IBM System z Technology Summit

DB2 9 & DB2 10 for z/OS Optimizer

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Disclaimer

Agenda

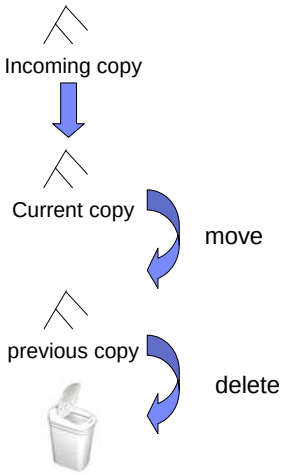
- **Bind/Prepare**
  - Plan management
  - Hints/Bind options
  - Explain
  - Dynamic Statement Caching
  - REOPT
- **Optimizer costing**
- **Runtime query performance**
- **Indexing**
- **Complex queries**

Plan Management Overview

- **Ability to backup your static SQL packages (DB2 9)**
- **At REBIND**
  - Save old copies of packages in Catalog/Directory
  - Switch back to previous or original version
- **Two flavors**
  - BASIC
    - 2 copies: Current and Previous
  - EXTENDED
    - 3 copies: Current, Previous, Original
  - Default controlled by a ZPARM
  - Also supported as REBIND options

Plan Management - BASIC support

REBIND … PLANMGMT(BASIC)



REBIND … SWITCH(PREVIOUS)

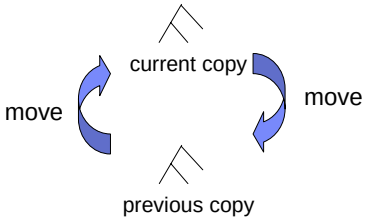
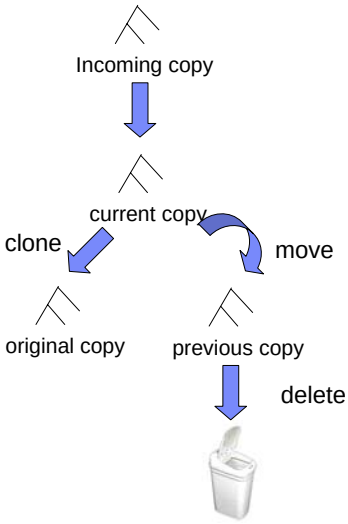


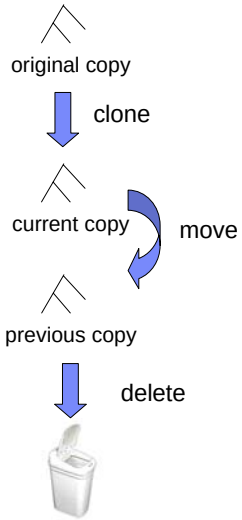
Chart is to be read from bottom to top

Plan Management - EXTENDED support

REBIND … PLANMGMT(EXTENDED)



REBIND … SWITCH(ORIGINAL)



Plan Management Notes

- **REBIND PACKAGE …**
  - PLANMGMT (BASIC)
    2 copies: Current and Previous
  - PLANMGMT (EXTENDED)
    3 copies: Current, Previous, Original
- **REBIND PACKAGE …**
  - SWITCH(PREVIOUS)
    Switch between current & previous
  - SWITCH(ORIGINAL)
    Switch between current & original
- **Most bind options can be changed at REBIND**
  - *But a few must be the same …*
- **FREE PACKAGE …**
  - PLANMGMTSCOPE(ALL) – Free package completely
  - PLANMGMTSCOPE(INACTIVE) – Free old copies
- **Catalog support**
  - SYSPACKAGE reflects active copy
  - SYSPACKDEP reflects dependencies of all copies
  - Other catalogs (SYSPKSYSTEM, …) reflect metadata for all copies
- **Invalidation and Auto Bind**
  - Each copy invalidated separately

3 important updates:

1. APAR PK80375 – SPT01 Compression (DB2 V8 & 9)
2. APAR PM09354 – Support DBPROTOCOL change
3. Article – Search for “Escaping the REBIND blues in DB2 9 for z/OS”

DB2 10 Updates to Plan Management

- **SYSIBM.SYSPACKCOPY**
  - New catalog table
  - Hold SYSPACKAGE-style metadata for any previous or original package copies
  - No longer need to SWITCH to see information on inactive copies
    - Complaint from DB2 9
- **APRETAINDUP option of REBIND**
  - Default YES
    - Retain duplicate for BASIC or EXTENDED
  - Optional NO
    - Do not retain duplicate access path as PREVIOUS or ORIGINAL
      - PREVIOUS/ORIGINAL must be from DB2 9 or later

What-if? BIND

- **BIND package to see what new**
- **Bind package EXPLAIN(ONLY) and/or SQLERROR(CHECK)**
  - Existing package copies are not overwritten
    - Performs explain or syntax/semantic error checks on SQL
  - Requires BIND, BINDAGENT, or EXPLAIN privilege.
  - Supported for BIND only
    - Not REBIND
    - Targeted to application changes
      - Eg. Development environment is DB2 LUW, production DB2 for z/OS

Retrieving Access Path with EXPLAIN(NO)

