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Platform: z/OS

Tune SQL like an expert in DB2 UDB for z/OS V8

Terry Purcell
IBM Silicon Valley Lab

Session: G7
Date/Time: Tuesday May 24th, 3:30 – 4:40pm

INTERNATIONAL DB2 USERS GROUP

Agenda

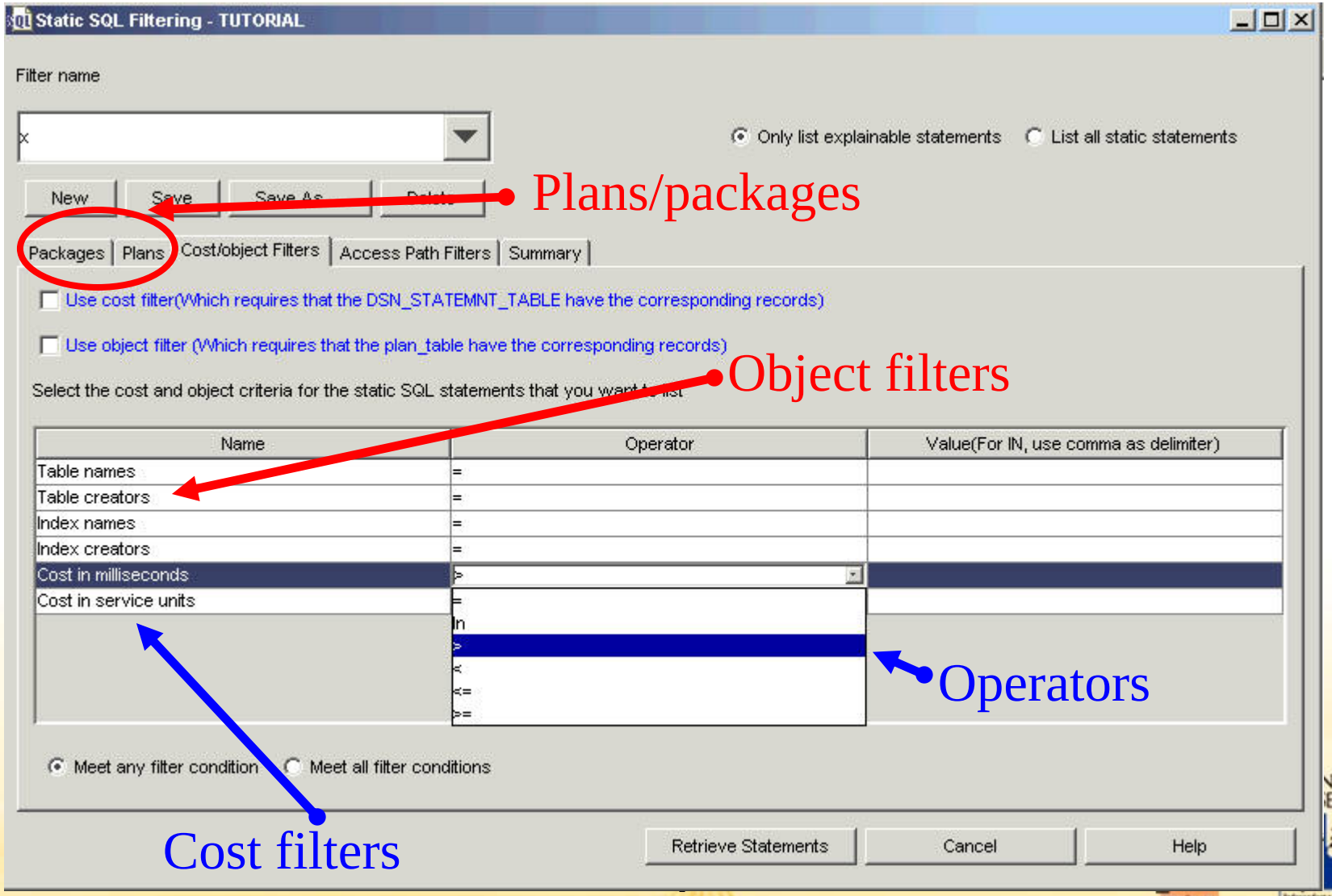
- Simple methods to find the problem query
- Query breakdown
- Comparing estimates with reality
- What do I do if the estimate is incorrect?
- Automating the process

Note: References to Visual Explain are Visual Explain for DB2 UDB for z/OS V8 only. This is a free tool downloadable from IBM at:
http://www-306.ibm.com/software/data/db2/zos/osc/ve/

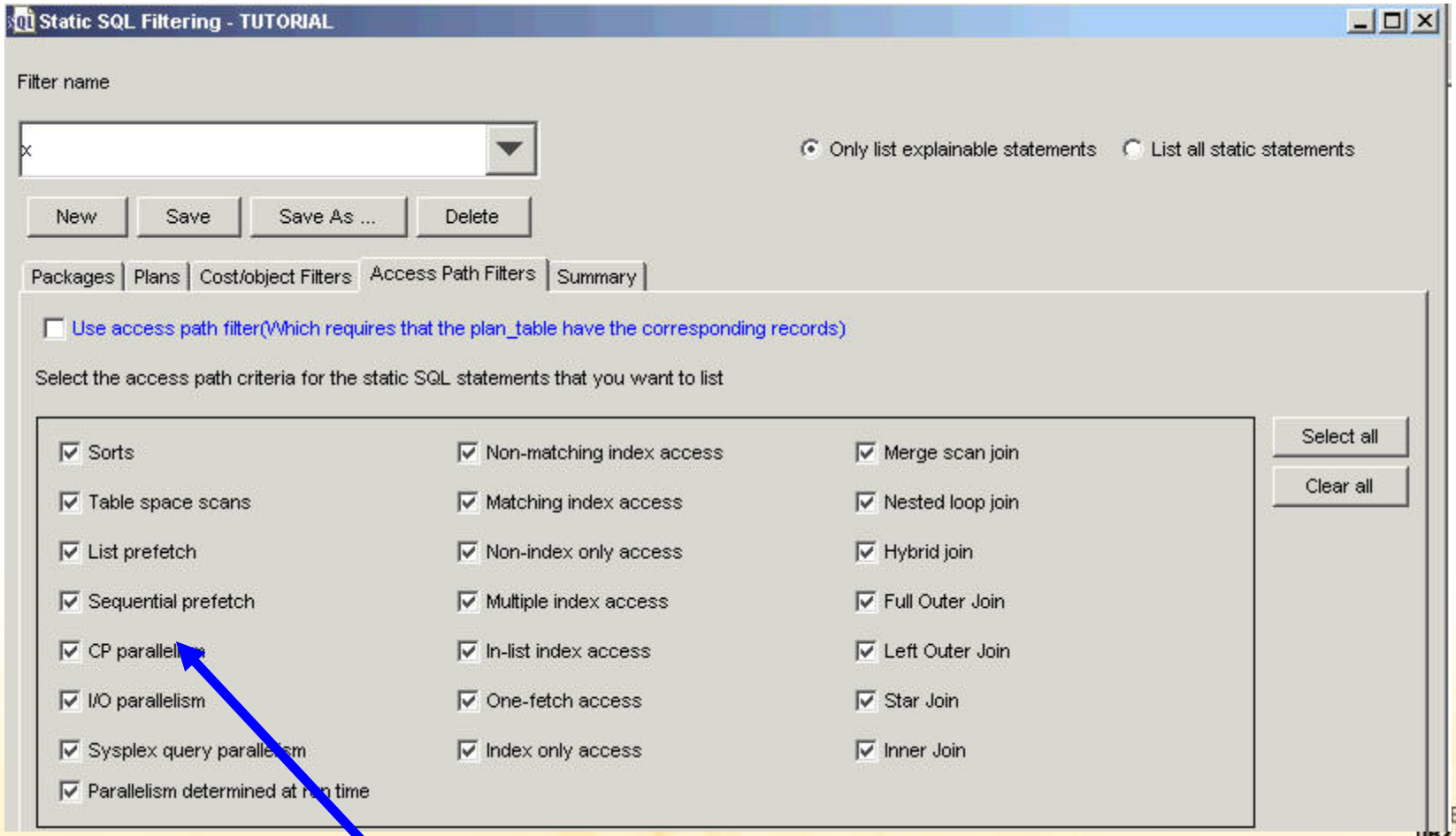
Finding the problem query

- Reactively
  - User complaint
  - Trace output
  - Etc…or any other traditional method
- Proactively
  - Using Visual Explain to
    - Search for previously explained static SQL
      - Apply cost (estimate) or access path filters
    - View dynamic statement cache
      - Reactive, but before user complaint!!
      - Apply filters based upon query execution

