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Change Control for DB2 Access Paths

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Agenda

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BIND and REBIND Essentials

Access Paths and Change Management

Version Management

- General Version Issues
- DB2 Version 7 to Version 8

Bind ImpactExpert Solution

BIND and REBIND Essentials

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The BIND and REBIND commands:

- Are used to create DB2 plans and packages
  - Many options to choose from, including:
    - DEGREE (ANY | 1)
    - EXPLAIN (YES | NO)
    - ISOLATION (RR | RS | CS | UR | NC)
    - OPTHINT(id)
    - ACQUIRE (USE | ALLOCATE)
    - RELEASE (COMMIT | DEALLOCATE)
    - VALIDATE (RUN | BIND)
    - *and more…*

BIND and Optimization

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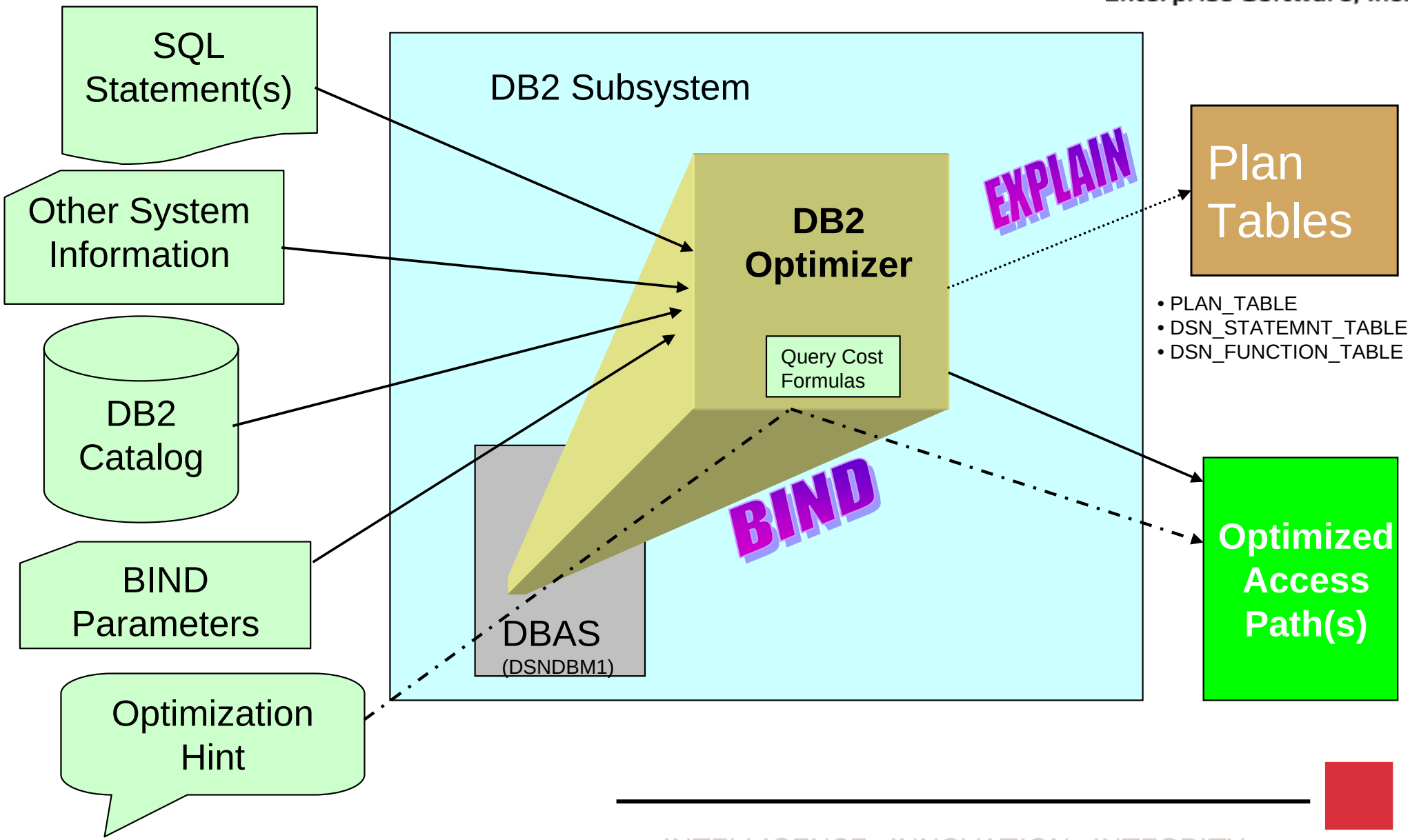

OK, So What?

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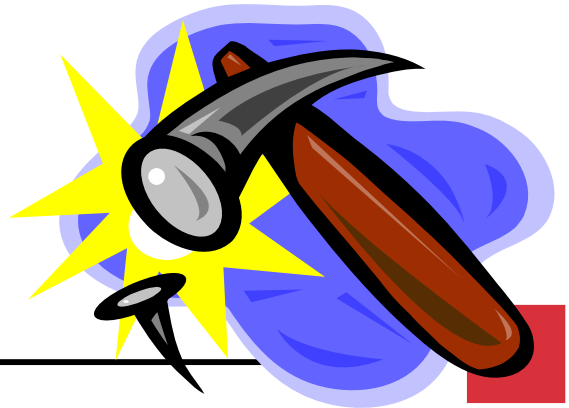
- **BIND and REBIND are critical for application performance**
- **It is a wise course of action to plan your REBIND strategy**
- **There are several common approaches:**
  - Daily maintenance: REBIND after RUNSTATS
    - Perhaps not every day, but REBIND are done after RUNSTATS
  - Global REBIND after migration to new DB2 version
  - Global REBIND after installing new PTFs
    - Above two mean access paths only change when DB2 changes
  - REBIND after *x* days / weeks / months …
  - Let it Ride! ("If it ain't broke, don't fix it.")



Let It Ride

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- Programs once bound, are (almost) never rebound.
- Reason:
  - Fear of access path degradation
- Result:
  - No improvement to access paths
  - No CPU savings from new DB2 efficiencies
  - Sub-optimal performance
  - Every DB2 program potentially suffers for fear that one or two SQL statements will become inefficient

Regular REBIND

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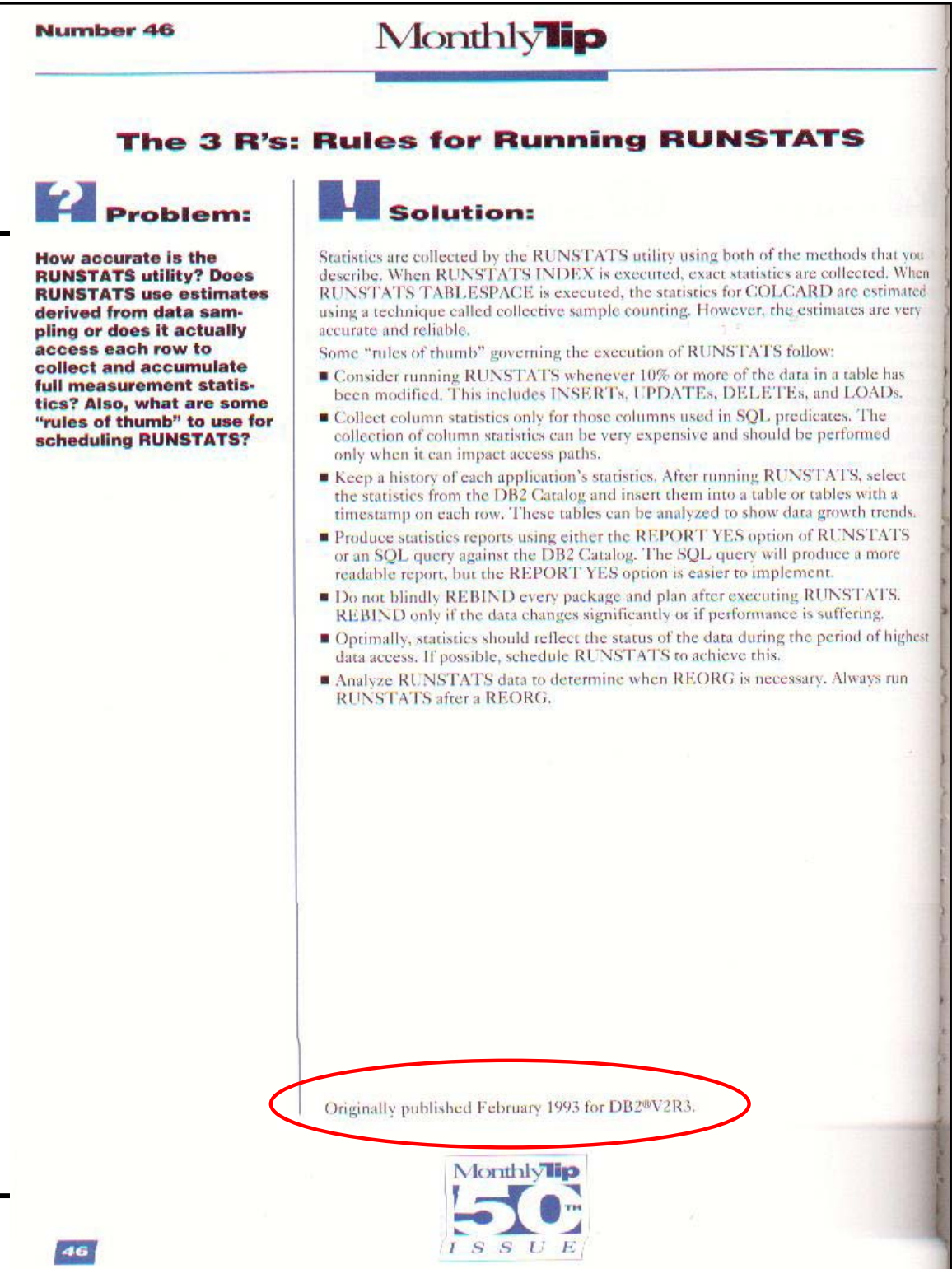
- **Better Approach**: Regular REBINDing
  - The Three R's *(next slide)*
- Reason:
  - Access paths are more up-to-date based on the current state of the data.
- Result:
  - Generally, improved access paths
  - CPU savings from new DB2 efficiencies
  - Optimal performance
- Of course, you can still get those "problem" access paths.

