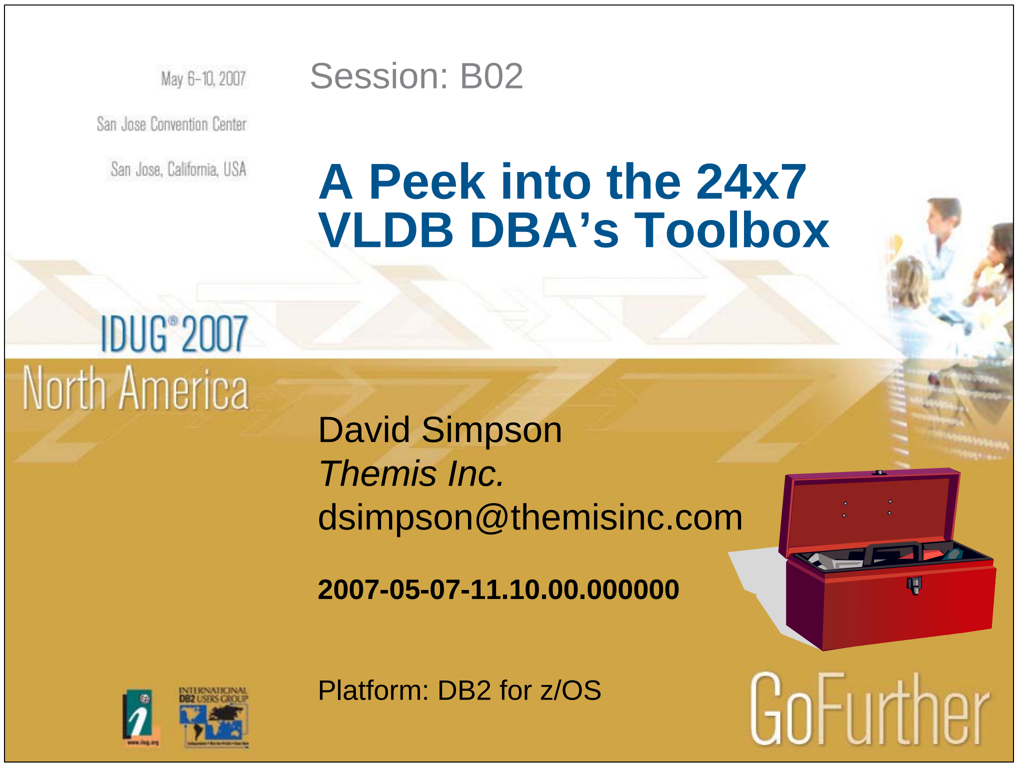

May 6–10, 2007

San Jose Convention Center

San Jose, California, USA

Session: B02

A Peek into the 24x7 VLDB DBA's Toolbox

IDUG® 2007 North America

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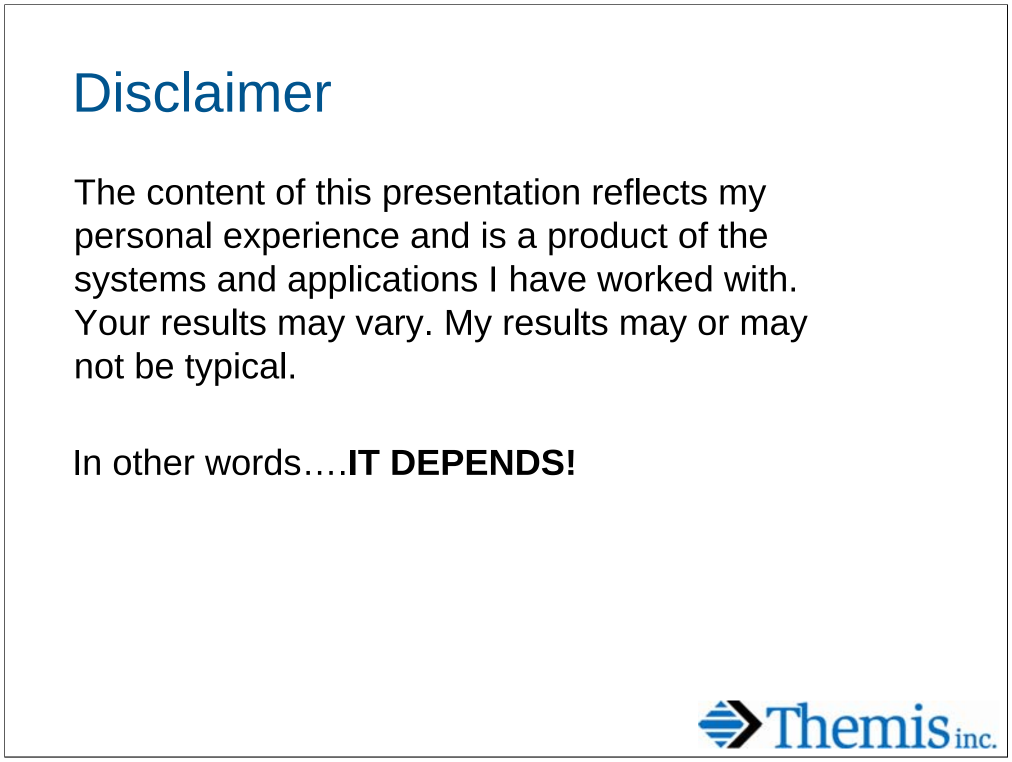
2007-05-07-11.10.00.000000

Platform: DB2 for z/OS

GoFurther

David Simpson is currently a Senior Technical Advisor at Themis Inc. He teaches courses on SQL, Application Programming, DB2 Administration as well as performance and tuning. He has supported transactional systems that use DB2 for z/OS databases in excess of 10 terabytes. David has worked with DB2 for 14 years as an application programmer, DBA and technical instructor. David is a certified DB2 DBA on both z/OS and LUW. David was voted Best User Speaker and Best Overall Speaker at IDUG North America 2006. He was also voted Best User Speaker at IDUG Europe 2006.



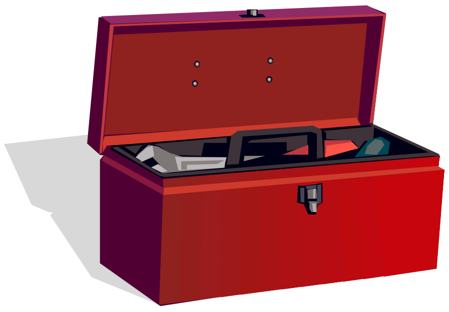
Disclaimer

The content of this presentation reflects my personal experience and is a product of the systems and applications I have worked with. Your results may vary. My results may or may not be typical.

In other words….**IT DEPENDS!**

Topics

- Running utilities 24x7
- Performing table maintenance 24x7
- Access Path Analysis
- Automate DBA tasks with REXX
- Real-world examples



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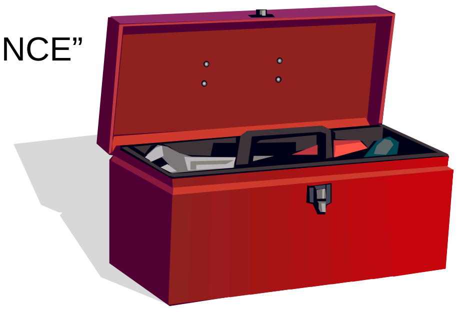
The topics in this presentation are all born from real live DBA experience. Running utilities and performing table maintenance are a challenge in any 24x7 environment. We have some developed some techniques that minimize the outage for these types of activities. We will also discuss tuning large-scale SQL and the automation of some common DBA tasks.

Utilities

- Reorgs
  - Plan “A” – large partitioned tables with NPIs
  - Plan “B” – large partitioned tables w/o NPIs
  - Plan “C” – really, really large partitioned tables with NPIs
- Copy “SHRLEVEL REFERENCE”
- Rebuild LARGE indexes



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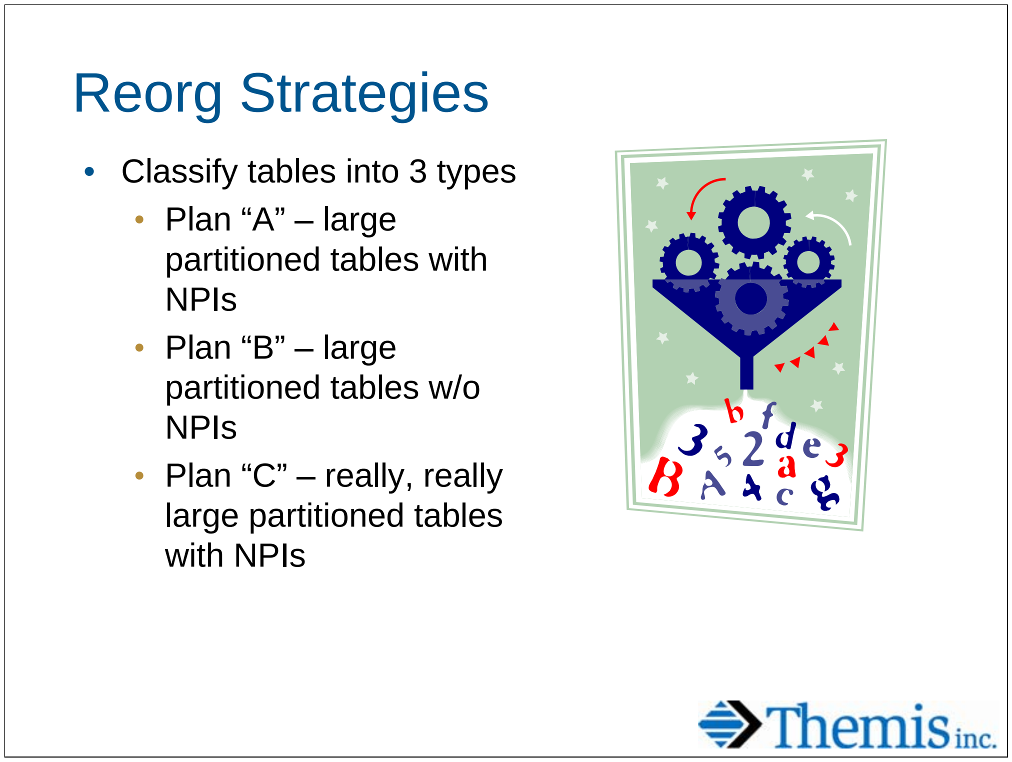
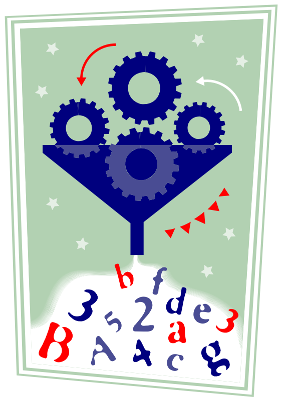
Running utilities in a large 24x7 environment can be a challenge. Accomplishing reorgs, taking a “stable” copy of data, and rebuilding indexes will be addressed here. A small maintenance window is assumed for accomplishing these tasks.



Reorg Strategies

- Classify tables into 3 types
  - Plan “A” – large partitioned tables with NPIs
  - Plan “B” – large partitioned tables w/o NPIs
  - Plan “C” – really, really large partitioned tables with NPIs

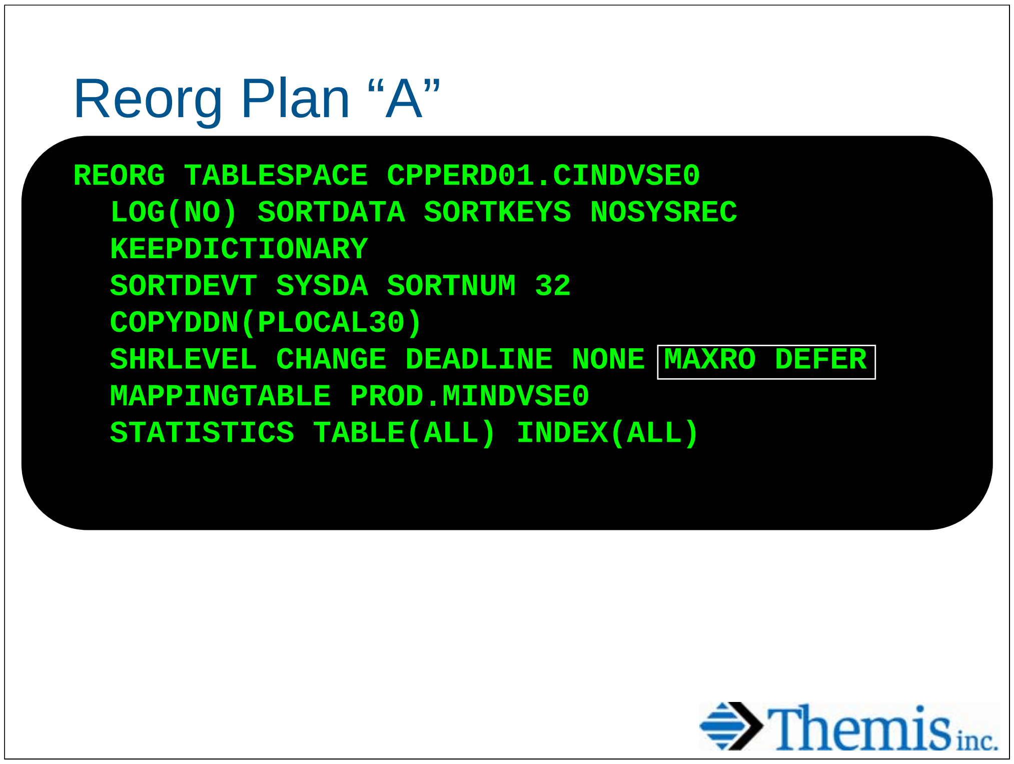


It helps to divide mission critical 24x7 tables into three categories for purposes of reorganization.

Plan “A” addresses large partitioned tables that have non-partitioning indexes (NPIs). These tablespces cannot be easily reorganized by partition due to the NPIs.

Plan “B” addresses large partitioned tables that do not have any NPIs. These tablespaces may be reorganized by partition.

Plan “C” addresses tables with NPIs that are too big to be reorganized in a single job.



Reorg Plan “A”

```
REORG TABLESPACE CPPERD01.CINDVSE0
  LOG(NO) SORTDATA SORTKEYS NOSYSREC
  KEEPDICTIONARY
  SORTDEVT SYSDA SORTNUM 32
  COPYDDN(PLOCAL30)
  SHRLEVEL CHANGE DEADLINE NONE MAXRO DEFER
  MAPPINGTABLE PROD.MINDVSE0
  STATISTICS TABLE(ALL) INDEX(ALL)
```

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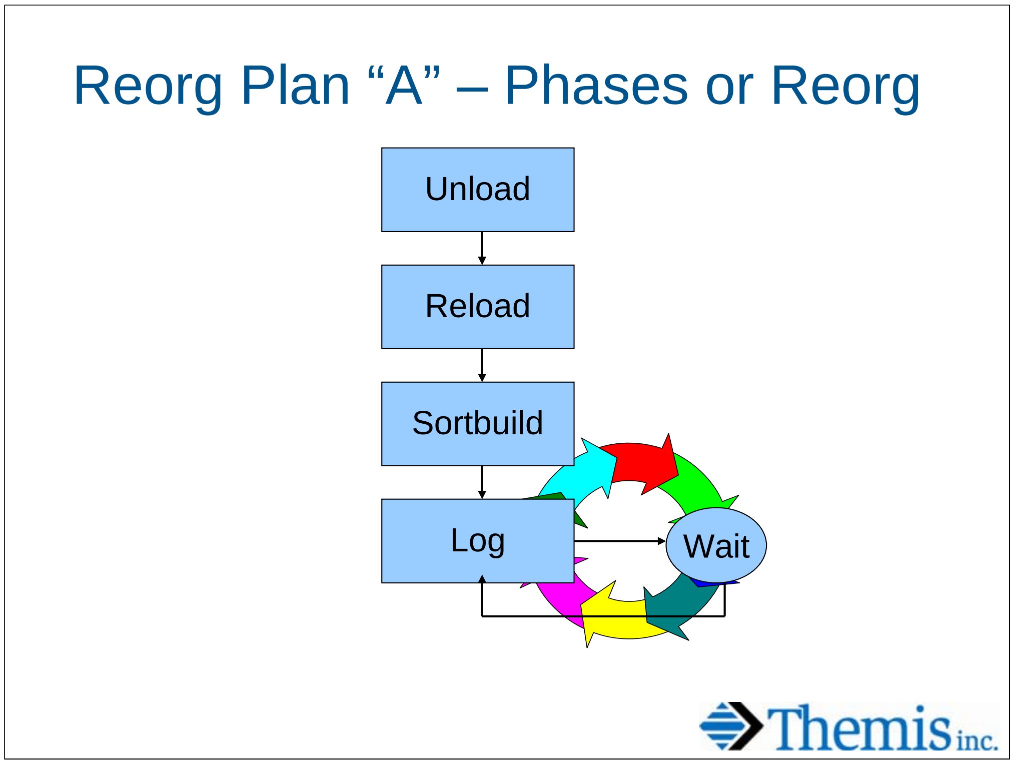
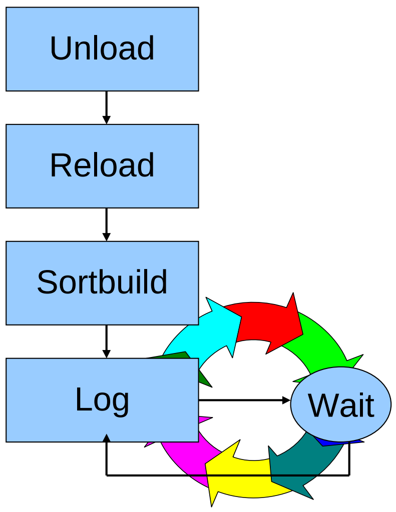
When a “Plan A” table needs to be reorganized, a job may be run to reorg the entire table and all indexes at once. The SHRLEVEL CHANGE option is used to allow application access to the table during the utility. Since these jobs run for a very long time (10-12 hours), the MAXRO DEFER option is used to control when the switch phase is attempted.