VE Static SQL Input – Cost Filters

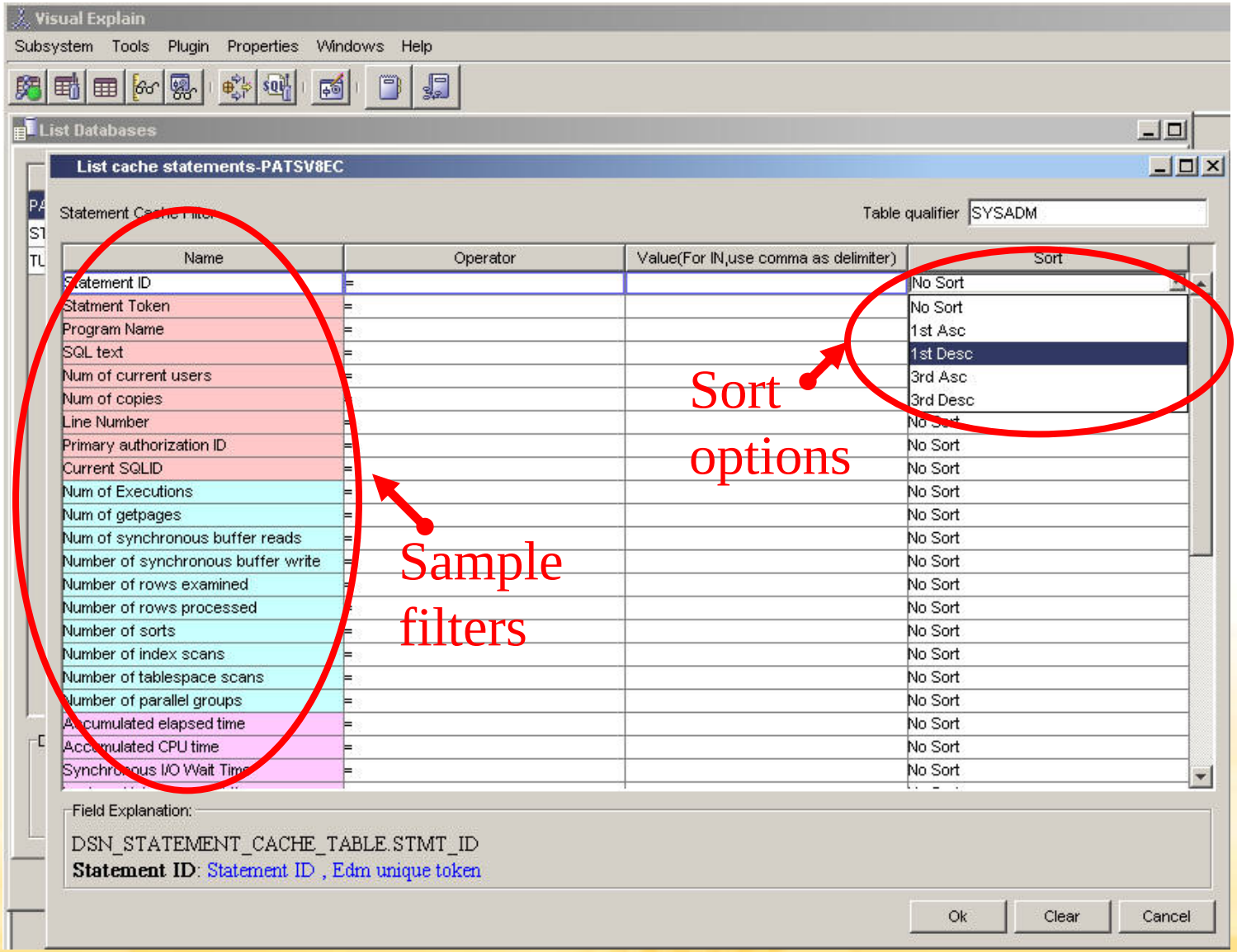


VE Static SQL Input – Access Path Filters

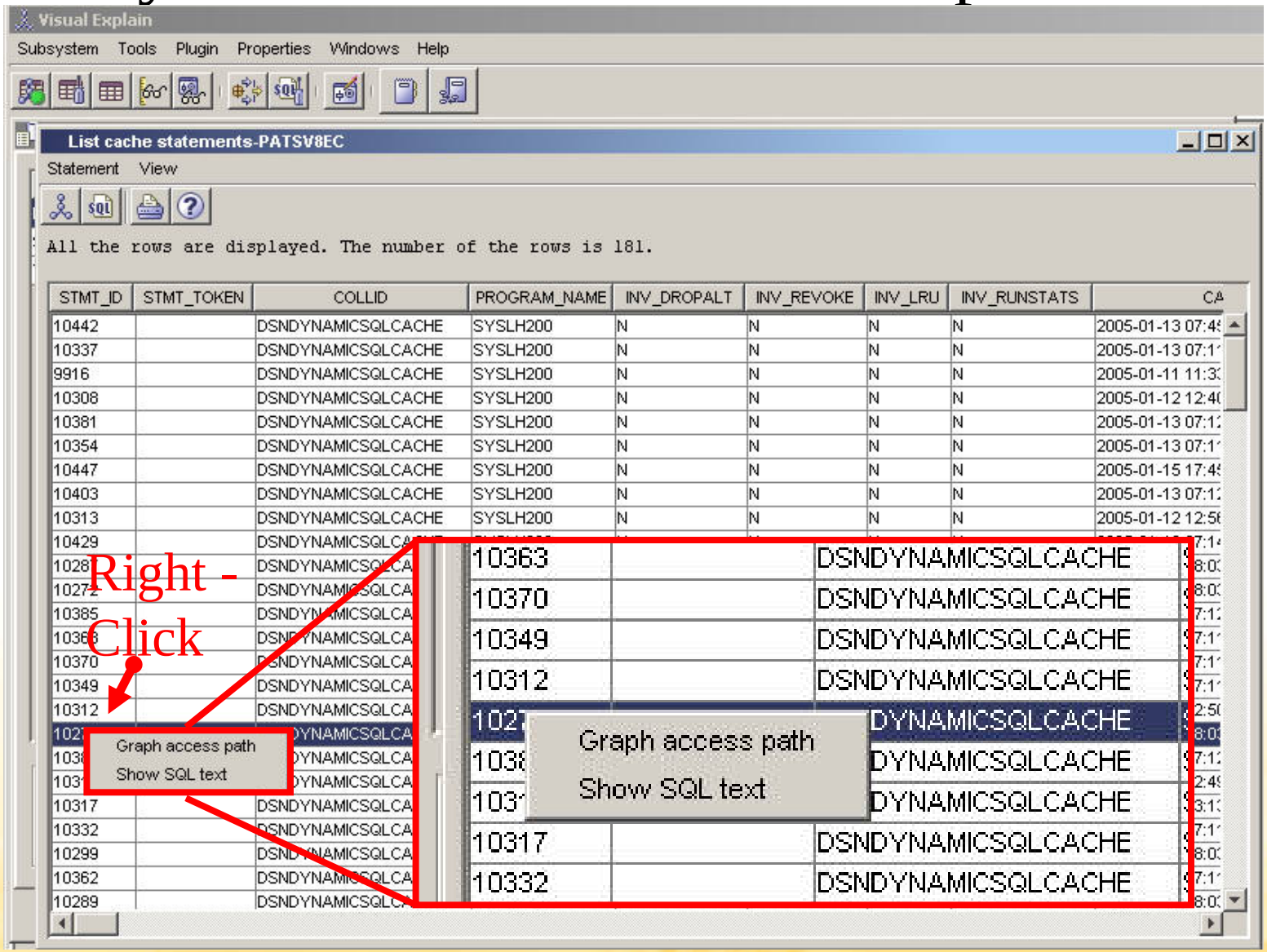


Access Path Filters

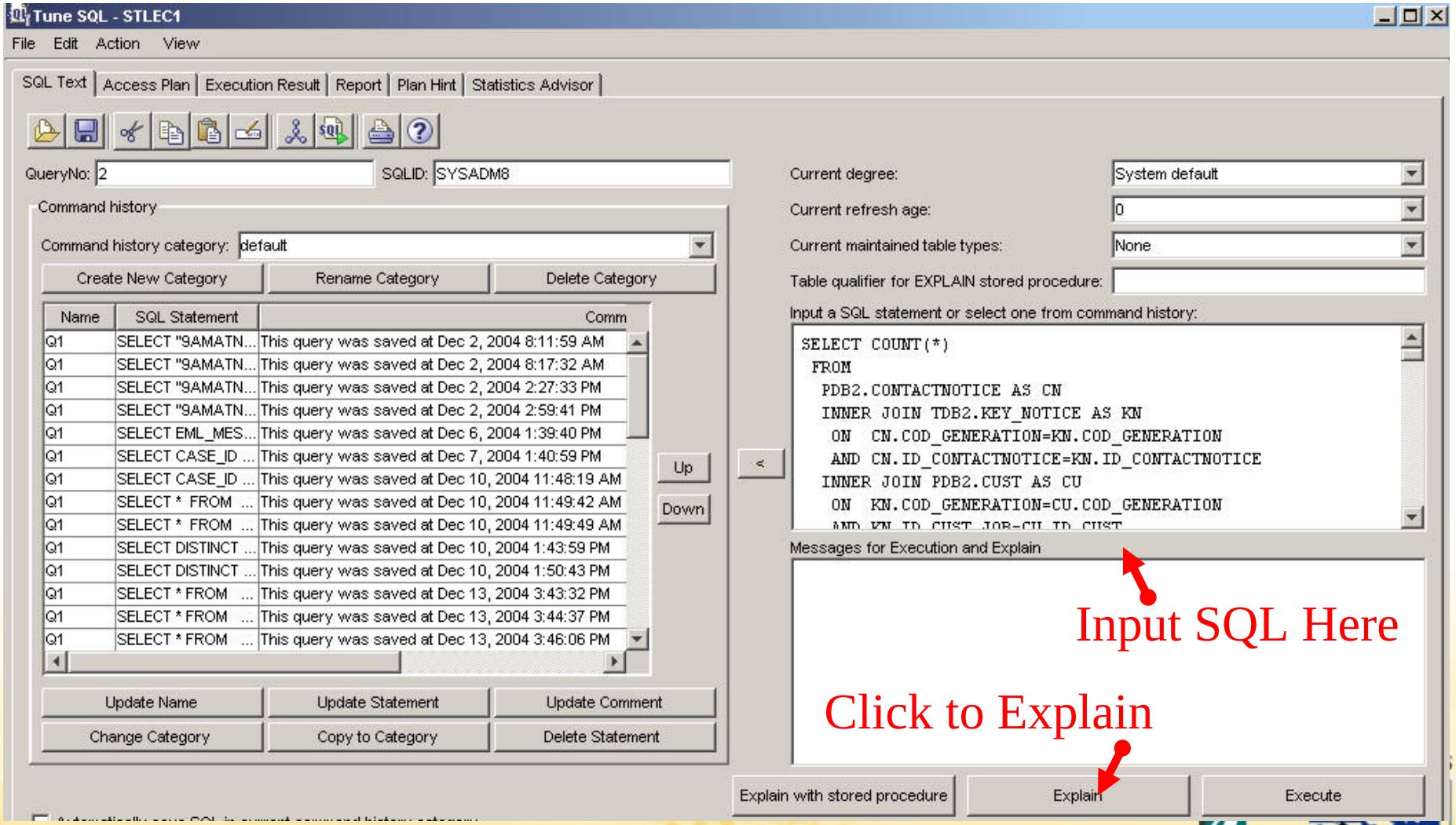
VE Dynamic Statement Cache Input



VE Dynamic Statement Cache Input



Using Visual Explain – Input/Explain Query



```
SELECT *
 FROM  PDB2.CONTACTNOTICE AS CN
  INNER JOIN TDB2.KEY_NOTICE AS KN
   ON  CN.COD_CLIENT      =KN.COD_CLIENT
   AND CN.COD_GENERATION  =KN.COD_GENERATION
   AND CN.ID_CONTACTNOTICE=KN.ID_CONTACTNOTICE
  INNER JOIN PDB2.CUST AS CU
   ON  KN.COD_CLIENT      =CU.COD_CLIENT
   AND KN.COD_GENERATION  =CU.COD_GENERATION
   AND KN.ID_CUST_JOB     =CU.ID_CUST
  INNER JOIN PDB2.CUST AS CU2
   ON  KN.COD_CLIENT      =CU2.COD_CLIENT
   AND KN.COD_GENERATION  =CU2.COD_GENERATION
   AND KN.ID_CUST_1       =CU2.ID_CUST
  INNER JOIN TDB2.KEY_PERSON AS KP
   ON  CU2.COD_CLIENT     =KP.COD_CLIENT
   AND CU2.COD_GENERATION =KP.COD_GENERATION
   AND CU2.ID_CUST        =KP.ID_CUST
  WHERE CN.DOM_NOTIFY          = 'FICH'
    AND CN.COD_GENERATION      = 'MB'
    AND CN.COD_CLIENT          = '0450'
    AND CN.DOM_STATUS_NOTICE   = 'ERL'
    AND CU2.DOM_PERSONGROUP    = 'PR'
    AND CU2.COD_LAND_DIVISION  = 'AT'
    AND CU2.DOM_STATUS         = 'BEST'
    AND CU2.DOM_CARE_STATE     = 'S';
```

Query Example

- Query performs poorly
  - 20+ min, expectation 1 min
  - Need to determine why?
- Base RUNSTATS are current
  - Let's assume that at least the basics are covered