The Three R's

- REORG
- RUNSTATS
- REBIND



Number 46

MonthlyTip

The 3 R's: Rules for Running RUNSTATS

? Problem:

How accurate is the RUNSTATS utility? Does RUNSTATS use estimates derived from data sampling or does it actually access each row to collect and accumulate full measurement statistics? Also, what are some "rules of thumb" to use for scheduling RUNSTATS?

H Solution:

Statistics are collected by the RUNSTATS utility using both of the methods that you describe. When RUNSTATS INDEX is executed, exact statistics are collected. When RUNSTATS TABLESPACE is executed, the statistics for COLCARD are estimated using a technique called collective sample counting. However, the estimates are very accurate and reliable.

Some "rules of thumb" governing the execution of RUNSTATS follow:

- Consider running RUNSTATS whenever 10% or more of the data in a table has been modified. This includes INSERTs, UPDATEs, DELETEs, and LOADs.
- Collect column statistics only for those columns used in SQL predicates. The collection of column statistics can be very expensive and should be performed only when it can impact access paths.
- Keep a history of each application's statistics. After running RUNSTATS, select the statistics from the DB2 Catalog and insert them into a table or tables with a timestamp on each row. These tables can be analyzed to show data growth trends.
- Produce statistics reports using either the REPORT YES option of RUNSTATS or an SQL query against the DB2 Catalog. The SQL query will produce a more readable report, but the REPORT YES option is easier to implement.
- Do not blindly REBIND every package and plan after executing RUNSTATS. REBIND only if the data changes significantly or if performance is suffering.
- Optimally, statistics should reflect the status of the data during the period of highest data access. If possible, schedule RUNSTATS to achieve this.
- Analyze RUNSTATS data to determine when REORG is necessary. Always run RUNSTATS after a REORG.

Originally published February 1993 for DB2®V2R3.

MonthlyTip 50™ ISSUE

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Problems With the Three R's

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- They pose a lot of questions…
  - —When should you REORGanize?
    - To properly determine requires RUNSTATS (or RTS).
    - So should it be RUNSTATS, REORG, RUNSTATS, REBIND?
  - —When should you run RUNSTATS?
    - To properly determine you need to know the make-up, usage, and volatility of your data.
  - —When should you REBIND?
    - When statistics have changed significantly enough to change access paths.

The Importance of Accurate DB2 Catalog Statistics

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Why correct statistics are so important

- The DB2 Optimizer makes all access path decisions
- Accurate stats help the Optimizer make the correct decisions
- Incorrect statistics tend to degrade performance due to bad access paths

"More than half of the bad access paths sent to IBM support are caused by incorrect statistics."

- According to Terry Purcell (IBM, SVL)

Getting Correct Statistics

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Ways to update statistics

- RUNSTATS utility
- REORG with inline statistics
- LOAD with inline statistics
- Using SQL for statistics manipulation
- Transferring statistics from another system
- Using tools for manipulation

OK, so When Should we REBIND?

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When do we REBIND?

- The best answer to this questions is: “Whenever data has changed significantly enough that it may impact the performance of the existing access paths.”
  - The problem is knowing *exactly* when this happens.
- **DB2 application performance can be negatively affected by uncontrolled REBINDs.**
- Causes
  - Optimizer inefficiency
  - Volatile tables
  - Catalog pollution
  - Inefficient use of RUNSTATS

Reviewing the Steps: The ~~3~~ 5 R's

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RUNSTATS (or RTS)

REORG

RUNSTATS

REBIND

Recheck

- In other words, what did the REBIND do?
  - Access path changes – better or worse?

EXPLAIN & Access Path Analysis

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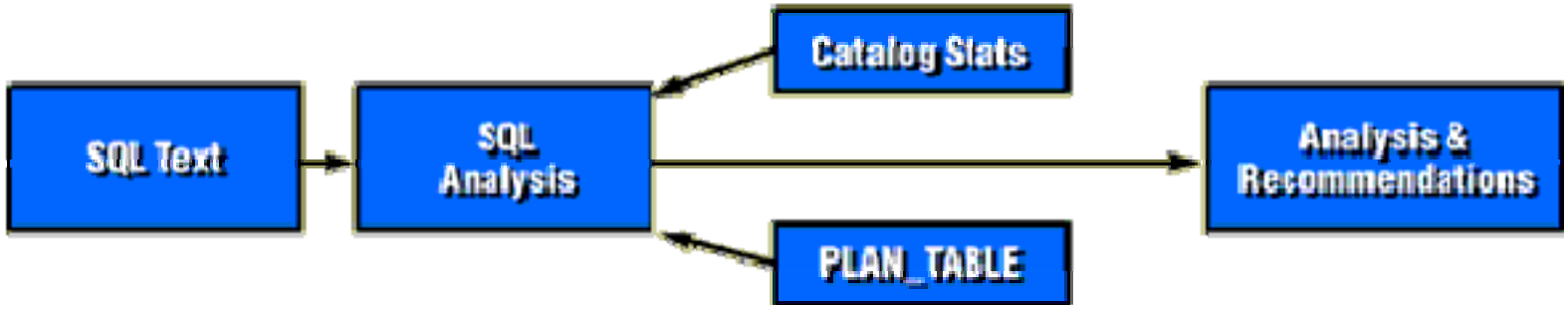

Hint used?

Index used?
- Single, Multiple

Matching column(s)?

Index only?

TS scan (page range)

Type of Join?
- Nested Loop
- Merge Scan
- Hybrid

SQL Text

Table & Index Information
- DDL
- Stats

Cardinality

Other Stuff
- Triggers
- RI
- Constraints

Prefetch?
- Sequential
- List

Parallelism used?
- I/O, CPU, Sysplex
- Degree

Sort required?
- Join, Unique, Group By, Order By

Locking

How Can This Be Done?

