Query Optimization and Performance with DB2 11 for z/OS

Central Ohio DB2 User Group (CODUG)

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May 13, 2016

Agenda

- Plan Management Usage
- Minimal intervention query performance
- In-Memory Data Cache (sparse index)
- DPSIs, page range & parallelism
- Misc Performance enhancements
- Optimizer externalization and statistics cleanup

Plan Management Usage

Static Plan Management - Target Usage

- Plan management provides protection from access path (performance) regression across REBIND/BIND
  - Access path fallback to prior (good) access path after REBIND
    - DB2 9 PLANMGMT(EXTENDED/BASIC) with SWITCH capability
  - DB2 10
    - Freeze access path across BIND/REBIND
      - **BIND/REBIND PACKAGE … APREUSE(ERROR)**
    - Access path comparison with BIND/REBIND
      - **BIND/REBIND PACKAGE… APCOMPARE(WARN | ERROR)**
  - DB2 11
      - **BIND/REBIND PACKAGE … APREUSE(WARN)**

DB2 11 Plan Management – APREUSE(WARN)

- DB2 10 delivered APREUSE(ERROR)
  - Allowed potential for reuse of prior plan to generate new runtime structure
  - Failure of reuse failed the entire package

- DB2 11 delivers APREUSE(WARN)
  - Upon failure of reuse, Optimizer will generate a new access path choice for that SQL
    - Thus failure of 1 SQL will not fail the entire package

APREUSE usage & implications

- Trade safety for potential CPU savings
  - Improved performance is one of the highlights of DB2 11
  - And the biggest gains often come from new access path choices
    - Example - one internal DB2 “query” workload had

      <2% CPU saving without REBIND (old runtime structure)

      <10% CPU savings with APREUSE (new runtime structure, old access path)

      >30% CPU saving without APREUSE (new access path)

      NOTE: this is NOT to demonstrate YOUR expected savings. Not all queries need new ap

- Migration is often a time when safety is desired
  - APREUSE(ERROR) in DB2 10 & 11 provides the most safety from change
  - May consider APREUSE(WARN) as 2nd step (after 1st step using ERROR)

Plan Management – Migration Preparation

- There is NO capability to FREE only an ORIGINAL copy
  - FREE PACKAGE PLANMGMTSCOPE(PLANMGMTINACTIVE)
    - FREEs both ORIGINAL and PREVIOUS

- ORIGINAL can become stale
  - The idea is to keep a “good and stable” backup in case of emergency
    - But it needs to be a recent good/stable backup

- Before migration to DB2 11
  - Perform FREE PACKAGE PLANMGMTSCOPE(PLANMGMTINACTIVE)
  - So that 1st REBIND in DB2 11 will save the pre-V11 CURRENT copy as ORIGINAL

  - BUT…..before doing that, read next slide……

DB2 11 and prior release package support

- DB2 11 supports packages from n-2 releases (DB2 9)
  - Pre-DB2 9 packages will be undergo AUTOBIND
    - AUTOBIND replaces the CURRENT which does NOT get saved as PREVIOUS/ORIGINAL
- REBIND all pre-V9 packages in V10 before DB2 11 migration
  - Any problems – REBIND SWITCH(PREVIOUS) in V10
    - ABIND=COEXIST will avoid AUTOBIND ping-pong in co-existence
  - Order of steps
    - REBIND all pre-V9 packages in V10. Once satisfied…….
    - FREE PACKAGE PLANMGMTSCOPE(PLANMGMTINACTIVE)
    - Migrate to DB2 11

Minimal Intervention Query Performance Improvements

Improve single matching index access options

- Improved predicate filtering – filtering rows earlier
  - Stage 2 predicate to indexable rewrites without “Index on Expression”
    - YEAR(DATE_COL)
    - DATE(TIMESTAMP_COL)
    - value BETWEEN C1 AND C2
    - SUBSTR(C1,1,10)
  - Single index access for OR IS NULL predicates
  - Indexability for IN/OR combinations
  - Push complex predicates inside materialized views/table expressions
  - Pruning (removing) “always true/false” literals (except “OR 0=1”)

