Copy Smarter
Unload/Load, DSN1COPY and beyond

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Overview

What are we trying to achieve?

- Create repeatable and reliable copy processes for DB2 data
- Handle deviations in table structures
- Create a scheduler friendly process
- Bonus points for speed

- Spoiler alert: It’s hard.

Building blocks of a copy process

- Copying the data is a small part. The full process looks like this:

• DDL for tablespaces, tables, indexes • Also views, triggers, constraints, etc. • Optionally rename objects • Allocate target objects with sufficient space	*Structures*
• Invoke copy programs to bring data from A to B	*Data*
• Copy catalog statistics and RTS • Rebuild indexes if required • Adjust versioning information, row format, RBA format • Take care of identity columns, sequences • Rebind	*Cleanup*

Requirement: Reliability

- Process should not break when objects are created, changed, or dropped
- Detect new page sets that were added
- Detect and reset restricted states
- Restart after failure

Requirement: Being scheduler-friendly

- Fixed set of jobs
- Number of jobs does not change
- Contents of jobs do not change
- Can be executed repeatedly

Requirement: Speed

- Programs that copy Db2 data:
  - Unload/Load
  - DSN1COPY
  - ADRDSSU / FlashCopy2
  - Vendor solutions

A quick look at DDL

- Needs to be handled, regardless of data copy mechanism
- Db2 for z/OS does not come with a full-fledged DDL generator, but has ADMIN_INFO_SQL (used by Data Studio)
- Db2 for LUW has db2look, which can work with Db2 for z/OS, but its output is always LUW syntax
- Db2 Admin Tool has ADB2GEN
- Home-grown solutions: REXX and ISPF file tailoring
- Renaming objects is harder than it sounds due to views, triggers
- Many vendor solutions available

What are our options to copy data?

- Every Db2 shop has Unload/Load (either from IBM or vendor)
- Every Db2 shop has DSN1COPY
- ADRDSSU always available, can trigger FlashCopy2

	Ease of use	Automation	Flexibility	Speed	Aware of Db2
Unload/Load	?	?	?	?	?
DSN1COPY	?	?	?	?	?
ADRDSSU / FlashCopy2	?	?	?	?	?
Vendor solutions	?	?	?	?	?

Copying the data with Unload/Load

- Easy to use, is often the go-to solution
- Db2 manages space for you
- Use LISTDEF and TEMPLATE to process many objects at once
- Changing SYSPUNCH may be tedious
  - Change table names
  - Change RESUME YES to RESUME NO REPLACE
  - Add OVERRIDE (SYSTEMPERIOD, IDENTITY, TRANSID, NONDETERMINISTIC), add ENFORCE NO
- Slow

Copying the data with Unload/Load

- DOs and DON'Ts:
  - Use SPANNED YES for LOB and XML data
  - Use IDXDEFER ALL with partition level LOAD, then rebuild indexes
  - Identify and skip empty partitions (this can save you hours)
  - Use the cross loader if possible
  - Do not use FORMAT INTERNAL – unreliable
  - Do not use partlevel LOAD if number of partitions or limit keys differ

Identity columns and sequences

- Must be adjusted in target
- Use MAXASSIGNEDVAL + INCREMENT as new value
- Sequence objects: Use ALTER SEQUENCE RESTART WITH
- Identity columns: Use ALTER TABLE ALTER COLUMN RESTART WITH
- Implicit XML sequences: Query repeatedly to increase value
  - Cannot be altered directly
  - SQLCODE = -20142, ERROR: SEQUENCE CANNOT BE USED AS SPECIFIED

Why do Unload/Load based copies fail?

- During Unload/Load:
  - Missing authorization
  - Missing or incomplete target objects
  - Incompatible target object (e.g., insufficient column length, wrong code page)
  - Insufficient work data sets for sort
  - Objects in use by other utility

Why do Unload/Load based copies fail?

