (not trace) by connection type most useful for initial analysis</u>**

  - **Omegamon DB2 Performance Expert ACCOUNTING REPORT LAYOUT(LONG) ORDER(CONNTYPE) EXCLUDE(PACKAGE(*)) to group by thread connection type such as TSO, CICS, DB2CALL, RRS, IMS, DRDA, etc. for the period of interest.**

  - **Also STATISTICS REPORT LAYOUT(LONG) for the corresponding period extremely desirable**

Accounting Class 1 and 2

AVERAGE	CLASS1	CLASS2
ELAPSED TIME	233ms	19ms
CPU TIME	2.95ms	2.71ms
WAIT TIME		14.76ms
NOT ACCOUNTED TIME		1.31ms

- For most cases
  - Class 1 for application + DB2 time
  - Class 2 for DB2 time only
- CICS without TS 2.2 or later threadsafe option
  - Class 1 CPU for task switch + DB2 time
  - Class 2 for DB2 time only

High NOT ACCOUNTED time – 2 most likely causes

- CPU wait under high CPU utilization, especially with lower dispatching priority
  - **E.g. goal mode with low priority for DB2 address space compared to DDF enclave, CICS, WebSphere address space, or DDF enclave with SYSOTHER (discretionary)**
- Excessive detailed online tracing with vendor tools

Other causes are much less frequent and widely varied

Some events not being captured by DB2, but more events are being captured in newer versions

Details on the web:

http://www.ibm.com/support/docview.wss?rs=64&context=SSEPEK&uid=swg21045823

What is DB2 Accounting Class 2 Not Accounted Time? The following simple formula defines DB2® Class 2 Not Accounted Time:

DB2 Class 2 Not Accounted Time = DB2 Class 2 Elapsed time - (DB2 Class 2 CPU time + DB2 Class 3 suspension time)

Usually the DB2 Class 2 Not Accounted time is very small or negligible. It represents time that DB2 is unable to account for. If you see significant DB2 Class 2 Not Accounted time, it could be due to one of the following reasons:

In some cases, high DB2 Class 2 Not Accounted time is caused by too much detailed online tracing or bugs in some vendor performance monitors. Reduce the level of tracing or stop the vendor performance monitor to help reduce the Not Accounted time to an acceptable level. This situation is usually the primary cause of high not-accounted-for-time on systems that are not CPU-constrained.

In a non-data sharing environment, it could be due to running on a very high CPU utilization environment and waiting for CPU cycles, especially with lower dispatching priority in Work Load Manager goal mode. A non-dedicated LPAR can be interrupted by another LPAR and lose the processor for some time.

Also in a non-data sharing environment, it could be due to running in a high MVS™ paging environment and waiting for storage allocation. If DB2 gets swapped out by losing control of the processor or waiting for a processor, this increased time is the result.

In a data sharing environment, prior to V7, it could be due to asynchronous coupling facility requests. For example, group buffer pool requests for > 4KB pages, long running coupling facility commands such as 'Read Directory Info' and 'Delete Name under mask', or conversion of synchronous requests to asynchronous requests due to a coupling facility subchannel busy condition. In V7 or later, the coupling facility suspensions due to asynchronous requests are shown under a new category called 'Asynch IXL Requests' in DB2 performance monitor. If the asynchronous write to the secondary group buffer pool (GBP) does not complete before synchronous write to the primary GBP with GBP duplexing, not accounted time can be the result.

Not accounted time can be the wait time for return from requests to be returned from VTAM® or TCP/IP.

Instrumentation Facility Interface (IFI) log read can cause not accounted time.

If the environment is very I/O intensive, the Media Manager might be running out of request blocks.

z/OS® events can cause not accounted time, such as SRM timer pops, for example when an SMF SRB is triggered to collect open data set statistics.

Waiting for package accounting can result in not accounted time.

Not accounted time can be accounted for by a PREPARE which is not found in the Dynamic Statement Cache.

Waiting for a page being moved from VP to HP can result in not accounted time.

DD consolidation (z/OS parameter DDCONS=YES DETAIL) has overhead that is not accounted. See DDCONS informational APAR II07124.

Data set open contention related to PCLOSET being too small can cause time that is not accounted.

Time for RMF interval data set statistics gathering can cause not accounted time.

DB2 internal suspend and resume can cause this not accounted time by looping when several threads are waiting for the same resource, but this case is very rare.