Reorg Plan "A" – Phases or Reorg



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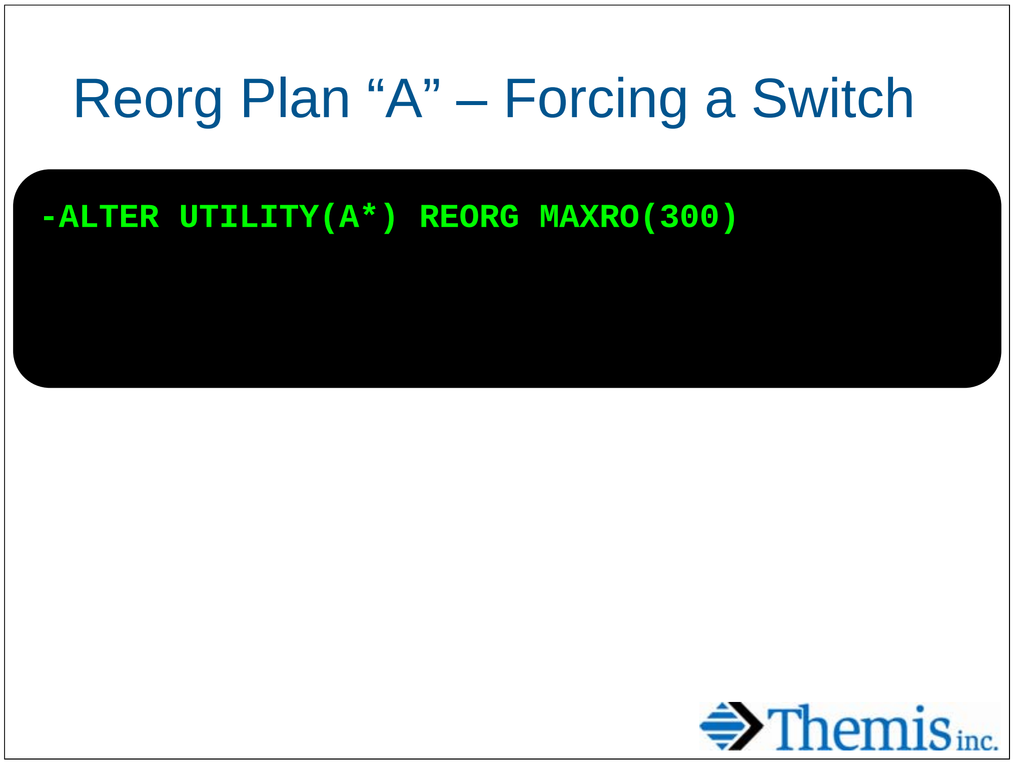
The log apply phase runs at the end of an online reorg to "catch up" the shadow copy of the data and indexes that was created during the reorg. Any insert, update or delete SQL activity that occurred during the reorg is applied to the shadow copy during this phase.

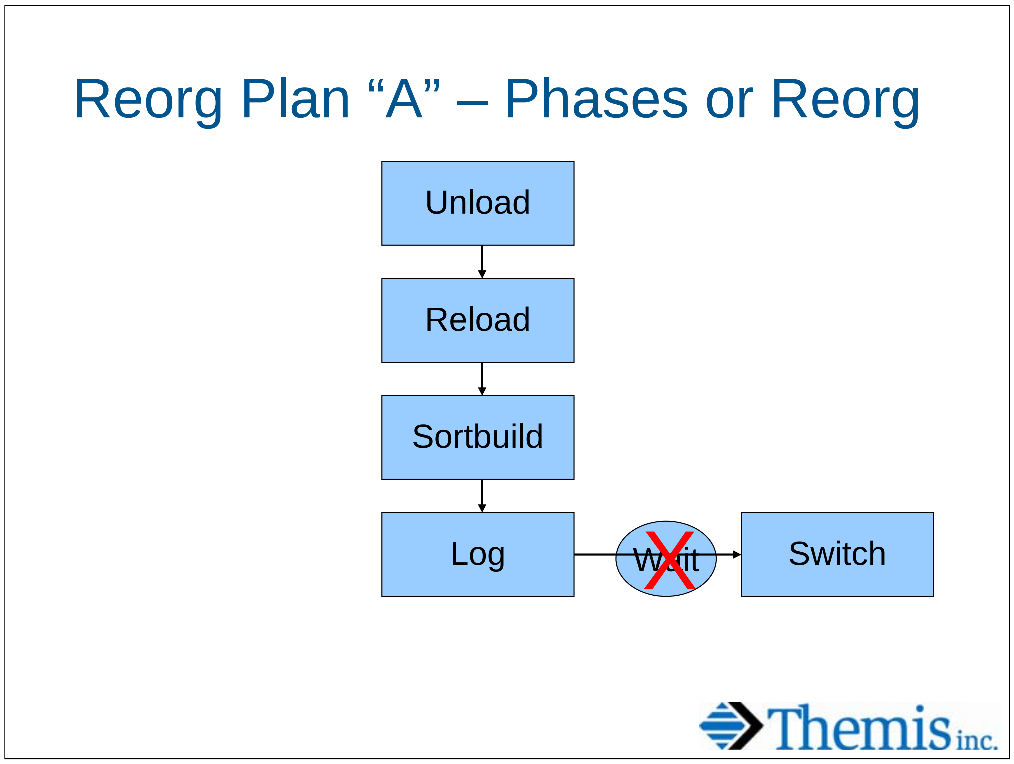
When MAXRO DEFER is specified, the reorg will go into a continuous loop during the log apply phase. The tablespace continues to be available for read/write access and any changes are continually applied to the shadow copy. The utility will not come out of the log phase until signaled to do so.



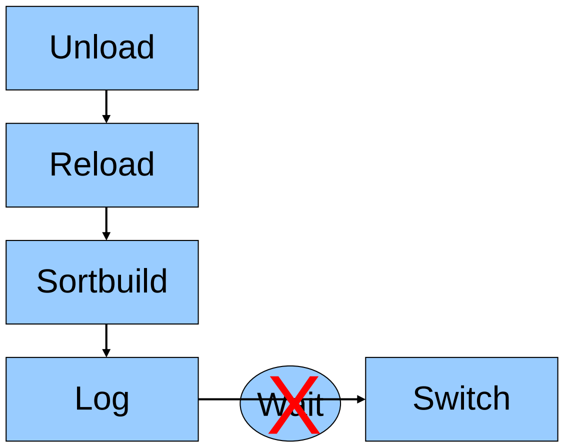
Reorg Plan “A” – Forcing a Switch

```
-ALTER UTILITY(A*) REORG MAXRO(300)
```

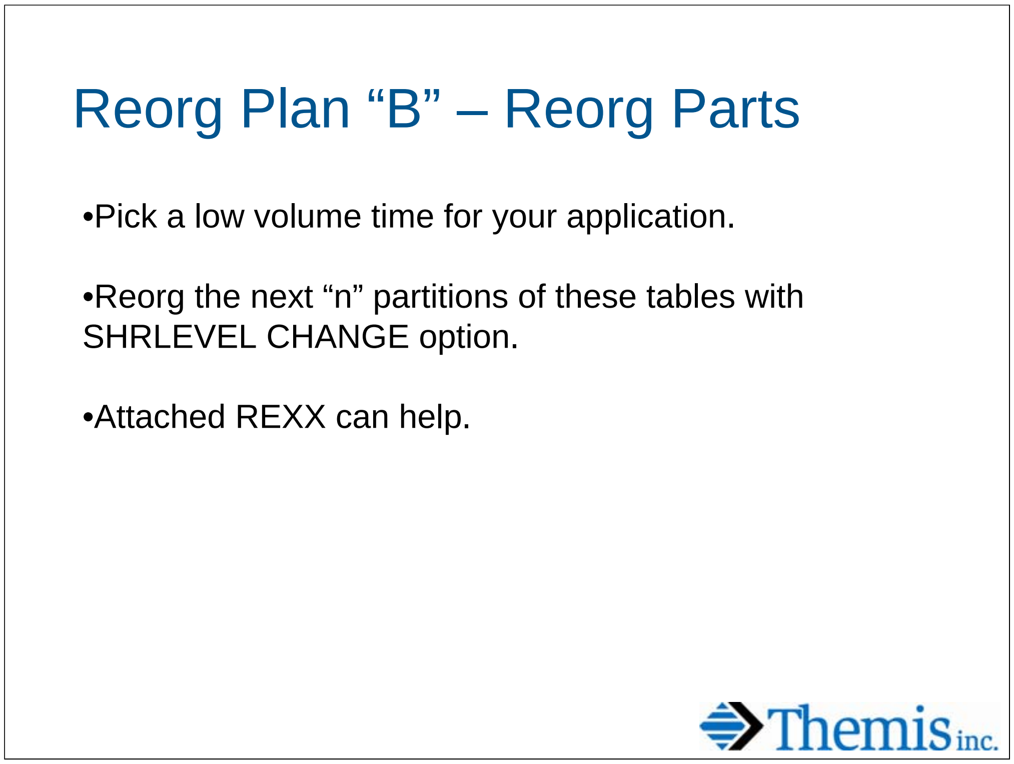
This is the DB2 command that may be issued to allow the reorg to complete. A specific utility id may be altered, or in this case, every utility id beginning with “A” will be altered. The value of MAXRO is changed from DEFER to a value of 300, meaning that the next cycle of the log phase estimated to complete in under 300 seconds will be the final pass of the log. The tablespace will be placed in read only status for this final pass to insure data integrity. Once the final pass of the log is complete, the utility will proceed to the switch phase.



Reorg Plan “A” – Phases or Reorg



Once the log phase is allowed to complete, the switch phase will begin. The switch phase requires that all activity be drained on the affected tablespace so that the underlying datasets may be swapped out. Since a plan “A” reorg is reorganizing all partitions, indexes and non-partitioning indexes (NPIs) of a tablespace, the switch phase can take a long time (10 to 15 minutes). By using MAXRO DEFER, the DBA can control when the switch occurs and force it into an application outage.



Reorg Plan “B” – Reorg Parts

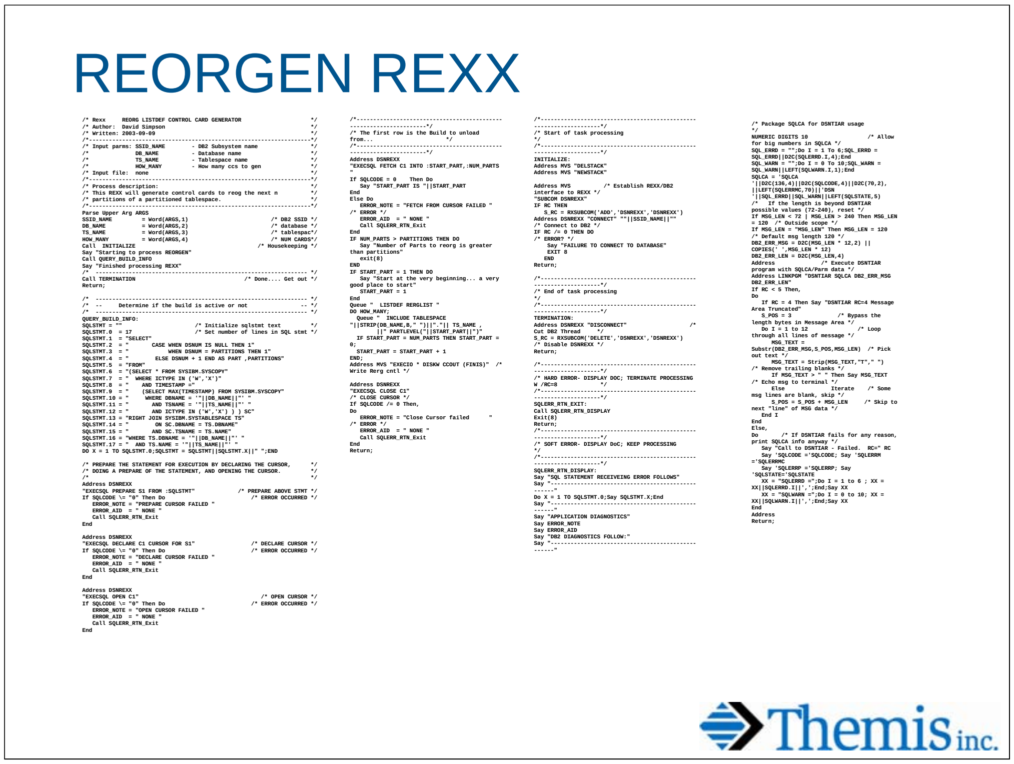
•Pick a low volume time for your application.

•Reorg the next “n” partitions of these tables with SHRLEVEL CHANGE option.

•Attached REXX can help.

For large partitioned tablespaces that have no NPIs, a partition level reorg strategy may be used. These reorgs may generally be run with no outage provided you pick a low volume time for your application. The phases of the reorg are the same as those discussed earlier, but the read only status and the drain for switching datasets only needs to be accomplished for a single partition. The time to accomplish a switch for a single partition is negligible (a few seconds), so an application may not even notice when it happens.

Plan “B” tablespaces are reorganized over time. If you want to reorg the entire table every quarter and there are 254 partitions, have a job that reorganizes 20 partitions each week.



REORGEN REXX

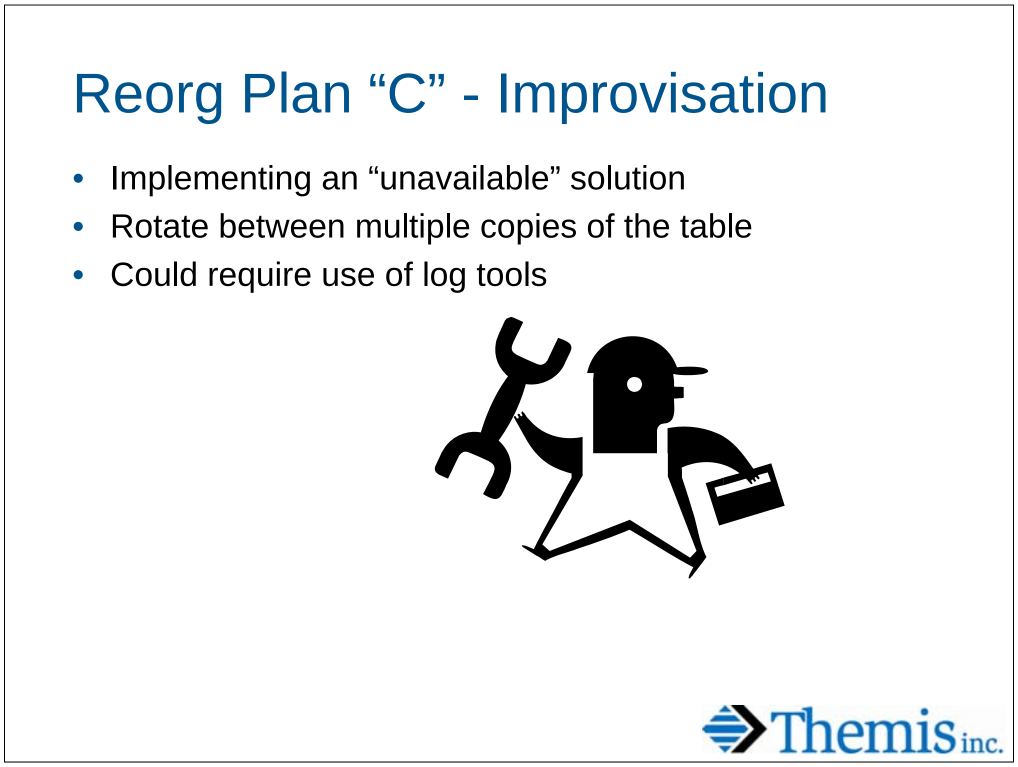
```
/* Rexx     REORG LISTDEF CONTROL CARD GENERATOR                         */
/* Author:  David Simpson                                                */
/* Written: 2003-09-09                                                   */
/*-----------------------------------------------------------------------*/
/* Input parms: SSID_NAME        - DB2 Subsystem name                    */
/*              DB_NAME          - Database name                         */
/*              TS_NAME          - Tablespace name                       */
/*              HOW_MANY         - How many ccs to gen                   */
/* Input file:  none                                                     */
/*-----------------------------------------------------------------------*/
/* Process description:                                                  */
/* This REXX will generate control cards to reog the next n              */
/* partitions of a partitioned tablespace.                               */
/*-----------------------------------------------------------------------*/
Parse Upper Arg ARGS
SSID_NAME         = Word(ARGS,1)                            /* DB2 SSID */
DB_NAME           = Word(ARGS,2)                            /* database */
TS_NAME           = Word(ARGS,3)                            /* tablespac*/
HOW_MANY          = Word(ARGS,4)                            /* NUM CARDS*/
Call  INITIALIZE                                        /* Housekeeping */
Say "Starting to process REORGEN"
Call QUERY_BUILD_INFO
Say "Finished processing REXX"
/*  ------------------------------------------------------------------- */
Call TERMINATION                                    /* Done.... Get out */
Return;

/*  ------------------------------------------------------------------- */
/*  --     Determine if the build is active or not                   -- */
/*  ------------------------------------------------------------------- */
QUERY_BUILD_INFO:
SQLSTMT = ""                      /* Initialize sqlstmt text         */
SQLSTMT.0  = 17                   /* Set number of lines in SQL stmt */
SQLSTMT.1  = "SELECT"
SQLSTMT.2  = "       CASE WHEN DSNUM IS NULL THEN 1"
SQLSTMT.3  = "            WHEN DSNUM = PARTITIONS THEN 1"
SQLSTMT.4  = "        ELSE DSNUM + 1 END AS PART ,PARTITIONS"
SQLSTMT.5  = "FROM"
SQLSTMT.6  = "(SELECT * FROM SYSIBM.SYSCOPY"
SQLSTMT.7  = "  WHERE ICTYPE IN ('W','X')"
SQLSTMT.8  = "    AND TIMESTAMP ="
SQLSTMT.9  = "    (SELECT MAX(TIMESTAMP) FROM SYSIBM.SYSCOPY"
SQLSTMT.10 = "     WHERE DBNAME = '"||DB_NAME||"' "
SQLSTMT.11 = "       AND TSNAME = '"||TS_NAME||"' "
SQLSTMT.12 = "       AND ICTYPE IN ('W','X') ) ) SC"
SQLSTMT.13 = "RIGHT JOIN SYSIBM.SYSTABLESPACE TS"
SQLSTMT.14 = "        ON SC.DBNAME = TS.DBNAME"
SQLSTMT.15 = "       AND SC.TSNAME = TS.NAME"
SQLSTMT.16 = "WHERE TS.DBNAME = '"||DB_NAME||"' "
SQLSTMT.17 = "  AND TS.NAME = '"||TS_NAME||"' "
DO X = 1 TO SQLSTMT.0;SQLSTMT = SQLSTMT||SQLSTMT.X||" ";END

/* PREPARE THE STATEMENT FOR EXECUTION BY DECLARING THE CURSOR,      */
/* DOING A PREPARE OF THE STATEMENT, AND OPENING THE CURSOR.         */
/*                                                                    */
Address DSNREXX
"EXECSQL PREPARE S1 FROM :SQLSTMT"            /* PREPARE ABOVE STMT */
If SQLCODE \= "0" Then Do                         /* ERROR OCCURRED */
   ERROR_NOTE = "PREPARE CURSOR FAILED "
   ERROR_AID  = " NONE "
   Call SQLERR_RTN_Exit
End

Address DSNREXX
"EXECSQL DECLARE C1 CURSOR FOR S1"                /* DECLARE CURSOR */
If SQLCODE \= "0" Then Do                         /* ERROR OCCURRED */
   ERROR_NOTE = "DECLARE CURSOR FAILED "
   ERROR_AID  = " NONE "
   Call SQLERR_RTN_Exit
End

Address DSNREXX
"EXECSQL OPEN C1"                                    /* OPEN CURSOR */
If SQLCODE \= "0" Then Do                         /* ERROR OCCURRED */
   ERROR_NOTE = "OPEN CURSOR FAILED "
   ERROR_AID  = " NONE "
   Call SQLERR_RTN_Exit
End
```

```
/*-------------------------------------------
----------------------*/
/* The first row is the Build to unload
from...                           */
/*-------------------------------------------
----------------------*/
Address DSNREXX
"EXECSQL FETCH C1 INTO :START_PART,:NUM_PARTS
"
If SQLCODE = 0    Then Do
   Say "START_PART IS "||START_PART
End
Else Do
   ERROR_NOTE = "FETCH FROM CURSOR FAILED "
/* ERROR */
   ERROR_AID  = " NONE "
   Call SQLERR_RTN_Exit
End
IF NUM_PARTS > PARTITIONS THEN DO
   Say "Number of Parts to reorg is greater
than partitions"
   exit(8)
END
IF START_PART = 1 THEN DO
   Say "Start at the very beginning... a very
good place to start"
   START_PART = 1
End
Queue "  LISTDEF RERGLIST "
DO HOW_MANY;
  Queue "  INCLUDE TABLESPACE
"||STRIP(DB_NAME,B," ")||"."|| TS_NAME ,
        ||" PARTLEVEL("||START_PART||")"
  IF START_PART = NUM_PARTS THEN START_PART =
0;
  START_PART = START_PART + 1
END;
Address MVS "EXECIO * DISKW CCOUT (FINIS)"  /*
Write Rerg cntl */

Address DSNREXX
"EXECSQL CLOSE C1"
/* CLOSE CURSOR */
If SQLCODE /= 0 Then,
Do
   ERROR_NOTE = "Close Cursor failed      "
/* ERROR */
   ERROR_AID  = " NONE "
   Call SQLERR_RTN_Exit
End
Return;
```

```
/*-------------------------------------------
-------------------*/
/* Start of task processing
*/
/*-------------------------------------------
-------------------*/
INITIALIZE:
Address MVS "DELSTACK"
Address MVS "NEWSTACK"

Address MVS          /* Establish REXX/DB2
interface to REXX */
"SUBCOM DSNREXX"
IF RC THEN
   S_RC = RXSUBCOM('ADD','DSNREXX','DSNREXX')
Address DSNREXX "CONNECT" ""||SSID_NAME||""
/* Connect to DB2 */
IF RC /= 0 THEN DO
/* ERROR? */
    Say "FAILURE TO CONNECT TO DATABASE"
    EXIT 8
   END
Return;

/*-------------------------------------------
-------------------*/
/* End of task processing
*/
/*-------------------------------------------
-------------------*/
TERMINATION:
Address DSNREXX "DISCONNECT"                /*
Cut DB2 Thread     */
S_RC = RXSUBCOM('DELETE','DSNREXX','DSNREXX')
/* Disable DSNREXX */
Return;

/*-------------------------------------------
-------------------*/
/* HARD ERROR- DISPLAY DOC; TERMINATE PROCESSING
W /RC=8             */
/*-------------------------------------------
-------------------*/
SQLERR_RTN_EXIT:
Call SQLERR_RTN_DISPLAY
Exit(8)
Return;
/*-------------------------------------------
-------------------*/
/* SOFT ERROR- DISPLAY DoC; KEEP PROCESSING
*/
/*-------------------------------------------
-------------------*/
SQLERR_RTN_DISPLAY:
Say "SQL STATEMENT RECEIVEING ERROR FOLLOWS"
Say "------------------------------------------
------"
Do X = 1 TO SQLSTMT.0;Say SQLSTMT.X;End
Say "------------------------------------------
------"
Say "APPLICATION DIAGNOSTICS"
Say ERROR_NOTE
Say ERROR_AID
Say "DB2 DIAGNOSTICS FOLLOW:"
Say "------------------------------------------
------"
```

