May 6-10, 2007

San Jose Convention Center

San Jose, California, USA

More Ways to Challenge the DB2 z/OS Optimizer

IDUG® 2007 North America

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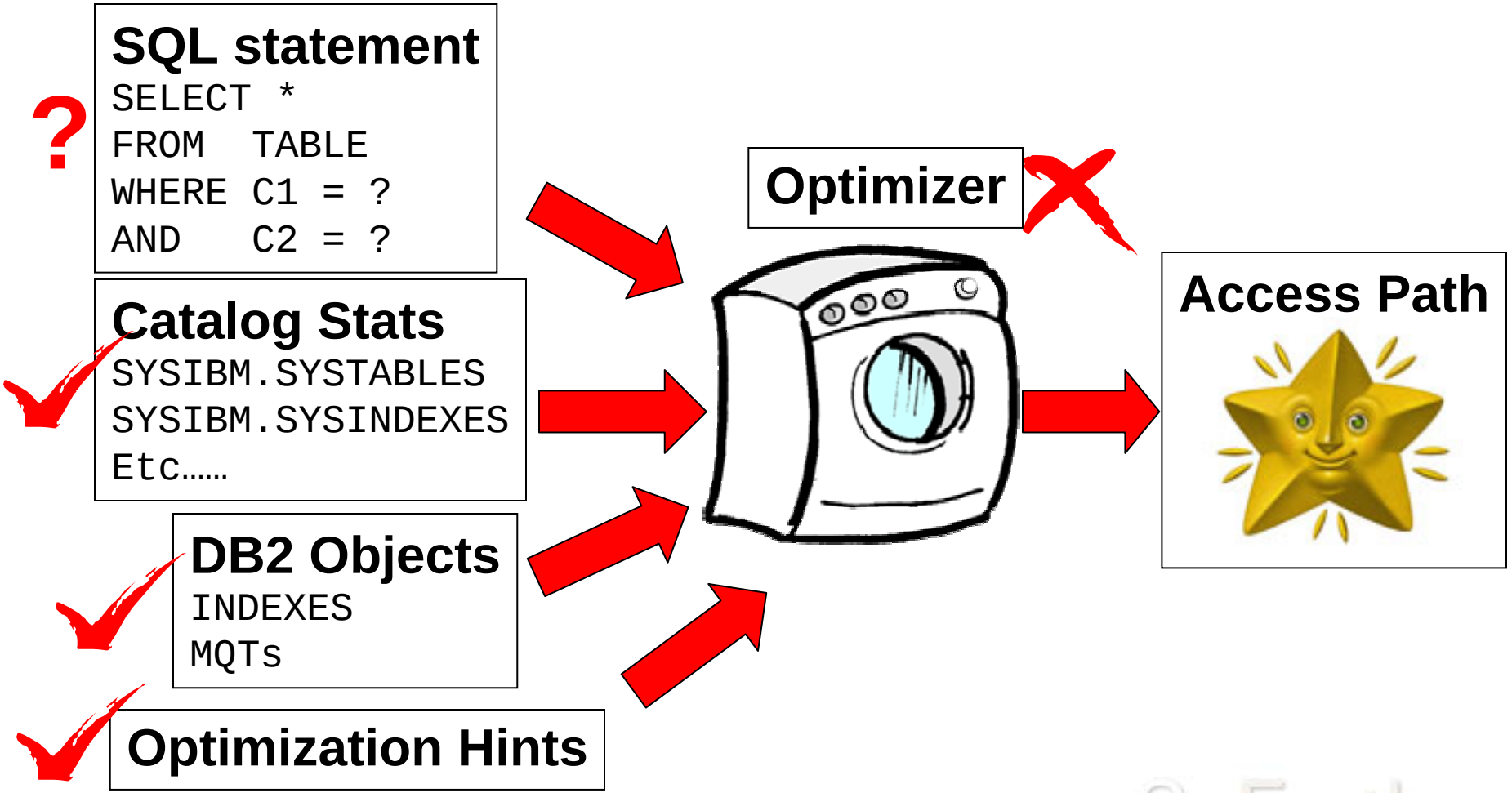
GoFurther

Agenda

- Introduction
- Process for validating the preferred access path
- Filter Factor Challenges
- Predicate Challenges
- Conclusion

What can you control?



Do you want to challenge the optimizer?

- Is the access path for your SQL obvious?
  - Is the optimizer able to apply the filtering early?
  - Are there indexes that support an efficient path?
  - Do statistics allow distinction between the choices?

- If no……
  - You're more likely to have performance regressions
    - From minor changes in statistics
    - At release or maintenance upgrade times

- So how do we challenge the optimizer less?

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Verifying the optimizer's choice

- What access path would you like to see?
  - Run counts per object
    - Per table
    - Per index
    - Per predicate
  - To verify the optimal join sequence and index(es)
- Compare this to optimizer's chosen access path

SQL Statement

- To determine the preferred access path
  - Run counts to see what the data shows the best access path to be……

```
SELECT *
FROM  CUSTOMERS C, ACCOUNTS A
WHERE C.CUSTNO = A.CUSTNO
  AND C.CUSTNO BETWEEN ? AND ?
  AND C.STATUS = ?
  AND C.GENDER = ?
  AND A.OPENDATE > ?
  AND A.CLOSEDATE < ?
```

Query Count

- Run a count of rows qualified from entire query
  - Requires knowledge of literal values

```
SELECT COUNT(*) = 6232 rows
FROM  CUSTOMERS C, ACCOUNTS A
WHERE C.CUSTNO = A.CUSTNO
   AND C.CUSTNO BETWEEN 1 AND 100000
   AND C.STATUS = 'Y'
   AND C.GENDER = 'F'
   AND A.OPENDATE  > '19600101'
   AND A.CLOSEDATE < '20070101'
```

Per Table Count

- Break apart the SQL per object
  - 1st level of granularity is per table

```
SELECT COUNT(*)
FROM  CUSTOMERS C
WHERE C.CUSTNO BETWEEN 1 AND 100000
  AND C.STATUS = 'Y'
  AND C.GENDER = 'F'
```

Is this all the single table predicates???

```
SELECT COUNT(*)
FROM  ACCOUNTS A
WHERE A.OPENDATE  > '19600101'
  AND A.CLOSEDATE < '20070101'
```

Optimizer Generated Predicates

- To ensure the “per object” counts are correct
  - Add all optimizer generated predicates
  - Given…..

```
WHERE C.CUSTNO = A.CUSTNO
  AND C.CUSTNO BETWEEN 1 AND 100000
```