  - Not always a good assumption!!!

Major causes of SQL performance problems

- Multi-table join
  - Poor choice of leading table
    - Insufficient statistics resulting in incorrect table chosen first
    - Indexes do not support most efficient table as leading
  - Inefficient join method or index usage on subsequent table(s)
    - Insufficient statistics resulting in poor estimate for current and/or prior tables accessed
    - Indexes do not support join (and possibly local) filtering
- Single table
  - Correct index or access method not chosen
    - Insufficient statistics to correctly decipher access choices
    - Indexes may not support filtering predicates

Agenda

- Simple methods to find the problem query
- Query breakdown
- Comparing estimates with reality
- What do I do if the estimate is incorrect?
- Automating the process

Query Breakdown – Breaking apart the SQL

- Separate the query into a single count for each table
  - Applying local predicates to each

```
SELECT COUNT(*)
FROM   PDB2.CONTACTNOTICE AS CN
WHERE  CN.DOM_NOTIFY         = 'FICH'
   AND CN.COD_GENERATION     = 'MB'
   AND CN.COD_CLIENT         = '0450'
   AND CN.DOM_STATUS_NOTICE = 'ERL'

SELECT COUNT(*)
FROM   TDB2.KEY_PERSON AS KP

  SELECT COUNT(*)
  FROM   TDB2.KEY_NOTICE AS KN

  SELECT COUNT(*)
  FROM  PDB2.CUST AS CU

SELECT COUNT(*)
FROM   PDB2.CUST AS CU2
WHERE  CU2.DOM_PERSONGROUP   = 'PR'
   AND CU2.COD_LAND_DIVISION = 'AT'
   AND CU2.DOM_STATUS        = 'BEST'
   AND CU2.DOM_CARE_STATE    = 'S';
```

Is that all the local predicates?