NOTES

- Other causes are much less frequent and widely varied
  - **Some events not being captured by DB2, but more events are being captured in newer versions**
  - **Online support document: http://www.ibm.com/support/docview.wss?rs=64&context=SSEPEK&uid=swg21045823**

Accounting Class 3

SUSPENSIONS	TOTAL TIME	#EVENTS
LOCK/LATCH	0.11ms	0.3
SYNC DATABASE I/O	8.73ms	8.86
SYNC LOG WRITE I/O	1.64ms	0.49
OTHER READ I/O	2.64ms	0.76
OTHER WRITE I/O	0.004ms	0.00
SERVICE TASK	1.60ms	0.47
......		
TOTAL CLASS 3 WAIT	14.76ms	10.88

- **Class 3 acctg strongly recommended: Negligible overhead except when high internal DB2 latch contention, eg over 10000/sec**

NOTES

- Lock/Latch wait = Lock wait + IRLM latch wait + internal DB2 latch wait
  - In the rare case of over 10000 per second, disabling class 3 may significantly bring down class 1 and 2 CPU time.
- Sync I/O wait = wait for read or write I/O by this application agent
  - Avg time = 8.73ms/8.86 = 0.985ms
- Other read I/O wait = wait for read I/O by another application agent or prefetch engine
- Other write I/O wait = wait for write I/O by another application agent or write engine, may include some time waiting for log write-ahead

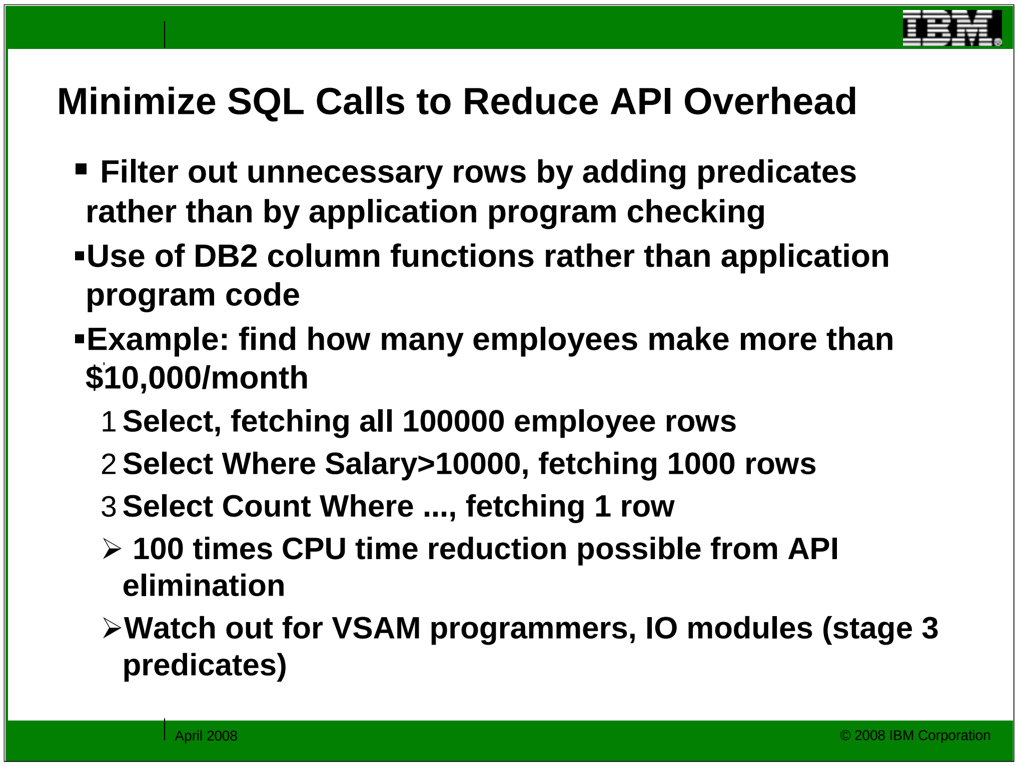
I/O wait time tuning

- Buffer pool tuning - discussed in Buffer Pool section

- I/O configuration tuning
  - Make sure of sufficient I/O resources
  - Faster device, such as ESS 800 or DS8000 as needed
  - Parallel Access Volume (PAV) beneficial if I/O contention with high IOSQ time in RMF
  - I/O striping

NOTES: agenda

- Minimizing #SQL calls, columns, host variables, predicates evaluated, SQL statements, rows searched
- OPT for N ROWS
- Existence check
- Dynamic SQL, JDBC/SQLJ
- Bind option acquire and release
- Thread reuse
- DB2 trace
- Distributed / stored procedure
- Catalog statistics check
- Compression, Encryption, Row-level Security



Bonnie would call item 1 using stage 3 predicates. So if your application programmers are using VSAM techniques or generalized IO modules, then you may see an extra 5 x to 10 x CPU time.