Predicate Indexability & Plan management

- REBIND SWITCH takes you back to the prior runtime structure
  - If that is a pre-V11 plan, then that is pre-V11 predicate indexability improvements
- APREUSE/APCOMPARE occurs after query (predicate) transformations
  - May result in the prior plan NOT being available due to rewritten predicates
  - For example:
    - OR COL IS NULL rewritten to a single index plan – prior multi-index or range-list plan not available

      APREUSE(ERROR) would fail or APREUSE(WARN) would get a new plan
- Stage 2 to indexable rewrite may mean same index, but increase in matchcols
  - APREUSE(ERROR) would fail
    - No changes in plan are acceptable
  - APREUSE(WARN) would succeed with reusing prior plan
    - If only change is MATCHCOLS increase

Index skipping and Early-out

- Improvements to queries involving GROUP BY, DISTINCT or non-correlated subq
  - Where an index can be used for sort avoidance
    - By skipping over duplicates in the index
- Improvement to join queries using GROUP BY, DISTINCT (not apreuse friendly)
  - By NOT accessing duplicates from inner table of a join if DISTINCT/GROUP BY removes duplicates
- Improvement to correlated subqueries
  - Early-out for ordered access to MAX/MIN correlated subqueries
    - When I1-fetch is not available
  - Optimize usage of the “result cache” for access to subquery with duplicate keys from the outer query
    - 100 element result cache dates back to DB2 V2 as a runtime optimization

In-memory data cache / Sparse Indexing

Sparse index (in-memory data cache)

- Similar in concept to hash join in other RDBMSs
  - Controlled by zparm MXDTCACH (default 20MB)

- Improved optimizer usage and memory allocation in DB2 11
  - Each sparse index/IMDC is given a % of MXDTCACH
    - From optimizer cost perspective
    - At runtime (based upon cost estimation)
  - Runtime will choose appropriate implementation based upon available storage
    - Hash, binary search, or spill over to workfile

IMDC/Sparse index – Performance considerations

- DB2 11 provides simple accounting/statistics data for sparse index
  - Sparse IX disabled
    - Suggest reducing MXDTCACH or allocating more memory to the system
  - Sparse IX built WF
    - Increase MXDTCACH (if above counter is = 0) or reduce WF BP VPSEQT (if high sync I/O)

- Memory considerations for sparse index
  - Default DB2 setting for MXDTCACH is conservative
  - Customers generally undersize WF BP (compared to data BPs)
    - And often set VPSEQT too high (close to 100) for sort BP
  - If sync I/O seen in WF BP or PF requests & issues with PF engines
    - Consider increasing MXDTCACH given sufficient system memory
    - Consider increasing WF BP size and setting VPSEQT=90

DPSI, Page Range & Parallelism

DB2 11 Page Range Screening

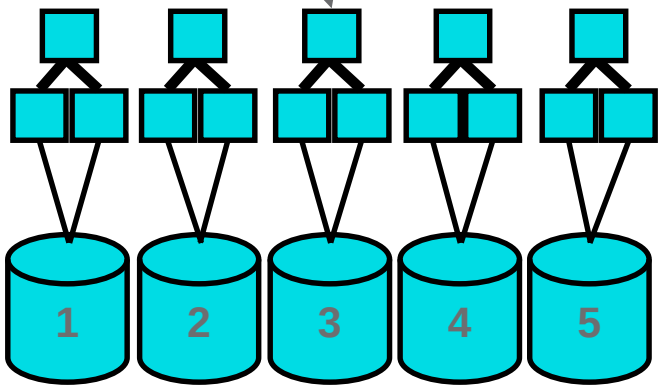
- Page range performance Improvements
  - Page Range Screening on Join Predicates
    - Access only qualified partitions
  - Pre-DB2 11, page range screening only applied to local predicates
    - With literals, host variables or parameter markers
  - Applies to index access or tablespace scan
    - Benefits NPIs by reducing data access only to qualified parts
    - Biggest benefit to DPSIs by reducing access only to qualified DPSI parts
- Only for equal predicates, same datatype/length

Page Range Join Probing (Join on Partitioning Col)

- Join recognizes page range screening
  - Only probe 1 part

YEAR	PARTNO
2011	1
2012	2
2013	3
2014	4
2015	5

T2
Partition by PARTNO
DPSI on ACCTNO




```
SELECT *
FROM T1, T2
WHERE T1.PARTNO = T2.PARTNO
AND T1.YEAR = 2013
AND T2.ACCTNO = 12345
```

Page range screening – who benefits?