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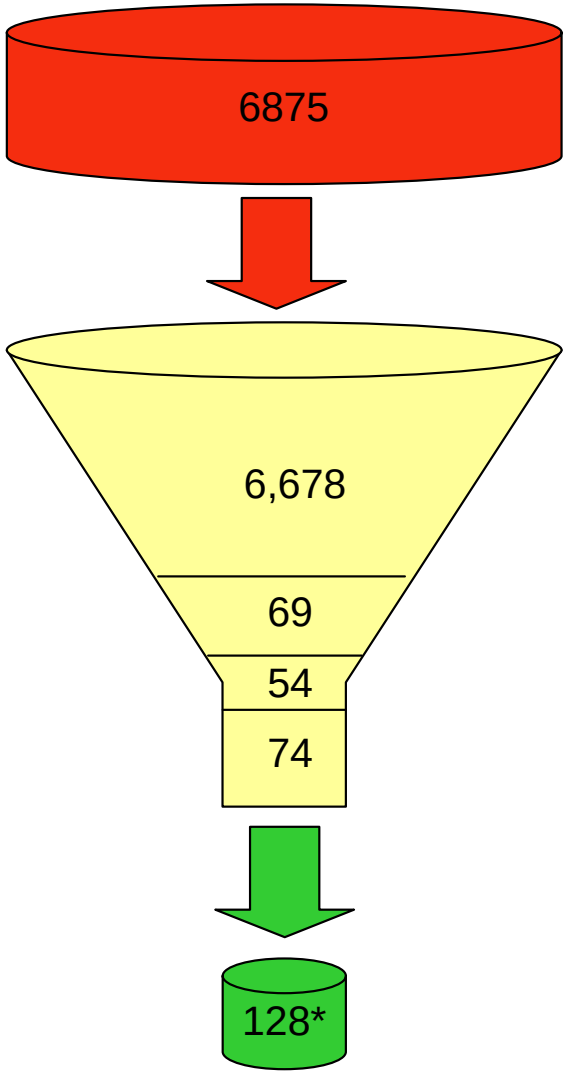
How do you determine what access paths have changed?

- Comparing old to new?
- Are they better or worse?
- Dealing with program changes?
  - Or just access path changes?

Do you evaluate every program that is rebound in production?

- Or do you just wait for irate users to call?

REBIND Protection



Total packages processed

Unchanged packages

Degraded packages

EXPLAIN(NO) packages

Improved packages

Actual REBINDs commands generated*

Summary

	Pack-ages	SQL Statements*
Processed	6875	
Analyzed	6821	53,468
Bound with explain(no)	54	
Degraded	69	110
Improved	74	571
Unchanged	6,678	52,787
Rebinds suppressed	6,747	
Rebinds generated	128	

* A single package will contain multiple SQL statements.

69 degraded plans/pkgs quarantined
54 unexplained plans identified
74 access path improvements
98% of rebinds were suppressed

•With rebind explain(yes) option enabled

Change Management

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- **Mainframe Environments Typically Require Strict Change Control**
  - Application Program Changes = Strict
  - Database Changes = Strict
  - System Software Changes = Strict
  - SubSystem Software Changes = Strict
  - Access Path Changes = ?????

When Are Access Paths Changed?

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- Any time the program changes
  - BIND is required
  - Unless the SQL does not change and you have a tool to manage the process
- Every time we REBIND whether the program changed or not
- New DB2 Releases and Versions
  - Sometimes required; sometimes just for performance
  - But a performance “gain” is not always “guaranteed”

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Access Path Validation:

Prior to System Level Migrations

DB2 V8 and REBIND

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You DO NOT have to REBIND all of your packages and plans when you move to V8.

However, it *is* a really good idea.

There are a lot of optimizer enhancements and performance improvements that you won't get without a REBIND.

- And there are some REBINDs you cannot avoid.

Issues Migrating to DB2 V8

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"The CPU ranges vary but generally the additional CPU cost is between 0 and 10%..."

DB2 UDB for z/OS Version 8 Performance topics - Redbook

"We have a very simple DB2 system, which I'm having fun trying to drive the CPU back down post V8. We have seen a batch CPU increase from V7 to V8 NFM of 40% and up."

Customer experience reported on the DB2 List Server

There are actions that you can take to mitigate any CPU overhead ... One obvious task is to REBIND all plans and packages after you migrate. Once you are in CM, if you REBIND, DB2 re-establishes fast column processing and your application also exploits more efficient access paths, already available under CM, that can possibly improve CPU costs."

DB2 UDB for z/OS Version 8 Performance topics – Redbook

DB2 V8 and SPROCs

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- What is this "fast column processing"?
- SPROC – SELECT Procedure
  - Introduced in DB2 V3
  - Enables faster column processing
    - Columns moved in one move instead of one at a time
    - No control over when SPROC is used – it just is
  - DB2 V8 requires 64 bit; V7 SPROC is 31 bit
    - DB2 V8 will disable SPROC until you REBIND
  - Can cause BIG performance degradation

Cannot Avoid

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And a few slides ago, you said "there are some REBINDs you cannot avoid." What does that mean?

From the DB2 V8 Installation Manual

...or not

2.7.1.30 Plans and packages bound prior to DB2 Version 2 Release 3

"If you have plans and packages that were bound prior to DB2 Version 2 Release 3, DB2 will autobind these packages. Thus, you may experience an execution delay the first time that such a plan is loaded. Also, DB2 may change the access path due to the autobind, potentially resulting in a more efficient access path."

More DB2 V8 SQL

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- **What about those Optimizer Enhancements?**
  - Stage 1 for Unlike Data Types
  - COL IS NOT NULL — now Stage 1
  - IN-list Processing Enhancements — on by default
    - In V7 (APARs PQ73454, PQ73749, PQ68662)
    - ZPARM was 0, but is now 50 by default
  - Non-correlated EXISTS Subquery Enhancement
  - Star Join Processing Enhancements
  - Volatile Tables
  - Backward Index Scan
  - Cost-based Parallel Sort
  - Distribution Statistics on Non-index Columns

And Other “Stuff”

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Then there are those “things” that require programs to be modified to get benefits… and, of course, you’ll have to BIND to use them:

- Multi-Row FETCH and INSERT
- Materialized Query Tables
- SELECT from INSERT
- IS NOT DISTINCT FROM
- REOPT(ONCE)
- Scalar Fullselect
- GROUP BY expressions

Want More Ammunition?

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REBIND plans/packages and update DBDs

DB2 Version 8 in new-function mode, uses a different format for its DBDs, packages and plans. So, before DB2 can use a DBD, plan or package from an earlier release of DB2, it must first be expanded to the new Version 8 format. This is an overhead you can easily do away with.

This is also true for DB2 Version 8 running in compatibility mode and enabling-new-function mode. DB2 must first expand the DBDs, plans and packages before it can use them. DB2 must also convert the DBDs, plans and packages to the old format before it can store them in the catalog. This is an extra overhead that exists while running in compatibility mode and enabling-new-function mode.

Attention: After you have entered new-function mode, we recommend that you plan to rebind all of your plans and packages. DB2 will then store the plans and packages in the DB2 catalog in the new format. DB2 will no longer need to expand the plans/packages each time it needs to use them.

We also recommend that you plan to make some small change to every database. This will also force DB2 to rebuild and store all the DBDs using the Version 8 format into the directory. DB2 will no longer need to expand the DBDs each time it needs to use them.

DB2 UDB for z/OS Version 8: Everything You Ever Wanted to Know, ... and More (IBM Redbook #SG24-6079)

So?

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Have I convinced you that you'll be BINDing and REBINDing a lot of plans and packages in DB2 V8?

Migrating to DB2 V8

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“Save critical access paths (optional)”

“Sometimes changes between releases of DB2 cause unwanted access path changes. Consult with your performance analysts to determine which queries are especially critical and ensure that there is a PLAN_TABLE that contains the good access path. Run EXPLAIN on your queries before migrating. Because EXPLAIN requires a rebind, your access paths might change. Therefore, extract the needed queries and then run EXPLAIN on them under a different application or program name. This action protects the existing application while the access path information is obtained. Then, after the access paths for the extracted queries are validated, you can update the APPLNAME or PROGNAME columns of the PLAN_TABLE to the correct name.”

DB2 UDB for z/OS Version 8 Installation Guide

Access Path Change Management

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What is needed:

- Predictive analysis for both Static SQL and Dynamic SQL
- Pre-Screen access paths in preparation for:
  - DB2 version upgrades
  - Major PTFs
  - System software changes
  - Hardware changes
- Pre-screen changed applications
  - Compare new DBRM to the catalog
  - Identify access path degradation for existing statements
  - Show the access path for new statements
  - Preview the access paths resulting from execution of BIND commands
  - Integrated into change control processes

Bind ImpactExpert

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Implementation scenarios

- Nightly production maintenance, i.e., REBIND after RUNSTATS.
- Migration to new DB2 releases and application of APARs, or anytime when global REBINDs are recommended.
- Hand-over of changed applications into production, i.e., pre-check access path changes *before* the BIND.
- Predicts V8 access paths *before* migration

How Bind ImpactExpert Works

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Finds the bad access types

- Table space Scan — ACCESSTYPE = R
- Non-matching IX Scan — ACCESSTYPE = I, MATCHCOLS = 0
- List Prefetch — PREFETCH = L
- Sort — METHOD = 3
- Multiple IX Access — ACCESSTYPE = MX
- Hybrid Join — METHOD = 4

How Bind ImpactExpert Works

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Weighs the bad access types so they can be compared with each other

Table space Scan	ACCESSTYPE=R	8
Non-matching IX Scan	ACCESSTYPE=I, MATCHCOLS=0	5
List Prefetch	PREFETCH = L	4
Sort	METHOD = 3	4
Multiple IX Access	ACCESSTYPE = MX	1
Hybrid Join	METHOD = 4	1

The weightings can be user-defined!