- **EXPLAIN PACKAGE**
  - Extract existing PLAN_TABLE information for packages
    - NOT a new explain
    - The package/copy must be created on DB2 9 or later
  - Useful if you didn't BIND with EXPLAIN(YES)
    - Or PLAN_TABLE entries are lost

```
>>-EXPLAIN----PACKAGE----------->

>>-----COLLECTION--collection-name--PACKAGE--package-name--------->

>----+-------------------------+----+------------------+-------->
     |                         |    |                  |
     +---VERSION-version-name---+    +---COPY--copy-id---+
```

- COPY-ID can be 'CURRENT', 'PREVIOUS', 'ORIGINAL'

Access Path Stability with statement level hints

- **Current limitations in hint matching**
  - QUERYNO is used to link queries to their hints – a bit fragile
  - For dynamic SQL, require a change to apps – can be impractical
- **New mechanisms:**
  - Associate query text with its corresponding hint … more robust
  - Hints enforced for the entire DB2 subsystem
    - irrespective of static vs. dynamic, etc.
  - Hints integrated into the access path repository
- **PLAN_TABLE isn't going away**
- **Only the "hint lookup" mechanism is being improved.**

Statement level hints (cont.)

- **Steps to use new hints mechanism**
  - Populate a user table DSN_USERQUERY_TABLE with query text
  - Populate PLAN_TABLE with the corresponding hints
  - Run new command BIND QUERY
    - To integrate the hint into the repository.
  - FREE QUERY can be used to remove the hint.

Statement-level BIND options

- **Statement-level granularity may be required rather than:**
  - Subsystem level ZPARMs (STARJOIN, SJTABLES, MAX_PAR_DEGREE)
  - Package level BIND options (REOPT, DEF_CURR_DEGREE)
- **For example**
  - Only one statement in the package needs REOPT(ALWAYS)

- **New mechanism for statement-level bind options:**
  - Similar to mechanism used for hints
  - DSN_USERQUERY_TABLE can also hold per-statement options

Literal Replacement

- **Dynamic SQL with literals can now be re-used in the cache**
  - Literals replaced with &
    - Similar to parameter markers but not the same
- **To enable either you:-**
  - Put CONCENTRATE STATEMENTS WITH LITERALS in the PREPARE ATTRIBUTES clause
  - Or set LITERALREPLACEMENT in the ODBC initialization file
  - Or set the keyword enableLiteralReplacement='YES' in the JCC Driver
- **Lookup Sequence**
  - Original SQL with literals is looked up in the cache
  - If not found, literals are replaced and new SQL is looked up in the cache
    - Additional match on literal usability
    - Can only match with SQL stored with same attribute, not parameter marker
  - If not found, new SQL is prepared and stored in the cache

Literal Replacement …

- **Example:**

```
WHERE ACCOUNT_NUMBER = 123456
```

  – This would be replaced by

```
WHERE ACCOUNT_NUMBER = &
```

- **Performance Expectation**
  - Using parameter marker still provides best performance
  - Biggest performance gain for repeated SQL with different literals
  - NOTE: Access path is not optimized for literals
    - True for parameter markers/host variables today
    - Need to use REOPT for that purpose

Dynamic SQL REOPT - AUTO

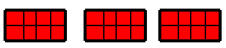
- **For dynamic SQL with parameter markers**
  - DB2 will automatically reoptimize the SQL when
    - Filtering of one or more of the predicates changes dramatically
      - Such that table join sequence or index selection may change
    - Some statistics cached to improve performance of runtime check
  - Newly generated access path will replace the global statement cache copy.
- **First optimization is the same as REOPT(ONCE)**
  - Followed by analysis of the values supplied at each execution of the statement

Agenda

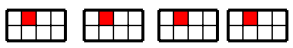
- **Bind/Prepare**
- **Optimizer costing**
  - RUNSTATS
  - Cost model enhancements
  - Subquery costing
- **Runtime query performance**
- **Indexing**
- **Complex queries**

Clusterratio Enhancement

- **New Clusterratio formula in DB2 9**
  - Including new DATAREPEATFACTOR statistic
    - Differentiates density and sequential



Dense (and sequential)



Sequential (not dense)

- **Controlled by zparm STATCLUS**
  - ENHANCED is default
  - STANDARD disables, and is NOT recommended

- **Recommend RUNSTATS before mass REBIND in first version AFTER V8**

Clusterratio Impacts

- **Clusterratio may be**
  - Higher for indexes
    - With many duplicates (lower colcardf)
      - In recognition of sequential RIDs
    - On smaller tables
      - Less clusterratio degradation from random inserts
    - Indexes that are reverse sequential
  - Lower for random indexes
    - No benefit from dynamic prefetch
- **Clusterratio(CR)/DataRepeatfactor (DRF) patterns**

	High DRF	Low DRF
High CR	**Sequential but not dense**	**Density matching clustering or small table**
Low CR	**Random index**	**Unlikely**

Histogram Statistics

- RUNSTATS **will produce equal-depth histogram**
  - Each quantile (range) will have approx same number of rows
    - Not same number of values
  - Another term is range frequency
- **Example**
  - 1, 3, 3, 4, 4, 6, 7, 8, 9, 10, 12, 15 (sequenced)
  - Lets cut that into 3 quantiles.
    - 1, 3, 3, 4 ,4 6,7,8,9 10,12,15