- Page range screening enhancement is not workload dependent
  - Depends instead on a partitioning scheme
    - Where the partitioning column(s) include join columns,

      but an index supporting a join does NOT include the partitioning columns as leading columns

- Performance benefit?
  - No benefit if index is a PI
    - Since index columns match partitioning columns
  - No benefit if NPI and partitioning columns exist in index
    - Since predicates on partitioning columns would be index screening
  - Significant benefit up to 40% CPU reduction for DPSIs
    - NOT expected any customer is using DPSIs in this scenario today.
    - May allow switch to DPSIs for this scenario

DPSI – DB2 11 Enhancements

- DPSI can benefit from page range screening from join
  - Assuming you partition by columns used in joins (see previous slides)

- For DPSIs on join columns and partition by other columns
  - DB2 11 Improves DPSI Join Performance (using parallelism)
    - Controlled by ZPARM PARAMDEG_DPSI

- Sort avoidance for DPSIs (also known as DPSI merge)
  - Use of Index On Expression (IOE)
    - Ability to avoid sorting with DPSI IOE (already available for DPSI non-IOE)
  - Index lookaside when DPSI used for sort avoidance

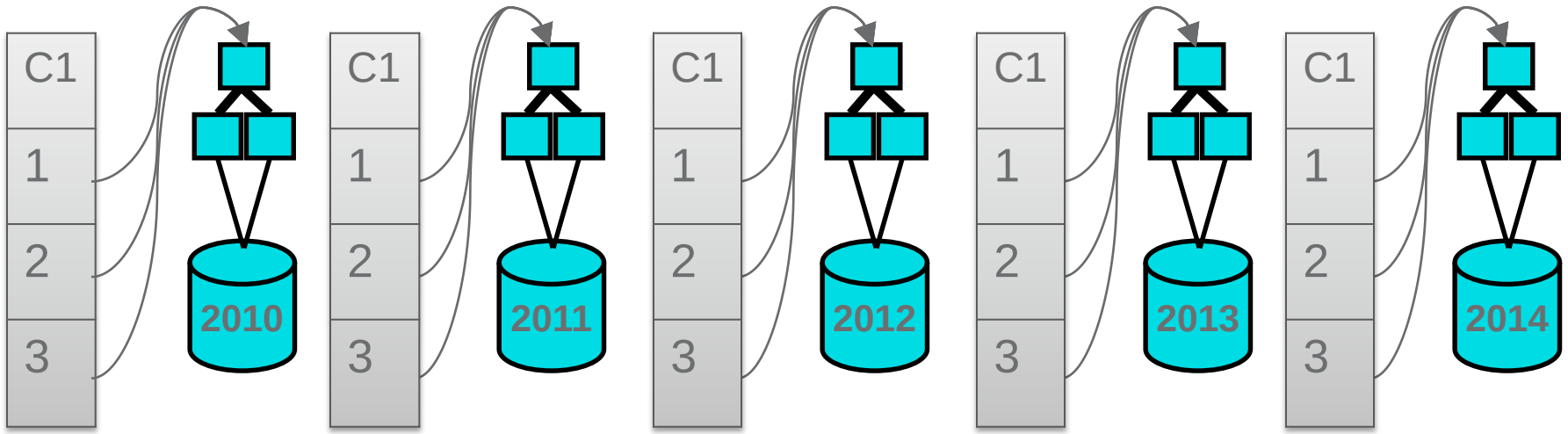
- Straw-model parallelism support for DPSI
  - Straw-model (delivered in V10) implies that DB2 creates more work elements than there are degrees on parallelism.