Weightings

In Production Maintenance

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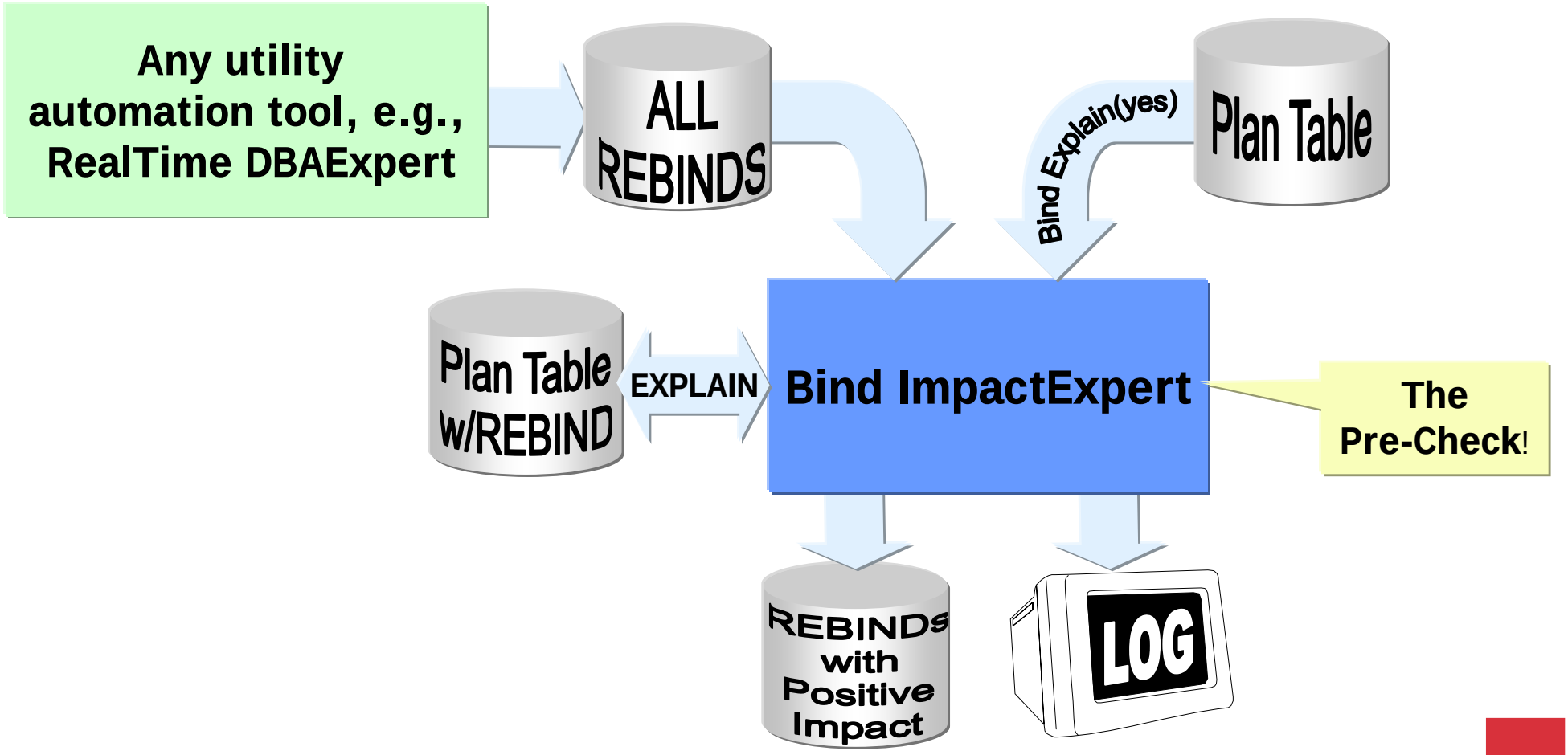
Guarantees REBINDs that improve performance



Running stand-alone, etc.

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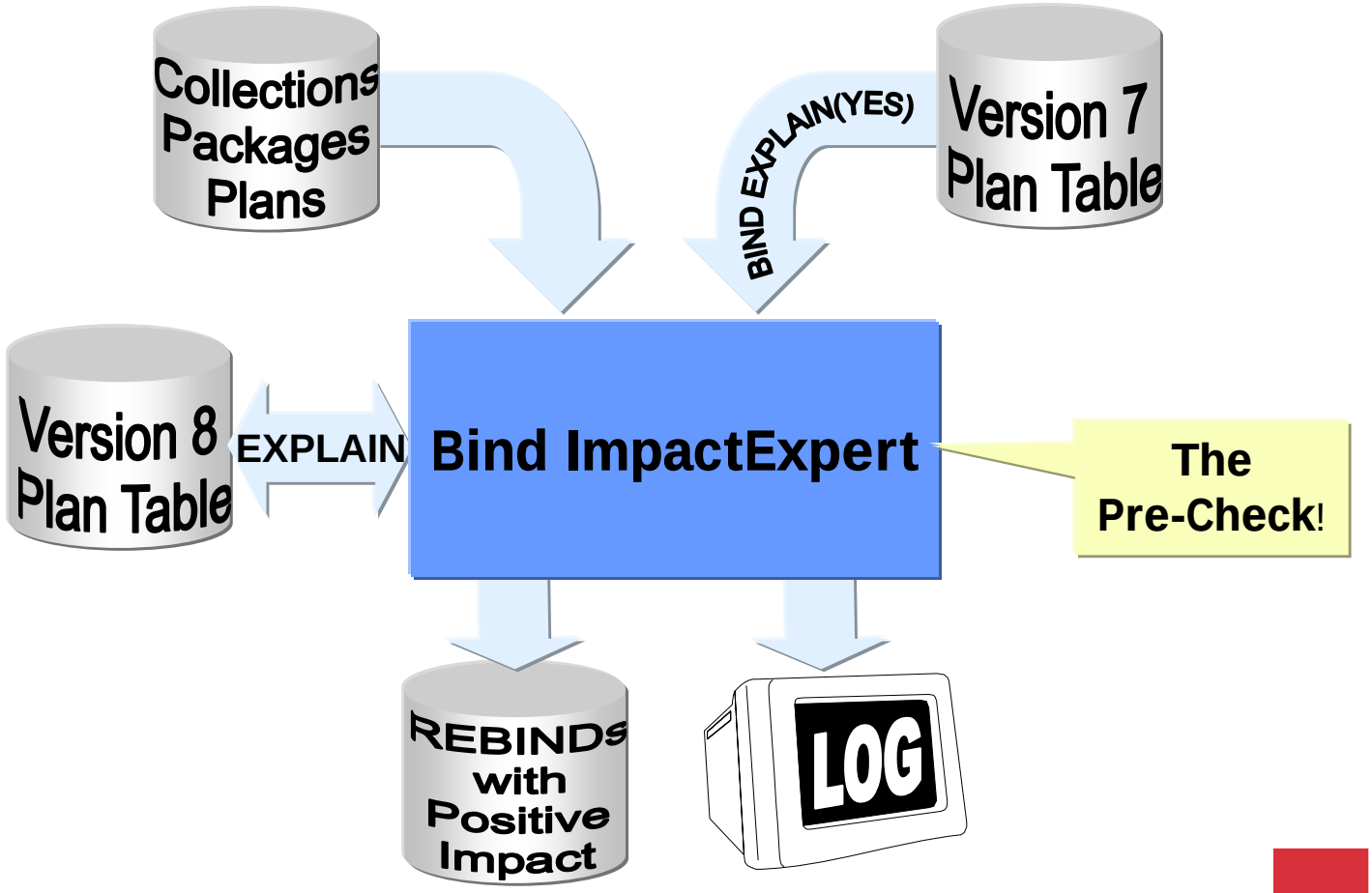
Runs stand-alone for global package/plan processing