  - Optimizer will generate

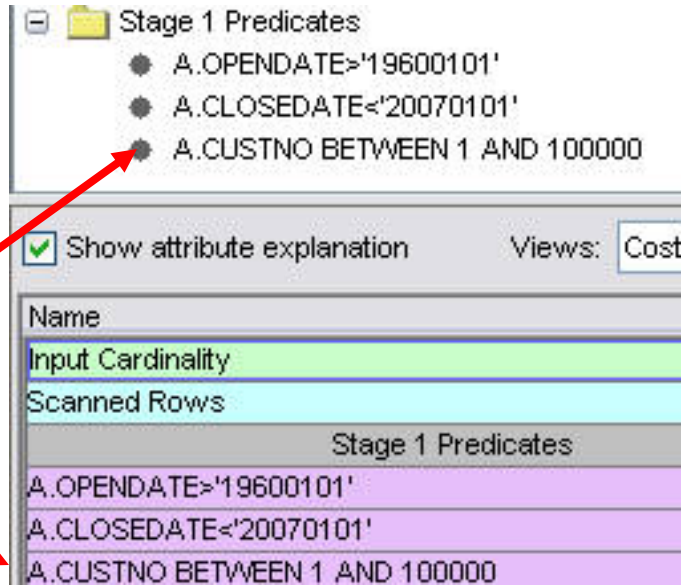
```
AND A.CUSTNO BETWEEN 1 AND 100000
```

  - Known as “Predicate Transitive Closure” (PTC)
    - Applies to =, <, <=, >, >=, BETWEEN

Determining Generated Predicates

- DB2 V8 Visual Explain
  - Shows existence of predicate
    - (But not that it was generated)

Extract from Query Graph Detail

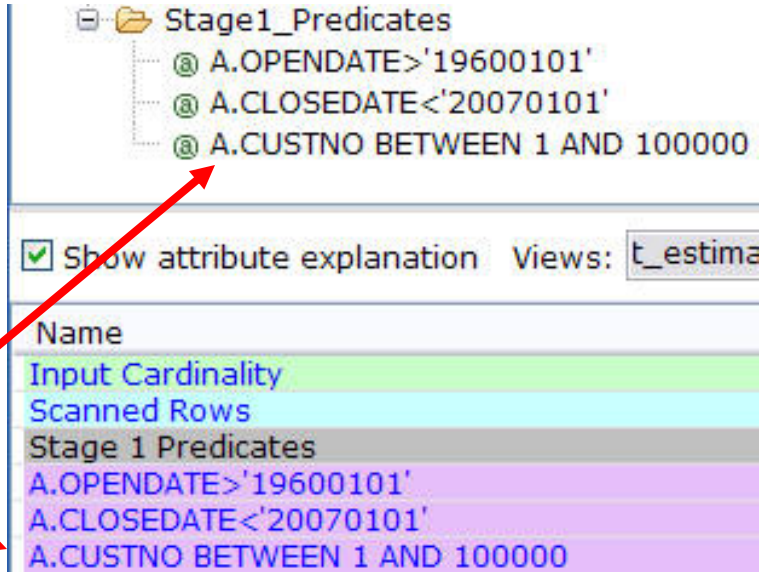


Extract from Predicate Report

Predicate Text
A.CUSTNO BETWEEN 1 AND 100000

Determining Generated Predicates

- DB2 9 OSC
  - Shows existence of predicate
    - (And that it was generated)



Extract from Query Graph Detail

Extract from Predicate Report

TABLE	COLNAME	TYPE	BT	S1	JN	AJ	PTC
ADMF001.ACCOUNTS	CUSTNO	BETWEEN	Y	Y	N	N	Y

Predicate Transitive Closure = 'Y'

OSC Predicate Report Notes

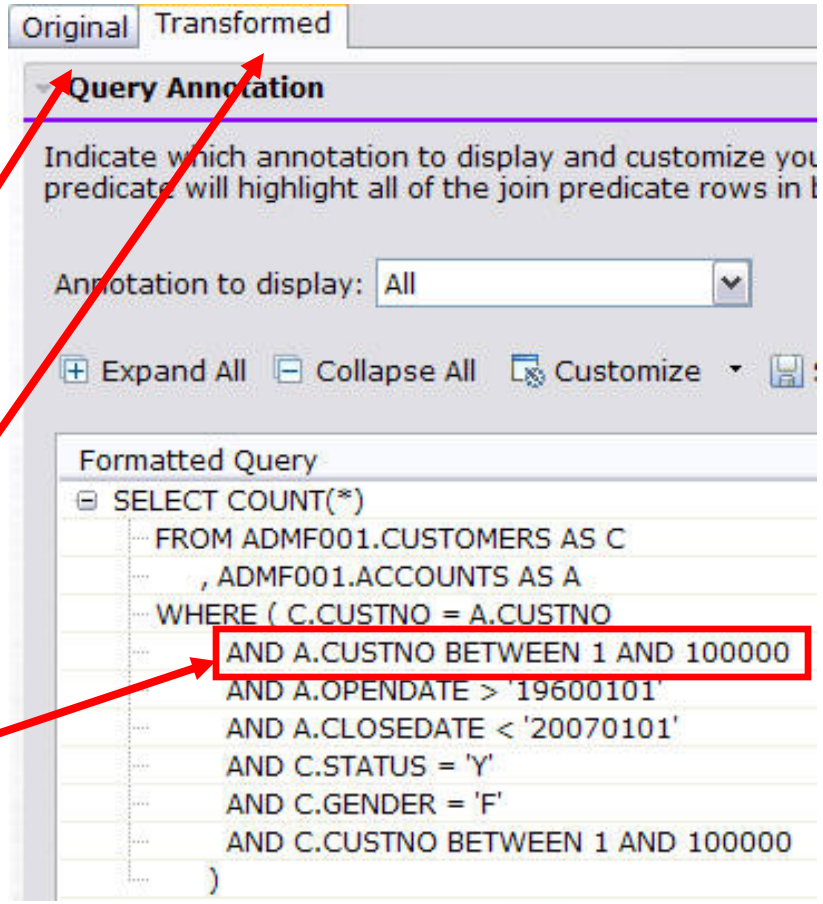
- Legend of OSC predicate report abbreviations

Predicate Report

	Legend for column names that have been truncated
FF	--Filter factor
BT	--Whether this predicate is a boolean term predicate
S1	--Whether the predicate is a stage 1 predicate
JN	--Whether this predicate is a join predicate
AJ	--Whether the predicate evaluation phase is after the join
PTC	--Whether the predicate is generated by transitive closure,which means that DB2 generates additional predicates to provide more information for access path selection when the set of predicates that belong to a query logically imply other predicates
MARKER	--Whether this predicate includes host variables, parameter markers, or special registers
PREDNO	--The predicate number