Minimize #SQL Calls - continued

- Singleton SELECT is more efficient than OPEN, FETCH, CLOSE
- Fetch First N Rows Only in V7, in subquery DB2 9
  - Limits the number of rows fetched to avoid fetching unwanted rows
  - Singleton Select (or SELECT INTO) can be used with Fetch First 1 Row even if multiple rows qualify
    - Avoids -811 SQLCODE
    - V8 supports ORDER BY for more meaningful query
  - Bigger improvement possible for CICS attach
- UPDATE without cursor is more efficient than OPEN, FETCH, cursor UPDATE, CLOSE
  - Up to 30% (possibly more if CICS) CPU time saving possible from singleton Select or Update compared to cursor operation

Minimize #SQL Calls - continued

- Reducing #SQL calls improves
  - API path length
  - Processor MIPS for row processing
    - Up to 2 to 3 times processor MIPS improvement possible from high-speed processor cache hit by repeated execution of a small set of modules/instructions and reduction in data moves
- V8 multi-row operation can significantly reduce the number of SQL calls issued
  - Up to 50% CPU reduction for simple (short-running) local Fetches, more for distributed

Minimize #Columns and Host Variables Referenced in SQL Calls

- Increasing order of cost
  - Local EBCDIC least -> ASCII or UNICODE or DRDA -> Single byte conversion -> Double byte conversion
  - Integer/char least and date/time/timestamp most expensive
- Try to avoid unnecessary columns
  - Doubled CPU time possible with 100 additional columns/host variables
- Put Varchar to end of row when many columns (>20)

F1	F2		V3	F4	F5		V6

DB2 9 Varchar Performance Improvement

- Remember the tuning recommendation for rows with many columns with any varchar present?

F1	F2		V3	F4	F5		V6

  - DB2 9 internally executes this recommendation and more

- 2 times or more improvement observed when many rows with many varchars are scanned and/or fetched using many predicates
- <5% improvement for a typical online transaction
- No difference if no varchar
- Reorg rebuilds compression dictionary if varchar columns when migrating to DB2 9 (PK41156)

April 2008

Impact on log record: log size can be bigger or smaller. This is not an option. This is only for data, not for indexes.

Minimize #Predicates Evaluated

- Place most filtering predicates first in AND. (for predicates of the same type)

WHERE HOME_STATE='MONTANA'	FF= 1%
AND HAIR='BROWN'	FF=10%
AND SEX='MALE'	FF=50%

- Weighted average of 1.01 predicates evaluated
- If sequence of predicates is reversed, then the weighted average is 1.55, or 50% more predicate evaluation, which can lead to up to 20% CPU increase.

- Conversely, place most filtering predicates last in OR and IN-list without ACCESSTYPE=N.

  eg STATE IN ('NEW YORK','FLORIDA','MONTANA')

Minimize #SQL Statements in a Program Where Possible

```
DO ....
    SELECT or INSERT or DELETE or UPDATE
END
                    instead of
SELECT, INSERT, DELETE, or UPDATE
SELECT, INSERT, DELETE, or UPDATE
SELECT, INSERT, DELETE, or UPDATE
```

- **Reduces EDM pool and thread storage**
- **Reduces allocate/deallocate cost at SQL execution and commit or deallocation**
- **Better exploitation of sequential detection and index lookaside**
  - **Potentially fewer Getpages, Lock requests, and faster I/O**

Minimize # rows searched

- Try to get the maximum matching index columns for the best index filtering
- Insure predicate comparison for the same data type and length
  - Example: "where indexed-column=host-variable“
  - Especially prior to V8
    - V8 made most typical unlike data type comparisons stage 1 or sargable and indexable

Dynamic SQL

- Reduce dynamic bind frequency via
  - Dynamic statement caching with CACHEDYNAMIC YES
  - REOPT(ONCE) in V8   REOPT(AUTO) in DB2 9
  - Improved monitoring in V8 Visual Explain
  - Next step in Optimization Support Center (DB2 9 and V8)