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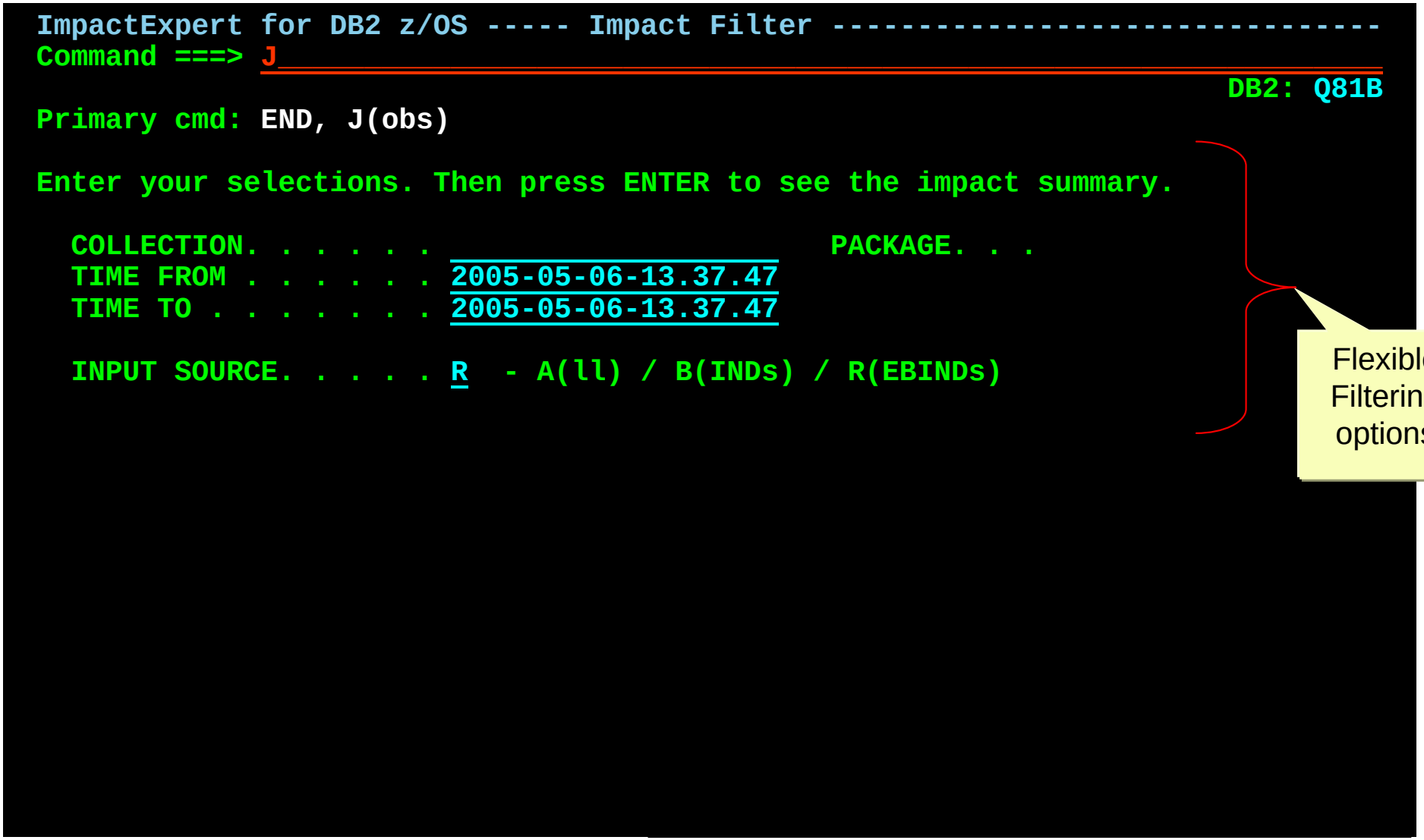

Flexible Filtering options

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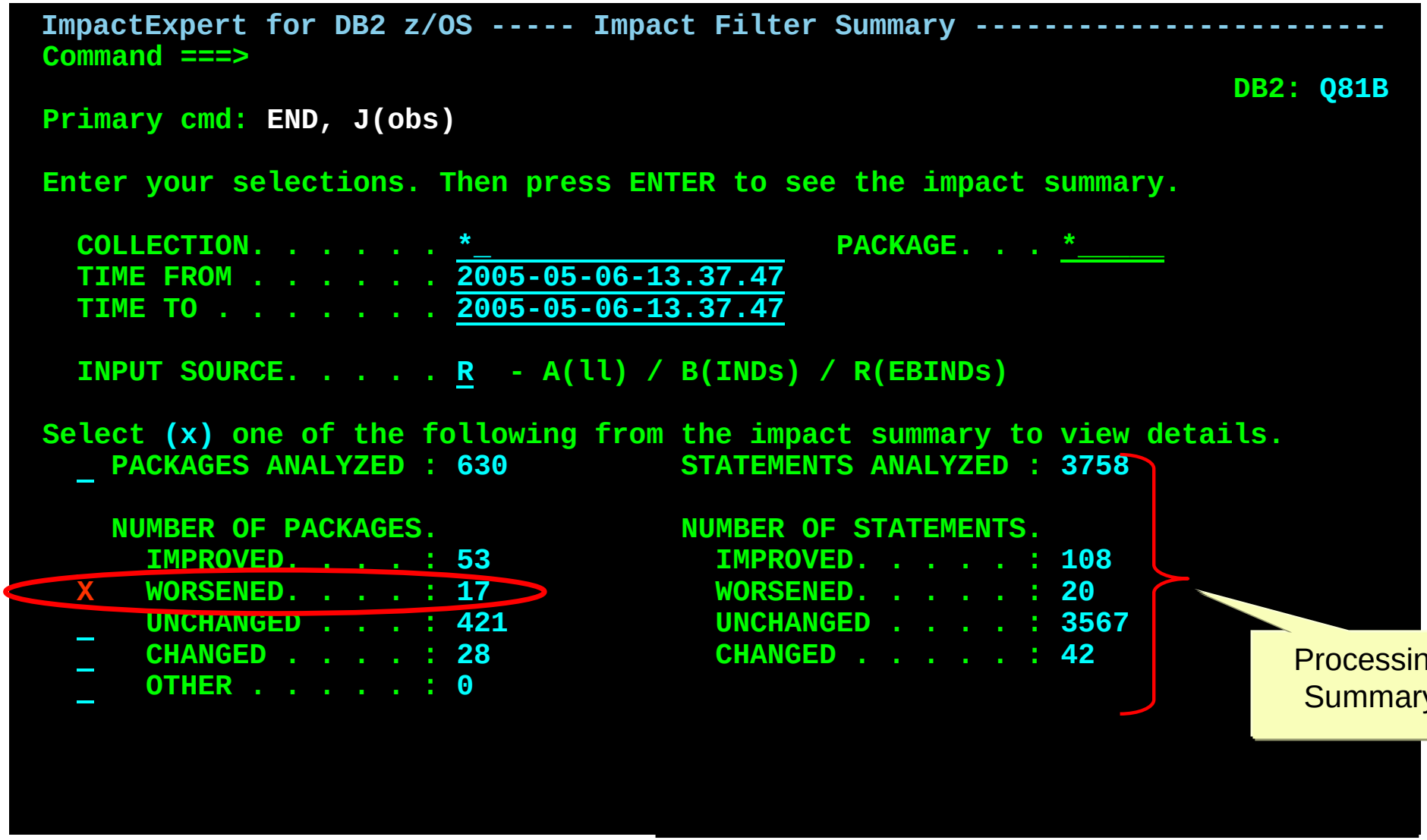

Bind ImpactExpert

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```
ImpactExpert for DB2 z/OS ----- Worsened Packages ---------- Package 9 from 26
Command ===> ____________________________________________________ Scroll

Primary cmd: END, L(ocate) -Package-
Line    cmd: S(tatement), C(reate REBIND)