Seq No	Low Value	High Value	Cardinality	Frequency
1	**1**	**4**	**3**	**5/12**
2	**6**	**9**	**4**	**4/12**
3	**10**	**15**	**3**	**3/12**

Histogram Statistics Notes

- **RUNSTATS**
  - Maximum 100 quantiles for a column
  - Same value columns WILL be in the same quantile
  - Quantiles will be similar size but:
    - Will try to avoid big gaps inside quantiles
    - Highvalue and lowvalue may have separate quantiles
    - Null WILL have a separate quantile
- **Supports column groups as well as single columns**
- **Think "frequencies" for high cardinality columns**

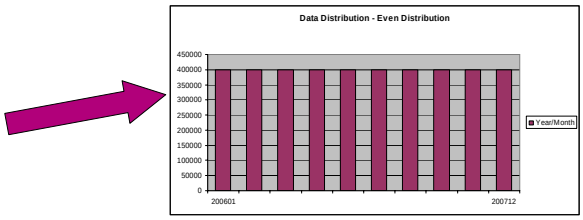
Histogram Statistics Example

- **SAP uses INTEGER (or VARCHAR) for YEAR-MONTH**

WHERE YEARMONTH BETWEEN 200601 AND 200612

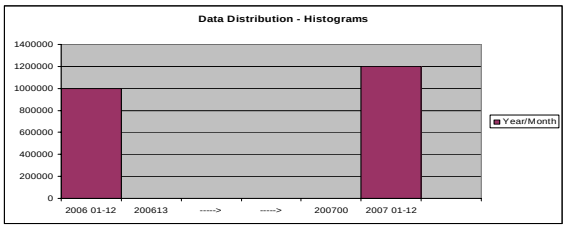
- Assuming data for 2006 & 2007
  - FF = (high-value – low-value) / (high2key – low2key)
  - FF = (200612 – 200601) / (200711 – 200602)
  - **10% of rows estimated to return**

Data assumed as evenly distributed between low and high range



Histogram Statistics Example

- Example (cont.)
  - Data only exists in ranges 200601-12 & 200701-12
    - Collect via histograms
      - 45% of rows estimated to return



No data between 200613 & 200700

WHERE YEARMONTH BETWEEN 200601 AND 200612

Autonomic Statistics Solution Overview

- **Autonomic Statistics is implemented though a set of Stored Procedures**
  - *Stored procedures are provided to enable administration tools and packaged applications to automate statistics collection.*
    - ADMIN_UTL_MONITOR
    - ADMIN_UTL_EXECUTE
    - ADMIN_UTL_MODIFY
  - Working together, these SP's
    - Determine what stats to collect
    - Determine when stats need to be collected
    - Schedule and Perform the stats collection
    - Records activity for later review
  - *See Chapter 11 "Designing DB2 statistics for performance" in the DB2 10 for z/OS Performance Monitoring and Tuning Guide for details on how to configure autonomic monitoring directly within DB2.*

RUNSTATS Simplification/Performance Overview

- **RUNSTATS options to SET/UPDATE/USE a stats profile**
  - Integrate specialized statistics into generic RUNSTATS job
    - RUNSTATS … TABLE tbl COLUMN(C1)… **SET PROFILE**
      - Alternatively use **SET PROFILE FROM EXISTING STATS**
    - RUNSTATS … TABLE tbl COLUMN(C5)… **UPDATE PROFILE**
    - RUNSTATS … TABLE tbl **USE PROFILE**

- **New option for page-level sampling**
  - But what percentage of sampling to use?
    - RUNSTATS … TABLE tbl **TABLESAMPLE SYSTEM AUTO**

Optimizer Validation with Realtime Stats

- **Index Probing & RTS lookup**

  - Estimate # of rids within a given start/stop index key range at bind/prepare

- **Exploited when these two conditions are met.**
  - Query has matching index-access local predicate
  - Predicate contain literals, or REOPT(ALWAYS|ONCE|AUTO)
- **And 1 of the following is also true**
  - Predicate is estimated to qualify no rows
  - Stats indicate the table contains no rows
  - Table is defined as VOLATILE or qualifies for NPGTHRSH
- **New EXPLAIN table to externalize runtime estimates**
  - User managed DSN_COLDIST_TABLE

DB2 10 - Minimizing Optimizer Challenges

- **Potential causes of sub-optimal plans**
  - Insufficient statistics
  - Unknown literal values used for host variables or parameter markers
- **DB2 10 Optimizer will evaluate the risk for each predicate**
  - For example: WHERE BIRTHDATE < ?
    - Could qualify 0-100% of data depending on literal value used
  - As part of access path selection
    - Compare access paths with close cost and choose lowest risk plan

Extending VOLATILE TABLE usage

- **VOLATILE TABLE support added in DB2 V8**
  - Targeted to SAP Cluster Tables
    - Use Index access whenever possible
    - **Avoids list prefetch**
      - Can be a problem for OR predicates or UPDATEs at risk of loop
- **DB2 10 provides VOLATILE to general cases**
  - Tables matching SAP cluster tables will maintain original limitations
    - Table with 1 unique index
  - Tables with > 1 index will follow NPGTHRSH rules
    - Use Index access whenever possible
    - **No limitation on list prefetch**
    - Less chance of getting r-scan when list-prefetch plan is only alternative