- Incremental bind in accounting
  - Static plan/package with VALIDATE(RUN) and bind time failure
  - Static SQL with REOPT(ALWAYS), or referencing Declared Temp Table, or private protocol in requestor

JDBC/SQLJ

- Use CACHEDYN YES for JDBC, or better yet use SQLJ or best choice is JLinQ (after DB2 9)
- Select/Update/Insert required columns only
  - More important in JDBC/SQLJ environment
- Store numeric as smallint or int to minimize conversion and column processing cost
  - Relative cost: Integer (lowest) -> Float -> Char -> Decimal -> Date/Time -> Timestamp (highest)
- Match Java and DB2 data type
  - V8 enhancement for non-matching data type

Existence Check

- SELECT FROM table WHERE EXISTS (SELECT FROM SYSIBM.SYSTABLES WHERE TYPE='A') …..
  - **In V7, all qualifying rows in this EXISTS subquery are retrieved and stored in a work file.**
    - **Select from SYSIBM.SYSTABLES where Type='A' Fetch First 1 Row Only followed by Select from outer table can be much faster.**
  - **In V8, this subquery execution is terminated as soon as a first qualifying row is found.**

Thread Reuse

- Thread reuse for 5 to 20% CPU time reduction for light transactions

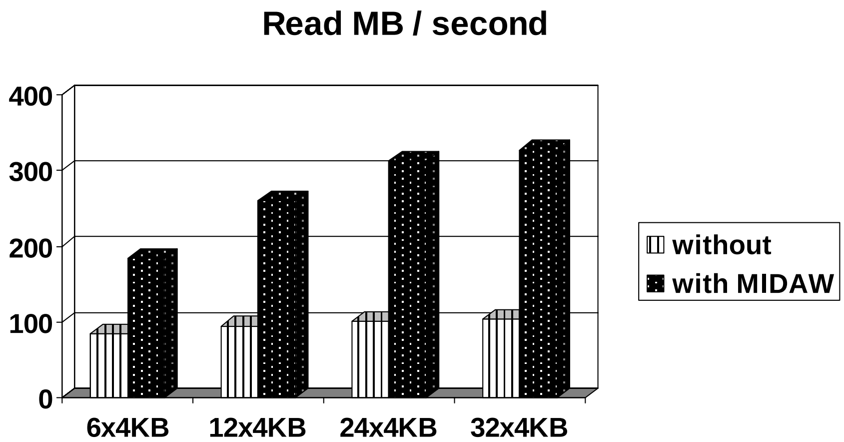
NORMAL TERMINATION	AVERAGE	TOTAL
NEW USER	1.00	174752
DEALLOCATION	0	0
RESIGNON	0	0
INACTIVE	0	0

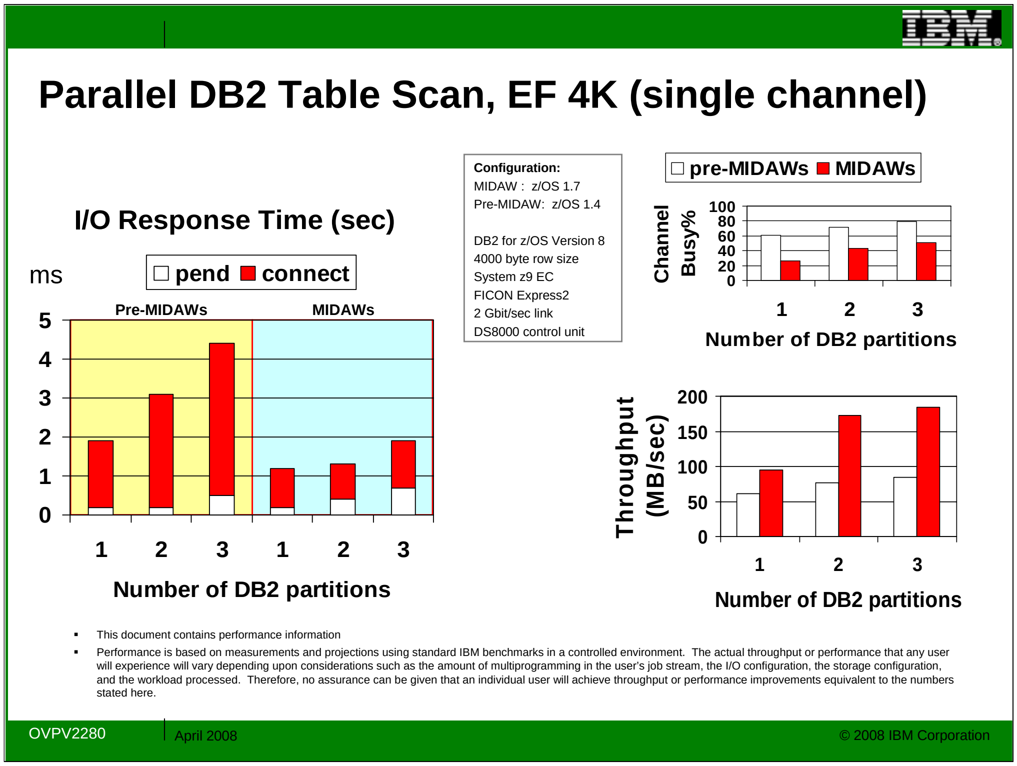
➢ All except DEALLOCATION indicate successful thread reuse.