                         COLLECTION/          PACKAGE/                  STATEMENTS
   JOB SUBMIT TIME       PLAN                 DBRM        REC  EX    IMP  WRS  OTH S
   -------------------   ------------------   --------    ---  ---   ---  ---  --- -
_  2005-09-15-09.53.58   IQA_COLLECTION_510   ADB2M101    NO          3    1    0 R
_  2005-09-15-09.53.58   IQA_COLLECTION_510   ADB2M101    NO          3    3    0 R
_  2005-09-15-09.53.58   IQA_COLLECTION_510   ADB2M101    NO          3    3    0 R
_  2005-09-15-09.53.58   IQA_COLLECTION_510   ADB2M101    NO          3    3    0 R
_  2005-09-15-09.36.12   IQA_COLLECTION_510   XDB2CN22    NO          0    1    0 R
_  2005-09-15-09.36.12   IQA_COLLECTION_510   XDB2CN01    NO          0    1    0 R
_  2005-09-15-09.36.12   ADB20410             SQLZU102    NO          0    1   10 R
_  2005-09-15-09.36.12   SQLZ0120             SQLZU102    NO          0    1   10 R
_  2005-09-15-09.36.12   ADB20410             PARSTYPE    NO          1    1    1 R
_  2005-09-15-09.36.12   MDB20330             O2DBIX      NO          4    2    0 R
_  2005-09-15-09.36.12   IQA0510              BAIMM200    NO          1    1    0 R
_  2005-09-15-09.36.12   IQA_COLLECTION_510   ADB2SET1    NO          7    3    0 R
_  2005-09-15-09.36.12   IQA_COLLECTION_510   ADB2M101    NO          3    3    0 R
_  2005-09-15-09.36.12   ADB20410             ADB2DSTS    NO          0    3    0 R
_  2005-09-15-09.36.12   ADB20410             ADB2DSTP    NO          2    1    0 R
_  2005-09-15-09.36.12   ADB20410             ADB2DSTB    NO          0    3    0 R
```

Statement overview for each package in the list

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```
ImpactExpert for DB2 z/OS ----- REBIND Impact ------------- Statement 1 from 23
Command ===> ____________________________________________ Scroll ===> CSR
                                                          DB2: D810

Primary cmd: END, SE(tup Analyze),
Line    cmd: S(elect), A(nalyze), D(ynamic Analyze), E(dit and Analyze)

Timestamp. . 2005-09-15-09.36.12.250000
Collection . ADB20410
Package. . . ADB2DSTP
Version. . . 2001-11-05-17.18.16.515822

                  BAD ACCESS TYPES
    STMTNO IMPACT BEFORE REBIND        WITH REBIND                 COST
    ------ ------ ------------------   ------------------   ------------
_    3478   IMP    SORT                                          9.56
_    3496   IMP    LP                                           23.34
_    3516   EQ     SORT                SORT                     23.34
_    3537   EQ                                                  08.34
_    3559   EQ     SORT                SORT                     23.34
S    3730   WRS    SORT                TS,SORT                 124.15
_    5120   EQ                                                  10.12
_    7584   EQ                                                   0.18
_    7597   EQ                                                   0.55
```

Presents the REBIND impact for each statement in the package

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```
 ImpactExpert for DB2 z/OS ----- Comparison --------- LINE 00000077 COL 001 080
 Command ===> ____________________________________________ Scroll ===> CSR
                                                          DB2: Q81B

 Primary cmd: END, CAN(cel)
 Collection . ADB20410                          StmtNo . . 3730
 Package. . . ADB2DSVD                          Stmtcost . 124.15

Statement Text + Access paths
-------------------------------------------------------------------------
  SELECT
    MAX ( X_HIST_TIMESTAMP )
  FROM
    PARSVTAB )
ORDER BY
  X_NAME , X_SEQNO
FOR FETCH ONLY
Access path before REBIND ------------! Access path with REBIND -------------

TABLE                QB PN AC MA ME IX ! TABLE                QB PN AC MA ME IX
  INDEX                    TY CO TH ON !   INDEX                    TY CO TH ON
- - - - - - - - - - - - - - - - - - - - ! - - - - - - - - - - - - - - - - - - - -
ADB2T071              1  1 I   1  0  N ! ADB2T071              1  1 R   0  0  N
  ADB2X0711                            !
                      1  2     0  3  N !                       1  2     0  3  N
ADB2T071              2  1 I1  0  0  Y ! ADB2T071              2  1 I1  0  0  Y
  ADB2X0711                            !   ADB2X0711
```

Presents the access path comparison

Bind ImpactExpert

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Change Control for BINDs

- Pre-Screen application changes using “stand-alone” mode
- Matches all statements in a new DBRM to the current DB2 catalog
- Highlights statements that are less efficient than the original
- Interfaces to SQL PerformanceExpert for in-depth diagnosis.

Bind ImpactExpert

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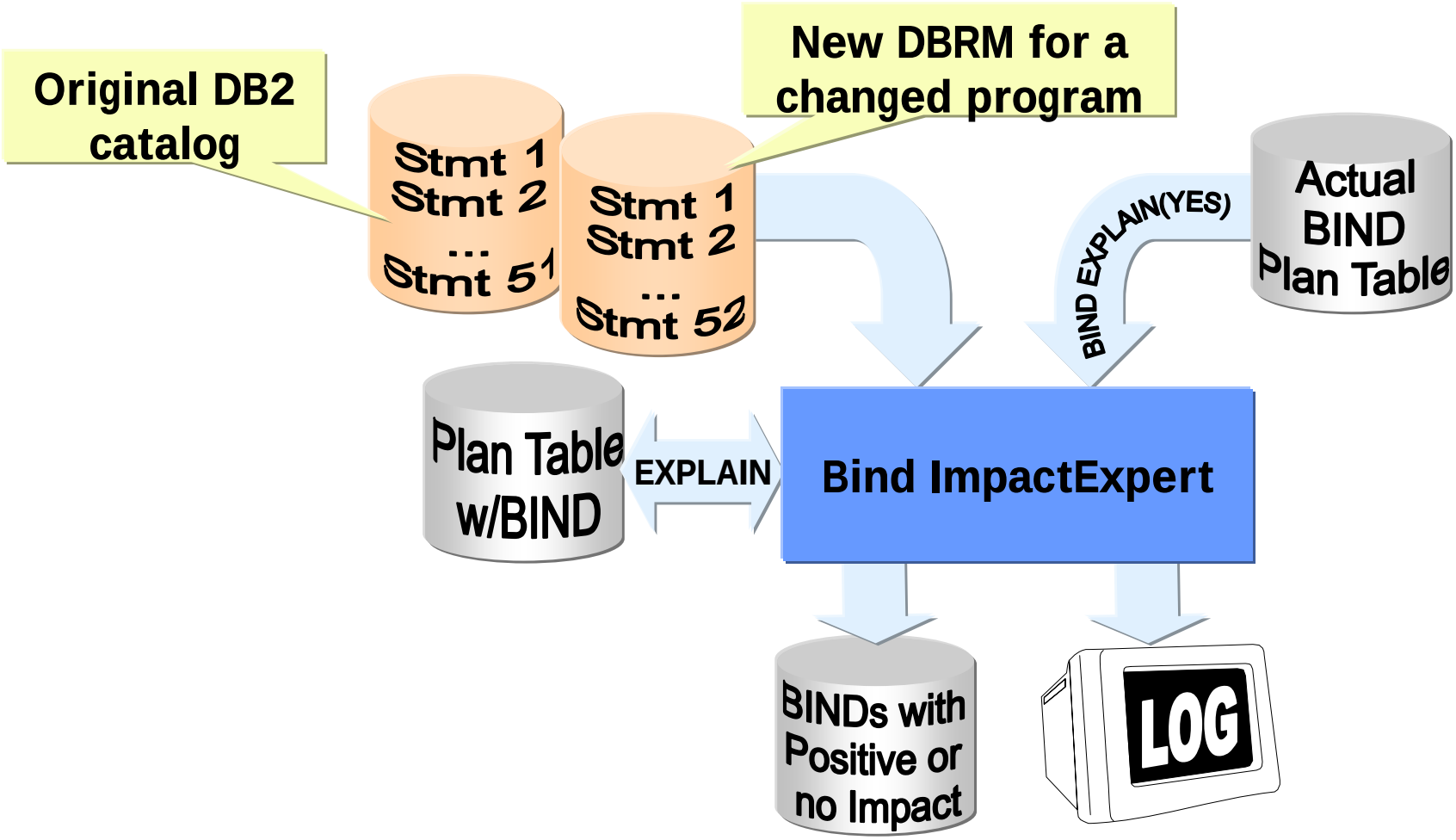
Finds BIND impacts of changed applications



Bind ImpactExpert

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```
ImpactExpert for DB2 z/OS ----- BIND Impact -------------- Statement 1 from 5
Command ===> ____________________________________________ Scroll ===> CSR
                                                          DB2: B810

Primary cmd: END, SE(tup Analyze)
Line    cmd: S(elect), D(ynamic Analyze DBRM), E(dit and Analyze DBRM),
             A(nalyze Old), O(Dynamic Analyze Old), P(Edit and Analyze Old)

Timestamp. . . 2005-09-23-08.18.05.530000
Collection . . IQA_COLLECTION_510
Package. . . . ADB2U855
Version. . . . 2005-06-09-13.04.46.922689
DBRM Library . SE.ADB20411.TDBRM

   STMTNO  STMTNO          BAD ACCESS TYPES
   ORIG    NEW     IMPACT  OLD VERSION           WITH BIND
   ------  ------  ------  --------------------  --------------------
S  2108    2212    WRS     SORT                  TS,SORT
_  4665    4723    WRS     NMIX                  TS
_  2075    2173    IMP     LP,SORT
_  4875    4983    IMP     TS                    NMIX
_  4891    3878    IMP     LP
_  2055    2092    EQ      NMIX                  NMIX
_  2039    2057    EQ      NMIX                  NMIX
_  3863    4002    EQ
_  N/A     2153    NEW
```