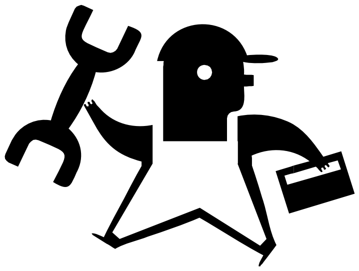
```
/* Package SQLCA for DSNTIAR usage
*/
NUMERIC DIGITS 10                  /* Allow
for big numbers in SQLCA */
SQL_ERRD = "";Do I = 1 To 6;SQL_ERRD =
SQL_ERRD||D2C(SQLERRD.I,4);End
SQL_WARN = "";Do I = 0 To 10;SQL_WARN =
SQL_WARN||LEFT(SQLWARN.I,1);End
SQLCA = 'SQLCA
'||D2C(136,4)||D2C(SQLCODE,4)||D2C(70,2),
||LEFT(SQLERRMC,70)||'DSN
'||SQL_ERRD||SQL_WARN||LEFT(SQLSTATE,5)
/*   If the length is beyond DSNTIAR
possible values (72-240), reset */
If MSG_LEN < 72 | MSG_LEN > 240 Then MSG_LEN
= 120  /* Outside scope */
If MSG_LEN = "MSG_LEN" Then MSG_LEN = 120
/* Default msg length 120 */
DB2_ERR_MSG = D2C(MSG_LEN * 12,2) ||
COPIES(' ',MSG_LEN * 12)
DB2_ERR_LEN = D2C(MSG_LEN,4)
Address              /* Execute DSNTIAR
program with SQLCA/Parm data */
Address LINKPGM "DSNTIAR SQLCA DB2_ERR_MSG
DB2_ERR_LEN"
If RC < 5 Then,
Do
   If RC = 4 Then Say "DSNTIAR RC=4 Message
Area Truncated"
   S_POS = 3              /* Bypass the
length bytes in Message Area */
   Do I = 1 to 12               /* Loop
through all lines of message */
      MSG_TEXT =
Substr(DB2_ERR_MSG,S_POS,MSG_LEN)  /* Pick
out text */
      MSG_TEXT = Strip(MSG_TEXT,"T"," ")
/* Remove trailing blanks */
      If MSG_TEXT > " " Then Say MSG_TEXT
/* Echo msg to terminal */
      Else              Iterate    /* Some
msg lines are blank, skip */
      S_POS = S_POS + MSG_LEN     /* Skip to
next "line" of MSG data */
   End I
End
Else,
Do       /* If DSNTIAR fails for any reason,
print SQLCA info anyway */
   Say "Call to DSNTIAR - Failed.  RC=" RC
   Say 'SQLCODE ='SQLCODE; Say 'SQLERRM
='SQLERRMC
   Say 'SQLERRP ='SQLERRP; Say
'SQLSTATE='SQLSTATE
   XX = "SQLERRD =";Do I = 1 to 6 ; XX =
XX||SQLERRD.I||',';End;Say XX
   XX = "SQLWARN =";Do I = 0 to 10; XX =
XX||SQLWARN.I||',';End;Say XX
End
Address
Return;
```

I have written a REXX exec that generates a listdef for the next few partitions of a partitioned tablespace. The REXX looks in SYSIBM.SYSCOPY for the last partitioned reorganized and starts with the next one. By using this step the same reorg job may be run each week to reorg different partitions of a plan “B” tablespace.



Reorg Plan “C” - Improvisation

- Implementing an “unavailable” solution
- Rotate between multiple copies of the table
- Could require use of log tools



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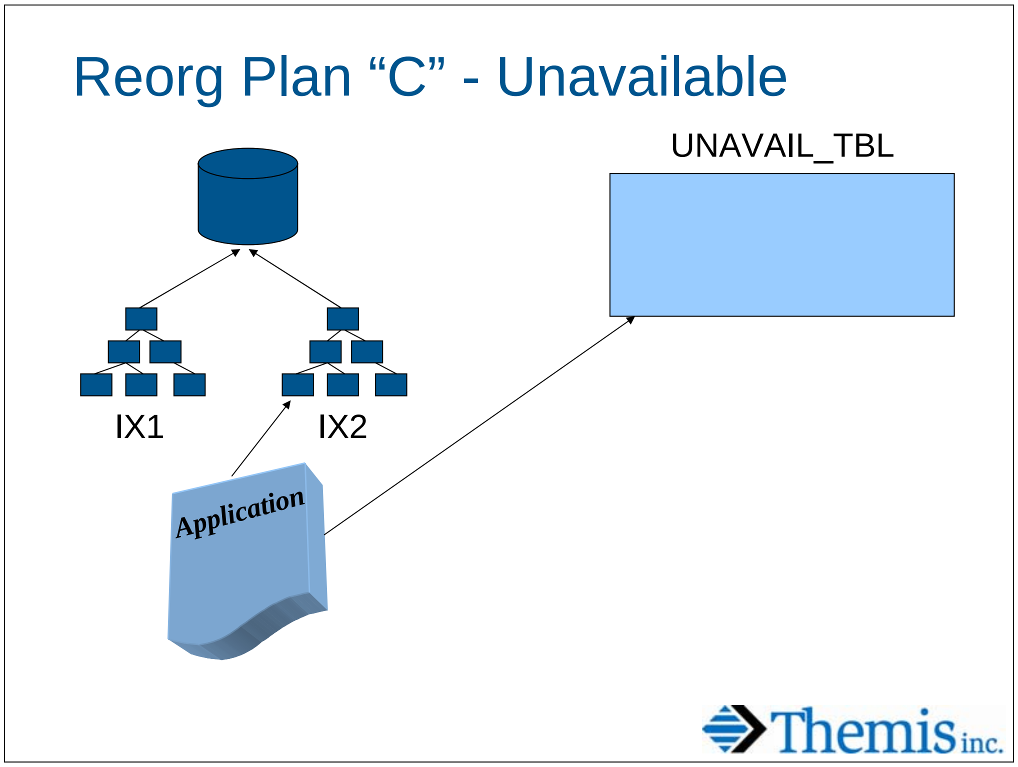
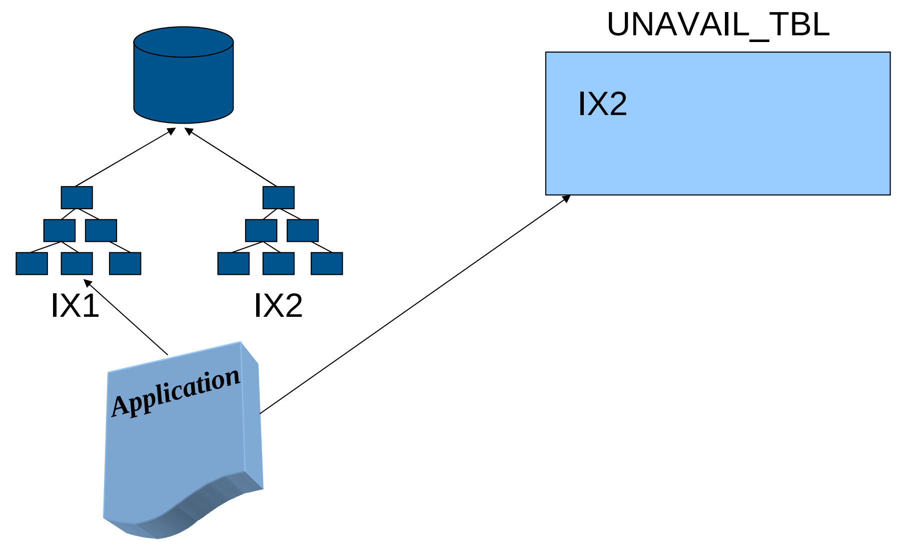
Plan “C” tablespaces are extra-large partitioned tablespaces that have NPIs. These tablespaces are too big to reorganize in a single step, so improvisation is needed to deal with them.



Reorg Plan "C" - Unavailable

One strategy is to create a table that may be used to check for the availability of a particular index. The application may be coded to periodically check to see if its primary access path is available. In this example, it is most efficient for the application to access the data via index IX2. As long as the unavailable table does not have a row indicating that IX2 is unavailable the application continues to use that access path.

Reorg Plan "C" - Unavailable



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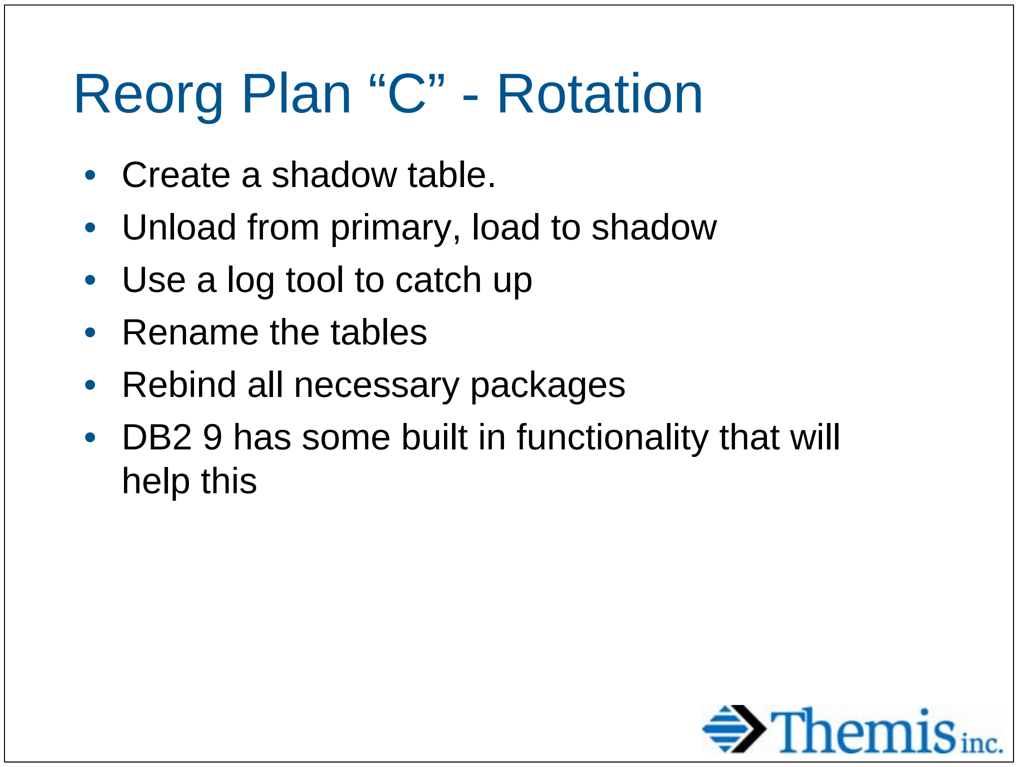
In this scenario, the application will shift to a less efficient access path by calling a different routine with a different set of packages based on the presence of a row in the unavailable table. IX2 may now be dropped for partition level reorgs on the base table. IX2 would be recreated at the end of the cycle and the row removed from the unavailable table. This scenario can only work if the application can also be put in a read only mode.



Reorg Plan “C” - Rotation

- Create a shadow table.
- Unload from primary, load to shadow
- Use a log tool to catch up
- Rename the tables
- Rebind all necessary packages
- DB2 9 has some built in functionality that will help this

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Another way to deal with extremely large tables is to actually create a second copy of the table. Data is unloaded from the base table and loaded into the secondary table. If the application has been writing data to the primary table during the “reorg” log tools can be employed to gather the changes and apply them to the reorganized copy. During a short application outage, the tables are renamed and all appropriate packages must have a rebind to direct them to the newly reorganized table.

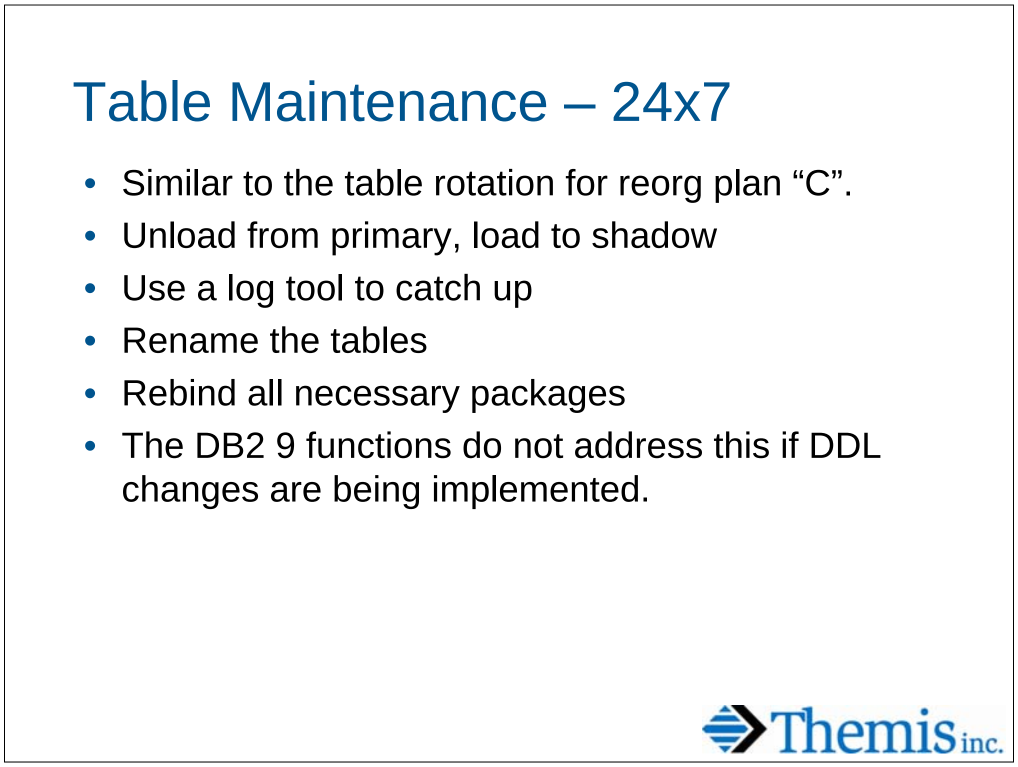

Table Maintenance – 24x7

- Similar to the table rotation for reorg plan “C”.
- Unload from primary, load to shadow
- Use a log tool to catch up
- Rename the tables
- Rebind all necessary packages
- The DB2 9 functions do not address this if DDL changes are being implemented.