DPSI Join on Non-Partitioning Column

- DB2 11 DPSI part-level Nested Loop Join
  - Share composite table for each child task (diagram shows a copy)
    - Each child task is a 2 table join
    - Allows each join to T2 to access index sequentially (and data if high CR)

```
SELECT *
FROM T1, T2
WHERE T1.C1 = T2.C1
```

T2
DPSI on C1



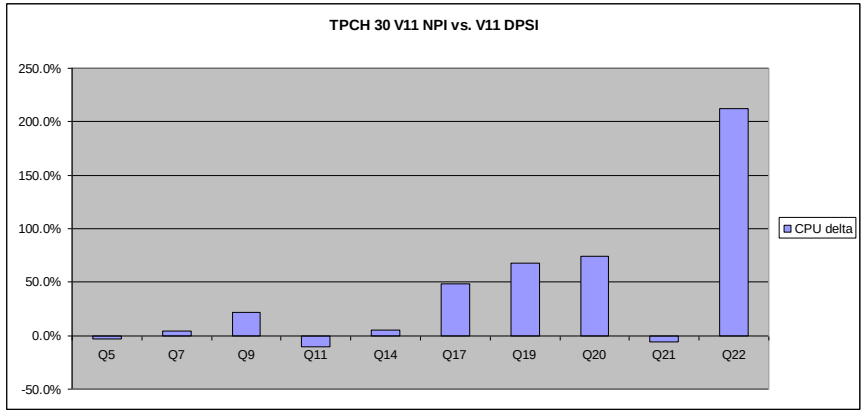
What does DB2 11 mean for DPSIs?

- A “partitioned” index means excellent utility performance
  - But historically there was one sweet spot ONLY for DPSIs
    - When local predicates in the query could limit partitions to be accessed

- Does DB2 11 allow me to switch all NPIs to DPSIs?
  - NO, but the sweet spot just got a little bigger
    - NPIs still are necessary in many workloads

- How do NPIs & DPSIs now compare?
  - Internal TPCH measurement
    - DPSIs increased CPU on avg by 8% vs NPIs

      But 1 query was 200% !!!!
  - DB2 11 ESP customer feedback
    - 2 customers reported > 75% CPU improvement for DPSIs (no other details provided)



Parallelism considerations

- Parallelism controls – default (‘1’) disabled
  - Static SQL – DEGREE bind parameter
  - Dynamic SQL – zparm CDSSRDEF or SET CURRENT DEGREE
- Number of degrees
  - Default PARAMDEG=0 which equals 2 * # of total CPs
    - Can be too high if few zIIPs
    - Conservative recommendation is 2 * # of zIIPs
- Parallelism requires sufficient resources

- DPSI performance can be improved with parallelism
  - Only DPSI part level join is controlled by zparm PARAMDEG_DPSI

Misc Performance items

CPU speed impact on access paths

- DB2 11 can reduce access path changes based upon different CPUs
  - CPU speed is one of the inputs to the optimizer
- Customers have seen CPU speed alter access paths
  - Across data sharing members
  - After CPU upgrade
  - Development vs production with different CPU speeds
- Less need to model production CPU speed in test in V11
  - Unless using Business Class machines
  - http://www-01.ibm.com/support/docview.wss?uid=swg21470440
    - Or google “DB2 production modelling”

Sort / Workfile Recommendations

- In-memory (from V9 to 11) is avoided if CURSOR WITH HOLD
  - Which is the default for ODBC & JDBC
- Ensure adequate WF BP, VPSEQT & datasets
  - Set VPSEQT=90 for sort (due to sparse index and/or DGTTs)
    - Evaluate sync I/Os in WF BP – may indicate sparse index spilling to WF
  - Provide multiple physical workfiles placed on different DASD volumes
  - Sort workfile placement example
    - 4-way Data Sharing Group
    - Assume 24 volumes are available
    - Each member should have 24 workfile tablespaces on separate volumes
    - All members should share all 24 volumes (i.e. 4 workfiles on each volume)