Global Optimization - Problem Scenario 1

- **V8, Large Non-correlated subquery is materialized***

```
SELECT * FROM SMALL_TABLE A
WHERE A.C1 IN
      (SELECT B.C1 FROM BIG_TABLE B)
```

  - "BIG_TABLE" is scanned and put into workfile
  - "SMALL_TABLE" is joined with the workfile

- **V9 may rewrite non-correlated subquery to correlated**
  - Much more efficient if scan / materialisation of BIG_TABLE was avoided
  - Allows matching index access on BIG_TABLE

```
SELECT * FROM SMALL_TABLE A
WHERE EXISTS
 (SELECT 1 FROM BIG_TABLE B WHERE B.C1 = A.C1)
```


Global Optimization - Problem Scenario 2

- **V8, Large outer table scanned rather than using matching index access***

```
SELECT * FROM BIG_TABLE A
WHERE EXISTS
 (SELECT 1 FROM SMALL_TABLE B WHERE A.C1 = B.C1)
```

  - "BIG_TABLE" is scanned to obtain A.C1 value
  - "SMALL_TABLE" gets matching index access

- **V9 may rewrite correlated subquery to non-correlated**

```
SELECT * FROM BIG_TABLE A
WHERE A.C1 IN
 (SELECT B.C1 FROM SMALL_TABLE B)
```

  - "SMALL_TABLE" scanned and put in workfile
  - Allows more efficient matching index access on BIG_TABLE

Global Optimization

- **Global opt internally represent subqueries as virtual tables**
  - Allows subquery to be considered in different join sequences
  - May or may not represent a physical workfile
    - Additional row added to PLAN_TABLE for non-correlated subq
      - PM30425 adds this new row for correlated
  - Apply only to subqueries that cannot be transformed to joins
    - SELECT only (not INSERT/SELECT, UPDATE, DELETE)

Correlated or non-correlated?.....I shouldn't have to care!

Agenda

- **Bind/Prepare**
- **Optimizer costing**
- **Runtime query performance**
  - Sort/sort avoidance
  - Sparse index
  - Predicate application
- **Indexing**
- **Complex queries**

GROUP BY Sort Avoidance

- **Improved sort avoidance for GROUP BY**
  - Reorder GROUP BY columns to match available index

```
SELECT … FROM T1
GROUP BY C2, C1      ←GROUP BY in C2, C1 sequence
Index 1 (C1, C2)     ←Index in C1, C2 sequence
```

  - Remove 'constants' from GROUP BY ordering requirement

```
SELECT … FROM T1
WHERE C2 = 5         ←C2 Constant
GROUP BY C2, C1
```

    - ordering requirement reduced to just C1

GROUP BY Sort Avoidance Implications

- **Implications of improved sort avoidance for GROUP BY**
  - May improve query performance!!!
  - Data may be returned in a different order
    - Always been true in any DB2 release
      - Also true in other DBMSs
    - Relational theory states that order is NOT guaranteed without ORDER BY

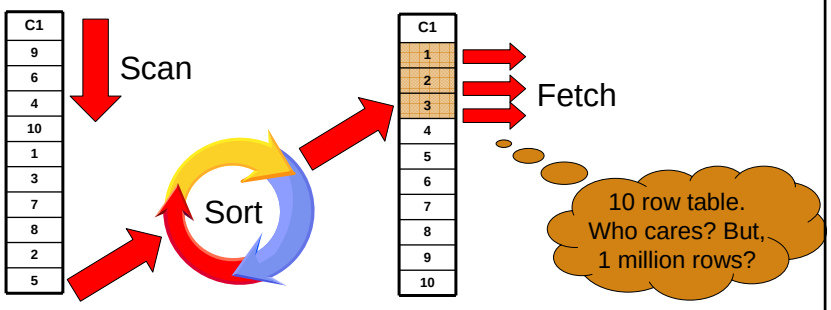
Sort Performance Enhancements

- **FETCH FIRST n ROWS ONLY (FFnR) and Sort**
  - DB2 9 added in-memory replacement for FFnR to avoid sort
    - Provided (n * (sort key + data)) < 32K
  - DB2 10 extends this to 128K
- **Avoid workfile usage for small sorts**
  - DB2 9 avoided allocating WF for final sort only
    - If <= 255 rows and result < 32K (sort key + data)
  - DB2 10 extends this to intermediate sorts also
    - Except for parallelism or SET function

Improving sort with FETCH FIRST

- **DB2 V8 example**
  - Sort is not avoided via index
    - Must sort all qualified rows

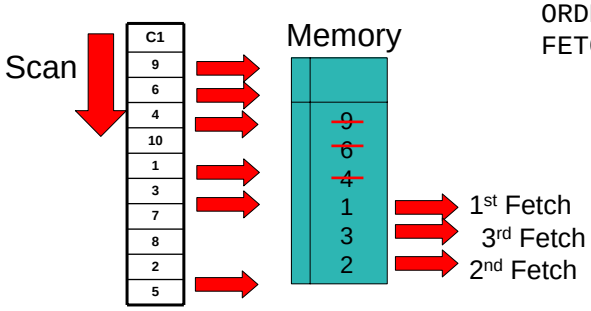
```
SELECT C1
FROM   T
ORDER BY C1
FETCH FIRST 3 ROWS ONLY
```



Improving sort with FETCH FIRST

- **DB2 9 example**
  - New algorithm for in-memory swap avoids (traditional) sort
    - Pointers maintain order

```
SELECT C1
FROM  T
ORDER BY C1
FETCH FIRST 3 ROWS ONLY
```



Suggestion: Add FETCH FIRST when subset is required.