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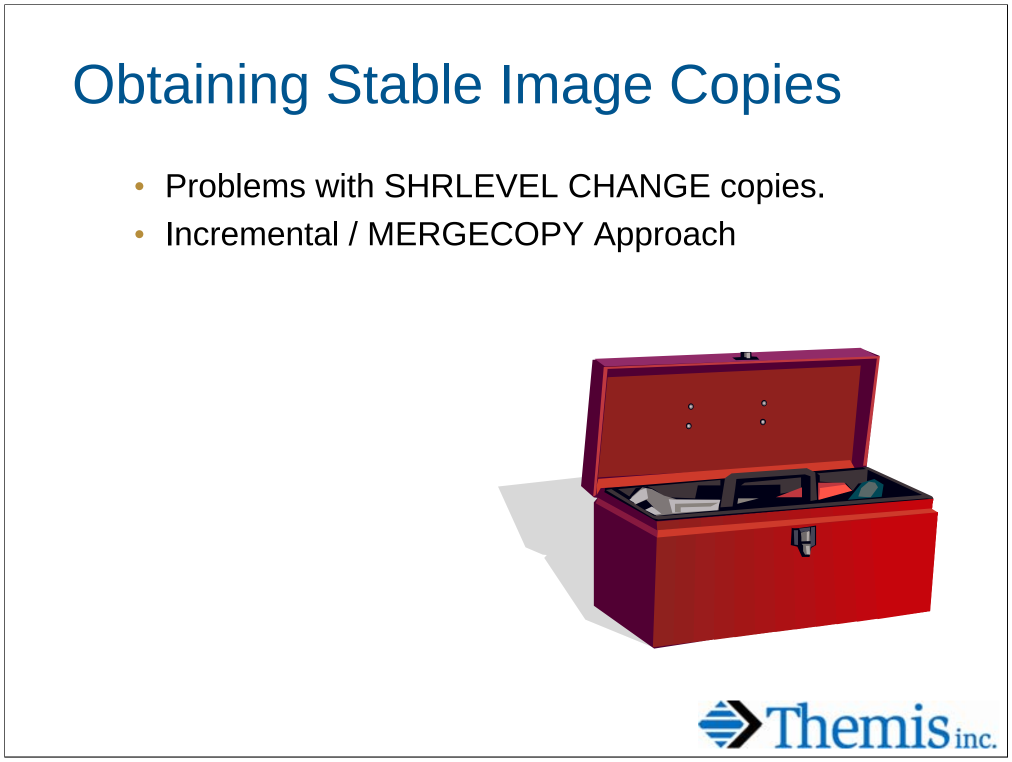
Similar issues can result when table maintenance is needed in a 24x7 environment and tables must be dropped and recreated. An often used techniques involves the use of a second table and renames (like my reorg plan “C”). Applying log updates may be more difficult if the tables are not identical, so a plan must be implemented to deal with this type of change.

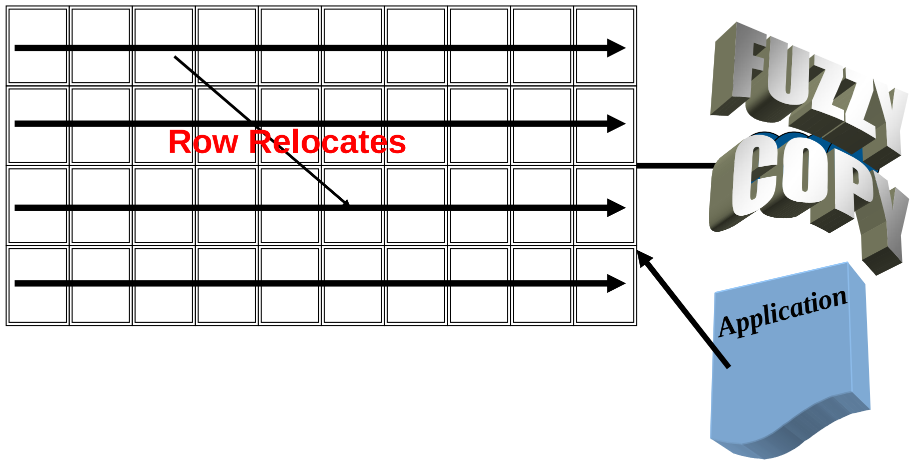


Obtaining Stable Image Copies

- Problems with SHRLEVEL CHANGE copies.
- Incremental / MERGECOPY Approach

In a 24x7 environment, image copies must be taken SHRLEVEL CHANGE. It is often desirable, however, to have a SHRLEVEL REFERENCE copy available.

SHRLEVEL CHANGE Copy



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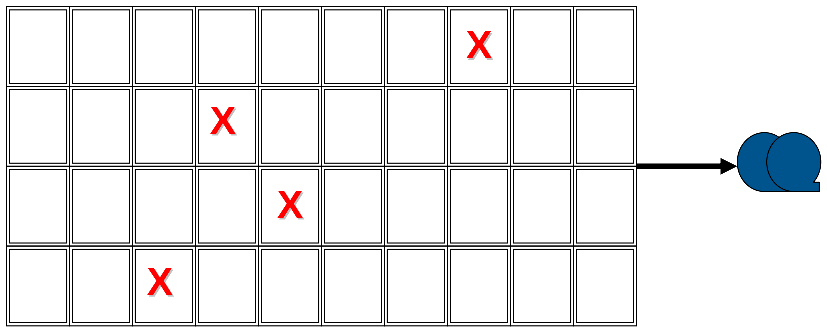
SHRLEVEL CHANGE copies do not represent a picture of the data at a stable point in time. When used in a recovery situation, the DB2 log must also be available to bring the recovered data to a consistent point. In addition to having rows from different points in time, it is also possible for duplicate rows to be present in the image copy due to row relocation.

Incremental Copy



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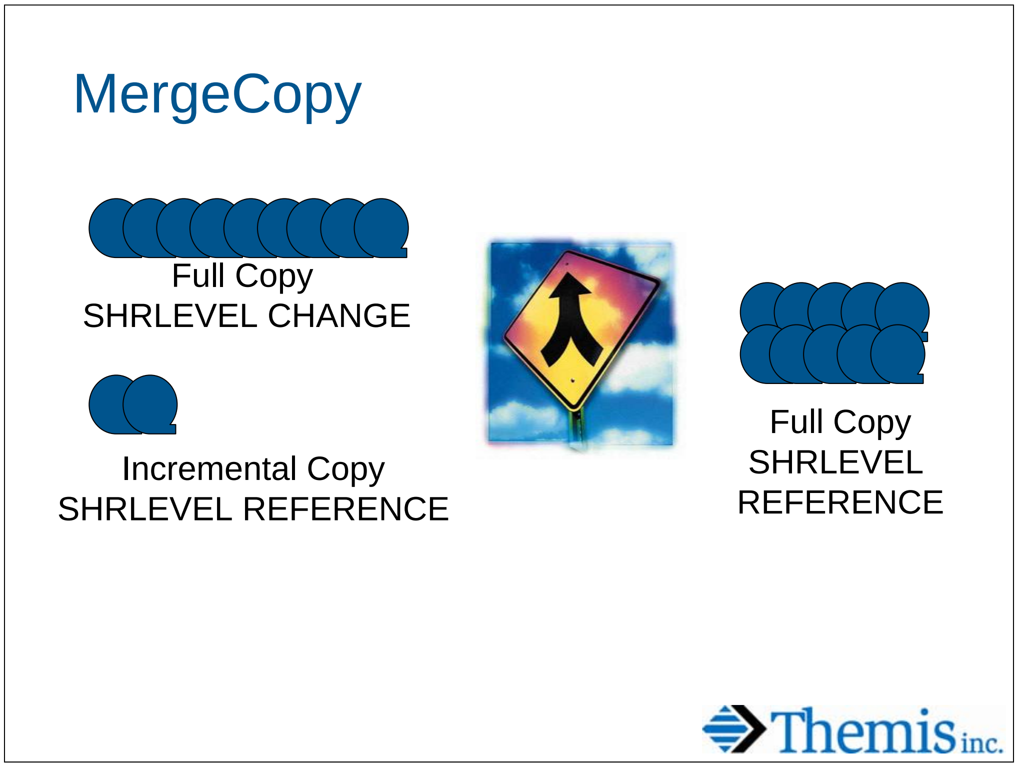
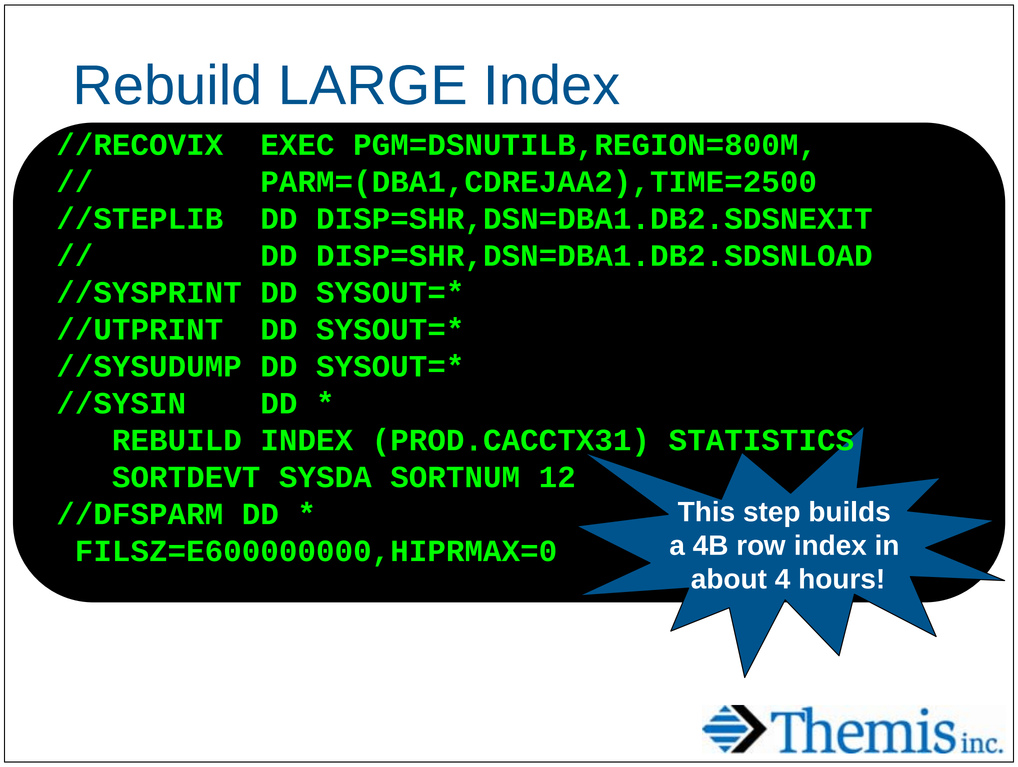
If a stable copy is needed, incremental copies may be helpful. Be sure the tablespace has the TRACKMOD YES property set and run an incremental copy. This copies only pages that have changed since the last copy. If few enough pages have changed, then this copy may be run as SHRLEVEL REFERENCE, thus representing a stable copy and minimizing the application outage.



MergeCopy

When the full SHRLEVEL CHANGE copy is merged with the incremental SHRLEVEL REFERENCE copy via the MERGECOPY utility, the result is a full image copy that is SHRLEVEL REFERENCE.



Rebuild LARGE Index

```
//RECOVIX   EXEC PGM=DSNUTILB,REGION=800M,
//          PARM=(DBA1,CDREJAA2),TIME=2500
//STEPLIB   DD DISP=SHR,DSN=DBA1.DB2.SDSNEXIT
//          DD DISP=SHR,DSN=DBA1.DB2.SDSNLOAD
//SYSPRINT DD SYSOUT=*
//UTPRINT   DD SYSOUT=*
//SYSUDUMP DD SYSOUT=*
//SYSIN     DD *
   REBUILD INDEX (PROD.CACCTX31) STATISTICS
   SORTDEVT SYSDA SORTNUM 12
//DFSPARM DD *
 FILSZ=E600000000,HIPRMAX=0
```

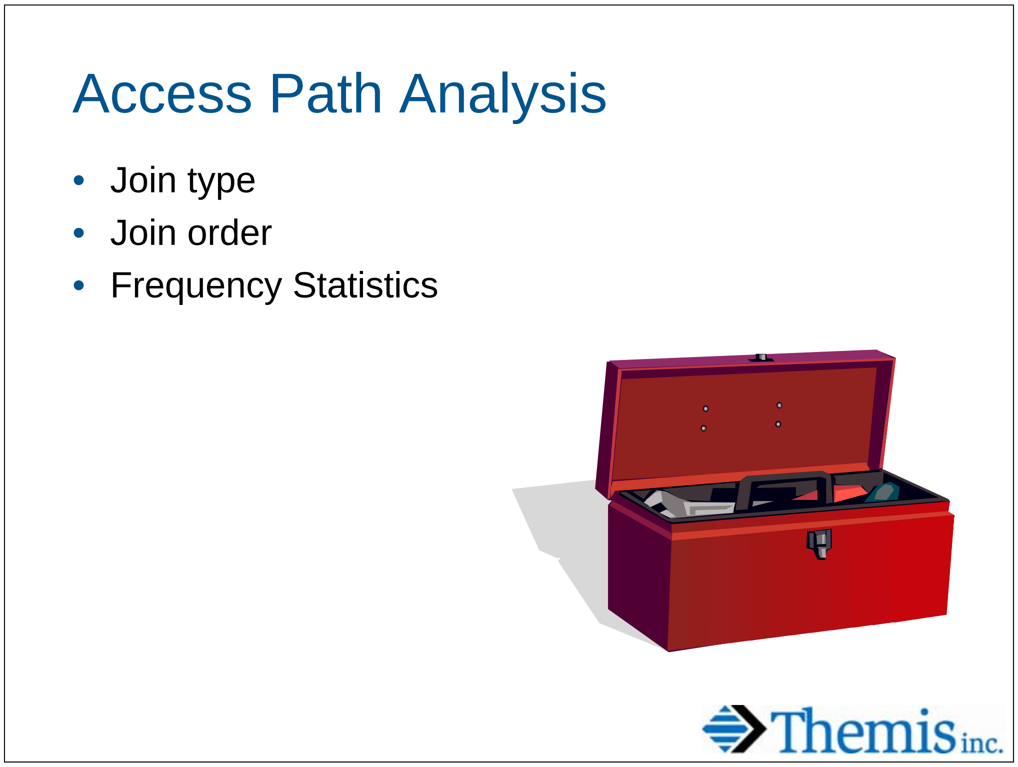
This step builds a 4B row index in about 4 hours!

Themis inc.

This step is used to build a 4 billion row index using DB2 Version 8 utilities with DFSORT. The SORTNUM parm indicates that DB2 will allocate 12 sort work datasets per parallel task. The DFSPARM override specifies that each subtask will sort approximately 600 million records and use of hiperspaces is disabled for this sort. Sort work files are dynamically allocated for this job.

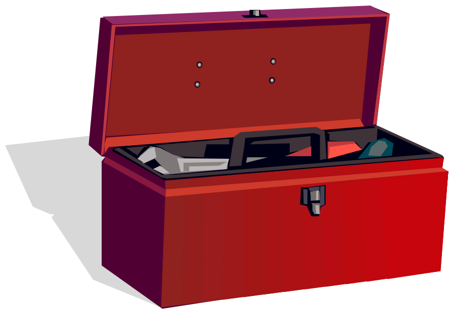
When sorting in parallel, always request lots of memory!

Note: If you are on DB2 Version 8, you are using DFSORT as the external sort tool. If you are not yet on Version 8, you are using your shop's sort tool of choice which may or may not be DFSORT. The above example assumes DFSORT as the tool. If you are using a different one some of the parms will differ.



Access Path Analysis

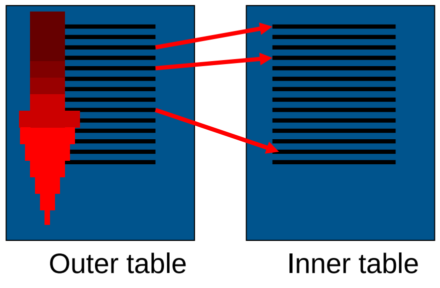
- Join type
- Join order
- Frequency Statistics



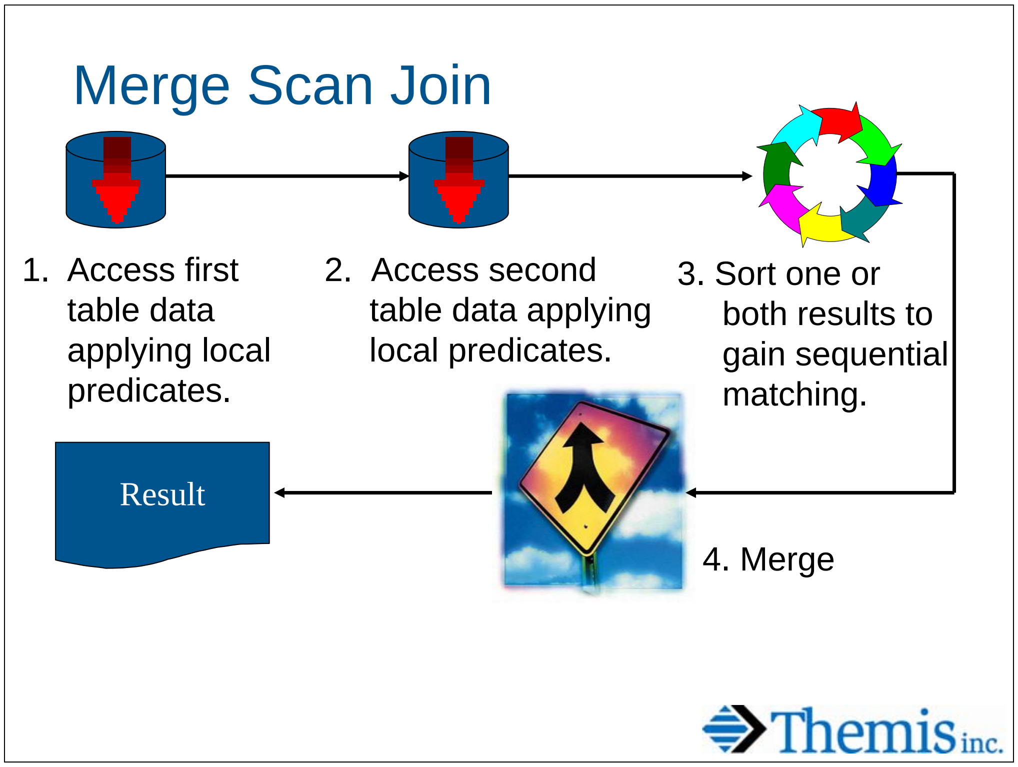
Themis inc.

Tuning large OLTP queries presents unique challenges in a very large database. Basic access paths will be discussed as well as desirable access paths for an OLTP environment. The impact of frequency statistics and the increasing importance of gathering them is also discussed.