Determining Generated Predicates

- New for DB2 9 OSC
  - Query Annotation shows the transformed query



Click-on Original or Transformed

New predicate appears in transformed query

Per Table Count

- With generated predicates

Preferred Table as leading

```
SELECT COUNT(*) = 5308 rows
FROM  CUSTOMERS C (cardf = 192960)
WHERE C.CUSTNO BETWEEN 1 AND 100000
  AND C.STATUS = 'Y'
  AND C.GENDER = 'F'
```

```
SELECT COUNT(*) = 86959 rows
FROM  ACCOUNTS A (cardf = 256663)
WHERE A.CUSTNO BETWEEN 1 AND 100000
  AND A.OPENDATE  > '19600101'
  AND A.CLOSEDATE < '20070101'
```

Use of Table Counts

- Table counts can be directly compared to the optimizer's estimate from Table Report
  - 9 OSC QUALROWS field
  - V8 VE Qualified Rows field

Table Report

	Legend for column names that have been truncated
PARTS	-- Number of partitions in tablespace
QUALROWS	-- Optimizer's estimate for how many rows qualify if this table were the outer table
CLU	-- Is the index the clustering index?
UR	-- Unique rule
CR	-- Clusterratiof

Per Index Count – 1st Table

- Break-apart 1st table query further per object (index)
  - Repeat for 2nd table.

```
SELECT COUNT(*) = 100000 rows
FROM  CUSTOMERS C (cardf = 192960)
WHERE C.CUSTNO BETWEEN 1 AND 100000
```

```
SELECT COUNT(*) = 22662 rows
FROM  CUSTOMERS C (cardf = 192960)
WHERE C.STATUS = 'Y'
  AND C.GENDER = 'F'
```

```
Indexes
CUSTIX1
(CUSTNO)
CUSTIX2
(STATUS
,GENDER)
```

Additional Index Comments

- It's not just about % of qualified rows from index
  - But % of qualified data pages dictates the data I/O

CUSTIX1 (CUSTNO)
- Clustering index (Clusterratio = 100%)
- 51.82% of rows qualified from approx 52% of data pages*

CUSTIX2 (STATUS ,GENDER)
- Non-clustering index (Clusterratio = 56.67%)
- 11.74% of rows qualified, from 76% of data pages*
- Combined filtering is 2.75%, but no single index support

** 2000/3860 getpages = 51.82%, 2944/3860 getpages = 76.27%

Per Predicate Count – 1st Table

- Break-apart 1st table query further per object (predicate)
  - Repeat for 2nd table.

```
SELECT COUNT(*) = 100000 rows
FROM  CUSTOMERS C
WHERE C.CUSTNO BETWEEN 1 AND 100000
```

```
SELECT COUNT(*) = 183058 rows
FROM  CUSTOMERS C
WHERE C.STATUS = 'Y'
```

```
SELECT COUNT(*) = 24118 rows
FROM  CUSTOMERS C
WHERE C.GENDER = 'F'
```

Use of Predicate Counts

- Simple calculation to turn counts into “actual” FF
  - For comparison with Optimizer FF
    - From Predicate Report (V8 VE or 9 OSC)

Predicate	Count	Table Cardf	Actual FF (count/cardf)
CUSTNO BETWEEN 1 AND 100000	100000	192960	0.5182
STATUS = 'Y'	183058	192960	0.9487
GENDER = 'F'	24118	192960	0.1249

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Filter Factors

- Optimizer assigns a “Filter Factor” (FF) to each predicate or predicate combination
  - Number between 0 and 1 of estimated filtering
    - 0.25 = 25% of the rows are estimated to qualify

Combining Filter Factors

- Individual Filter Factors (FFs) are combined to determine the total filtering per object
  - AND predicate FFs are multiplied
  - OR predicate FFs are added
- Available statistics determine “degree” of multiplication

Assigning and combining Filter Factors

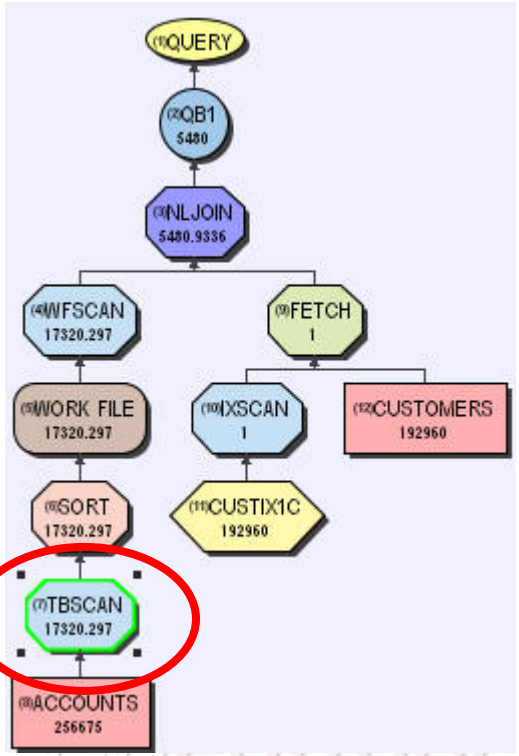
- Accuracy of FFs and how to combine them is important for
  - Index matching
  - Total index filtering
  - Total table level filtering
- Therefore……for each object, the goal is:
  - To accurately assign the individual predicate FFs
  - To correctly combine the individual FFs
- **The more objects involved, the more important for optimizer to be able to distinguish between them**

Optimizer Calculations

- Optimizer will combine all FFs for each object
  - Optimizer chose tablespace scan of ACCOUNTS table 1st
    - Earlier counts show CUSTOMERS as preferred 1st table

Input Cardinality	256675
Scanned Rows	256675
Stage 1 Predicates	Filter Factor
A.OPENDATE>'19600101'	0.9973
A.CLOSEDATE<'20070101'	0.1306
A.CUSTNO BETWEEN 1 AND 100000	0.5182
Stage 1 Returned Rows	17320.297
Stage 2 Returned Rows	17320.297
Output Cardinality	17320.297

256675 * 0.9973 * 0.1306 * 0.5182 ~= 17320 rows



Comparing Table estimates

- How does the optimizer table estimate compare to reality?

Table	Count	Estimate
CUSTOMERS	5,308	31,644
ACCOUNTS	86,959	17,320

Overestimation

Underestimation

Comparing Predicate Estimates

- Table (and index) estimates are calculated from individual FF estimates
  - So how do these compare with reality?