- Post Unload/Load:
  - Incorrect sequences and identity columns
  - Inaccessible due to restricted states
  - Inconsistencies if data was unloaded with SHRLEVEL CHANGE

Transfer Unload files from/to non-z/OS

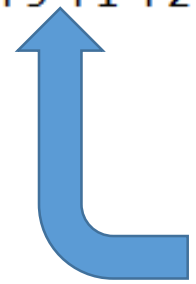
- Either use FORMAT DELIMITED, then FTP as text
  - Does not work well for binary data, LOB, XML
- Or use standard LOAD format, then FTP as binary
  - Either use: **`QUOTE SITE RDW`**
    Each record is prefixed by a 4 byte field, first 2 bytes = length
  - Or use: **`QUOTE STRU R`**
    X'FF01' = end of record, X'FF02' = end of file, X'FF' becomes X'FFFF'
- Properly transfer VBS data sets with binary data
  - Use: **`QUOTE MODE B`**, then **`QUOTE TYPE E`**
  - Use: **`SITE LRECL=X RECFM=VBS BLOCKSIZE=27998`**
  - On a PC, you will need a separate program to split/merge record fragments

Transfer Unload files from/to non-z/OS

- Binary transfer with file structure: Record ends are lost

```
 -----------
1.3
F0F
103
 -----------
1234...8
FFFF00FF
123412F8
 -----------
```

```
Offset(h)  00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
00000000   F1 00 F3 F1 F2 F3 F4 01 02 FF F8                ñ.óñòóô..ÿø
```

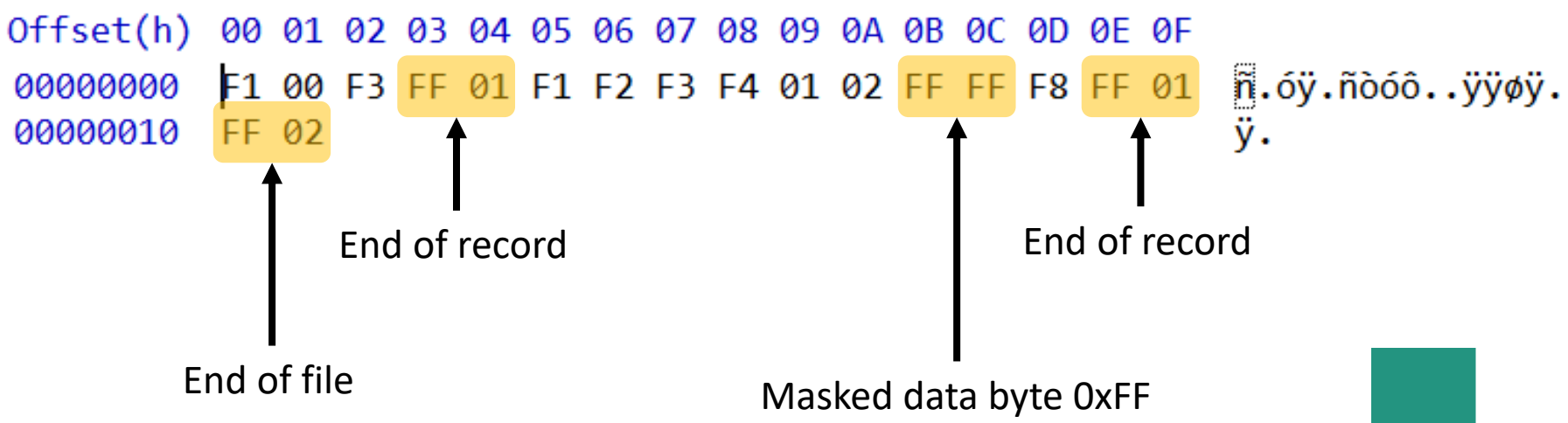


First record ends right here, but there is nothing that would indicate that

Transfer Unload files from/to non-z/OS

- Binary transfer with record structure

```
 ----------
1.3
F0F
103
 ----------
1234...8
FFFF00FF
123412F8
 ----------
```



What are our options to copy data?

- Every Db2 shop has Unload/Load (either from IBM or vendor)
- Every Db2 shop has DSN1COPY
- ADRDSSU always available, can trigger FlashCopy2

	Ease of use	Automation	Flexibility	Speed	Aware of Db2
Unload/Load	Good	Fair	Good	Bad	Yes
DSN1COPY	?	?	?	?	?
ADRDSSU / FlashCopy2	?	?	?	?	?
Vendor solutions	?	?	?	?	?