Nested Loop Join



Nested loop joins are usually the optimal access path for fast running queries in an OLTP environment. An outer table is chosen and local predicates are applied. For each row selected in the outer table, the inner table is accessed (hopefully via an index) and rows are matched up. Access continues to bounce between the two tables until no more qualifying rows are found on the outer table.



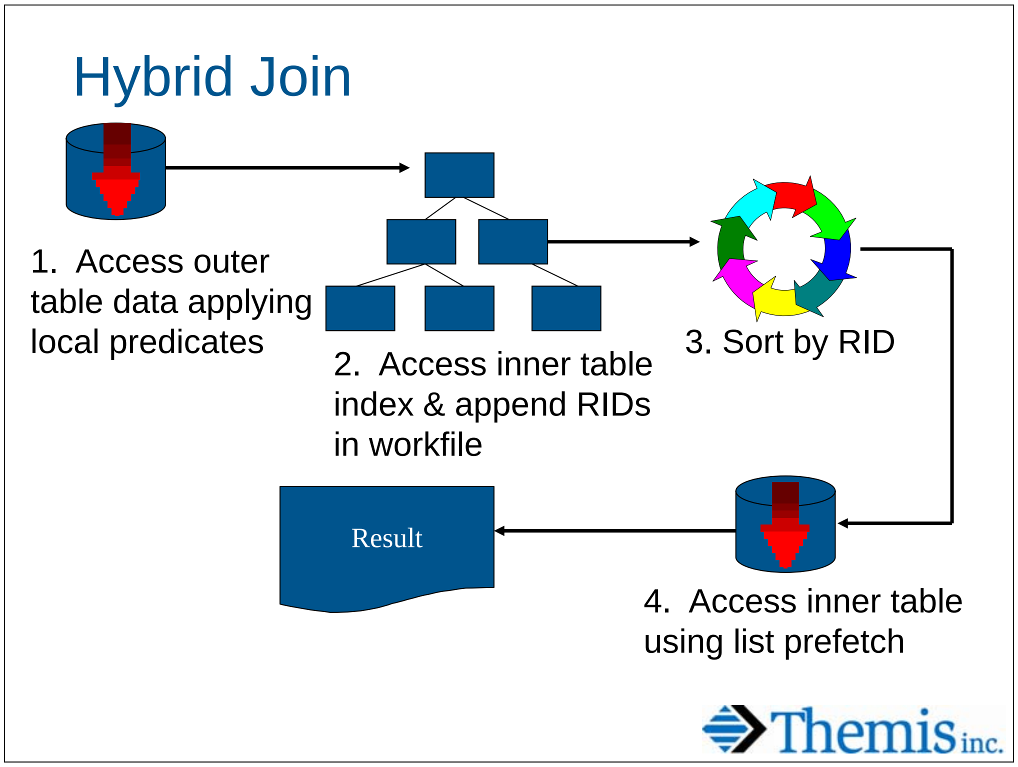
Merge Scan Join

1. Access first table data applying local predicates.
2. Access second table data applying local predicates.
3. Sort one or both results to gain sequential matching.
4. Merge
Result
Themis inc.

Merge scan joins access each table independently while applying local predicates. One or both of the results may be sorted to obtain sequential matching. The two results are then merged into a result set.

Merge scan joins work well with large results, particularly when the data is not clustered or accessed in the same sequence. Indexes may be used on either table to more efficiently apply the local predicates.

For OLTP systems, this is usually not a desirable access path.



Hybrid Join

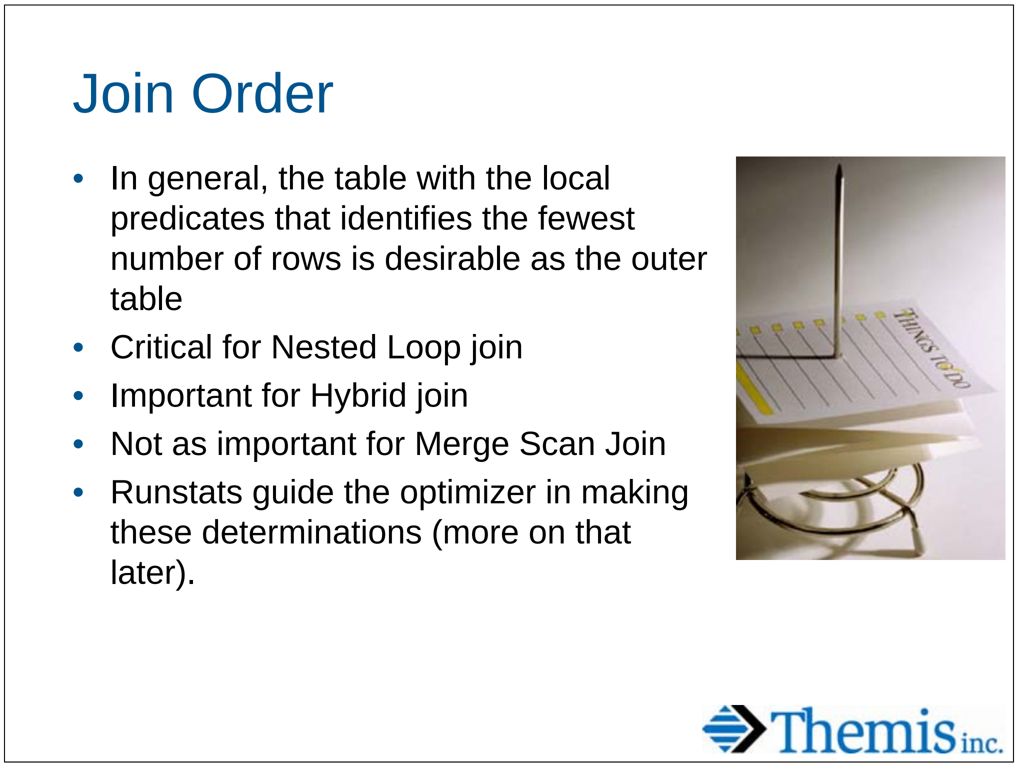
1. Access outer table data applying local predicates
2. Access inner table index & append RIDs in workfile
3. Sort by RID
4. Access inner table using list prefetch
Result
Themis inc.

The hybrid join was developed to take advantage of list prefetch when joining via a non-clustered index. In theory, it has always been a good thing when used appropriately. In practice it has always generated a knee-jerk reaction to eliminate it from an access path.

For OLTP systems, this is usually not a desirable access path.

In version 8, we started seeing many more hybrid joins in access paths for larger batch queries. We started testing alternatives that forced DB2 to use either a nested loop join or a merge scan join. We found that in most cases the hybrid join was the optimal access path.

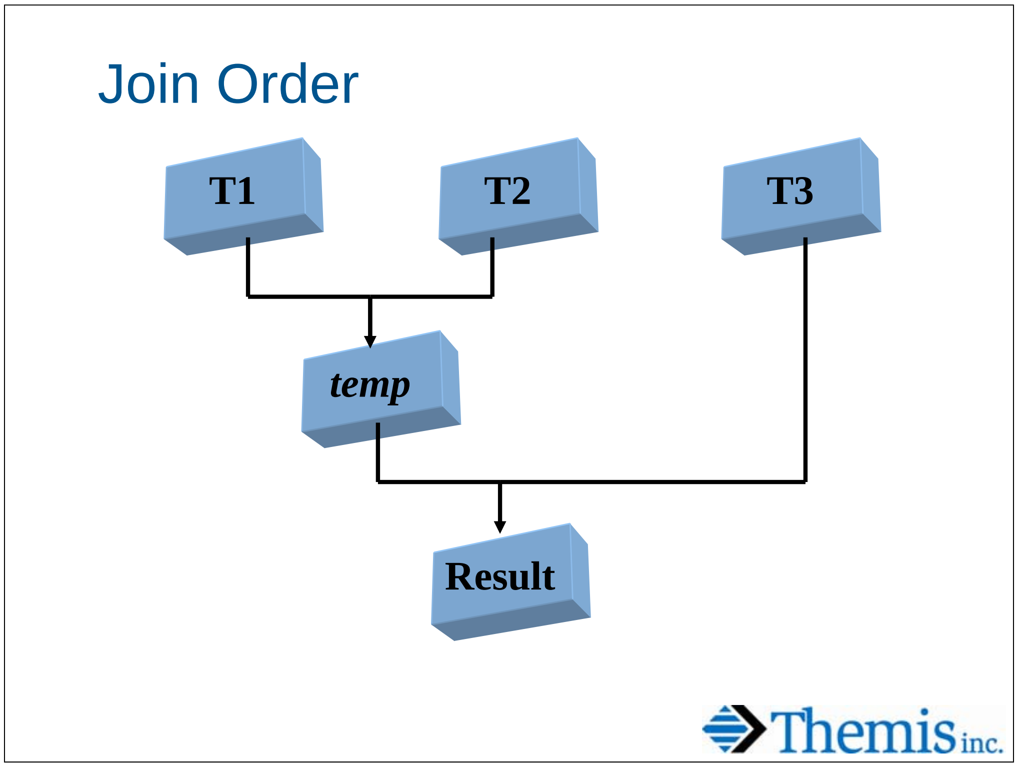
So… it still depends!

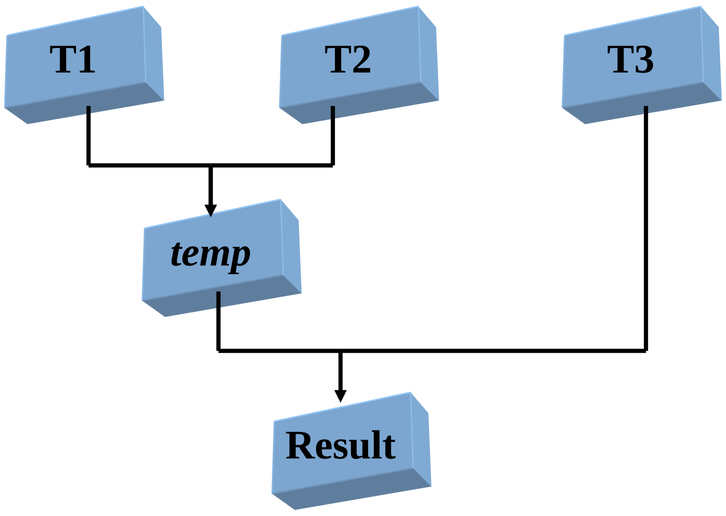


Join Order

- In general, the table with the local predicates that identifies the fewest number of rows is desirable as the outer table
- Critical for Nested Loop join
- Important for Hybrid join
- Not as important for Merge Scan Join
- Runstats guide the optimizer in making these determinations (more on that later).

Join order is one of the most critical factors in the performance of multi-table joins. This is particularly true if the join itself is providing lots of filtering. Queries that eliminate rows from consideration early in the join will perform better than those where rows are thrown away late in the join. As always, statistics provide the optimizer with the information necessary to determine these costs. Giving the optimizer good information is critical for insuring good decisions.

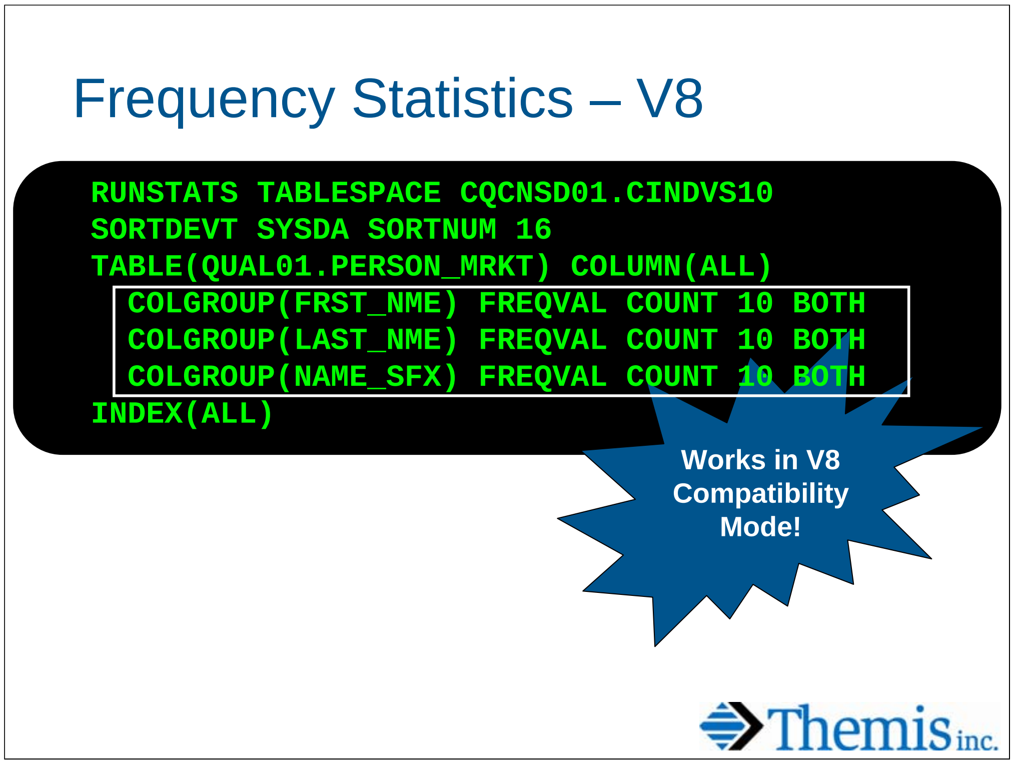

Join Order



Themis inc.

Tables are joined 2 at a time. In a three or more table join, intermediate results are formed at each step and then joined to the next table. Join order can be critical to query performance. Better performance results when the fewest number of records is passed to the next level. It is desirable to have the best filters on the first tables joined.

Of course DB2 determines the actual order of tables joined (based on available statistics), not the author of the SQL.



Frequency Statistics – V8

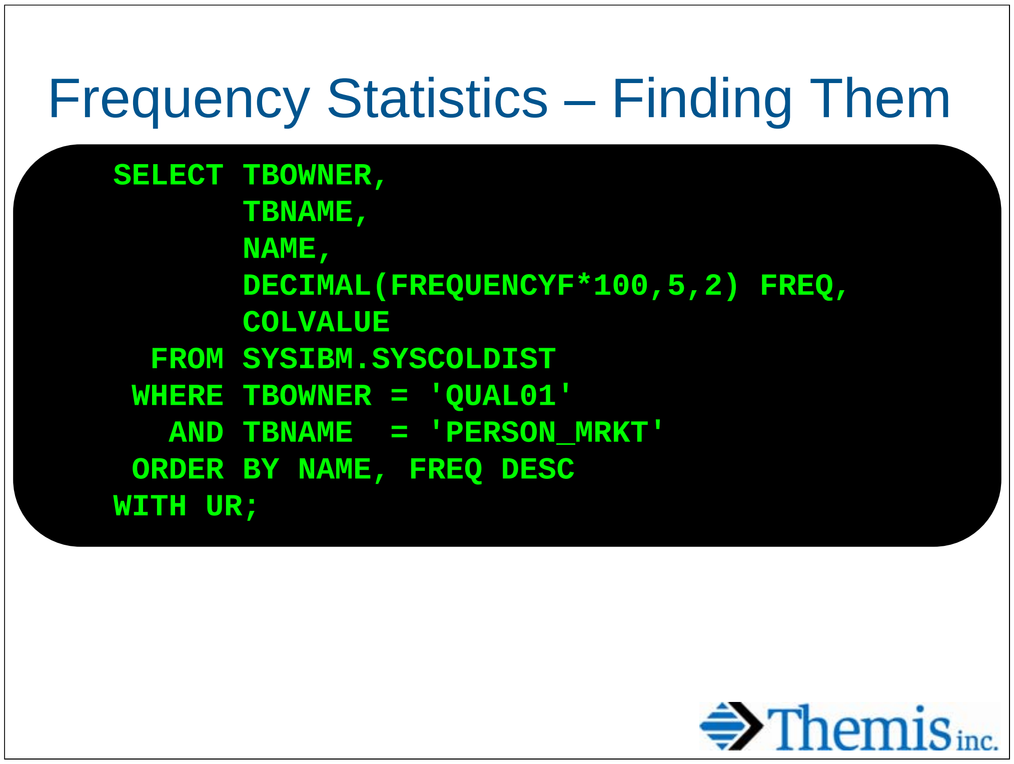
```
RUNSTATS TABLESPACE CQCNSD01.CINDVS10
SORTDEVT SYSDA SORTNUM 16
TABLE(QUAL01.PERSON_MRKT) COLUMN(ALL)
  COLGROUP(FRST_NME) FREQVAL COUNT 10 BOTH
  COLGROUP(LAST_NME) FREQVAL COUNT 10 BOTH
  COLGROUP(NAME_SFX) FREQVAL COUNT 10 BOTH
INDEX(ALL)
```

Works in V8 Compatibility Mode!

Version 8 provides the ability to gather distribution statistics for non-indexed columns. Distribution statistics have existed in prior releases of DB2, but the RUNSTATS utility was not able to collect them for non-indexed columns. The DBA could always provide them via inserts to SYSCOLDIST. DSTATS is a popular sample program used to gather and insert these statistics for desired columns prior to version 8.

By default, RUNSTATS will continue to gather distribution statistics on indexed columns only. The DBA must request the collection of these statistics on other columns, as shown above.

The syntax above is requesting distribution statistics on 3 non-indexed columns for the 10 most frequent and 10 least frequent values for the column.