Predicate	Actual FF	Estimate
C.CUSTNO BETWEEN 1 AND 100000	0.5182	0.5182
STATUS = 'Y'	0.9487	0.9487
GENDER = 'F'	0.1249	0.3333
A.CUSTNO BETWEEN 1 AND 100000	0.5001	0.5182
OPENDATE > '19600101'	1.0000	0.9973
CLOSEDATE < '20070101'	0.6940	0.1306

Reason for overestimation

Reason for underestimation

Equal Predicate Calculations

- Index on STATUS, GENDER
  - RUNSTATS collects leading column FREQVAL by default
    - Optimizer uses this in it's estimate

Predicate	Colcardf	Actual FF	Estimate
STATUS = 'Y'	2	0.9487	0.9487
GENDER = 'F'	3	0.1249	0.3333

```
SYSCOLDIST CATALOG STATISTICS FOR STATUS
       FREQUENCY             COLVALUE
       ---------             --------
       9.4868366500829E-01 X'00E8'
       5.1316334991708E-02 X'00D5'
```

Hex 'E8' = Y

- No special RUNSTATS currently on GENDER
  - FF estimate uses 1/colcardf = 1/3
    - Run RUNSTATS to collect skew information

```
RUNSTATS TABLESPACE TPTEST.TPTSTTS1
         TABLE(ADMF001.CUSTOMERS)
         COLGROUP(GENDER) FREQVAL COUNT 10
```

Range Predicate Calculations

- Simple calculation for INTEGER column
  - (Highvalue – Lowvalue) / (High2key – Low2key)
    - (100000 – 1) / (192959 – 2) = 0.5182

Predicate	High2key	Low2key	Actual FF	Estimate
C.CUSTNO BETWEEN 1 AND 100000	192959	2	0.5182	0.5182
A.CUSTNO BETWEEN 1 AND 100000	192959	2	0.5001	0.5182

Range Predicate Calculations

- Challenges with “dates” stored as CHAR(8)
  - Invalid dates are “valid” as numerics or chars

Predicate	Colcardf	High2key	Low2key	Actual FF	Estimate
OPENDATE > '19600101'	372	20150630	19760225	1.0000	0.9973
CLOSEDATE < '20070101'	64	99991231	19940509	0.6940	0.1306

  - High2key/Low2key spans a very wide range (in this example)
    - But no data exists between 2015 – 9998
  - Collect Frequency stats to assist range estimate

```
RUNSTATS TABLESPACE TPTEST.TPTSTTS2
         TABLE(ADMF001.ACCOUNTS)
         COLGROUP(CLOSEDATE) FREQVAL COUNT 60
```

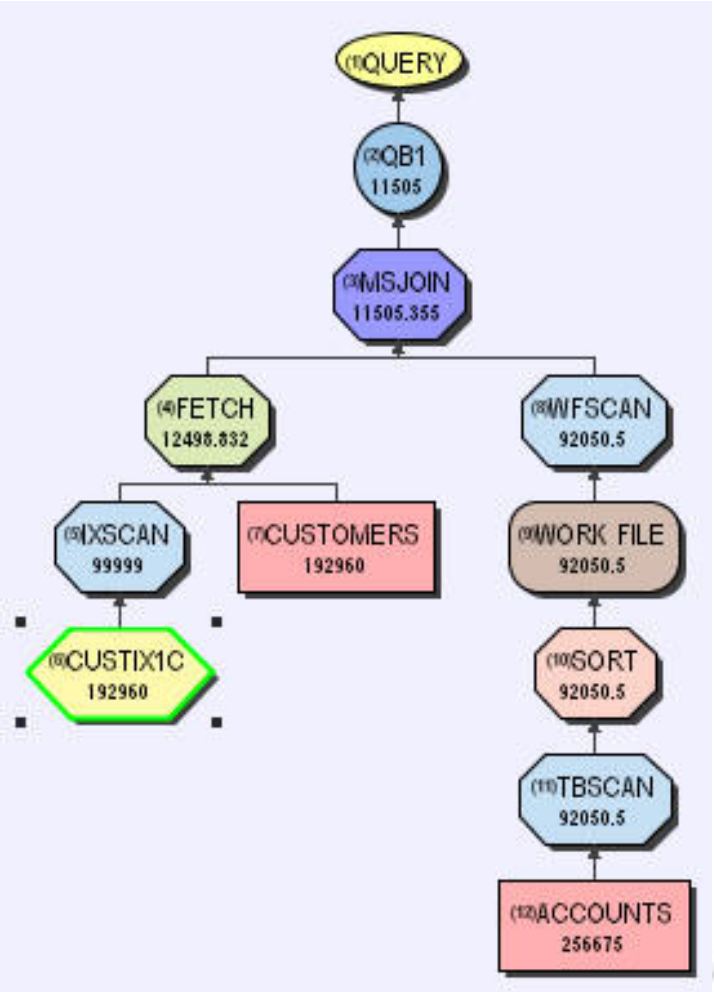
Estimates after RUNSTATS

- All estimates now closer to reality

Predicate	Actual FF	Estimate
C.CUSTNO BETWEEN 1 AND 100000	0.5182	0.5182
STATUS = 'Y'	0.9487	0.9487
GENDER = 'F'	0.1249	0.1249
A.CUSTNO BETWEEN 1 AND 100000	0.5001	0.5182
OPENDATE > '19600101'	1.0000	0.9973
CLOSEDATE < '20070101'	0.6940	0.6939

Access Path after RUNSTATS

- Leading table is CUSTOMERS
  - Counts proved this table was preferred
  - Literals required to exploit statistics
    - REOPT for host variables / parameter markers



What happens if I use host variables?

- FF estimates use default calculations
  - How do these compare?
    - **None of these are close to reality!!!**

Predicate	Colcardf	Actual FF	Estimate
C.CUSTNO BETWEEN ? AND ?	192960	0.5182	0.001
STATUS = ?	2	0.9487	0.5
GENDER = ?	3	0.1237	0.4126
A.CUSTNO BETWEEN ? AND ?	182272	0.5182	0.001
OPENDATE > ?	372	1.0000	0.1
CLOSEDATE < ?	64	0.6940	0.3333

1/2 = 0.5

1/2 * (192960 – 33739) = 0.4126

Note 1: Range/Between predicates use default interpolation (next slide)
Note 2: GENDER excludes 33739 NULL rows from FF calculation

Range Predicate Estimates

- For host vars/parameter markers or default stats
  - Optimizer uses following formulas for range predicates*

COLCARDF	Factor for Op	Factor for LIKE/BETWEEN
>=100,000,000	1/10,000	3/100,000
>=10,000,000	1/3,000	1/10,000
>=1,000,000	1/1,000	3/10,000
>=100,000	1/300	1/1,000
>=10,000	1/100	3/1,000
>=1,000	1/30	1/100
>=100	1/10	3/100
>=2	1/3	1/10
=1	1	1
<=0	1/3	1/10

Note: Op is one of these operators: <, <=, >, >=.

Predicate	Colcardf	Estimate
C.CUSTNO BETWEEN ? AND ?	192960	0.001
A.CUSTNO BETWEEN ? AND ?	182272	0.001
OPENDATE > ?	372	0.1
CLOSEDATE < ?	64	0.3333

*Table documented in Admin Guide

What if I don't run RUNSTATS at all?