Query Breakdown – Applying all local predicates

- Consider transitively closed predicates also
  - Be aware of restrictions such as LIKE, IN, subqueries and expressions
  - Based upon join and local predicates
    - CN.COD_GENERATION=KN.COD_GENERATION
    - CN.COD_CLIENT =KN.COD_CLIENT
    - KN.COD_GENERATION=CU.COD_GENERATION
    - KN.COD_CLIENT =CU.COD_CLIENT
    - KN.COD_GENERATION=CU2.COD_GENERATION
    - KN.COD_CLIENT =CU2.COD_CLIENT
    - CU2.COD_GENERATION=KP.COD_GENERATION
    - CU2.COD_CLIENT =KP.COD_CLIENT
    - **CN.COD_GENERATION = 'MB'**
    - **CN.COD_CLIENT = '0450'**

} Also apply to KN, CU, CU2, KP

Query Breakdown – Counts

```
SELECT COUNT(*) = 1,472
FROM  PDB2.CONTACTNOTICE AS CN
WHERE CN.DOM_NOTIFY         = 'FICH'
  AND CN.COD_GENERATION     = 'MB'
  AND CN.COD_CLIENT         = '0450'
  AND CN.DOM_STATUS_NOTICE  = 'ERL'
```

```
SELECT COUNT(*) = 420,973
FROM  PDB2.CUST AS CU
WHERE CU.COD_CLIENT      = '0450'
  AND CU.COD_GENERATION  = 'MB'
```

```
SELECT COUNT(*) = 20,114
FROM   TDB2.KEY_PERSON AS KP
WHERE  KP.COD_CLIENT      = '0450'
  AND  KP.COD_GENERATION  = 'MB'
```

```
SELECT COUNT(*) = 267,011
FROM  PDB2.CUST AS CU2
WHERE CU2.DOM_PERSONGROUP    = 'PR'
  AND CU2.COD_LAND_DIVISION  = 'AT'
  AND CU2.DOM_STATUS         = 'BEST'
  AND CU2.DOM_CARE_STATE     = 'S'
  AND CU2.COD_CLIENT         = '0450'
  AND CU2.COD_GENERATION     = 'MB'
```

```
SELECT COUNT(*) = 156,347
FROM   TDB2.KEY_NOTICE AS KN
WHERE  KN.COD_CLIENT      = '0450'
  AND  KN.COD_GENERATION  = 'MB'
```

** Generally want most filtered table accessed first

Agenda

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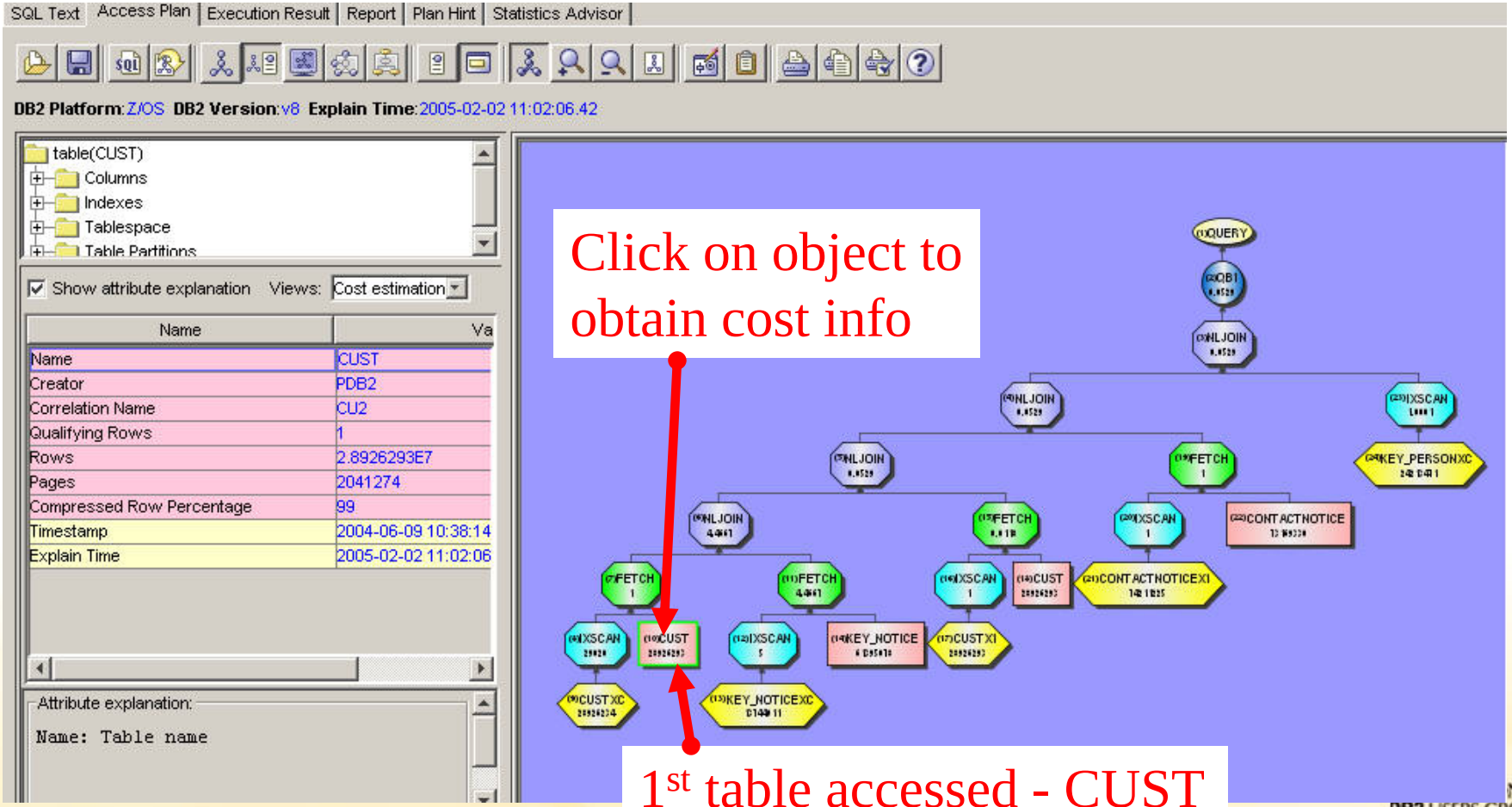
Using Visual Explain - Access Path Analysis



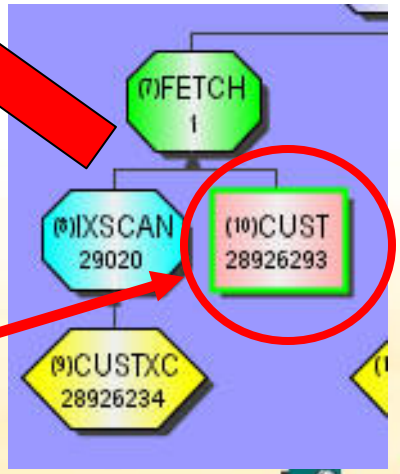
Using Visual Explain – Cost Estimates

Show attribute explanation Views: Cost estimation

Name	Va
Name	CUST
Creator	FDB2
Correlation Name	CU2
Qualifying Rows	1
Rows	2.8926293E7
Pages	2041274
Compressed Row Percentage	99
Timestamp	2004-06-09 10:38:14
Explain Time	2005-02-02 13:37:51