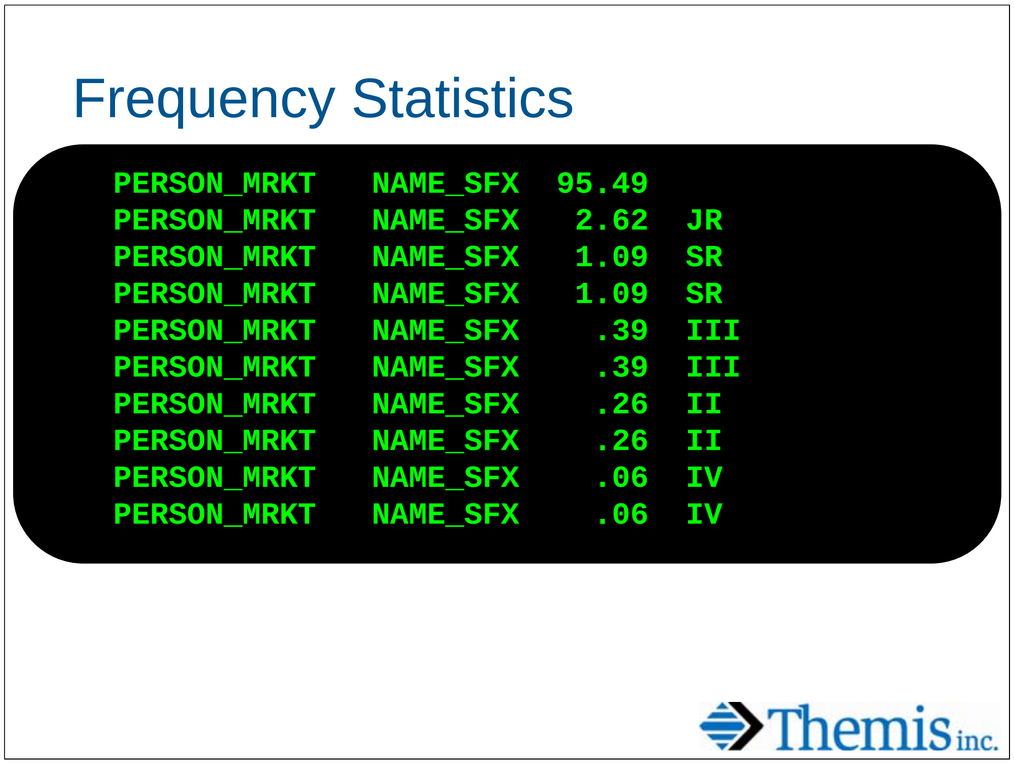


Frequency Statistics – Finding Them

```
SELECT TBOWNER,
       TBNAME,
       NAME,
       DECIMAL(FREQUENCYF*100,5,2) FREQ,
       COLVALUE
  FROM SYSIBM.SYSCOLDIST
 WHERE TBOWNER = 'QUAL01'
   AND TBNAME  = 'PERSON_MRKT'
 ORDER BY NAME, FREQ DESC
WITH UR;
```

Themis inc.

Here is a query to display the distribution statistics for a table.

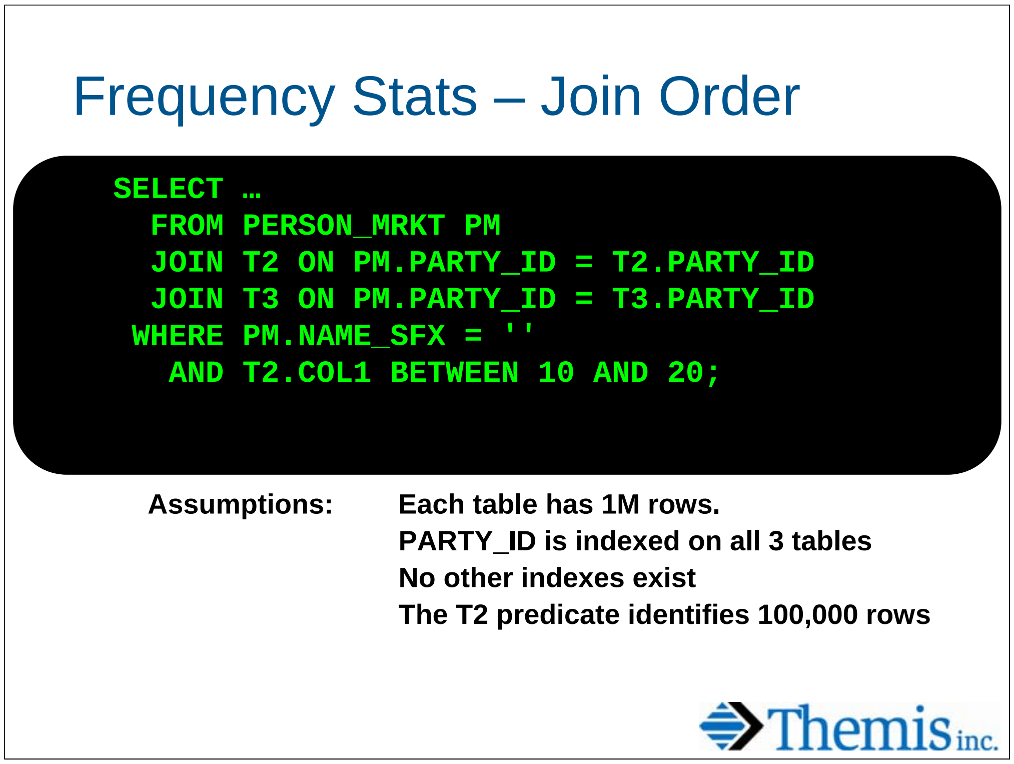


Frequency Statistics

```
PERSON_MRKT   NAME_SFX  95.49
PERSON_MRKT   NAME_SFX   2.62  JR
PERSON_MRKT   NAME_SFX   1.09  SR
PERSON_MRKT   NAME_SFX   1.09  SR
PERSON_MRKT   NAME_SFX    .39  III
PERSON_MRKT   NAME_SFX    .39  III
PERSON_MRKT   NAME_SFX    .26  II
PERSON_MRKT   NAME_SFX    .26  II
PERSON_MRKT   NAME_SFX    .06  IV
PERSON_MRKT   NAME_SFX    .06  IV
```

The results of the query show the values as percentages of the total number of rows on the table. Some values occur twice in this example because there were fewer than 20 possible values. This means that some values were both in the top 10 most frequent and infrequent values on the table.

This data indicates that 95% of the time, the value for NAME_SFX is blank.



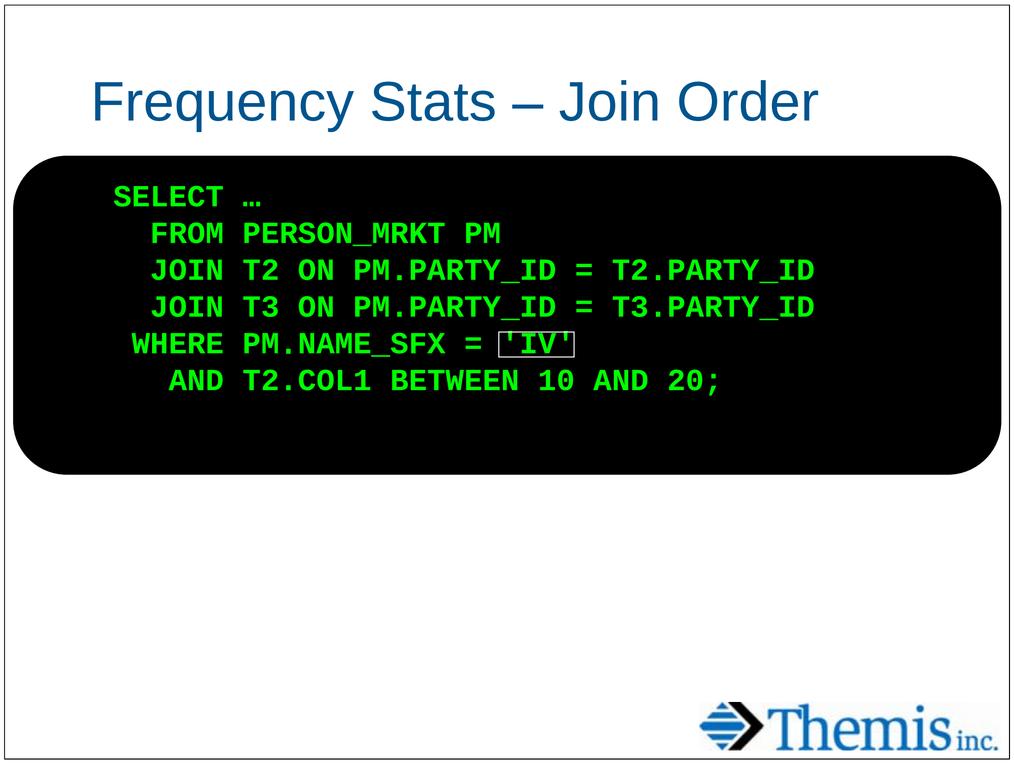
Frequency Stats – Join Order

```
SELECT …
  FROM PERSON_MRKT PM
  JOIN T2 ON PM.PARTY_ID = T2.PARTY_ID
  JOIN T3 ON PM.PARTY_ID = T3.PARTY_ID
 WHERE PM.NAME_SFX = ''
   AND T2.COL1 BETWEEN 10 AND 20;
```

Assumptions:

Each table has 1M rows.
PARTY_ID is indexed on all 3 tables
No other indexes exist
The T2 predicate identifies 100,000 rows

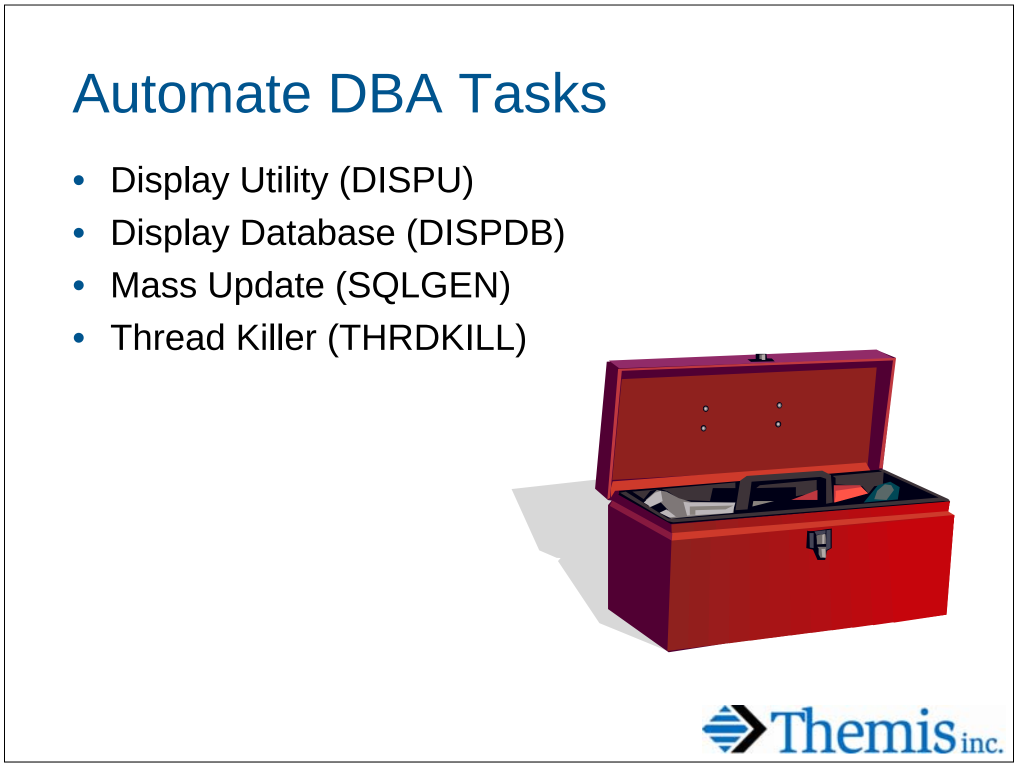
Consider the impact of distribution statistics on the above query. Since there are no indexes on columns other than the key, the optimizer will be forced to scan one of the tables and then join based on the key to the other two. It will be important for performance to identify the right table to scan first. If distribution statistics are provided on NAME_SFX, the optimizer will know that this predicate qualifies 95% of the rows on that table. It will then likely choose T2 as the outer table, since only 100,000 rows would need to be joined to the other two.



Frequency Stats – Join Order

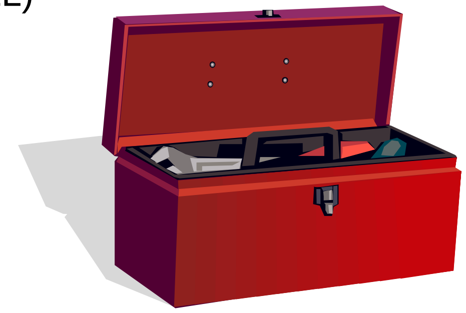
```
SELECT …
  FROM PERSON_MRKT PM
  JOIN T2 ON PM.PARTY_ID = T2.PARTY_ID
  JOIN T3 ON PM.PARTY_ID = T3.PARTY_ID
 WHERE PM.NAME_SFX = 'IV'
   AND T2.COL1 BETWEEN 10 AND 20;
```

In this example, less than 1% of the data on PERSON_MRKT will qualify, so the optimizer would be more likely to scan this table first.



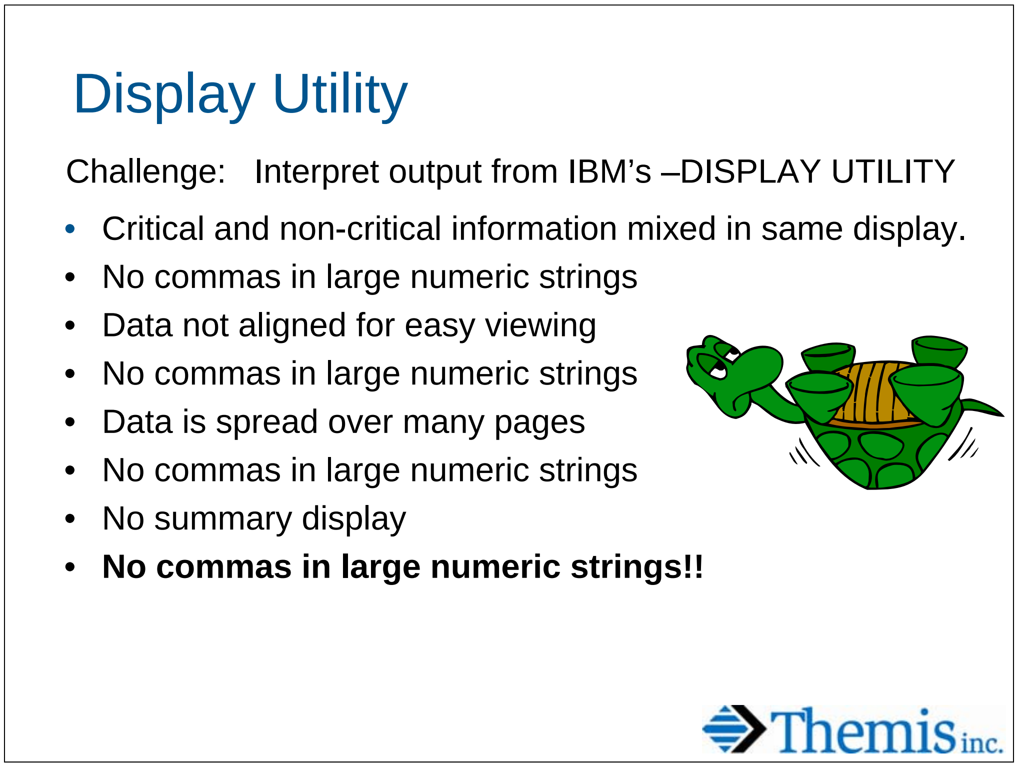
Automate DBA Tasks

- Display Utility (DISPU)
- Display Database (DISPDB)
- Mass Update (SQLGEN)
- Thread Killer (THRDKILL)



Themis inc.

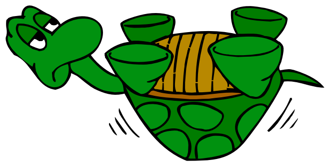
All DBAs have re-occurring tasks that can be time consuming. Third party products help fill some gaps, but there is often the need to perform a task that the products do not address (or we don't want to pay for). Here are three such tasks where we have written our own custom solution. REXX execs are used that are relatively easy to write.



Display Utility

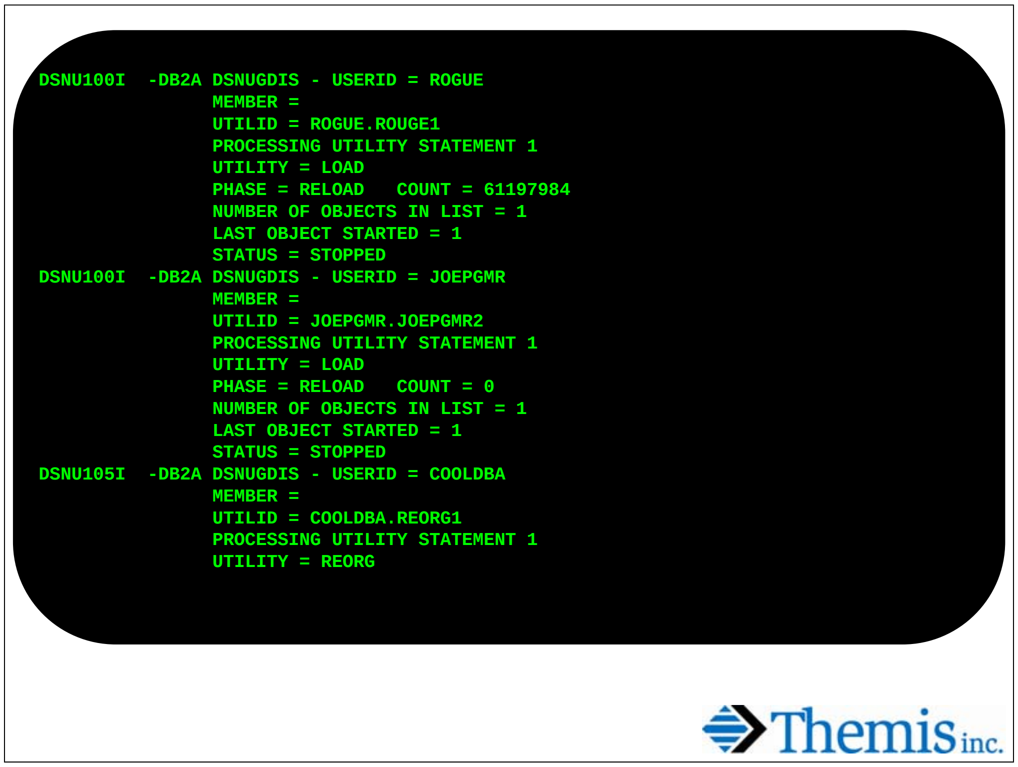
Challenge: Interpret output from IBM's –DISPLAY UTILITY

- Critical and non-critical information mixed in same display.
- No commas in large numeric strings
- Data not aligned for easy viewing
- No commas in large numeric strings
- Data is spread over many pages
- No commas in large numeric strings
- No summary display
- **No commas in large numeric strings!!**



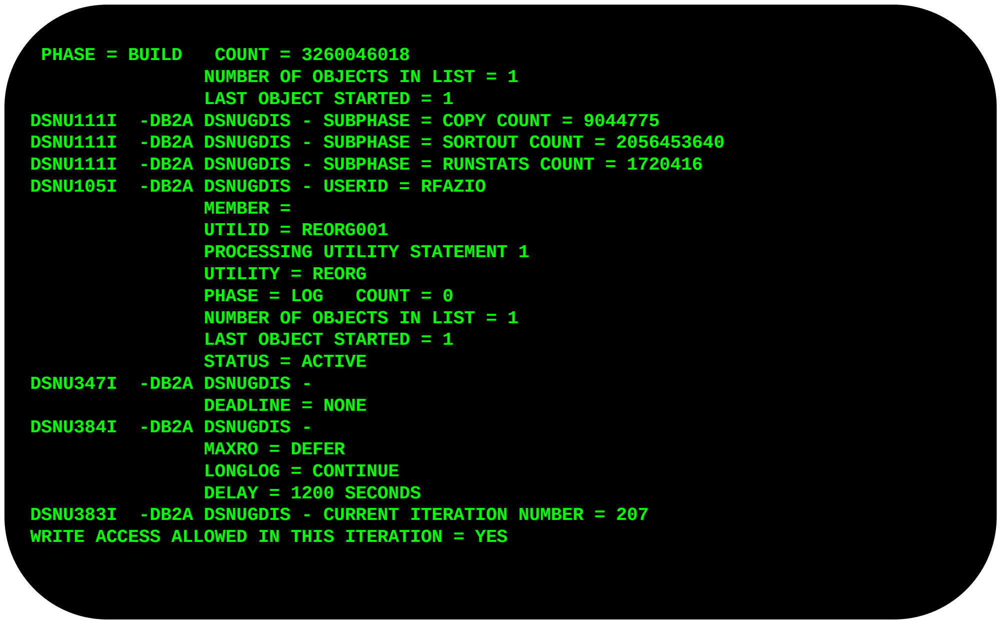
Themis inc.