Improvements to predicate application

- **Major enhancements to OR and IN predicates**
  - Improved performance for AND/OR combinations and long IN-lists
    - General performance improvement to stage 1 predicate processing
  - IN-list matching
    - Matching on multiple IN-lists
    - Transitive closure support for IN-list predicates
    - List prefetch support
    - Trim IN-lists from matching when preceding equals are highly filtering
  - SQL pagination
    - Single index matching for complex OR conditions
- **Many stage 2 expressions to be executed at stage 1**
  - Stage 2 expressions eligible for index screening
    - Not applicable for list prefetch
  - Externalized in DSN_FILTER_TABLE column PUSHDOWN

IN-list Table - Table Type 'I' and Access Type 'IN'

- The IN-list predicate will be represented as an in-memory table if:
  - **List prefetch is chosen, OR**
  - **More than one IN-list is chosen as matching.**
  - **The EXPLAIN output associated with the in-memory table will have:**
    - **New Table Type: TBTYPE – 'I'**
    - **New Access Type: ACTYPE – 'IN'**

```
SELECT *
   FROM T1
   WHERE T1.C1 IN (?, ?, ?);
```

QBNO	PLANNO	METHOD	TNAME	ACTYPE	MC	ACNAME	QBTYPE	TBTYPE	PREFETCH
1	1	0	DSNIN001(01)	*IN*	0		SELECT	*I*	
1	2	1	T1	I	1	T1_IX_C1	SELECT	T	*L*

IN-list Predicate Transitive Closure (PTC)

```
SELECT *
FROM T1, T2
WHERE T1.C1 = T2.C1
  AND T1.C1 IN (?, ?, ?)

  AND T2.C1 IN (?, ?, ?) ←   Optimizer can generate
                             this predicate via PTC
```

- **Without IN-list PTC (DB2 9)**
  - Optimizer will be unlikely to consider T2 is the first table accessed
- **With IN-list PTC (DB2 10)**
  - Optimizer can choose to access T2 or T1 first.

SQL Pagination

- **Targets 2 types of queries**
  - Cursor scrolling (pagination) SQL
    - Retrieve next n rows
      - Common in COBOL/CICS and any screen scrolling application
    - Not to be confused with “scrollable cursors”
  - Complex OR predicates against the same columns
    - Common in SAP
- **In both cases:**
  - The OR (disjunct) predicate refers to a single table only.
  - Each OR predicate can be mapped to the same index.
  - Each disjunct has at least one matching predicate.

Simple scrolling – Index matching and ORDER BY

- Scroll forward to obtain the next 20 rows
  - Assumes index is available on (LASTNAME, FIRSTNAME)
  - WHERE clause may appear as:

```
WHERE (LASTNAME='JONES' AND FIRSTNAME>'WENDY')
   OR (LASTNAME>'JONES')
ORDER BY LASTNAME, FIRSTNAME;
```

  - DB2 10 supports
    - Single matching index access with sort avoided 
  - DB2 9 requires
    - Multi-index access, list prefetch and sort
    - OR, extra predicate (AND LASTNAME >= ‘JONES’) for matching single index access and sort avoidance

Complex OR predicates against same index

- Given WHERE clause
  - And index on one or both columns

```
WHERE (LASTNAME='JONES' AND FIRSTNAME='WENDY')
   OR (LASTNAME='SMITH' AND FIRSTNAME='JOHN');
```

- DB2 9 requires
  - Multi-index access with list prefetch
- DB2 10 supports
  - Matching single index access – no list prefetch
  - Or, Multi-index access with list prefetch

Minimizing impact of RID failure

- **RID overflow can occur for**
  - Concurrent queries each consuming shared RID pool
  - Single query requesting > 25% of table or hitting RID pool limit
- **DB2 9 will fallback to tablespace scan***
- **DB2 10 will continue by writing new RIDs to workfile**
  - Work-file usage may increase
    - Mitigate by increasing RID pool size (default increased in DB2 10).
    - MAXTEMPS_RID zparm for maximum WF usage for each RID list

* Hybrid join can incrementally process. Dynamic Index ANDing will use WF for failover.