Distributed/Stored Procedure

- Stored procedure to avoid DRDA overhead for each SQL call
  - Example: 10 Select, Insert, Update, and/or Delete calls in stored procedure
    - Results in 600us instead of 2100us overhead (10 SQL calls * 210us per SQL call) on z900 (2064-1) processor
    - Also faster response time because of as low as 1 rather than 10 message send/receive

Channel speed comparisons with and without MIDAW





These are some measurements with relatively new processors, new software, new channel configurations and new disks. Note the sustained scan rates of 100 megabytes per second or 170 MB / sec. for parallel access on one channel. For reading 32 pages at 4K each, the response time for sequential access is 1.2 milliseconds. Contrast that with the old rule of thumb of 64 ms.

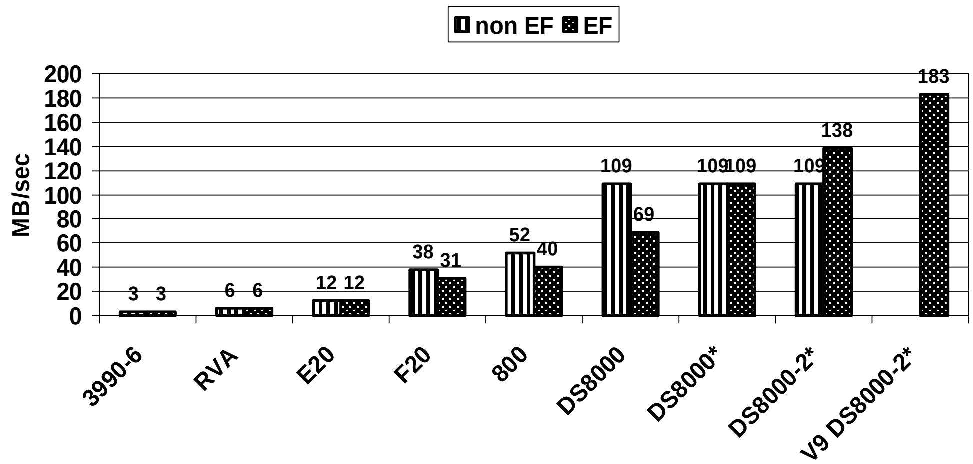
Configuration: MIDAW: z/OS 1.7 **Pre-MIDAW:** z/OS 1.4