- Every object looks the same to optimizer

TABLE	CARDF	NPAGESF	TABNO	QUALROWS	
ADMF001.ACCOUNTS	-1	-1	2	111.111145	
INDEX	CLU	UR	NLEAF	NLEVEL	CR
ADMF001.ACCTIX1C	Y	U	-1	-1	0.0
TABLE	CARDF	NPAGESF	TABNO	QUALROWS	
ADMF001.CUSTOMERS	-1	-1	1	40.0	
INDEX	CLU	UR	NLEAF	NLEVEL	CR
ADMF001.CUSTIX1C	Y	U	-1	-1	0.0
ADMF001.CUSTIX2	N	D	-1	-1	0.0

Tables – Same # rows, pages

Indexes – Same # leaf, levels & clusterratio (also 1st & fullkeycard)

Predicate	Actual FF	Estimate
C.CUSTNO BETWEEN 1 AND 100000	0.5182	0.1
STATUS = 'Y'	0.9487	0.04
GENDER = 'F'	0.1237	0.04
A.CUSTNO BETWEEN 1 AND 100000	0.5182	0.1
OPENDATE > '19600101'	1.0000	0.3333
CLOSEDATE < '20070101'	0.6940	0.3333

Equal predicates – same FF

Range/Between predicates use default interpolation

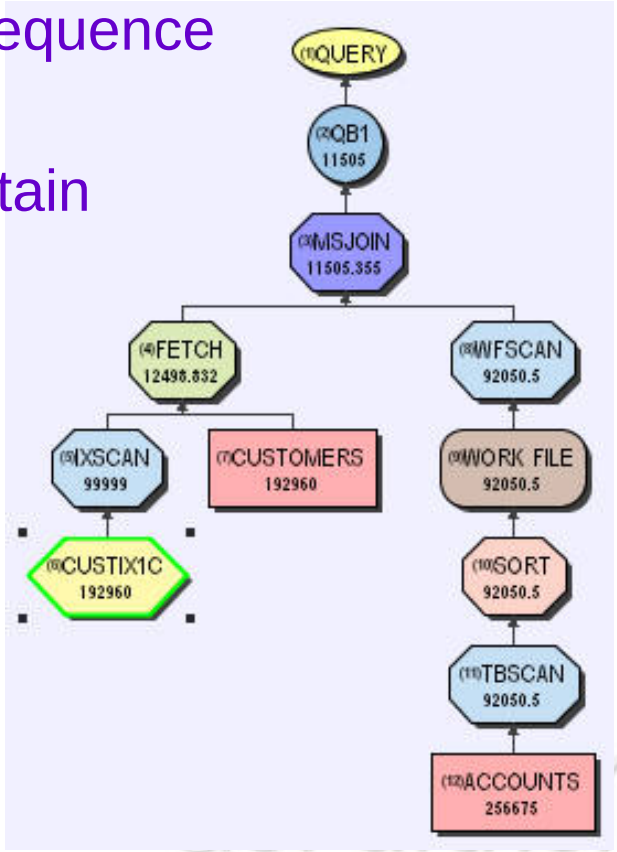
Filter Factor Conclusions

- Skew/Correlation important for costing each object
  - Without RUNSTATS
    - All predicates, tables, indexes, use defaults
      - Optimizer cannot distinguish where the filtering is
  - With host variables/parameter markers
    - Optimizer cannot take advantage of frequencies
      - Exception is NULL frequencies
    - Range predicates use optimistic defaults
    - Correlation is still utilized

And if I can't match FF estimate to reality?

- If you can't provide the perfect statistics
  - Must make the access path obvious another way
- For original query
  - No index to support the preferred join sequence
    - Account table as inner (CUSTNO)
  - Requires literals and special stats to obtain preferred join sequence

```
SELECT *
FROM  CUSTOMERS C, ACCOUNTS A
WHERE C.CUSTNO = A.CUSTNO
  AND C.CUSTNO BETWEEN ? AND ?
  AND C.STATUS = ?
  AND C.GENDER = ?
  AND A.OPENDATE > ?
  AND A.CLOSEDATE < ?
```

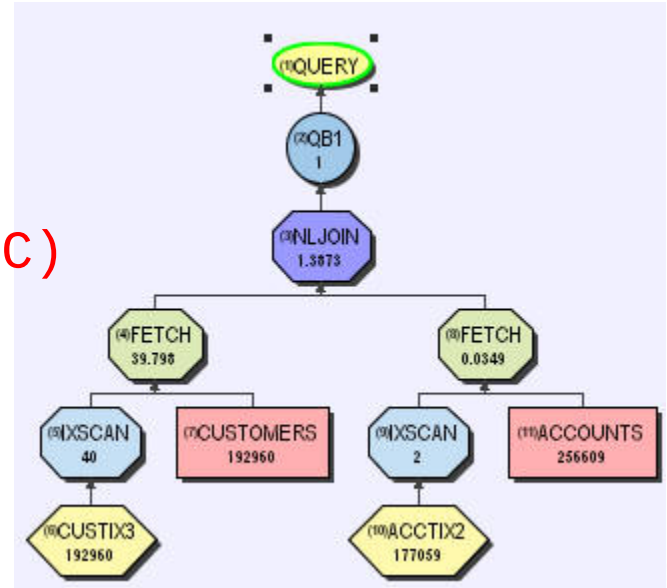


Indexing to overcome statistics limitations

- After creating indexes
  - On CUSTOMERS to support local filtering (as outer)
  - On ACCOUNTS to support the join predicate (as inner)
- Preferred join sequence now chosen with host variables