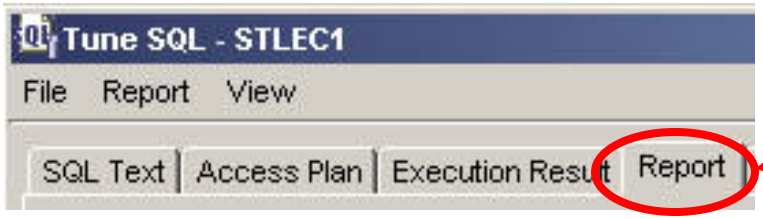
CUST table (CU2)

Estimate 1 row qualifies



Click on table object for statistics

Using Visual Explain - Cost Estimates



Click on Report Tab for summary

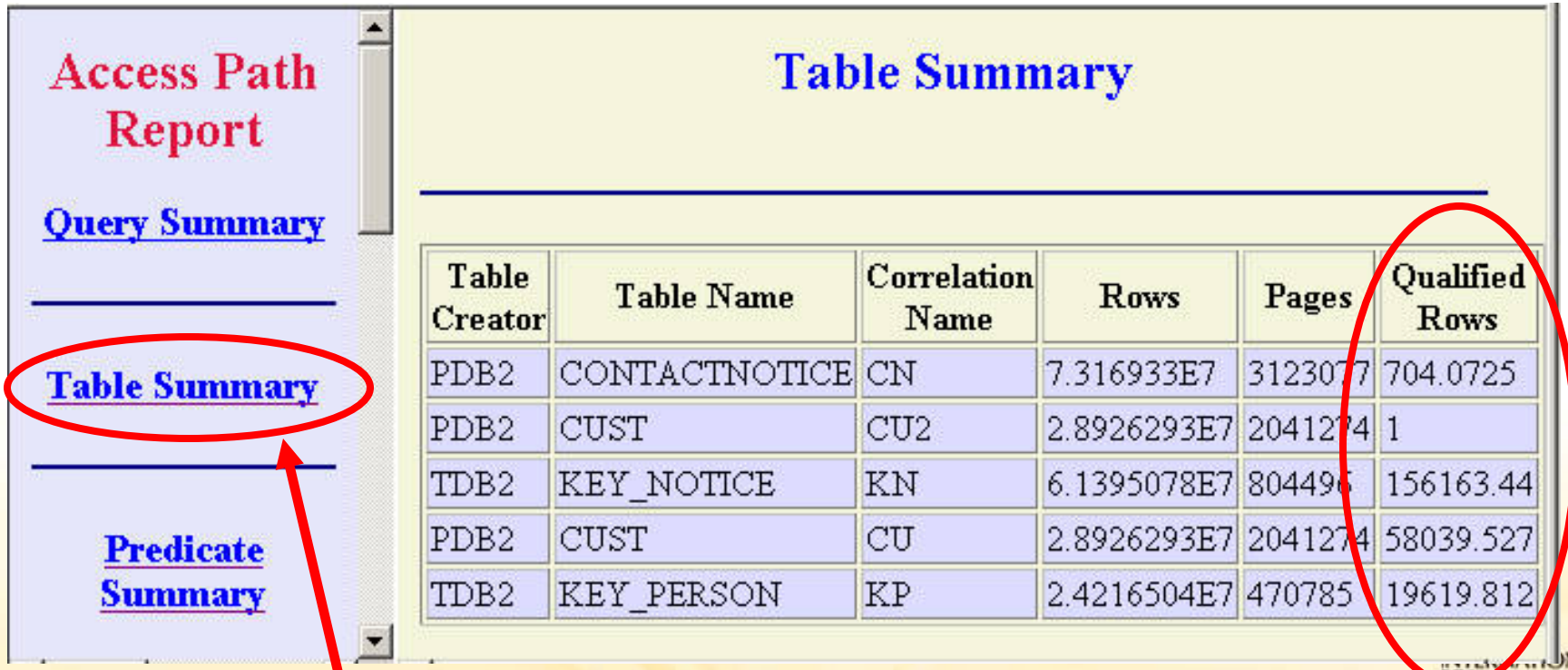


Table Creator	Table Name	Correlation Name	Rows	Pages	Qualified Rows
PDB2	CONTACTNOTICE	CN	7.316933E7	3123077	704.0725
PDB2	CUST	CU2	2.8926293E7	2041274	1
TDB2	KEY_NOTICE	KN	6.1395078E7	804496	156163.44
PDB2	CUST	CU	2.8926293E7	2041274	58039.527
TDB2	KEY_PERSON	KP	2.4216504E7	470785	19619.812

Choose Table Summary (Predicate Summary used in later step)

Comparing Table Counts Vs Cost Estimates

- How do the counts compare with estimates?

Reason CU2 accessed 1st

Table	Count	% of cardf	Estimate	% of cardf
CUST (CU)	420,973	1.45%	58,039	0.2%
CUST (CU2)	267,011	0.92%	1	0.000003%
CONTACTNOTICE	1,472	0.002%	704	0.0009%
KEY_PERSON	20,114	0.03%	19,619	0.03%
KEY_NOTICE	156,347	0.65%	156,163	0.65%

From COUNTs

From Table Summary

Agenda

- Simple methods to find the problem query
- Query breakdown
- Comparing estimates with reality
- What do I do if the estimate is incorrect?
- Automating the process

What do I do if the estimate is incorrect?

- Start by narrowing your scope…..
  - What estimate is incorrect?
    - "Qualified row estimates" vs "Real table counts" are incorrect
  - But there is more than one that is incorrect?
    - Focus on the worst one – CUST (CU2)
  - Where to next?
    - Table qualified row estimates are a combination of individual predicate estimates……**so drill down further to the predicates.**

Predicate Report

Predicate Summary

Predicate Number	Left-hand Side	Left-hand Side Column Cardinality	Predicate Type	Right-hand Side	Right-hand Side Column Cardinality	Filter Factor
2	COD_GENERATION	6	EQUAL	VALUE		0.1695
3	DOM_PERSONGROUP	18	EQUAL	VALUE		0.0556
4	COD_LAND_DIVISION	461	EQUAL	VALUE		0.0022
5	DOM_STATUS	57	EQUAL	VALUE		0.0175
6	DOM_CARE_STATE	24	EQUAL	VALUE		0.0417
7	COD_CLIENT	169	EQUAL	VALUE		0.0059

How does this match reality? Focus on 1 predicate at a time

Comparing predicate estimate with reality

- CU2.COD_LAND_DIVISION = 'AT'
  - Run count

```
SELECT COUNT(*)  = 26,149,368
FROM  PDB2.CUST AS CU2
WHERE CU2.COD_LAND_DIVISION = 'AT'
```

Only 99.7% wrong!!!