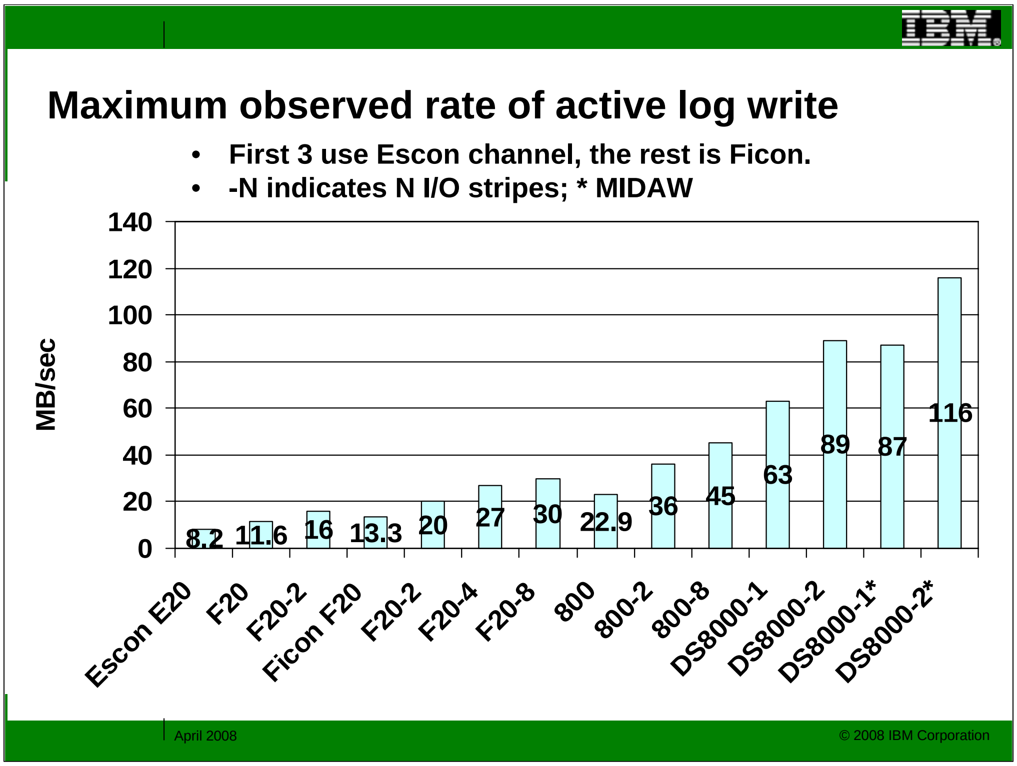
DB2 for z/OS V8 4000 byte row size System z9 109

FICON Express 2 2 Gbit/sec link DS8000 control unit

This document contains performance information. Performance is based on measurements and projections using standard IBM benchmarks 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.

Disk performance for sequential read





Faster DS8000 Turbo out, but not measured yet.

IO performance rules of thumb

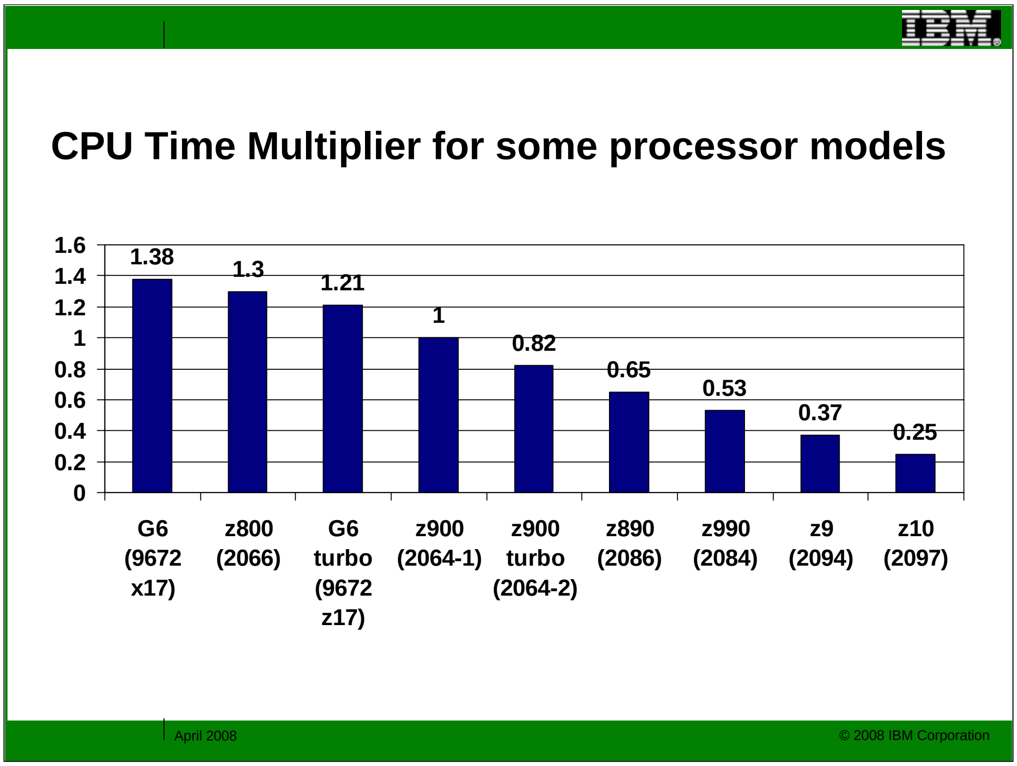
	4 K read	32 x 4K read
Old Rule of thumb	20 ms	64 ms
Current DS8300	1 - 2 ms	1.2 ms

Faster: 10 – 20 X 50 X

The old rule of thumb for random I/O was 20 milliseconds (ms). Access from the cache can be as low as 0.28 ms, so customers often report access time for random reads of a 4K page as 1 to 2 ms. That's 10 to 20 times faster.