RID processing enhancements

- Pre-DB2 11
  - DB2 10 added RID failover to WF
    - Did not apply to queries involving column function
  - A single Hybrid Join query could consume 100% of the RID pool
    - Causing other concurrent queries to hit RID limit if > 1 RID block needed

- DB2 11
  - RID failover to WF extended to all scenarios when RID limit is hit
  - Hybrid join limited to 80% of the RID pool

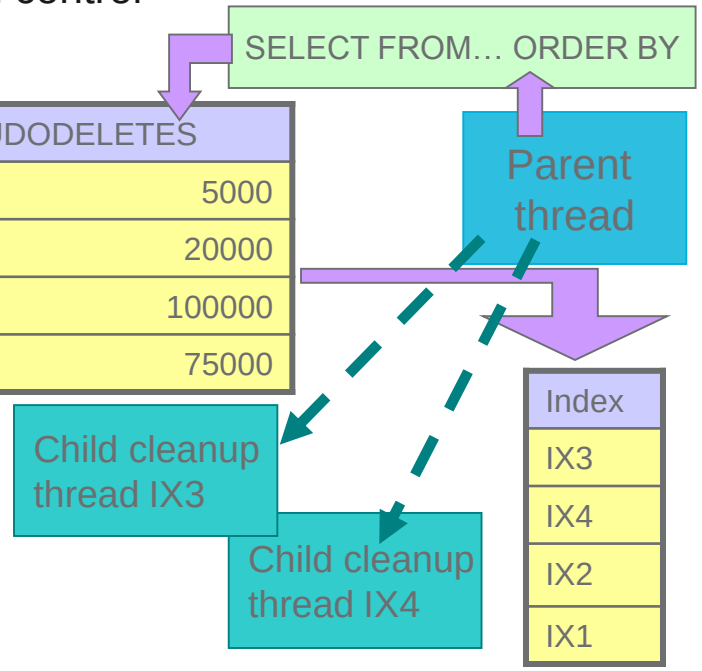
  - ZPARM MAXTEMPS_RID recommendation (DB2 10 & 11)
    - Set to NONE if failover to WF results in regressions

Reorg minimization enhancements – Indexes

- Pseudo-deletes
  - Index keys deleted/updated are marked pseudo-deleted and remain until REORG or when leaf page is full of pseudo-deletes
    - These degrade index scan performance
- DB2 11 adds automated clean up of pseudo-deletes
  - Cleanup is done under zIIP eligible system tasks
    - ZPARM INDEX_CLEANUP_THREADS to control # of concurrent tasks (default 10)
    - Catalog SYSIBM.SYSINDEXCLEANUP for table level control

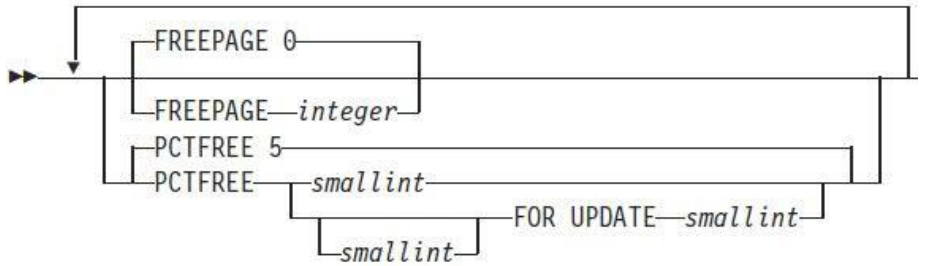
NAME	…	NPAGES	…	REORGPSEUDODELETES
IX1	nn	100	xx	5000
IX2	nn	1000	xx	20000
IX3	nn	500	xx	100000
IX4	nn	2000	xx	75000