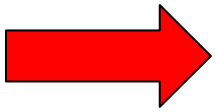
Count	Cardf	Count / cardf	Filter factor
26,149,368	28,926,293	0.904 (90.4%)	0.0022 (0.22%)

  - How can actual percentage (from count) differ from filter factor?
    - Data must not be evenly distributed (data is skewed)

Evaluating Data Skew

- Run the query below
  - Result clearly shows that data is not evenly distributed

```
SELECT COD_LAND_DIVISION, COUNT(*)
FROM  PDB2.CUST
GROUP BY COD_LAND_DIVISION
ORDER BY 2 DESC
```



```
COD_LAND_DIVISION
---------+---------+------
AT         26149368 (90.4%)
             960390
DE           841482
CZ           173971
HU           117924
SI            92994
IT            92763
... Not all displayed
```

Comparing Predicate Counts Vs Cost Estimates

- First estimate is correct, others are disasters

Predicate	Count	Filter Factor Estimate
COD_GENERATION = ‘MB’	0.1695	0.1695 ✓
DOM_PERSONGROUP = 'PR'	0.8643	0.0556 ✗
COD_LAND_DIVISION = 'AT'	0.9041	0.0022 ✗
DOM_STATUS = 'BEST'	0.9575	0.0175 ✗
DOM_CARE_STATE = 'S'	0.8206	0.0417 ✗
COD_CLIENT = '0450'	0.08	0.0059 ✗

Calculated as count / table cardf
(note 0.1695 = 16.95%)

RUNSTATS to collect Data Skew

- Run RUNSTATS on CUST table
  - V8 COLGROUP keyword allows frequencies on non-indexed columns

```
RUNSTATS TABLESPACE IDVKUNDA.IDVCUST
      TABLE(PDB2.CUST)
      COLGROUP(COD_CLIENT)           FREQVAL COUNT 10
      COLGROUP(DOM_STATUS)           FREQVAL COUNT 10
      COLGROUP(COD_LAND_DIVISION) FREQVAL COUNT 10
      COLGROUP(DOM_PERSONGROUP)  FREQVAL COUNT 10
      COLGROUP(DOM_CARE_STATE)     FREQVAL COUNT 10
```

New Predicate Report

Predicate Summary

Predicate Number	Left-hand Side	Left-hand Side Column Cardinality	Predicate Type	Right-hand Side	Right-hand Side Column Cardinality	Filter Factor
2	COD_GENERATION	6	EQUAL	VALUE		0.1695
3	DOM_PERSONGROUP	18	EQUAL	VALUE		0.8643
4	COD_LAND_DIVISION	461	EQUAL	VALUE		0.9041
5	DOM_STATUS	57	EQUAL	VALUE		0.9575
6	DOM_CARE_STATE	24	EQUAL	VALUE		0.8206
7	COD_CLIENT	169	EQUAL	VALUE		0.08

Count
0.1695 ✓
0.8643 ✓
0.9041 ✓
0.9575 ✓
0.8206 ✓
0.08 ✓

How well does this match reality? Perfectly now

** But don't always expect perfection **

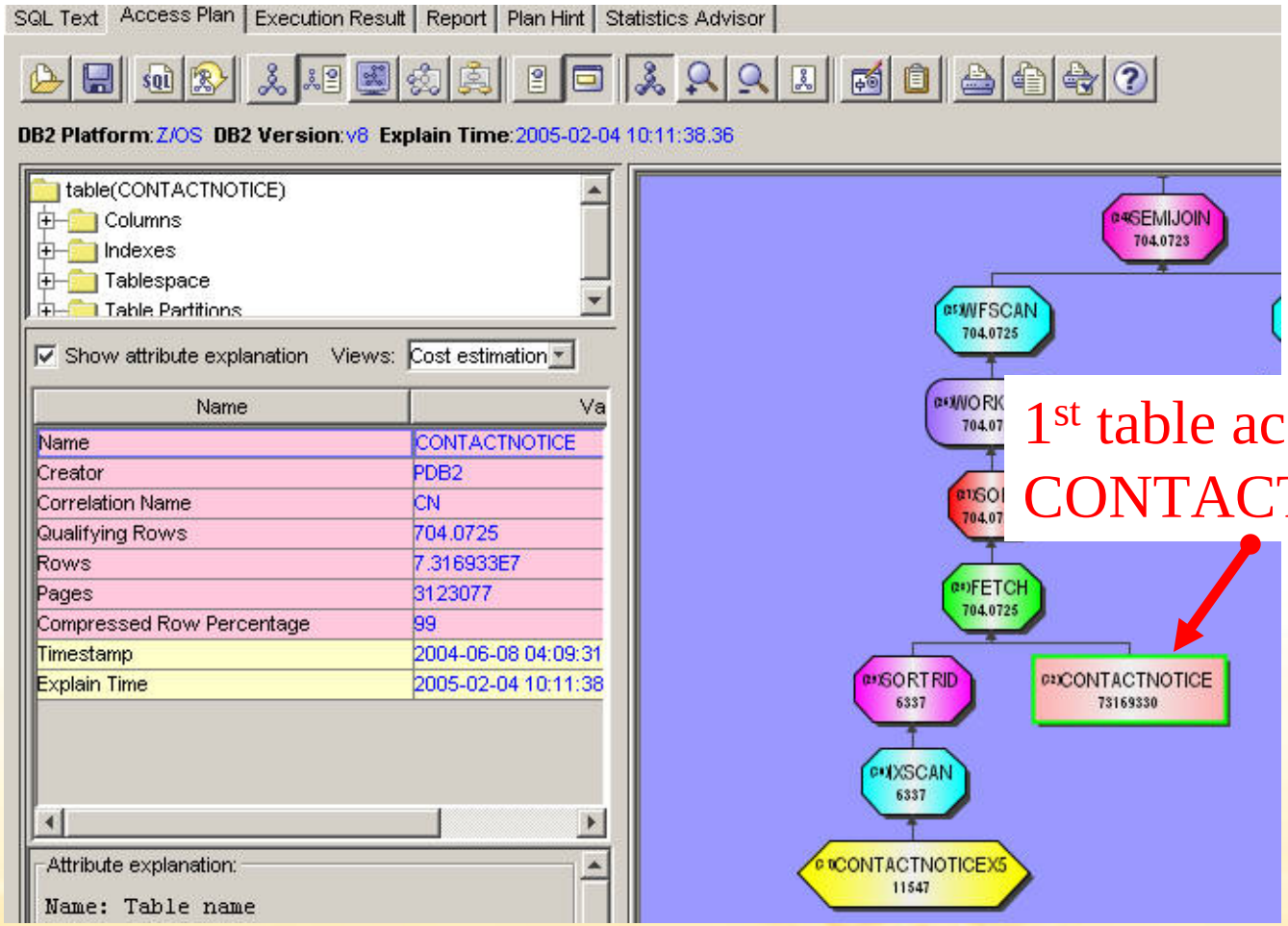
New Table Report

Table Summary

Table Creator	Table Name	Correlation Name	Rows	Pages	Qualified Rows	Count
PDB2	CUST	CU2	2.8926293E7	2041274	240891.62	**267,011**
TDB2	KEY_PERSON	KP	2.4216504E7	470785	19619.812	**20,114**
PDB2	CUST	CU	2.8926293E7	2041274	419204.44	**420,973**
TDB2	KEY_NOTICE	KN	6.1395078E7	804496	156163.44	**156,347**
PDB2	CONTACTNOTICE	CN	7.316933E7	3123077	704.0725	**1,472**