Compares old to new and automatically identifies the SQL changes and their impact *before* you BIND

Also identfies NEW statements!

Bind ImpactExpert

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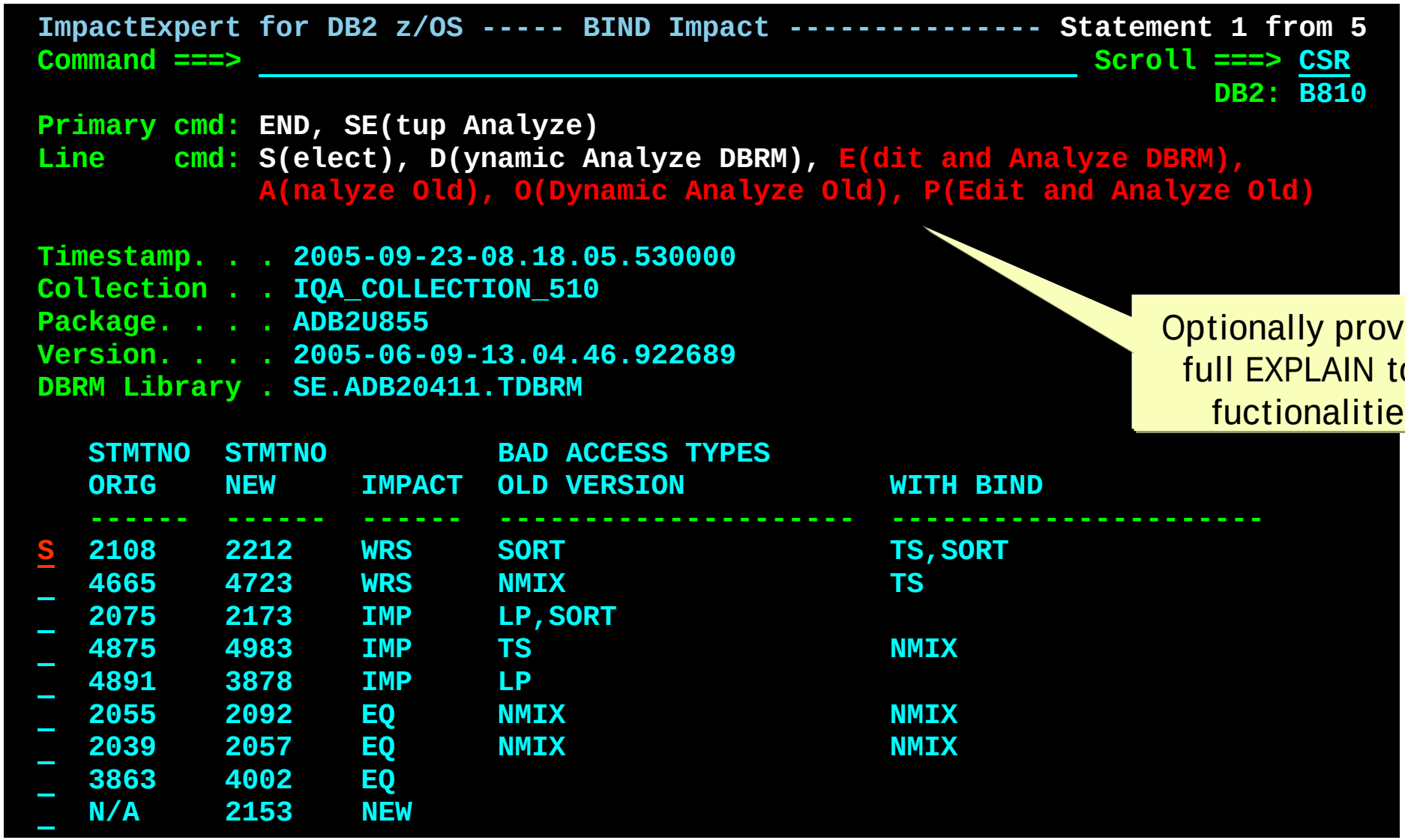

Optionally provides full EXPLAIN tool fuctionalities

Bind ImpactExpert

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```
ImpactExpert for DB2 z/OS ----- Recommendations ---- LINE 00000077 COL 001 080
Command ===> _____________________________________________ Scroll ===> CSR
                                                          DB2: D810
Primary cmd: END, SAVExxx, SHOWxxx, P(rint Violation), PA(Print All),
T(ext explain), D(ata explain), L(Catlg Long), S(Catlg Short), W(BroWse view)