Agenda

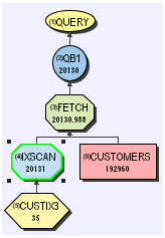
- **Bind/Prepare**
- **Optimizer costing**
- **Runtime query performance**
- **Indexing**
  - Index on expression
  - Tracking index use
  - Sparse index
  - Include columns
- **Complex queries**

Index on Expression

- **DB2 9 supports "index on expression"**
  - Can turn a stage 2 predicate into indexable

```
SELECT *
FROM CUSTOMERS
WHERE YEAR(BIRTHDATE) = 1971
```

```
CREATE INDEX ADMF001.CUSTIX3
    ON ADMF001.CUSTOMERS
(YEAR(BIRTHDATE) ASC)
```



Name	Value
Input RIDs	192960
Index Leaf Pages	241
Matching Predicates	Filter Factor
ADMF001.CUSTOMERS.= CAST(1971 AS INTEGER)	0.1043
Scanned Leaf Pages	26
Output RIDs	20131
Total Filter Factor	0.1043
Matching Columns	1

Previous FF = 1/25
Now, RUNSTATS collects frequencies. Improved FF accuracy

Index Enhancement - Tracking Usage

- **Additional indexes require overhead for**
  - Utilities
    - REORG, RUNSTATS, LOAD etc
  - Data maintenance
    - INSERT, UPDATE, DELETE
  - Disk storage
  - Optimization time
    - Increases optimizer's choices
- **But identifying unused indexes is a difficult task**
  - Especially in a dynamic SQL environment

Tracking Index Usage

- **RTS records the index last used date.**
  - SYSINDEXSPACESTATS.LASTUSED
    - Updated once in a 24 hour period
      - RTS service task updates at 1st externalization interval (set by STATSINT) after 12PM.
    - if the index is used by DB2, update occurs.
    - If the index was not used, no update.
- **"Used", as defined by DB2 as:**
  - As an access path for query or fetch.
  - For searched UPDATE / DELETE SQL statement.
  - As a primary index for referential integrity.
  - To support foreign key access

Tracking Index Usage Implications

- **What can you do with this information?**
  - LAST_USED only shows when the index was last used
    - Cannot predict future use
  - Assume you decide to DROP an index due to lack of usage
    - Is the index UNIQUE?
      - Is there another index that can guarantee that UNIQUEness?
    - Related statistics will be dropped
      - Same issue as “What If?” Optimization
      - For index on C1, C2, C3
        - > RUNSTATS options to collect statistics

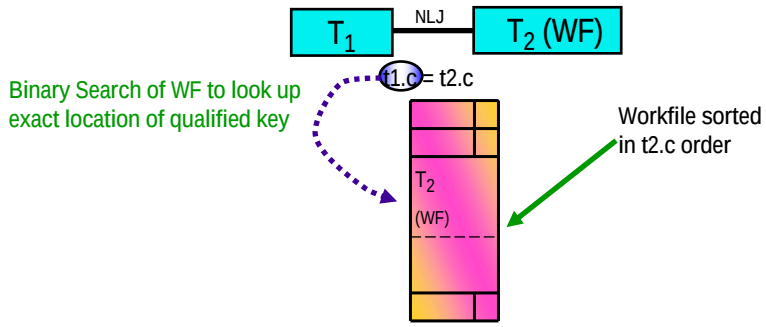
```
COLGROUP (C1) FREQVAL COUNT 10
COLGROUP (C1, C2, C3)
```


Data Caching and Sparse Index

- **Data Caching**
  - Built at runtime
    - Is a runtime enhancement to sparse index
  - Extended to non-star join in DB2 9
- **New ZPARM MXDTCACH**
  - Maximum extent in MB, for data caching per thread
  - If memory is insufficient
    - Fall-back to sparse index at runtime
- **Considered when lacking an index on join column(s):**
  - Temporary tables
  - Subqueries converted to joins
  - …..any table

How does Data Caching WF work?

- Data Cache contains the full result of materialized result
  - Sparse index will be a subset of WF entries
- Example, WF may have 10,000 entries
  - Cache is “binary searched” to find target location of search key



Index Include Columns

- **Index INCLUDE columns**
  - Create an Index as UNIQUE, and add additional columns
  - Ability to consolidate redundant indexes

```
INDEX1 UNIQUE (C1)
INDEX2 (C1,C2)
```

Consolidate to

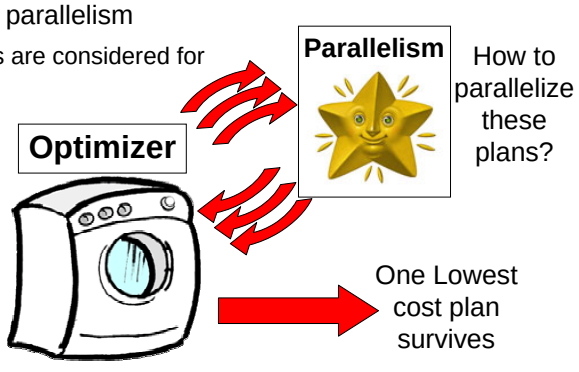
```
INDEX1 UNIQUE (C1) INCLUDE (C2)
```

Agenda

- **Bind/Prepare**
- **Optimizer costing**
- **Runtime query performance**
- **Indexing**
- **Complex queries**
  - Parallelism
  - BI/DW

Parallelism Enhancements

- **In V8**
  - Lowest cost is BEFORE parallelism
- **In DB2 9**
  - Lowest cost is AFTER parallelism
    - Only a subset of plans are considered for parallelism