How well does this match reality? Not Perfect, but closer

Revised Access Path



- Query now performs well
  - < 20 sec
  - original > 20 min

1st table accessed - CONTACTNOTICE

Agenda

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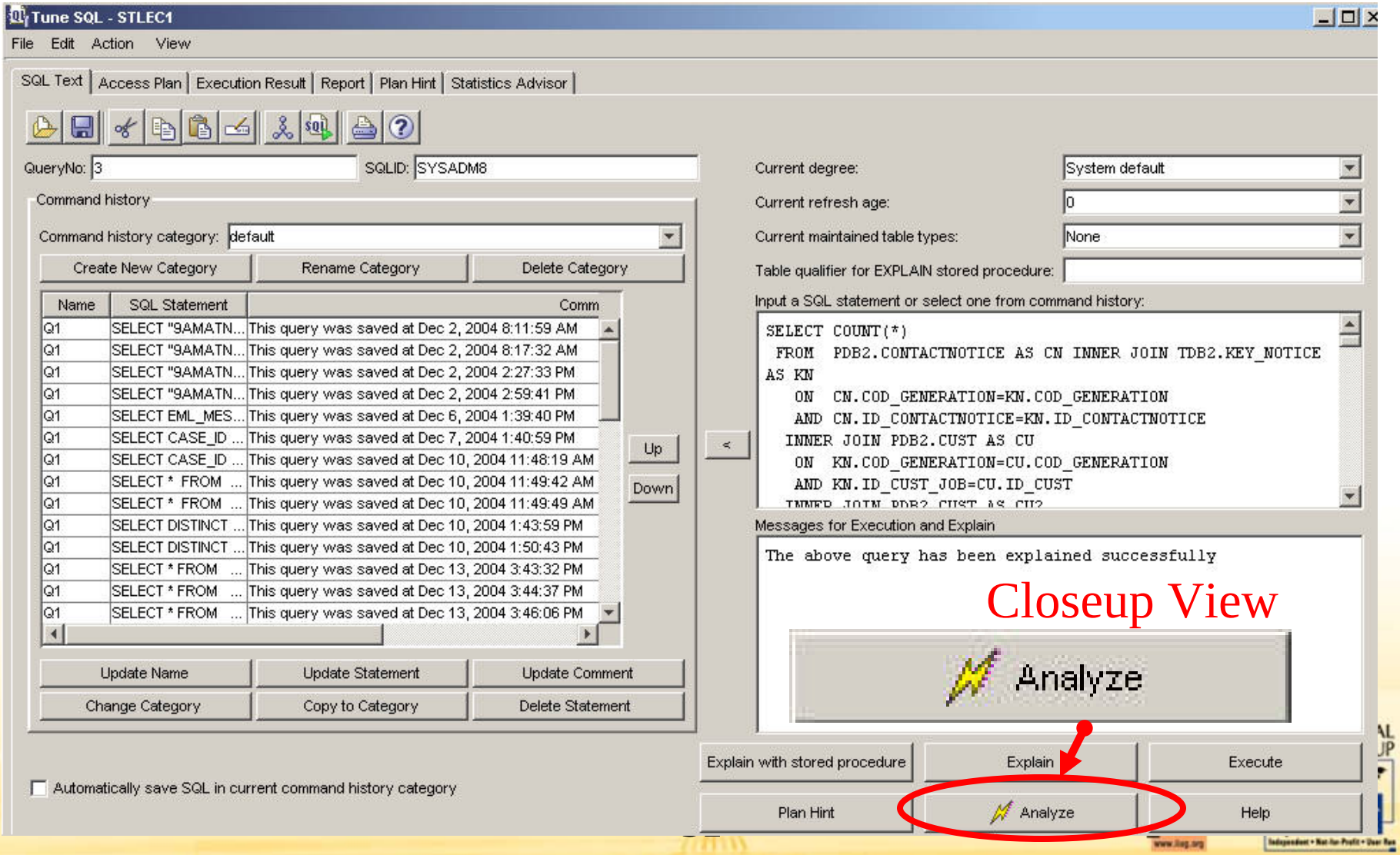
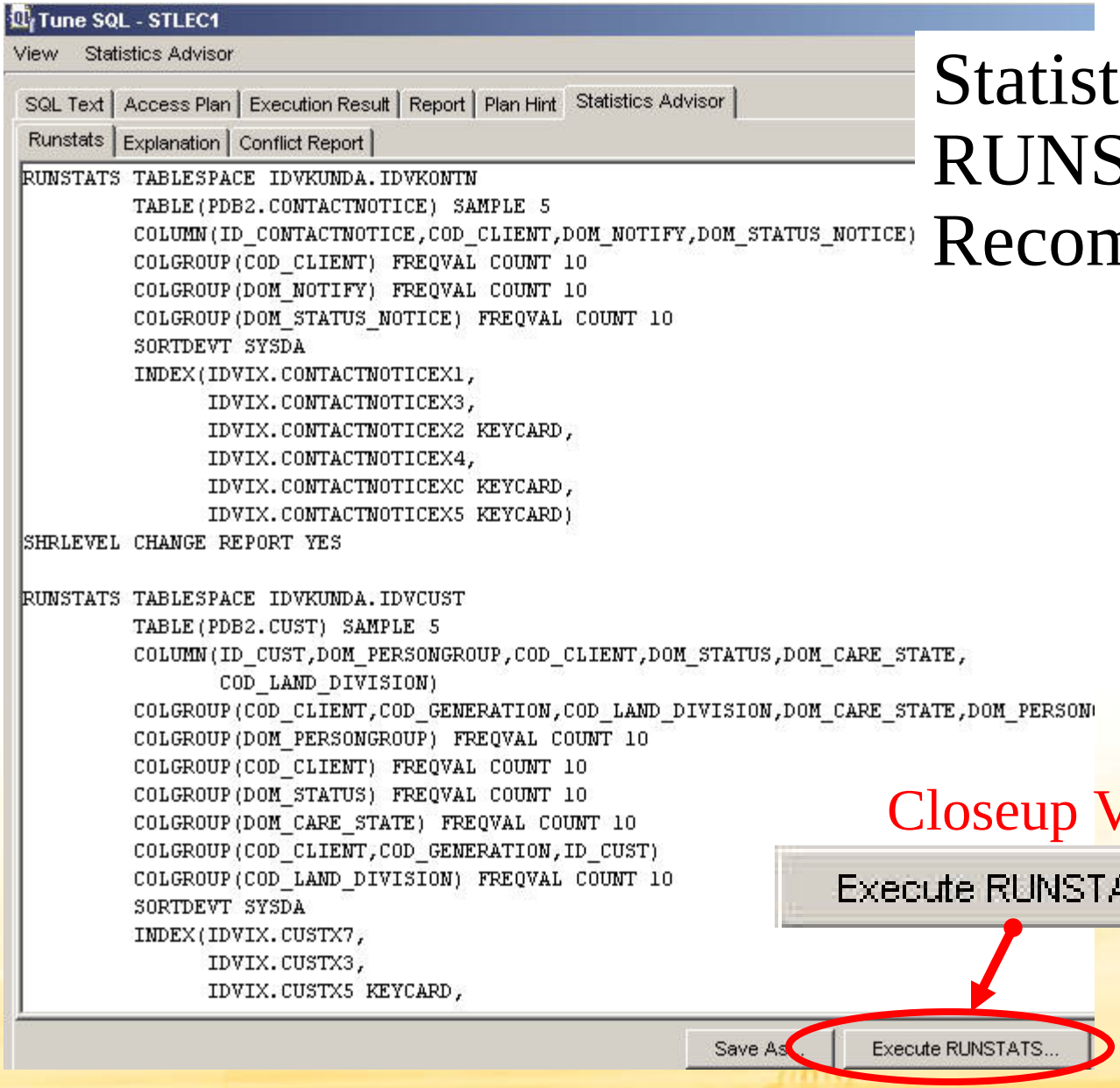
Automating the SQL Tuning Process



Statistics Advisor – RUNSTATS Recommendations



Closeup View

RUNSTATS Recommendations - Closeup

```
RUNSTATS TABLESPACE IDVKUNDA.IDVCUST
         TABLE(PDB2.CUST) SAMPLE 5
         COLUMN(ID_CUST,DOM_PERSONGROUP,COD_CLIENT,DOM_STATUS
                ,DOM_CARE_STATE,COD_LAND_DIVISION)
         COLGROUP(COD_CLIENT,COD_GENERATION,COD_LAND_DIVISION
                  ,DOM_CARE_STATE,DOM_PERSONGROUP,DOM_STATUS)
         COLGROUP(COD_CLIENT,COD_GENERATION,ID_CUST)
         COLGROUP(DOM_PERSONGROUP) FREQVAL COUNT 10
         COLGROUP(COD_CLIENT) FREQVAL COUNT 10
         COLGROUP(DOM_STATUS) FREQVAL COUNT 10
         COLGROUP(DOM_CARE_STATE) FREQVAL COUNT 10
         COLGROUP(COD_LAND_DIVISION) FREQVAL COUNT 10
```

Column Statistics

Correlation Statistics

Frequency Statistics

– Same as manual evaluation

Statistics Advisor

- Automated statistics determination
  - Often queries have inefficient OR unstable performance due to lack of statistics
  - SA automates the analysis of statistics required for an SQL statement
- Goal
  - Automate SOLUTION to many common SQL performance problems
  - Solve SQL performance problems quickly and easily

Statistics Advisor or Manual Analysis?