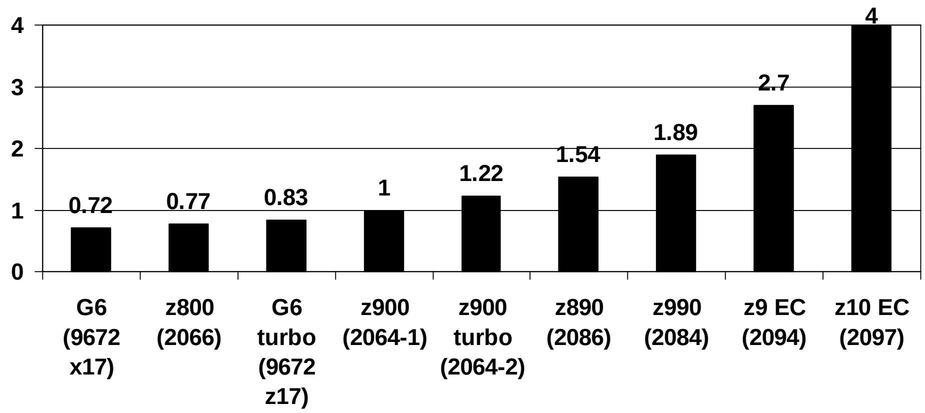
The old rule of thumb for sequential I/O of 32 pages at 4K was 64ms. Sequential IO with fiber channels (up to 4 Gb per second) and MIDAW improved that number to 1.2 ms. That's 50 times faster.

If we compare the data rate for sequential access to random access at 1 ms per page, the ratio is 27 times faster.



These are the improvements in performance from a single uniprocessor, expressed as a CPU multiplier. So if a process takes one second of CPU time on the z900, it runs .37 second on the z9 EC and roughly .25 second on the z10 EC or 4 times faster.

Recent single-processor relative CPU speeds



Index page split reduction

- **Bigger index page**
  - **4K, 8K, 16K, or 32K page**
    - **Up to 8 times less index split**
  - **Good for heavy inserts to reduce index splits**
    - **Especially recommended if high latch class 6 contention in data sharing**
      - ***Two forced log writes per split in data sharing***
    - **Or high latch class 254 contention in non data sharing shown in IFCID 57**

Index page split reduction - continued

- Asymmetric index page split depending on an insert pattern
  - Instead of 50-50 split
  - Up to 50% reduction in index split
  - -20% class 2 CPU, -31% elapsed time, -50% log write I/O and async CF requests in one data sharing measurement
    - 2 log write I/O’s per split in data sharing
  - -10% CPU, -18% elapsed time, -20% index Getpage and Buffer Update in one non data sharing measurement

Access Path Enhancements

- Cross query block optimization
  - Optimization across, rather than within, query blocks
  - More predicate transitive closure across query blocks

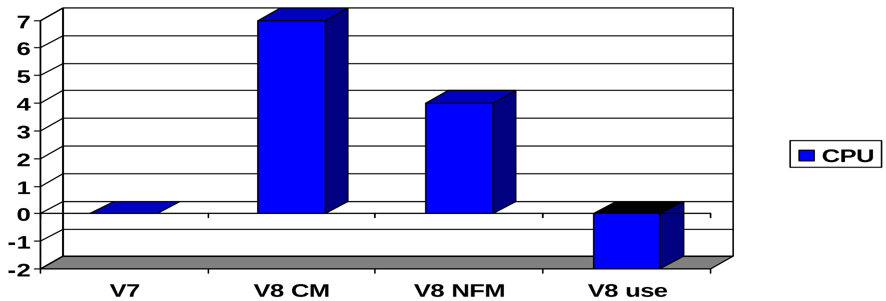
- Histogram statistics over a range of column values
  - Useful in range as well as equal predicates with high cardinality, eg Salary
  - Equal-depth (each interval with roughly same number of rows)

Index Compression

Difference between data and index compression

	Data	Index
Level	Row	Page (1)
Comp on disk	Yes	Yes
Comp in Buffer Pool	Yes	No
Comp in Log	Yes	No
Comp Dictionary	Yes	No (2)
Average Comp Ratio	10% to 90%	25 to 75% (3)

V8 best practice performance plan example scenario



Data sharing Better statistics DB design adjustments
REBIND Cluster, index
PGFIX(YES) application changes
zIIP multirow fetch & insert
zparms SQL adjustments

Your situation will vary. Less CPU is better.