SYSIBM.SYSINDEXSPACESTATS



Reorg minimization enhancements – TS Updates

- Indirect references
  - Update to var length or compressed row where row cannot fit in original location – DB2 will relocate row but leave original RID
    - Degrades data access since access to row requires extra getpage
- DB2 11 adds capability to allocate % free for updates
  - Leaves % space available during INSERTs or utilities
    - Utilities (LOAD/REORG) allocate the space, INSERT will not consume this
  - Zparm PCTFREE_UPD default 0, values
    - 0-99 (but may not want allocate value as system default)
    - Auto – uses RTS to determine %
  - Tablespace level control
    - 0-99, -1 means start with 5%, then RTS adjusts at REORG

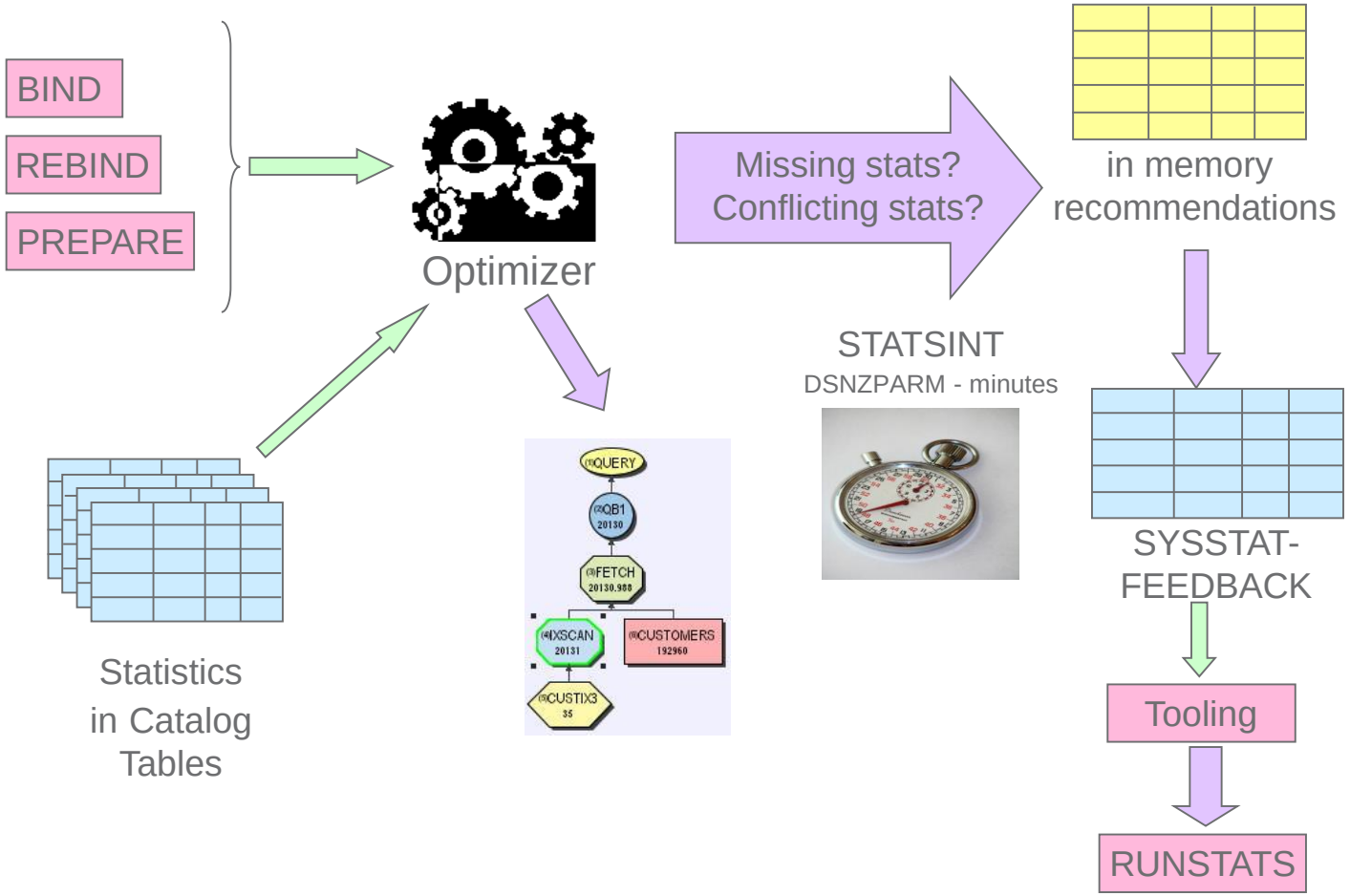


Optimizer externalization of missing statistics

DB2 Optimizer and Statistics - Challenge

- DB2 cost-based optimizer relies on statistics about tables & indexes
- Customers often gather only standard or default statistics
  - E.g. RUNSTATS TABLE(ALL) INDEX(ALL) KEYCARD
- Queries would often perform better if DB2 optimizer could exploit more complete statistics
- Customers have difficulty knowing which statistics are needed

DB2 11 – Optimizer externalization of missing statistics



DB2 11 Solution: Optimizer Externalization

- During access path calculation, optimizer will identify missing or conflicting statistics
  - On every BIND, REBIND or PREPARE
    - Asynchronously writes recommendations to SYSIBM.SYSSTATFEEDBACK (NFM)
  - DB2 also provides statistics recommendations on EXPLAIN
    - Populates DSN_STAT_FEEDBACK synchronously (CM if table exists)

- Contents of SYSSTATFEEDBACK or DSN_STAT_FEEDBACK can be used to generate input to RUNSTATS
  - Contents not directly consumable by RUNSTATS
  - Requires DBA or tooling to convert to RUNSTATS input

Optimizer Feedback - Controls

- Explain capability is available regardless of zparm value
  - Only requires existence of DSN_STAT_FEEDBACK table

- ZPARM STATFDBK_SCOPE
  - NONE – Disable collection of recommended RUNSTATS
  - STATIC – Collect for static queries only
  - DYNAMIC – Collect for dynamic queries only
  - ALL – Collect for all SQL (default)

- SYSTABLES.STAT_FEEDBACK updateable column (table control)