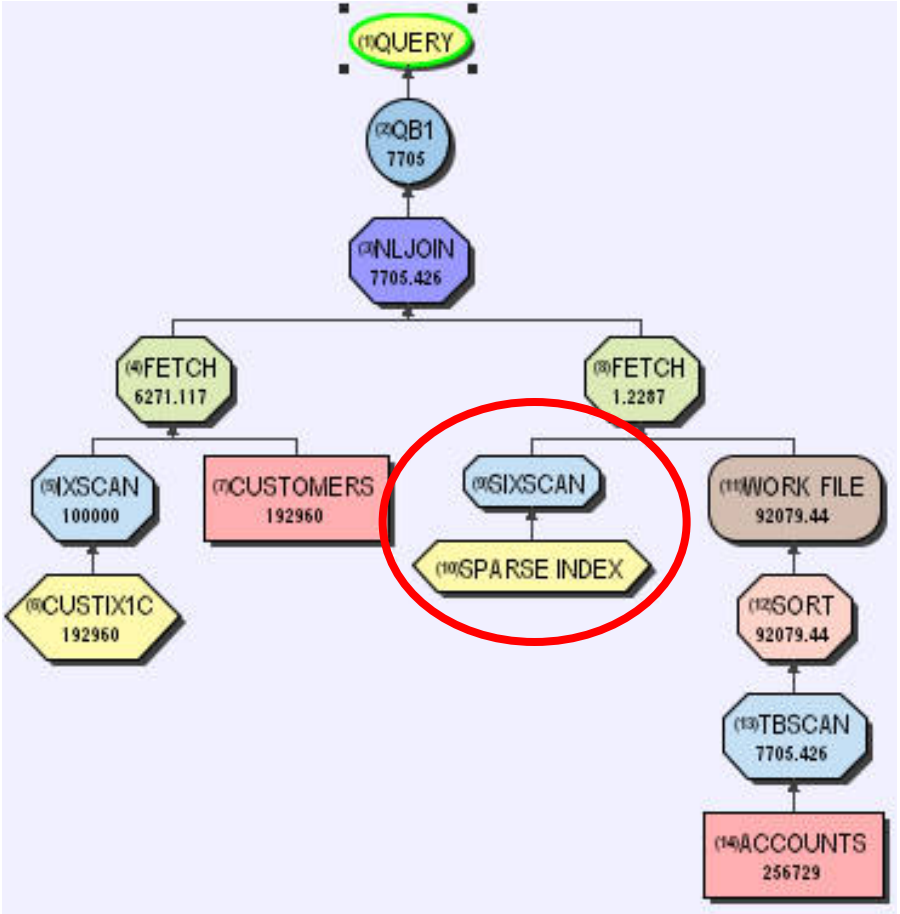
```
CREATE INDEX ADMF001.CUSTIX3
    ON ADMF001.CUSTOMERS
(STATUS  ASC, GENDER ASC, CUSTNO ASC)

CREATE INDEX ADMF001.ACCTIX2
    ON ADMF001.ACCOUNTS
(CUSTNO ASC)
```



And if I don't create the indexes?

- DB2 9 can create a "sparse index" at runtime
  - To support join
- Previously only available for Star Join



What about skew over a range?

- For high cardinality columns with range skew
  - Too many FREQVAL statistics to collect
- Optimizer assumes data is evenly distributed between LOW2KEY & HIGH2KEY
  - Estimate does not match reality

```
SELECT COUNT(*) = 20131 rows
FROM  CUSTOMERS
WHERE BIRTHDATE BETWEEN '1971-01-01' AND '1971-12-31'
```

Count	Cardf	Actual FF	Estimate
20131	192960	0.1043	0.0311

New Statistics in DB2 9

- Histogram statistics added in DB2 9
  - Also known as quantiles
  - Similar to frequencies
    - But each “frequency” specifies a range

```
RUNSTATS TABLESPACE TPTEST.TPTSTTS1
 TABLE(ADMF001.CUSTOMERS) INDEX(ALL) KEYCARD
 COLGROUP(BIRTHDATE) HISTOGRAM
```

- After histograms…..

Actual FF	Estimate
0.1043	0.1064

Stage 1 Predicates	Filter Factor
ADMF001.CUSTOMERS.BIRTHDATE BETWEEN '1971-01-01' AND...	0.1064

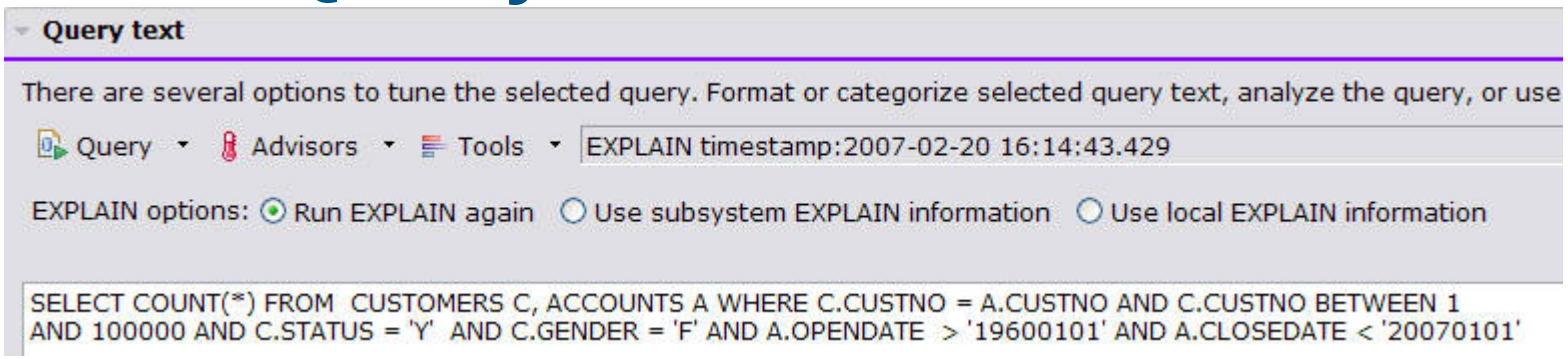
Improving FF estimates in DB2 V8

- What have we done in V8?
  - V8 Visual Explain provides optimizer estimates
    - Statistics Advisor (SA) identifies statistics conflicts and potentially missing statistics
  - COLGROUP keyword added to RUNSTATS
    - Simplifies collection of skew/correlation statistics
  - REOPT(ONCE) for dynamic SQL
    - Reopt at 1st execution using 1st set of literal values

Improving FF estimates in DB2 9

- What have we done in 9?
  - OSC further extends VE functionality
    - Workload based OSC/SA
      - Rather than single query V8 VE/SA
    - More details
      - Including transformed SQL text
      - Query annotation with statistics mapped to SQL
  - Histograms added to RUNSTATS
    - Provides distribution for higher cardinality columns
  - REOPT(AUTO)
    - Only reoptimizes when values change by x%

OSC Query Formatter/Annotation



- DB2 9 OSC will take an unformatted query
  - And format this, and add costing detail
    - Table cardf, Column cardinalities, FFs etc

Formatted Query	Annotation
SELECT COUNT(*)	
FROM ADMF001.CUSTOMERS AS C	CARDF=192,960 QUALIFIED_ROWS=6,271.117 NPAGESF=3,860
, ADMF001.ACCOUNTS AS A	CARDF=256,729 QUALIFIED_ROWS=92,079.44 NPAGESF=2,469
WHERE (C.CUSTNO = A.CUSTNO	COLCARDF=192,960/182,272 MAX_FREQ=/ FF=5.182420864002779E-6
AND A.CUSTNO BETWEEN 1 AND 100000	COLCARDF=182,272 MAX_FREQ= FF=0.5182397961616516 LOW2KEY=2
AND A.CLOSEDATE < '20070101'	COLCARDF=64 MAX_FREQ=21.35364528354802% FF=0.6939460039138794 LOW2KEY=
AND A.OPENDATE > '19600101'	COLCARDF=372 MAX_FREQ= FF=0.9973117709159851 LOW2KEY=19766002
AND C.GENDER = 'F'	COLCARDF=3 MAX_FREQ=70.02746683250413% FF=0.12540936470031738
AND C.STATUS = 'Y'	COLCARDF=2 MAX_FREQ= FF=0.4999999403953552 LOW2KEY=N HI
AND C.CUSTNO BETWEEN 1 AND 100000	COLCARDF=192,960 MAX_FREQ= FF=0.5182397961616516 LOW2KEY=2
)	