- Statistics Advisor is a 1st step
  - May resolve the majority of queries with unstable or inefficient access paths
  - Although currently only single query based, RUNSTATS recommendations improve optimizer's knowledge for all queries
- Deeper manual analysis may still be required
  - You may wish to validate the recommendations from SA
  - SA makes assumptions about need for frequency or correlation statistics, run counts to verify real need.
- Other problems may still exist
  - Inadequate indexing, inefficient predicates etc.

Agenda

- Simple methods to find the problem query
- Query breakdown
- Comparing estimates with reality
- What do I do if the estimate is incorrect?
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- What if this presentation didn't cover my SQL problem?

Try Another Problem

- Table count does not match estimate

```
SELECT COUNT(*) = 114,856
FROM SAPR3.PAYR
WHERE REGION = 'K03'
    AND DIV    = 'WFB2'
    AND DEPT   = 'ARPS'
```

114,856 vs 143

Table Summary

Table Creator	Table Name	Correlation Name	Rows	Pages	Qualified Rows
SAPR3	PAYR		1.7267799E7	862780	143.2536

Predicate Counts

- Run Predicate counts

Predicate Summary

Predicate Number	Left-hand Side	Left-hand Side Column Cardinality	Predicate Type	Right-hand Side	Right-hand Side Column Cardinality	Filter Factor
2	REGION	35	EQUAL	VALUE		0.0286
3	DIV	42	EQUAL	VALUE		0.0238
4	DEPT	82	EQUAL	VALUE		0.0122

SELECT COUNT(*) = 302,949
FROM SAPR3.PAYR
WHERE DEPT = 'ARPS'

SELECT COUNT(*) = 314,174
FROM SAPR3.PAYR
WHERE REGION = 'K03'

SELECT COUNT(*) = 302,949
FROM SAPR3.PAYR
WHERE DIV = 'WFB2'

Predicates - Actual vs Estimates

- Compare Actual vs Estimate

Predicate	Count	Cardf	Count / cardf	Filter Factor
REGION = 'K03'	314,174	17,267,799	0.0182	0.0286
DIV = 'WFB2'	302,949	17,267,799	0.0175	0.0238
DEPT = 'ARPS'	302,949	17,267,799	0.0175	0.0122

Filter Factor – Actual vs Estimate - Not Perfect, but close

So why the difference in table actual vs estimate?

Detecting Correlation - Counts

- Run Predicate counts
  - Distinct occurrences of each column

```
SELECT COUNT(DISTINCT REGION)  =  35 REGIONs
      ,COUNT(DISTINCT DIV)     =  42  DIVs
      ,COUNT(DISTINCT DEPT)    =  82 DEPTs
FROM SAPR3.PAYR
```

  - Distinct occurrences of the column group

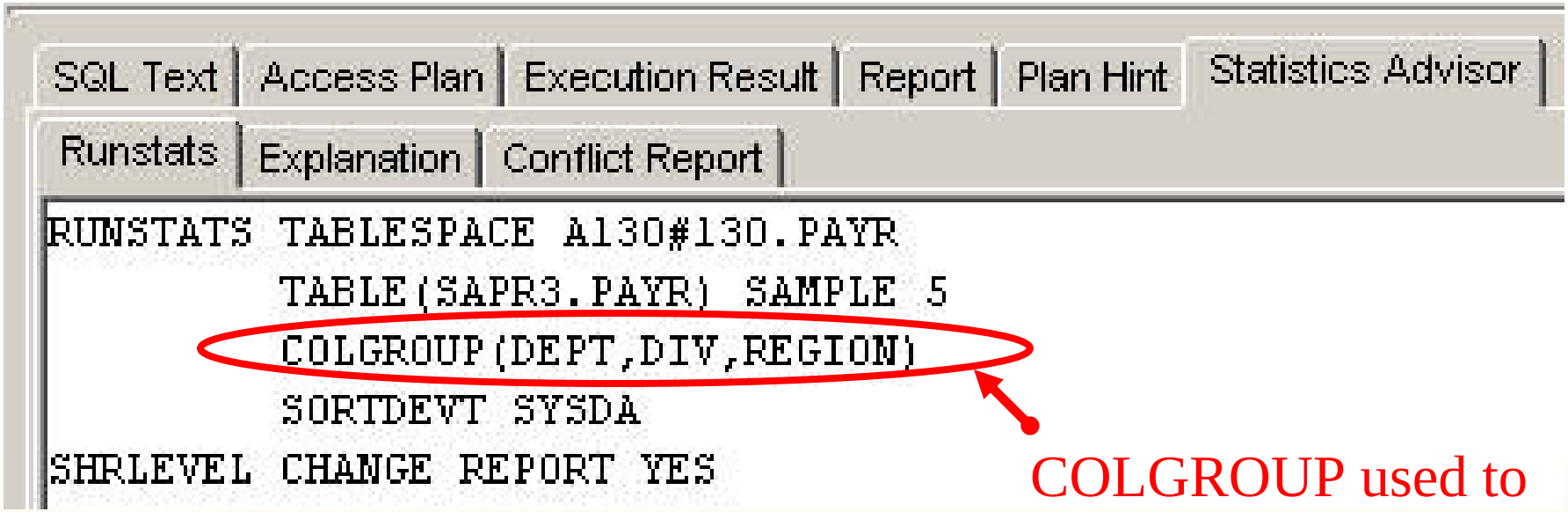
```
SELECT COUNT(*)  =  167 Combinations of REGION, DIV, DEPT
FROM
(SELECT DISTINCT REGION, DIV, DEPT
 FROM SAPR3.PAYR) AS A
```

Detecting Correlation - Calculation

- Calculation to detect correlation
  - If the product of the individual counts > group count
    - Then columns are correlated
      - Product of counts = 35 * 42 * 82 = 120,540
      - Group count = 167
      - 120,540 > 167
    - Therefore, columns are correlated

- Trivia
  - Optimizer treats columns as independent unless statistics demonstrate otherwise
  - 17,267,799 * 1/35 * 1/42 * 1/82 = 143.2536 ← Look familiar?

Statistics Advisor Recommendations



Revised Table Estimate

- Qualified Rows Estimate after RUNSTATS

Table Summary

Table Creator	Table Name	Correlation Name	Rows	Pages	Qualified Rows
SAPR3	PAYR		1.7267799E7	862780	103399.94

- Why do we care?

Closer to 114,856 (count)

  - For single table access
    - May influence choice of access method, including index choice, usage of list or sequential prefetch etc
  - For multi-table access
    - Qualified row estimate used as input to subsequent tables. Choice of join sequence, join method, and access method (index?) for each table.

Summary

- Many more examples possible
- Basic fundamentals remain the same
  - Run counts to compare table/predicate estimates with reality to:
    - Detect correlation,
    - Identify data skew,
    - Find optimistic or poor filter factors (eg. Range predicate with parameter markers or column expressions).
- Using Statistics Advisor
  - So simple that even the help desk could do it!!
- Using the method outlined in this presentation
  - Take query tuning to the next level and tune SQL like an expert

Tune SQL like an expert in DB2 UDB for z/OS V8
Session: G7

Thankyou for listening!!!

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