  - Y | N - indicates whether to externalize recommendations for this table
    - Yes is default. N means DB2 will not externalize for this table

- SYSSTATFEEDBACK.BLOCK_RUNSTATS updateable column (individual statistic control)
  - blank | Y – blank means okay to collect
    - Y(es) indicates to tooling or user that statistic should not be collected;
  - DB2 does not use this column as input, only tooling does

Recommendation to focus on

- Suggest focusing on these “FREQVAL” reasons
  - BASIC
    - Basic statistics are missing (TABLE(ALL) INDEX(ALL))
  - CONFLICT
    - There is a conflict between table & index statistics, or frequency & cardinality
    - Implies that statistics were run on different objects at different times
  - LOWCARD
    - Low cardinality column (often skewed)
  - NULLABLE
    - NULL is often the most frequently occurring value
  - DEFAULT
    - Implies column value “looks” like a default value (zero, blank, etc)
- Other reasons are targeted and may require further investigation

Further notes about interpreting recommendations

- DB2 is only recommending that a statistic could have been used
  - This is not a guarantee that the statistic is needed.
  - There is still a benefit to try to 1st determine whether collecting the statistic may add value
    - For a TYPE='F' recommendation – is the data really skewed?
    - What value to use for "COUNT integer"?

      10 is a good default

      If COLCARDF<=10, then use COLCARDF-1
  - REASON should also be considered
    - For example - TYPE='F',REASON='NULLABLE'

      If NULL is most frequently occurring, then you only need COUNT 1 (not 10)

Clearing out old statistics

- Old (stale) statistics
  - Customers often run “specialized” statistics as a once-off to try to solve an issue or as a prior default.
    - These old statistics can become stale and cause access path issues
    - Simplest way to find these is to look for tables with rows having different STATSTIMEs in SYSCOLDIST

- DB2 11 delivers
  - RUNSTATS reset option
    - Sets all relevant catalog values to -1, and clears tables such as SYSCOLDIST

    - Recommend running “regular” RUNSTATS after RESET

```
RUNSTATS TABLESPACE db-name.ts-name
TABLE table-name RESET ACCESSPATH
```

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