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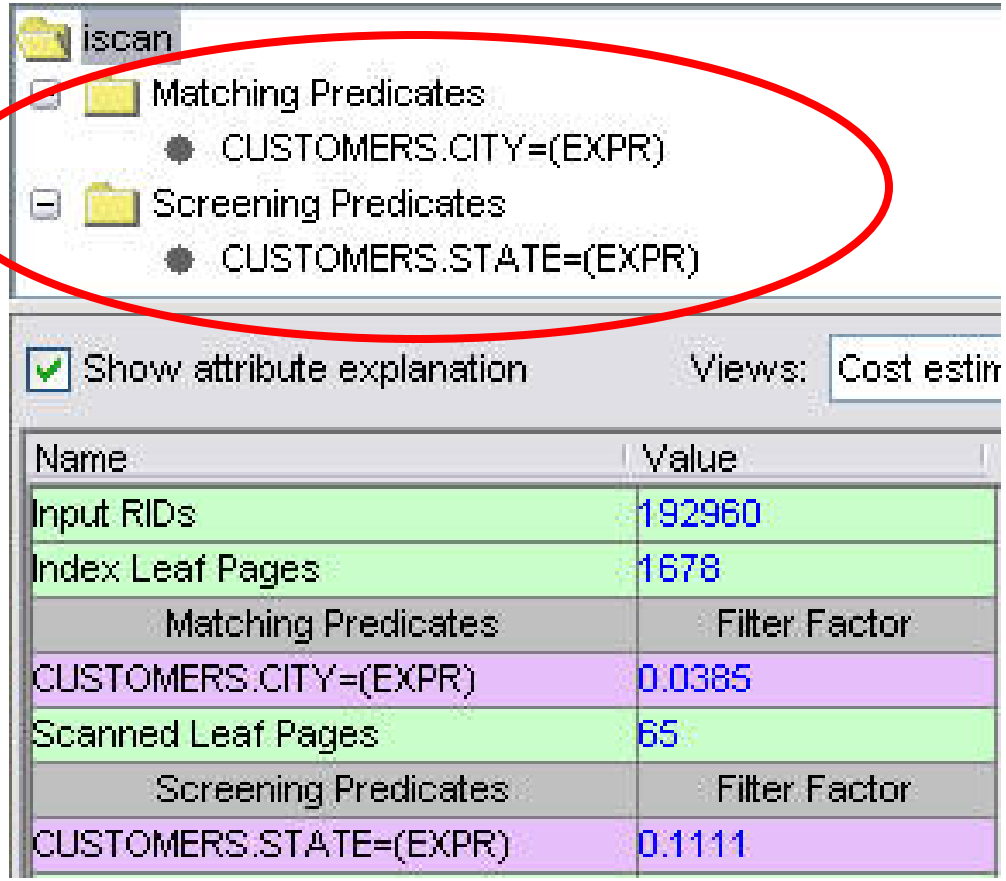
Can my predicates be applied early?

- Index Matching Predicates
  - Only indexable predicates will limit the index entries read
    - As matching or page range
- Stage 1 Predicates
  - Simple stage 1 and non-matching indexable predicates can be applied as index screening
    - To limit data rows accessed
- Stage 2 Predicates
  - Cannot be applied to the index before data access
    - But will be applied to index at stage 2 if index-only
- The stage of predicate application can affect the optimizer's choice of index or table join sequence/method.

Index matching/screening

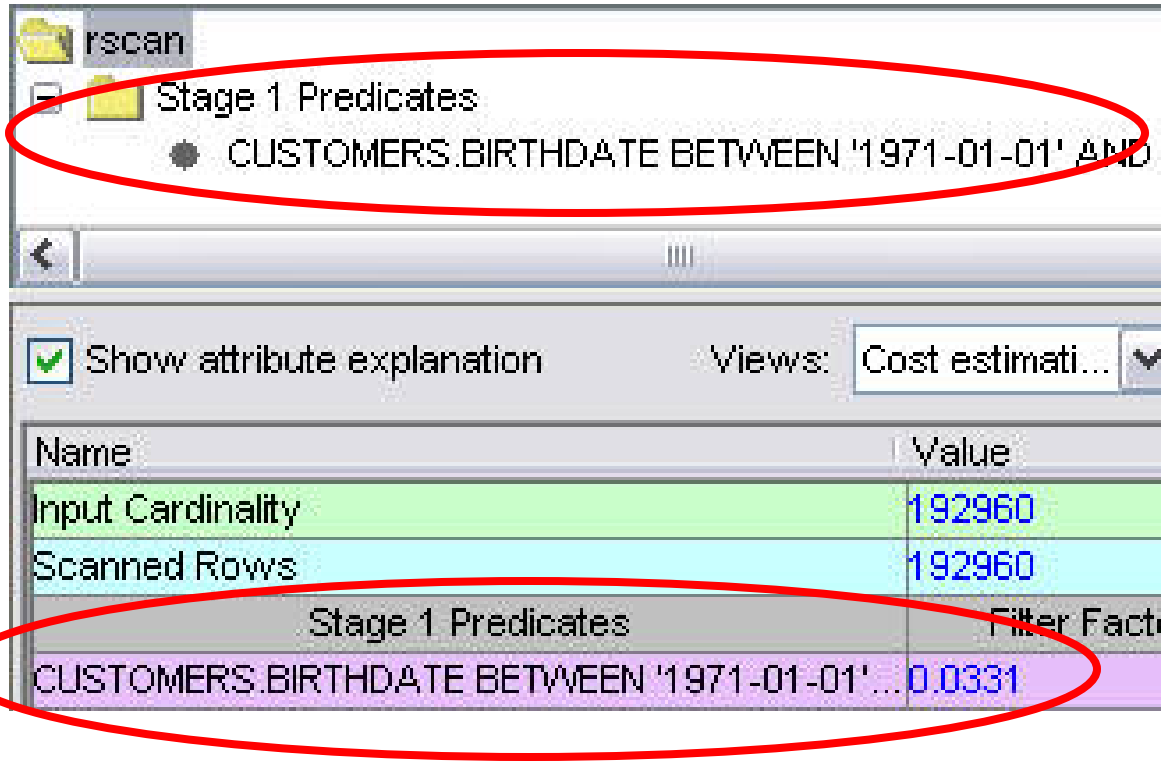
- Index on CITY, CUSTNO, STATE
- 1 matching
- 1 screening




```
SELECT *
FROM CUSTOMERS
WHERE CITY = ?
  AND STATE = ?
```