Additional DB2 9 Parallelism Enhancements

- **Degree can cut on non-leading table**
  - –Benefit for leading workfile, 1-row table etc.
- **Histogram statistics exploited for more even distribution**
- **New zparm PARA_EFF**
  - –Controls optimizer cost reduction applied for parallelism benefit
    - Default 50 (%)
    - Lower PARAMDEG can tolerate higher PARA_EFF
    - Higher PARAMDEG may mean lower PARA_EFF

Removal Of Parallelism Restrictions #1

- Support parallelism for multi-row fetch
  - **In previous releases**
    - parallelism is disabled for the last parallel group in the top level query block
      - if there is no more table to join after the parallel group
      - and there is no GROUP BY clause or ORDER BY clause
  - Example:- SELECT * FROM CUSTOMER
    - There is no parallel group in the query and there are no table joins
    - There is no GROUP BY clause
    - There is no ORDER BY clause
    - So NO PARALLELISM will be used
- **This restriction is only removed if the CURSOR is DECLARED as READ ONLY**
  - Ambiguous Cursors will not have the restriction removed

Removal Of Parallelism Restrictions #2

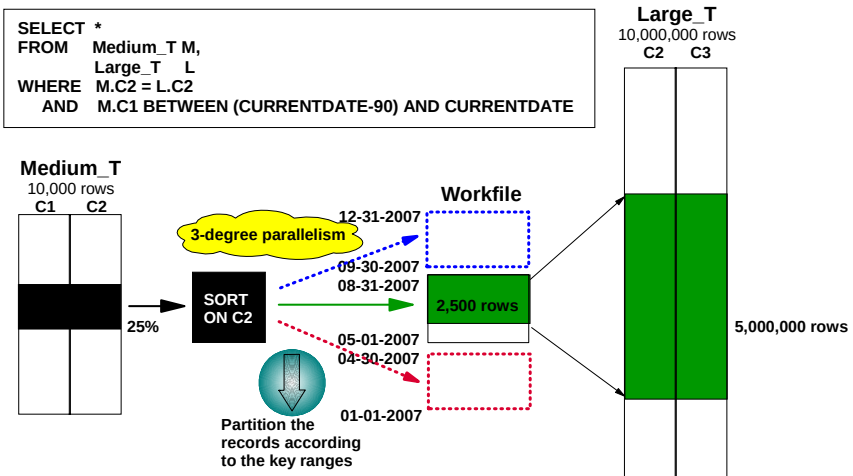
- **Allow parallelism if a parallel group contains a work file**
  - DB2 generates temporary a work file when view or table expression is materialized
  - This type of work file can not be shared among child task in previous releases of DB2, hence parallelism is disabled
  - DB2 10 will make the work file shareable
    - only applies to CP mode parallelism and no full outer join case

Parallelism Enhancements - Effectiveness

- **Previous Releases of DB2 may use Key Range Partitioning**
  - Key Ranges Decided at Bind Time
  - Based on Statistics (low2key, high2key, column cardinality)
    - Assumes uniform data distribution
    - Histograms can help
      - But rarely collected
  - If Statistics are outdated or data is not uniformly distributed what happens to performance?

Key range partition - Today

```
SELECT  *
FROM    Medium_T M,
        Large_T    L
WHERE   M.C2 = L.C2
  AND   M.C1 BETWEEN (CURRENTDATE-90) AND CURRENTDATE
```



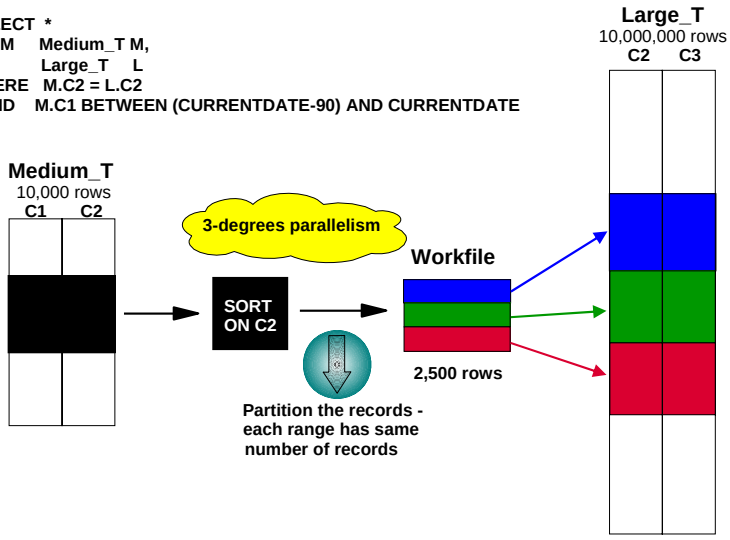
M.C1 is date column, assume currentdate is 8-31-2007, after the between predicate is applied, only rows with date between 06-03-2007 and 8-31-2007 survived, but optimizer chops up the key ranges within the whole year after the records are sorted :-(

Parallelism Effectiveness – Record range

- **DB2 10 can use** Dynamic record range partitioning
  - Materialize the intermediate result in a sequence of join processes
  - Results divided into ranges with equal number of records
  - Division doesn't have to be on the key boundary
    - Unless required for group by or distinct function
  - Record range partitioning is dynamic
    - no longer based on the key ranges decided at bind time
  - Now based on number of composite records and parallel degree
    - Data skew, out of date statistics etc. will not have any effect on performance