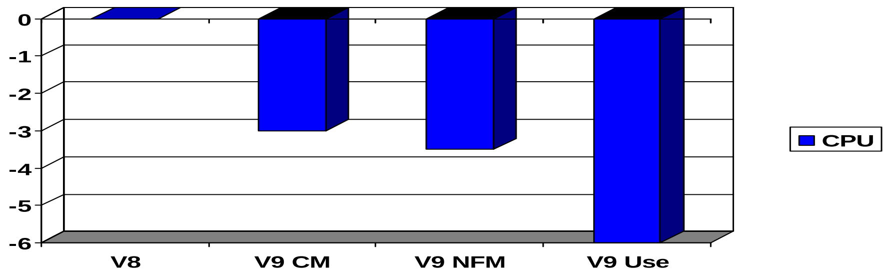
April 2008

Your situation and mileage will vary, but this is a common shape for a V8 performance plan, starting with zero for the V7 base line. When you move to V8, CPU time generally increases from 5% to 10%, shown here as 7. Start with long term page fix for buffer pools with high numbers of pages read and written. Reorg and collect improved statistics for non-uniform distribution of data on non-indexed columns. The V8 CM performance plan REBINDs the primary packages, and adjusts DSNZPARMs. The CM REBIND process provides most of the improved access paths. Data sharing batching helps in CM. During CM, a zIIP is added if your peak work load includes DRDA SQL, parallel query or LOAD, REORG and REBUILD.

In moving to NFM, some additional DSNZPARMS are adjusted and REBIND all plans and packages. Database designs start taking advantage of new clustering & indexing options, such as NOT PADDED for large varchar indexed columns. After making the design changes, REORG the data; REORG or REBUILD the indexes; get improved statistics & REBIND. The data sharing group is quiesced, and protocol 2 locking is used.

V8 use takes more advantage of the V8 performance improvements: MQTs, DPSI, more not-padded indexes, multi-row Fetch, cursor Update, cursor Delete, & Insert. Use other SQL improvements to reduce V8 CPU, less than V7. The work may grow, but some of the growth uses the zIIP.

DB2 9 z10, z9, z890 & z990 performance plan example scenario



Utilities
Histogram statistics
REBIND
DSNZPARMS

DB design adjustments
Index improvements
application changes
native SQL procedures
SQL adjustments

Your situation will vary. Less CPU is better.
z800 and z900 expect +5% to +10% CPU

April 2008

If you have a z10, z9, z990 or z890, this is expected to be a common shape for a DB2 9 performance plan, starting with zero for the V8 baseline. When you first move to DB2 9, total DB2 CPU time generally decreases from 0% to 5% for z9, z890 and z990 customers, shown here as a first step -3%. Utility CPU reductions help immediately. Some work will be about the same (+/-3%). Start with reorgs and collect improved histogram statistics when useful. The DB2 9 CM performance plan REBINDs the primary packages and adjusts DSNZPARMs. The REBINDs provide most of the improved access paths. On z800 or z900 the initial CPU expectation is +5 to +10% regression, more if there are many columns, so making adjustments is more important.

In moving to NFM, some additional DSNZPARMS are adjusted and all plans and packages are rebound. The DB2 9 use line takes wider advantage of DB2 9 performance improvements. Database designs start taking advantage of new indexing options, such as compression, index on expression and larger pages. After making the design changes, REORG the data and REORG or REBUILD the indexes, get the improved statistics and REBIND. Native SQL procedures, added use of zIIP, and improved SQL continue the improvements in this phase.

Scenario: Customer mix of DB2 CPU time is 30% in utilities, 70% in SQL access. With 10% improvement for the utilities, we get a -3% net, assuming that SQL is the same as before. With optimization improvements, another -½% improvement shows up in DB2 9 NFM. Then as design adjustments, reorgs and rebinds are performed, we get improvements from varchar improvements, native SQL procedures and improved SQL, another -3%.

Summary

✓DB2 V8 and DB2 9 provide substantial improvements

✓Some changes are automatic

✓More changes require system or database changes

✓Some require programming changes

✓Basics matter for performance