Stage 1 predicates

- This WHERE clause predicate is stage 1

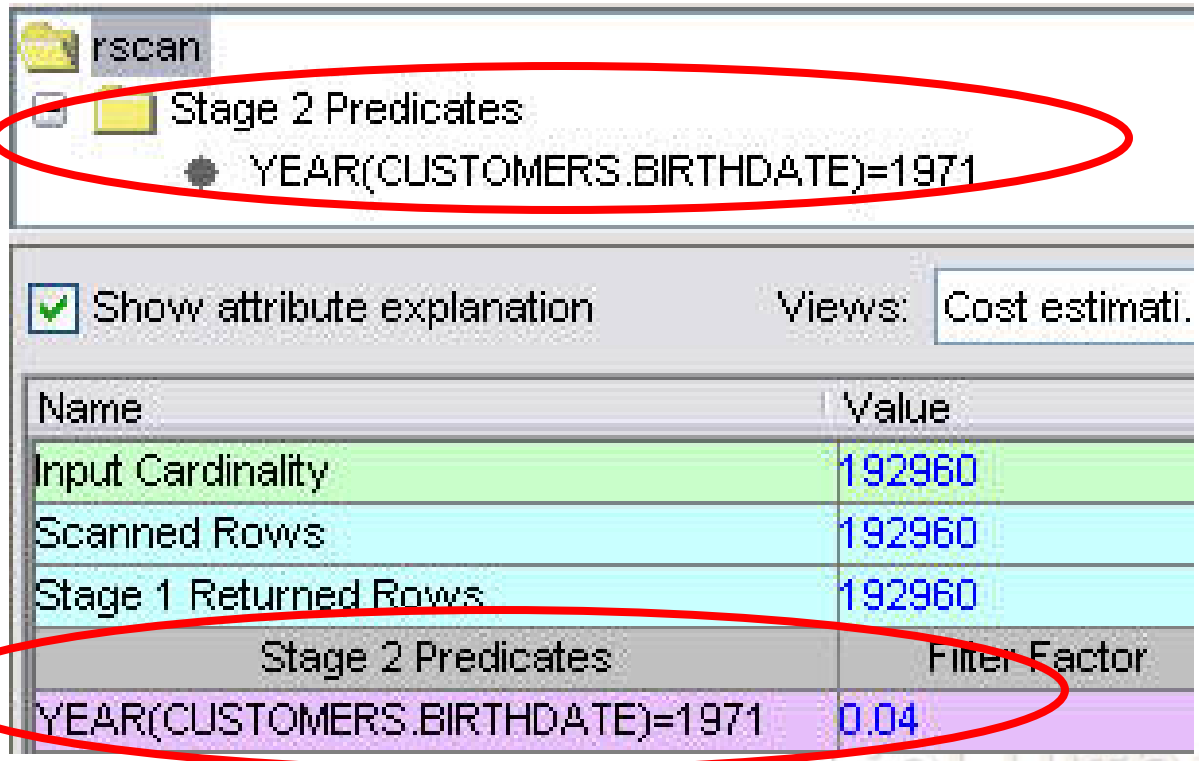



```
SELECT *
FROM CUSTOMERS
WHERE BIRTHDATE BETWEEN ‘1971-01-01’ AND ‘1971-12-31’
```

Stage 2 predicates

- This WHERE clause predicate is stage 2

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



Note: This column expression uses a default FF (1/25)

Predicate Report – Stage 1 or 2

- From the V8 VE predicate report
  - "Is Sargable" value of "N" means stage 2

Is Sargable	Is Join Predicate	Is After Join Predicate	Has parameter marker	Predicate Text
N	N		N	YEAR (CUSTOMERS.BIRTHDATE) =1971

- From DB2 9 OSC predicate report
  - Y/N for "S1"

S1	--Whether the predicate is a stage 1 predicate

Improving Predicate Application

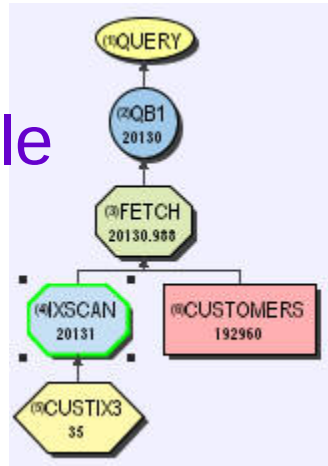
- Consider manual rewrite to promote predicate application
  - Stage 1 is more efficient than stage 2
  - Indexable is more efficient than stage 1

Stage 2	Stage 1	Indexable
*DEC_COL = :inthost		DEC_COL = DECIMAL(:inthost)
QTY * 2 = :dechost		QTY = :dechost / 2
YEAR(DCOL) = 2007		DCOL BETWEEN '2007-01-01' AND '2007-12-31'
:host BETWEEN C1 AND C2		:host >= C1 AND :host <= C2
DCOL + 10 YEARS < CURRENT DATE		DCOL < CURRENT DATE - 10 YEARS
LOCATE('P',LASTNAME) > 0	LASTNAME LIKE '%P%'	
	DCOL <> '9999-12-31'	DCOL < '9999-12-31'
	GENDER <> 'F'	GENDER = 'M'

* Most datatype/length mismatches resolved in V8

What if I can't rewrite my predicate?

- 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.
FF is more accurate

Agenda

- Introduction
- Process for validating the preferred access path
- Filter Factor challenges
- Predicate Challenges
- Conclusion

What have we covered?

- Method for comparing optimizer estimates with reality
- Importance for optimizer to be able to distinguish a "good access path"
  - And challenges in estimating FF when
    - Host variables/parameter markers are used
    - RUNSTATS are not run
    - Point or range skew is unknown
  - If you can't distinguish statistically
    - Indexing should provide guidance to a good access path

What (else) have we covered?

- Features available to assist with query tuning
  - DB2 V8 Visual Explain
  - DB2 9 Optimization Service Center
- Enhancements to FF estimation
  - DB2 V8
    - COLGROUP keyword for RUNSTATS
    - REOPT(ONCE) for dynamic SQL
  - DB2 9
    - Histogram statistics in RUNSTATS
    - REOPT(AUTO) for dynamic SQL
    - RUNSTATS collects statistics on “Indexed expression”

More Ways to Challenge the DB2 z/OS Optimizer

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VE
www-306.ibm.com/software/data/db2/zos/downloads/ve.html
OSC
www-306.ibm.com/software/data/db2/zos/downloads/osc.html