Dynamic record range partition

```
SELECT  *
FROM    Medium_T M,
        Large_T   L
WHERE   M.C2 = L.C2
  AND   M.C1 BETWEEN (CURRENTDATE-90) AND CURRENTDATE
```

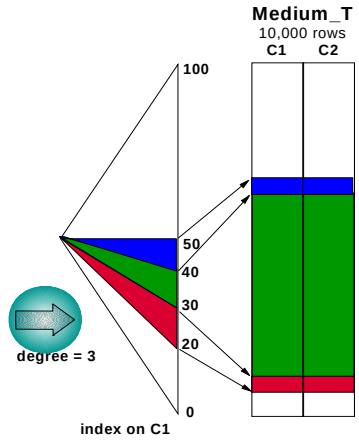


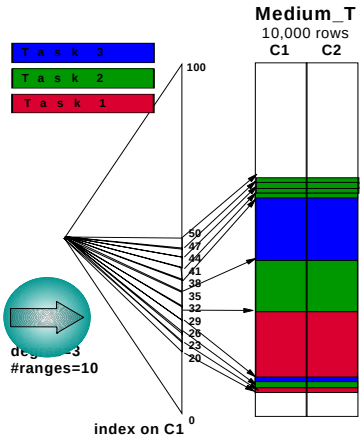
Parallelism Effectiveness - Straw Model

- **Previous releases of DB2 divide the number of keys or pages by the number representing the parallel degree**
  - One task is allocated per degree of parallelism
  - The range is processed and the task ends
  - Tasks may take different times to process
- **DB2 10 can use the Straw Model workload distribution method**
  - More key or page ranges will be allocated than the number of parallel degrees
  - The same number of tasks as before are allocated (same as degree)
  - Once a task finishes it's smaller range it will process another range
  - Even if data is skewed this new process should make processing faster

STRAW Model

```
SELECT *
FROM   Medium_T M
WHERE  M.C1 BETWEEN 20 AND 50
```

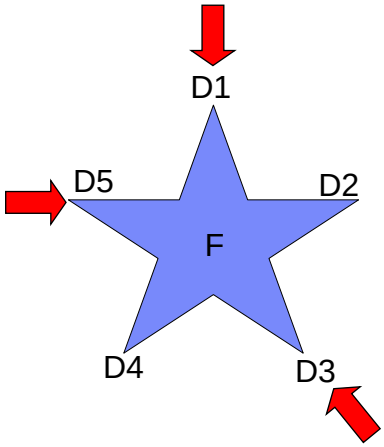




Divided in key ranges before DB2 10 **Divided in key ranges with Straw Model**

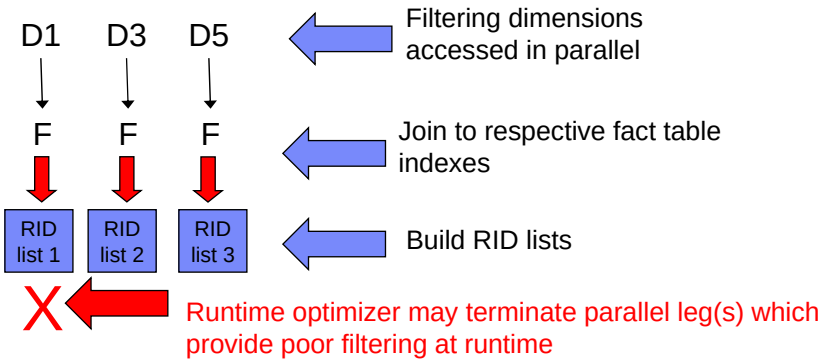
Dynamic Index ANDing Challenge

- **Filtering may come from multiple dimensions**
  - Creating multi-column indexes to support the best combinations is difficult



Index ANDing – Pre-Fact

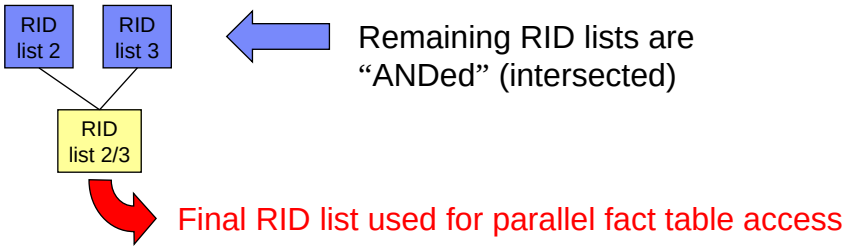
- **Pre-fact table access**
  - –Filtering may not be (truly) known until runtime



Index ANDing – Fact and Post-Fact

- **Fact table access**
  - –Intersect filtering RID lists
  - –Access fact table
    - •From RID list
- **Post fact table**
  - –Join back to dimension tables

Using parallelism



Dynamic Index Anding Highlights

- **Pre-fact table filtering**
  - Filtering dimensions accessed concurrently
- **Runtime optimization**
  - Terminate poorly filtering legs at runtime
- **More aggressive parallelism**
- **Fallback to workfile for RID pool failure**
  - Instead of r-scan

APAR PK76100 – zparm to enable EN_PJSJ