Interpreting output from the standard –DISPLAY UTILITY command can be a challenge. The data that comes out of this display is comprehensive, but there is not a summary screen. A major complaint among DBAs is the lack of commas in the output counts. Also, critical and non-critical information are mixed in same display.

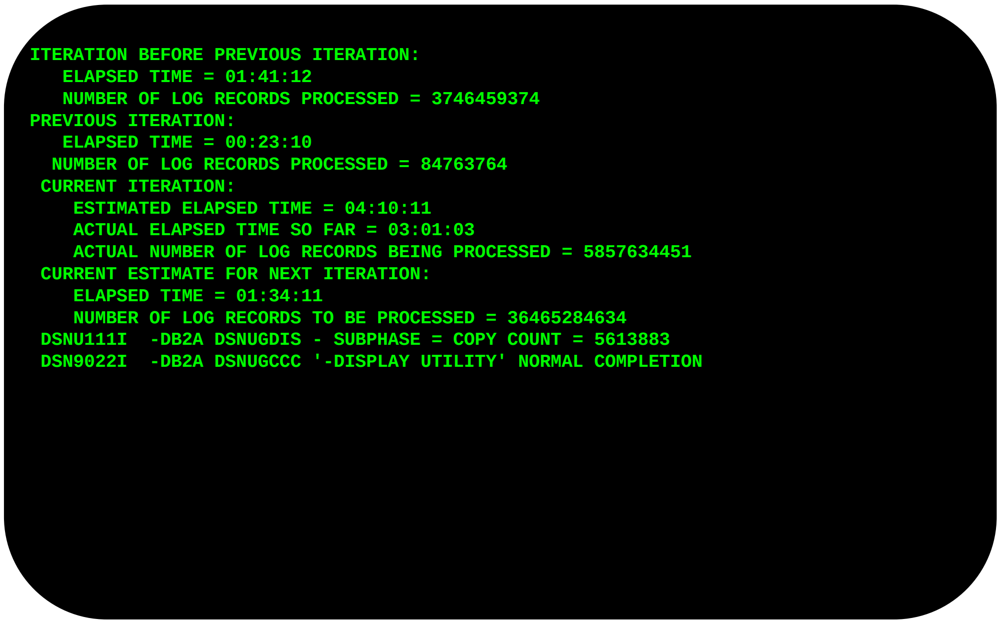


```
DSNU100I  -DB2A DSNUGDIS - USERID = ROGUE
                MEMBER =
                UTILID = ROGUE.ROUGE1
                PROCESSING UTILITY STATEMENT 1
                UTILITY = LOAD
                PHASE = RELOAD   COUNT = 61197984
                NUMBER OF OBJECTS IN LIST = 1
                LAST OBJECT STARTED = 1
                STATUS = STOPPED
DSNU100I  -DB2A DSNUGDIS - USERID = JOEPGMR
                MEMBER =
                UTILID = JOEPGMR.JOEPGMR2
                PROCESSING UTILITY STATEMENT 1
                UTILITY = LOAD
                PHASE = RELOAD   COUNT = 0
                NUMBER OF OBJECTS IN LIST = 1
                LAST OBJECT STARTED = 1
                STATUS = STOPPED
DSNU105I  -DB2A DSNUGDIS - USERID = COOLDBA
                MEMBER =
                UTILID = COOLDBA.REORG1
                PROCESSING UTILITY STATEMENT 1
                UTILITY = REORG
```

Here is the output from the standard –DISPLAY UTILITY(*) command in an environment with 4 utilities running. 2 are active and 2 are stopped. Note that the output takes three screens to cover. Also note the lack of commas.

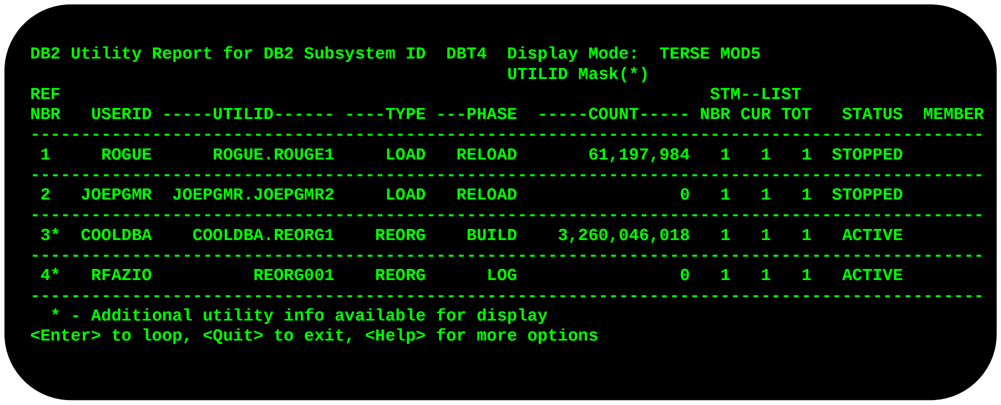


```
 PHASE = BUILD   COUNT = 3260046018
                NUMBER OF OBJECTS IN LIST = 1
                LAST OBJECT STARTED = 1
DSNU111I  -DB2A DSNUGDIS - SUBPHASE = COPY COUNT = 9044775
DSNU111I  -DB2A DSNUGDIS - SUBPHASE = SORTOUT COUNT = 2056453640
DSNU111I  -DB2A DSNUGDIS - SUBPHASE = RUNSTATS COUNT = 1720416
DSNU105I  -DB2A DSNUGDIS - USERID = RFAZIO
                MEMBER =
                UTILID = REORG001
                PROCESSING UTILITY STATEMENT 1
                UTILITY = REORG
                PHASE = LOG   COUNT = 0
                NUMBER OF OBJECTS IN LIST = 1
                LAST OBJECT STARTED = 1
                STATUS = ACTIVE
DSNU347I  -DB2A DSNUGDIS -
                DEADLINE = NONE
DSNU384I  -DB2A DSNUGDIS -
                MAXRO = DEFER
                LONGLOG = CONTINUE
                DELAY = 1200 SECONDS
DSNU383I  -DB2A DSNUGDIS - CURRENT ITERATION NUMBER = 207
WRITE ACCESS ALLOWED IN THIS ITERATION = YES
```



```
ITERATION BEFORE PREVIOUS ITERATION:
   ELAPSED TIME = 01:41:12
   NUMBER OF LOG RECORDS PROCESSED = 3746459374
PREVIOUS ITERATION:
   ELAPSED TIME = 00:23:10
  NUMBER OF LOG RECORDS PROCESSED = 84763764
 CURRENT ITERATION:
    ESTIMATED ELAPSED TIME = 04:10:11
    ACTUAL ELAPSED TIME SO FAR = 03:01:03
    ACTUAL NUMBER OF LOG RECORDS BEING PROCESSED = 5857634451
 CURRENT ESTIMATE FOR NEXT ITERATION:
    ELAPSED TIME = 01:34:11
    NUMBER OF LOG RECORDS TO BE PROCESSED = 36465284634
 DSNU111I  -DB2A DSNUGDIS - SUBPHASE = COPY COUNT = 5613883
 DSN9022I  -DB2A DSNUGCCC '-DISPLAY UTILITY' NORMAL COMPLETION
```

REXX DISPU Summary Screen



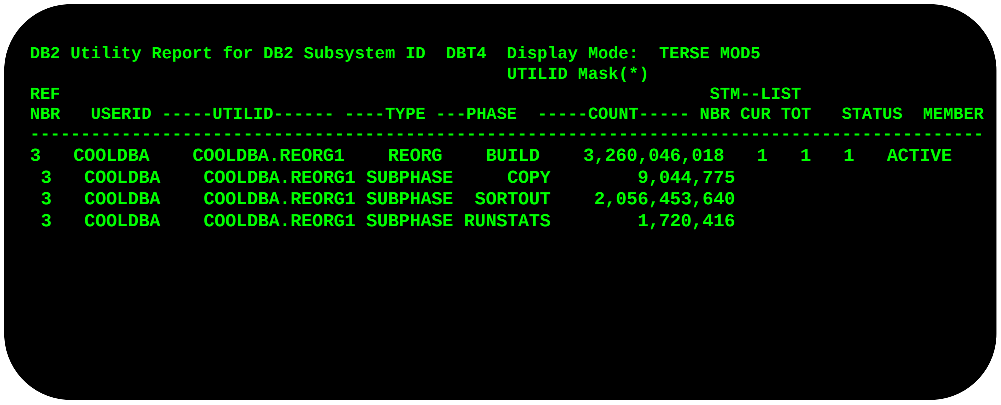
```
DB2 Utility Report for DB2 Subsystem ID  DBT4  Display Mode:  TERSE MOD5
                                               UTILID Mask(*)
REF                                                                STM--LIST
NBR   USERID -----UTILID------ ----TYPE ---PHASE  -----COUNT----- NBR CUR TOT   STATUS  MEMBER
----------------------------------------------------------------------------------------------
 1     ROGUE      ROGUE.ROUGE1     LOAD   RELOAD       61,197,984   1   1   1  STOPPED
----------------------------------------------------------------------------------------------
 2   JOEPGMR  JOEPGMR.JOEPGMR2     LOAD   RELOAD                0   1   1   1  STOPPED
----------------------------------------------------------------------------------------------
 3*  COOLDBA    COOLDBA.REORG1    REORG    BUILD    3,260,046,018   1   1   1   ACTIVE
----------------------------------------------------------------------------------------------
 4*   RFAZIO          REORG001    REORG      LOG                0   1   1   1   ACTIVE
----------------------------------------------------------------------------------------------
  * - Additional utility info available for display
<Enter> to loop, <Quit> to exit, <Help> for more options
```

Themis inc.

Here is the summary screen for our REXX called DISPU. On a single screen you can view all 4 utilities and their status. Check out those commas!

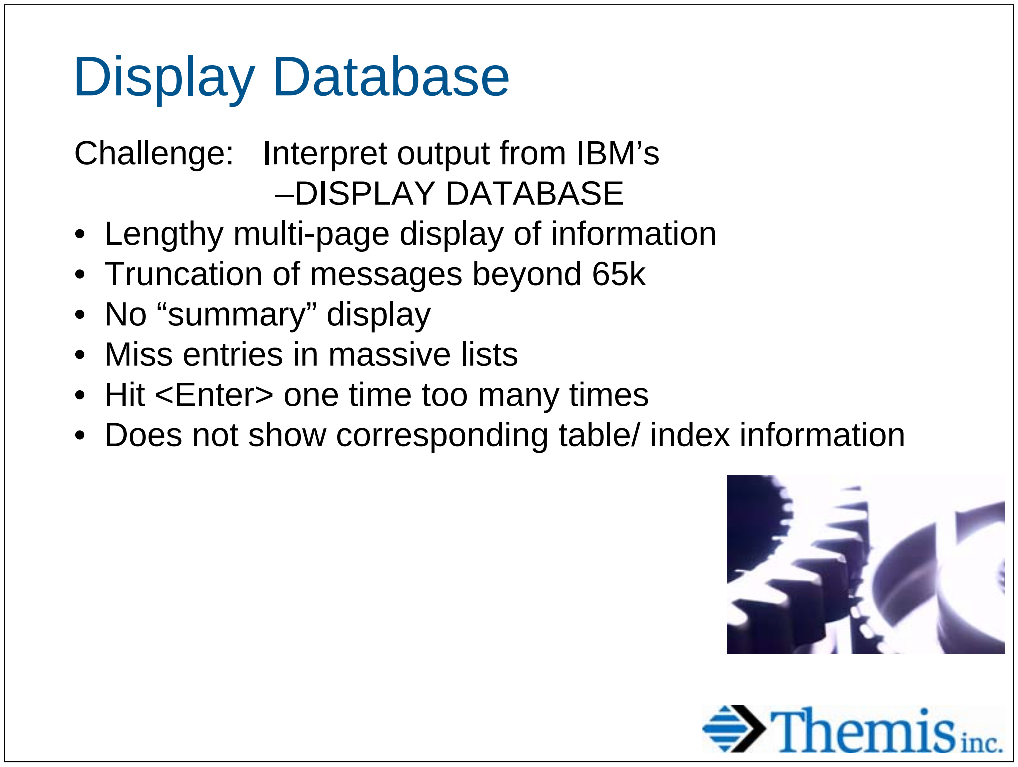
Rich Fazio is the author of this REXX. It is part of a bundle of scripts that he will provide when you email him at rfazio@transunion.com.

REXX DISPU Detail Screen



```
DB2 Utility Report for DB2 Subsystem ID  DBT4  Display Mode:  TERSE MOD5
                                               UTILID Mask(*)
REF                                                                 STM--LIST
NBR   USERID -----UTILID------ ----TYPE ---PHASE  -----COUNT----- NBR CUR TOT   STATUS  MEMBER
----------------------------------------------------------------------------------------------
3   COOLDBA    COOLDBA.REORG1    REORG    BUILD    3,260,046,018   1   1   1   ACTIVE
 3   COOLDBA    COOLDBA.REORG1 SUBPHASE     COPY         9,044,775
 3   COOLDBA    COOLDBA.REORG1 SUBPHASE  SORTOUT     2,056,453,640
 3   COOLDBA    COOLDBA.REORG1 SUBPHASE RUNSTATS         1,720,416
```

A utility may be selected for greater detail. On the detail screen a line for each subtask is displayed with its counts. From either screen utilities may be terminated. A mask may be supplied on either screen to determine which utilities are shown.



Display Database

Challenge: Interpret output from IBM's –DISPLAY DATABASE

- Lengthy multi-page display of information
- Truncation of messages beyond 65k
- No "summary" display
- Miss entries in massive lists
- Hit <Enter> one time too many times
- Does not show corresponding table/ index information

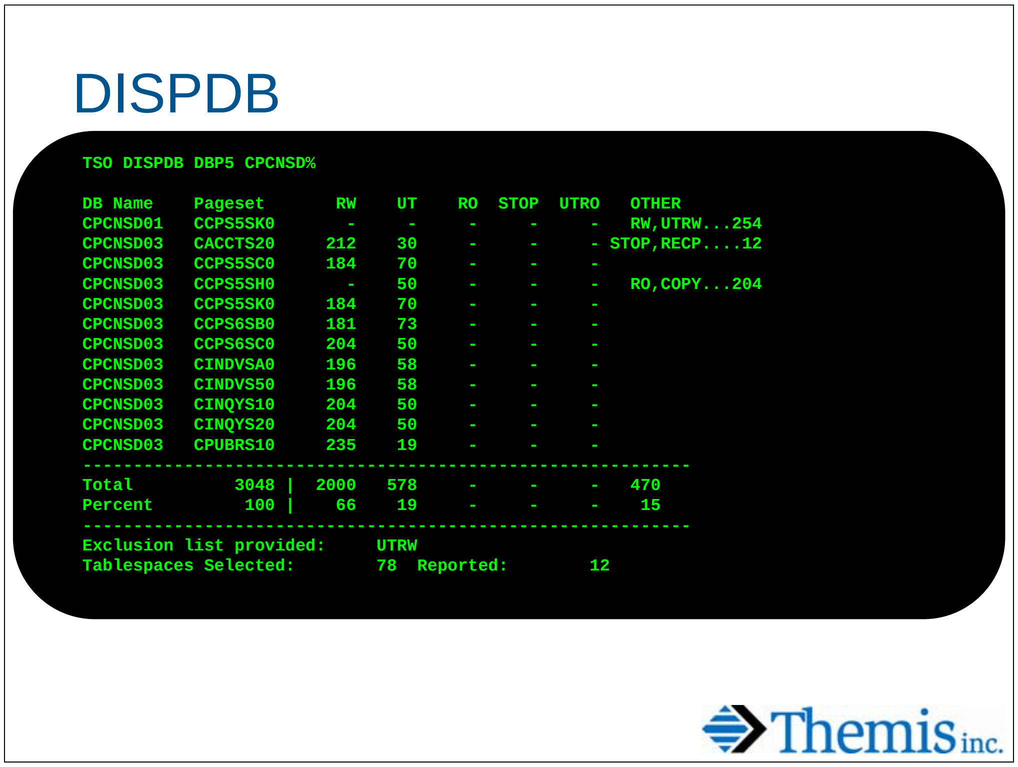
Themis inc.

-DISPLAY DATABASE has similar issues to –DISPLAY UTILITY….however, it's almost worse.

Messages span many pages, also, it is easy for a restricted state to sneak by.

Lastly, the display buffer is only so big (64k)…once it's full, the display ends (whether you have a LIMIT(*) or not).

In V8, this gets better and worse… worse because there can be up to 4000 partitions, but there have been some display efficiencies built into the IBM display that cut down on the amount of screen space used.