Collection . ADB20410                                  STMTCOS
Package. . . ADB2HOVI                                  MIL.SEC
Statement Text + Violations                            SERV.UNI
-------------------------------------------------------------------------------
                ----- RULE-NO.:  9072   (WARNING) -----
Predicate is stage 2 (neither stage 1 nor indexable)). QBLOCKNO: 1, Predicate:
'XYZ' BETWEEN CREATOR AND NAME
Try to rewrite the predicate as stage 1 or indexable or try to add another (
stage 1 or indexable) predicate for this column(s) to the WHERE or ON clause.
                ----- RULE-NO.:  9201   (WARNING) -----
A predicate like: 'VALUE BETWEEN COL1 AND COL2' should be rewritten like:
'VALUE >= COL1 AND VALUE <= COL2'.
Then the predicates are INDEXABLE.
                ----- RULE-NO.:  9086   (ERROR) -----
Tablespace scan on a SEGMENTED tablespace for table NEUMANN.SYSTABLES and the
number of pages to read is 302245 (NPAGES). QBLOCKNO: 1, PLANNO: 1
Look for additional rule violations and their recommendations that can possibly
help you to avoid the tablespace scan and therefore to improve the access path.
```

Supports rules and recommendations

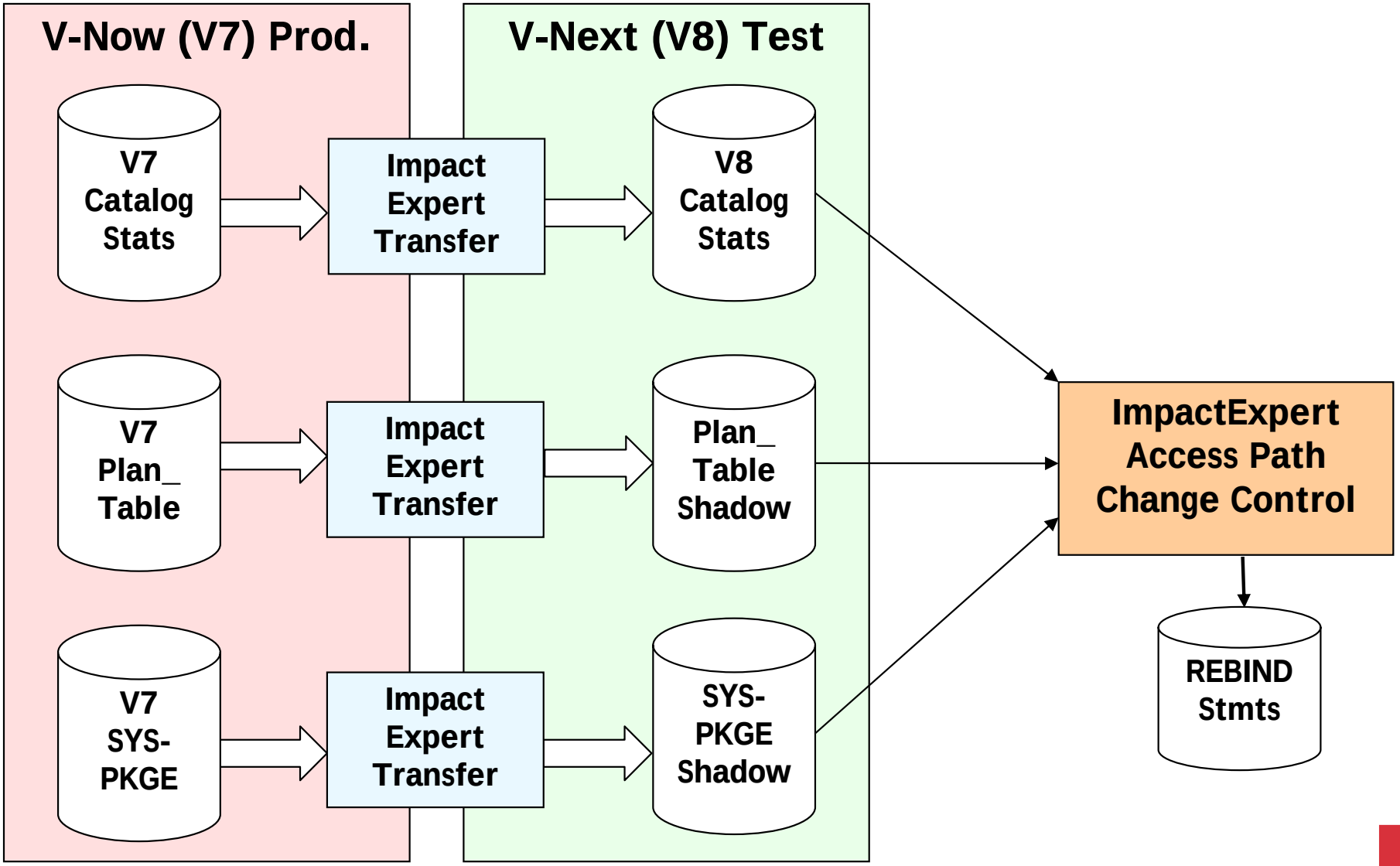
Bind ImpactExpert EarlyPrecheck

NEON Enterprise Software, Inc.

- **Predictive analysis for both Static SQL and Dynamic SQL**
- **Pre-Screen access paths in preparation for:**
  - DB2 version upgrades
  - Major PTFs
  - System software changes
  - Hardware changes

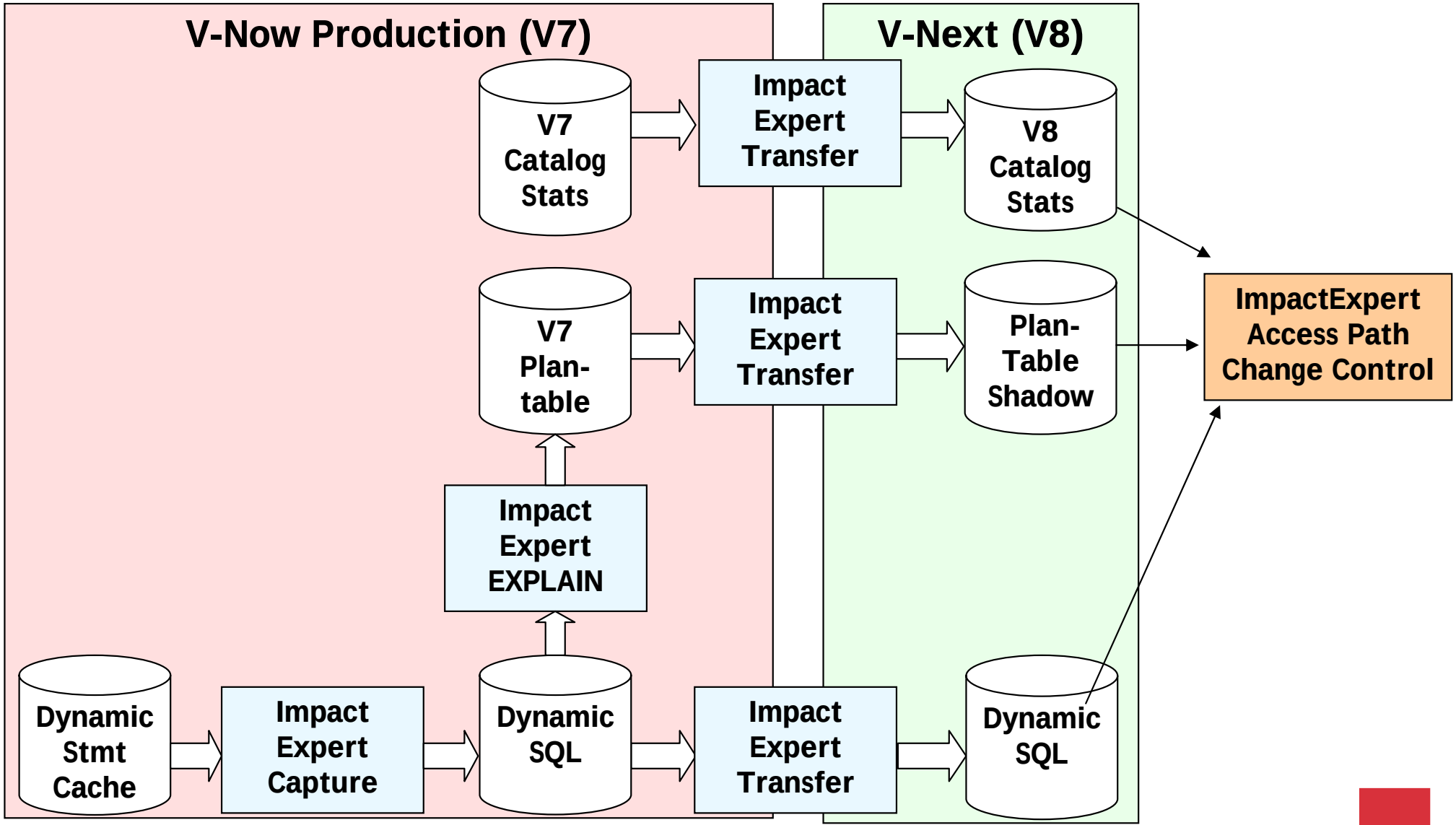
EarlyPrecheck Static SQL

NEON
Enterprise Software, Inc.



EarlyPrecheck Dynamic SQL

NEON Enterprise Software, Inc.



EarlyPrecheck Dynamic SQL

NEON Enterprise Software, Inc.

```
ImpactExpert for DB2 z/OS --- Static Statement Summary --------- Type 1 from 11
Command ===> ____________________________________________ Scroll ===> PAGE
                                                          DB2: Q81D

Primary cmd: END, J(obs), RES(et)
Line    cmd: P(ackages/Plans), S(tatements)

  COLLECTION. . . . . . ____________________   PACKAGE. . . _________
  TIME FROM . . . . . . 2006-05-03-12.45.34   PLAN . . . . _________
  TIME TO . . . . . . . 2006-05-03-12.45.34
```

	CATEGORY	DESCRIPTION	COUNT
_	PROCESSED	Statements processed by ImpactExpert	1529
_	UNCHANGED	Statements without access path changes	924
_	IMPROVED	Statements with improved access path	81
_	CHANGED	Statements with changed access path	28
_	WORSENED	Statements with degraded access path	82
_	NEW	New Statements	1
_	V8 RULE 2	Sort first qblock	11
_	V8 RULE 4	IX scan to TS scan for small tables	352
_	V8 RULE 5	NMIX scan on large index to TS scan	16
_	V8 RULE 8	Index change to smaller index	22
_	ERROR	Statements with explain errors	12

V8 Rules for expected ACP changes

Bind ImpactExpert Summary

NEON Enterprise Software, Inc.

- Prevents rebinds of packages containing SQL statements with degraded access paths
- Provides an interface to investigate the access paths of SQL statements
- Optionally suppresses non-productive REBINDS
- Includes a batch comparison process to help focus QA or Change Control resources
- Supports early prechecking before migrating to DB2 V8
- Does it all stand-alone, without any other product dependencies!

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