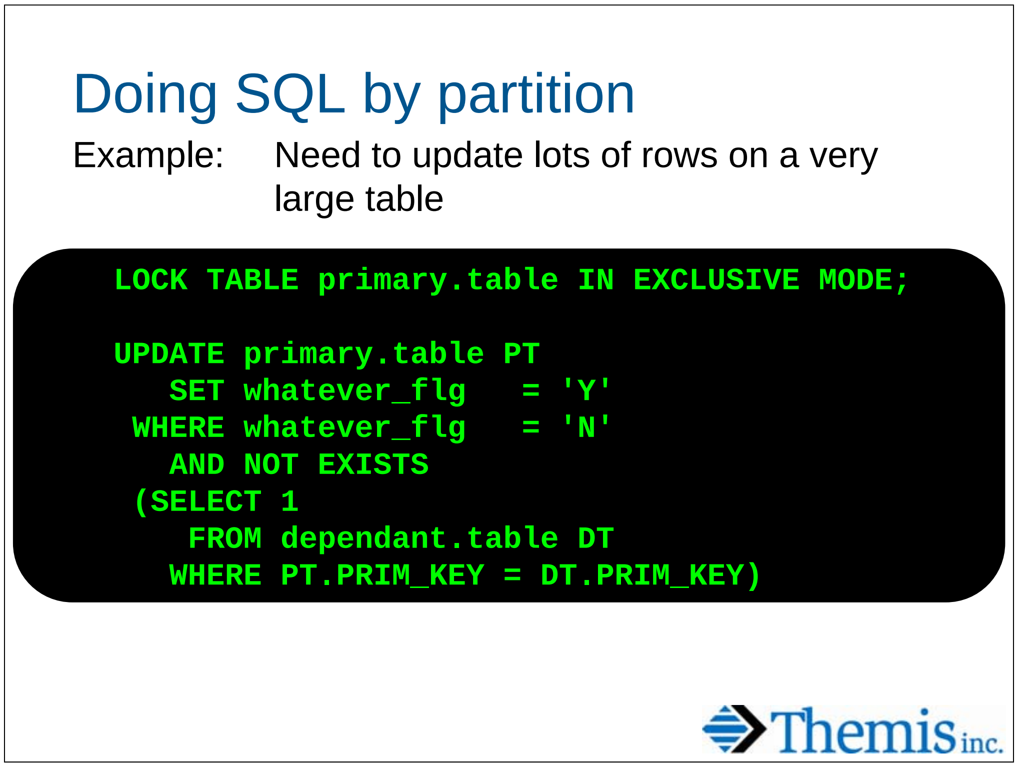
DISPDB

```
TSO DISPDB DBP5 CPCNSD%

DB Name    Pageset       RW     UT    RO STOP  UTRO   OTHER
CPCNSD01   CCPS5SK0       -     -     -     -     -   RW,UTRW...254
CPCNSD03   CACCTS20     212     30    -     -     - STOP,RECP....12
CPCNSD03   CCPS5SC0     184     70    -     -     -
CPCNSD03   CCPS5SH0       -     50    -     -     -   RO,COPY...204
CPCNSD03   CCPS5SK0     184     70    -     -     -
CPCNSD03   CCPS6SB0     181     73    -     -     -
CPCNSD03   CCPS6SC0     204     50    -     -     -
CPCNSD03   CINDVSA0     196     58    -     -     -
CPCNSD03   CINDVS50     196     58    -     -     -
CPCNSD03   CINQYS10     204     50    -     -     -
CPCNSD03   CINQYS20     204     50    -     -     -
CPCNSD03   CPUBRS10     235     19    -     -     -
------------------------------------------------------------
Total           3048 |  2000   578    -     -     -   470
Percent          100 |    66    19    -     -     -    15
------------------------------------------------------------
Exclusion list provided:     UTRW
Tablespaces Selected:        78  Reported:        12
```

DISPDB Rexx focuses upon consolidating the status messages into a single line. Additional information is also gathered and displayed on a second line.

This REXX is also part of Rich Fazio’s suite.



Doing SQL by partition

Example: Need to update lots of rows on a very large table

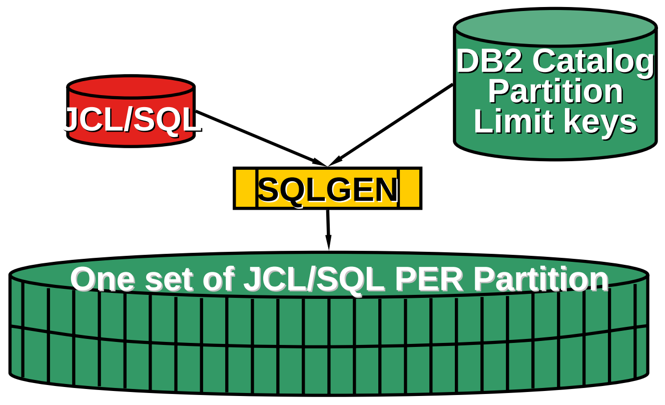
```
LOCK TABLE primary.table IN EXCLUSIVE MODE;

UPDATE primary.table PT
   SET whatever_flg   = 'Y'
 WHERE whatever_flg   = 'N'
   AND NOT EXISTS
 (SELECT 1
    FROM dependant.table DT
   WHERE PT.PRIM_KEY = DT.PRIM_KEY)
```

Sometimes new columns get added to the database. I'll default the column to "N" and set all the "Y" values based upon the application criteria after the fact…this can take hours…but usually, it's ok.

Sometimes, the need to get these flags populated can be critical to the business. Speed is everything. A normal update (above) takes 2-3 hours. The only way to get this done quickly is with parallelism. Too bad DB2 does not have "UPDATE" parallelism…..well… not built in anyway.

SQLGEN

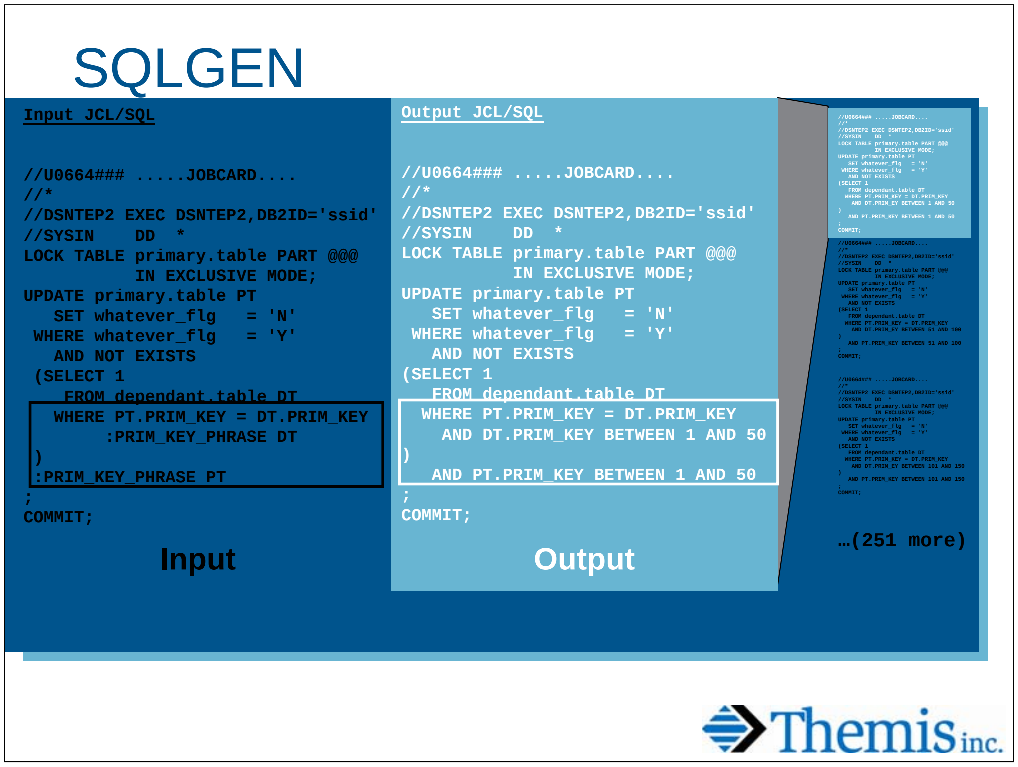


Themis inc.

SQLGEN reads in an SQL Stmt (or JCL w/SQL Stmt) and modifies a query to allow embedding of partition limit ranges.

The partition ranges for the system are retrieved from the DB2 catalog and applied to the SQL.

Multiple queries (jobs) are created for parallel execution.



SQLGEN

Input JCL/SQL

```
//U0664### .....JOBCARD....
//*
//DSNTEP2 EXEC DSNTEP2,DB2ID='ssid'
//SYSIN    DD  *
LOCK TABLE primary.table PART @@@
           IN EXCLUSIVE MODE;
UPDATE primary.table PT
   SET whatever_flg   = 'N'
 WHERE whatever_flg   = 'Y'
   AND NOT EXISTS
 (SELECT 1
    FROM dependant.table DT
   WHERE PT.PRIM_KEY = DT.PRIM_KEY
        :PRIM_KEY_PHRASE DT
 )
 :PRIM_KEY_PHRASE PT
;
COMMIT;
```

Input

Output JCL/SQL

```
//U0664### .....JOBCARD....
//*
//DSNTEP2 EXEC DSNTEP2,DB2ID='ssid'
//SYSIN    DD  *
LOCK TABLE primary.table PART @@@
           IN EXCLUSIVE MODE;
UPDATE primary.table PT
   SET whatever_flg   = 'N'
 WHERE whatever_flg   = 'Y'
   AND NOT EXISTS
(SELECT 1
   FROM dependant.table DT
  WHERE PT.PRIM_KEY = DT.PRIM_KEY
    AND DT.PRIM_KEY BETWEEN 1 AND 50
)
   AND PT.PRIM_KEY BETWEEN 1 AND 50
;
COMMIT;
```

Output

```
//U0664### .....JOBCARD....
//*
//DSNTEP2 EXEC DSNTEP2,DB2ID='ssid'
//SYSIN    DD  *
LOCK TABLE primary.table PART @@@
           IN EXCLUSIVE MODE;
UPDATE primary.table PT
   SET whatever_flg   = 'N'
 WHERE whatever_flg   = 'Y'
   AND NOT EXISTS
(SELECT 1
   FROM dependant.table DT
  WHERE PT.PRIM_KEY = DT.PRIM_KEY
    AND DT.PRIM_EY BETWEEN 1 AND 50
)
   AND PT.PRIM_KEY BETWEEN 1 AND 50
;
COMMIT;
//U0664### .....JOBCARD....
//*
//DSNTEP2 EXEC DSNTEP2,DB2ID='ssid'
//SYSIN    DD  *
LOCK TABLE primary.table PART @@@
           IN EXCLUSIVE MODE;
UPDATE primary.table PT
   SET whatever_flg   = 'N'
 WHERE whatever_flg   = 'Y'
   AND NOT EXISTS
(SELECT 1
   FROM dependant.table DT
  WHERE PT.PRIM_KEY = DT.PRIM_KEY
    AND DT.PRIM_EY BETWEEN 51 AND 100
)
   AND PT.PRIM_KEY BETWEEN 51 AND 100
;
COMMIT;


//U0664### .....JOBCARD....
//*
//DSNTEP2 EXEC DSNTEP2,DB2ID='ssid'
//SYSIN    DD  *
LOCK TABLE primary.table PART @@@
           IN EXCLUSIVE MODE;
UPDATE primary.table PT
   SET whatever_flg   = 'N'
 WHERE whatever_flg   = 'Y'
   AND NOT EXISTS
(SELECT 1
   FROM dependant.table DT
  WHERE PT.PRIM_KEY = DT.PRIM_KEY
    AND DT.PRIM_EY BETWEEN 101 AND 150
)
   AND PT.PRIM_KEY BETWEEN 101 AND 150
;
COMMIT;
```

…(251 more)

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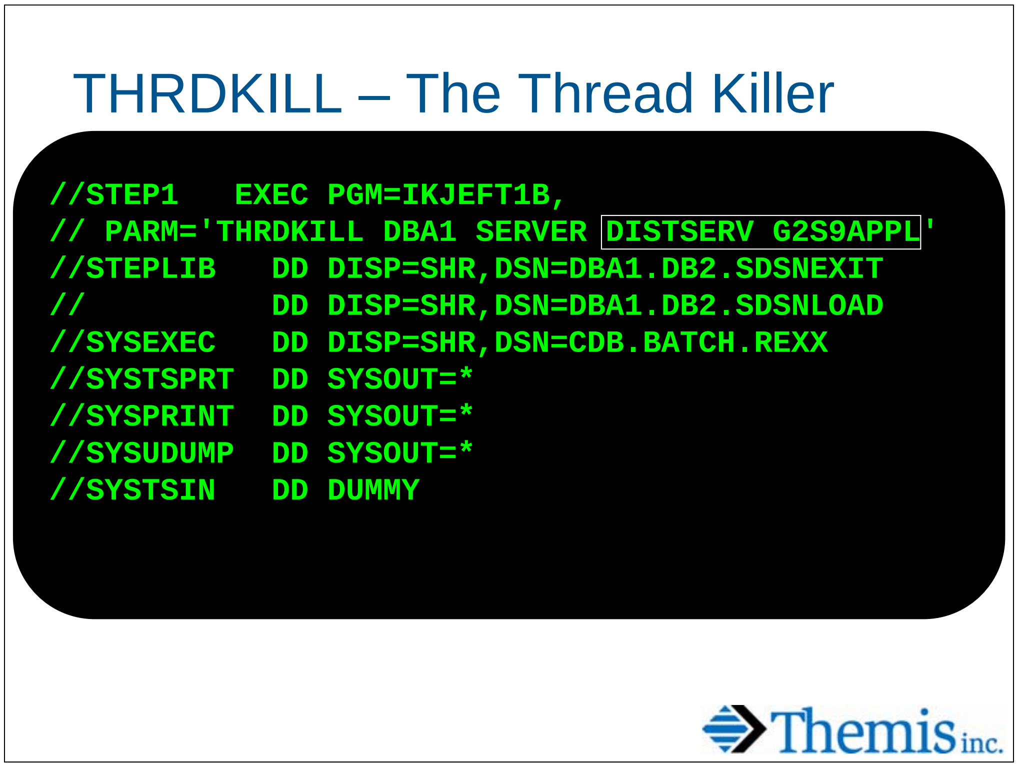
SQLGEN generates one job per partition with the appropriate limitkeys included in the SQL. The LOCK TABLE statement at the top of each job is desirable to avoid row or page locks from being acquired. In V8, this will automatically lock at the partition level. Prior to V8, this statement will lock the entire table by default. You may need to alter the tablespace to LOCKPART YES to avoid the jobs from colliding with each other.

Here's the inputs and outputs.

The LEFT JCL was read into the REXX. **Note the ":PRIM_KEY_PHRASE".** This tells the processor where to insert the partition range and how. The processor defaults to generating an "AND" statement before the limit key range added.

The RIGHT JCL was generated by the REXX. Note: this is just one of 254 jobs created by this one execution. Each JOB has the partition range for a single DB2 Part.



THRDKILL – The Thread Killer

```
//STEP1    EXEC PGM=IKJEFT1B,
// PARM='THRDKILL DBA1 SERVER DISTSERV G2S9APPL'
//STEPLIB   DD DISP=SHR,DSN=DBA1.DB2.SDSNEXIT
//          DD DISP=SHR,DSN=DBA1.DB2.SDSNLOAD
//SYSEXEC   DD DISP=SHR,DSN=CDB.BATCH.REXX
//SYSTSPRT  DD SYSOUT=*
//SYSPRINT  DD SYSOUT=*
//SYSUDUMP  DD SYSOUT=*
//SYSTSIN   DD DUMMY
```

THRDKILL looks for DB2 threads that are connected with a given plan and authid. The REXX issues –CANCEL THREAD commands for each thread located. It may optionally display the commands without actually executing them. This script comes in handy when an application that has hundreds of active threads needs to be canceled en masse.

This one is mine… email me for the source.

Summary

- Use your tools… existing tools can be put to creative use.
- Build more tools.
- Understand your tables and queries.
- Explain, explain, explain!

Credits

- **Rich Fazio, TransUnion**
- **Dan Luksetich, YL&A**
- **Bob Little, Acxiom Corp.**

Questions?

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Reference

<u>IBM Books</u>

SC18-7426 DB2 UDB for OS/390 and z/OS SQL Reference V8

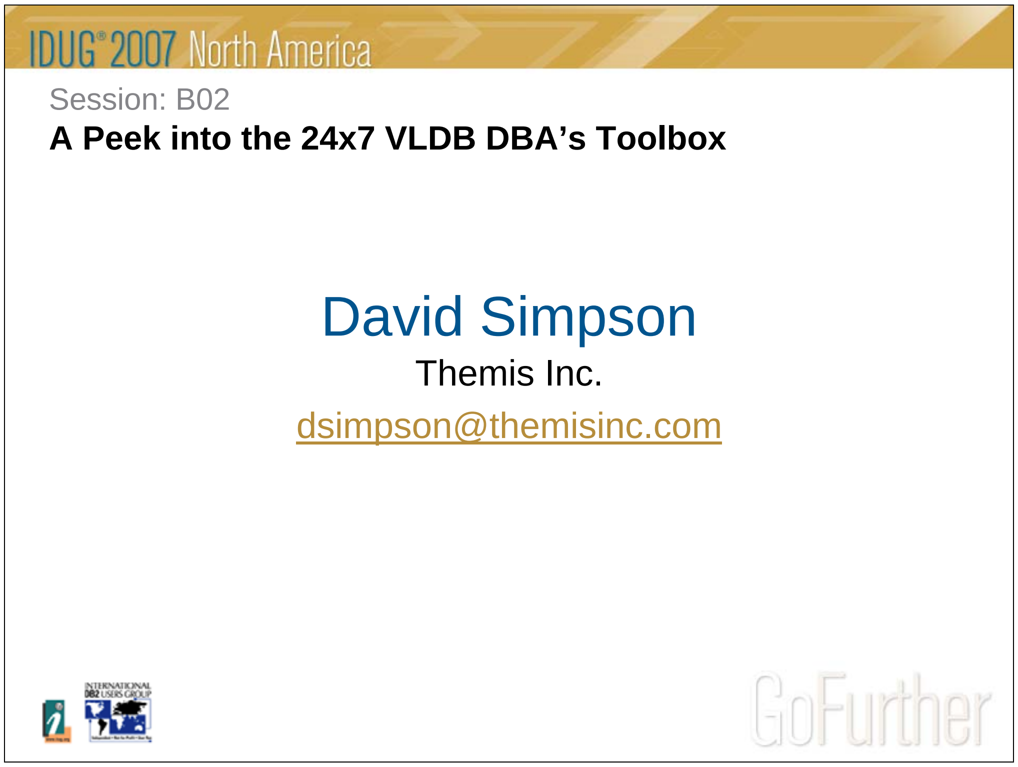
SC18-7413 DB2 UDB for OS/390 and z/OS Administration Guide V8

SC18-7427 DB2 UDB for OS/390 and z/OS Utility Guide and Reference V8

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

<u>Previous IDUG Presentations</u>

IDUG North America 2004 – VLDB High Performance Techniques/ Experiences by Rich Fazio



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A Peek into the 24x7 VLDB DBA's Toolbox

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GoFurther