Copy the data with DSN1COPY

- Much faster than Unload/Load
- Works outside of Db2
- Need to allocate target VSAM clusters
- Need to check object compatibility **very thoroughly**
- Need to write / generate a lot of JCL with correct SYSXLAT members

Find all LOB tablespaces for a given table

```
SELECT
  STRIP(R.TBOWNER)        AS "BASE_TBCREATOR",
  STRIP(R.TBNAME)         AS "BASE_TBNAME",
  STRIP(R.COLNAME)        AS "BASE_COLNAME",
  R.PARTITION             AS "PARTITION",
  STRIP(S.DBNAME)         AS "LOB_DBNAME",
  STRIP(S.NAME)           AS "LOB_TSNAME",
  S.PGSIZE                AS "LOB_PGSIZE",
  S.DSSIZE                AS "LOB_DSSIZE",
  STRIP(R.AUXTBOWNER)     AS "AUX_TBCREATOR",
  STRIP(R.AUXTBNAME)      AS "AUX_TBNAME",
  STRIP(X.CREATOR)        AS "AUX_IXCREATOR",
  STRIP(X.NAME)           AS "AUX_IXNAME",
  X.PGSIZE                AS "AUX_IXPGSIZE",
  X.PIECESIZE             AS "AUX_IXPIECESIZE"
FROM
  SYSIBM.SYSAUXRELS R
INNER JOIN
  SYSIBM.SYSTABLES T
ON
  T.CREATOR = R.AUXTBOWNER AND
  T.NAME = R.AUXTBNAME
INNER JOIN
  SYSIBM.SYSTABLESPACE S
ON
  S.DBNAME = T.DBNAME AND
  S.NAME = T.TSNAME
INNER JOIN
  SYSIBM.SYSTABLEPART P
ON
  S.DBNAME = P.DBNAME AND
  S.NAME = P.TSNAME AND
  P.PARTITION IN (0 , 1)
INNER JOIN
  SYSIBM.SYSINDEXES X
ON
  X.TBCREATOR = R.AUXTBOWNER AND
  X.TBNAME = R.AUXTBNAME
INNER JOIN
  SYSIBM.SYSINDEXPART XP
ON
  XP.IXCREATOR = X.CREATOR AND
  XP.IXNAME = X.NAME AND
  XP.PARTITION IN (0 , 1)
WHERE
  R.TBOWNER = ? AND
  R.TBNAME = ?
FOR READ ONLY WITH UR
```


UBS HAINER

Find eligible image copy

```
SELECT
  DSNUM         AS IQDSNUM,
FROM
  SYSIBM.SYSCOPY
WHERE
  DBNAME = ? AND
  TSNAME = ? AND
  DSNUM IN (0, 1) AND
  ICTYPE = 'F' AND
  (
    STYPE IN (' ', 'R', 'S', 'W', 'X') OR
    (STYPE = 'T' AND DSNUM <> 0) OR
    (STYPE = 'T' AND DSNUM = 0
       AND LOWDSNUM = 1 AND HIGHDSNUM = 1)
  ) AND
  SHRLEVEL IN ('R', 'C')
ORDER BY
  TIMESTAMP DESC
FOR READ ONLY WITH UR
```

- IQDSNUM = 0: Tablespace level
- IQDSNUM > 0: Partition level
- Considers FlashCopy consistent image copies

Find eligible image copy

```
SELECT
  STRIP(C1.DSNAME)  AS ICDSN,
  C1.TIMESTAMP      AS ICTS,
  HEX(C1.START_RBA) AS ICRBA,
  C1.DEVTYPE        AS ICDEVT,
  C1.DSVOLSER       AS ICVOL,
  C1.ICUNIT         AS ICUNIT,
  C1.FILESEQNO      AS ICSEQNO,
  C1.NPAGESF        AS ICNPAGES,
  C1.ICBACKUP       AS ICBACKUP,
  C1.ICTYPE         AS ICTYPE,
  C1.STYPE          AS ICSTYPE
FROM
  SYSIBM.SYSCOPY C1
WHERE
  C1.DBNAME = ? AND
  C1.TSNAME = ? AND
  C1.ICTYPE = 'F' AND
  C1.DSNUM = ? AND
  C1.STYPE IN (' ', 'R', 'S', 'T', 'W', 'X') AND
  C1.SHRLEVEL IN ('R', ?)
AND (
    C1.DSNUM = 0
    OR EXISTS (
    SELECT * FROM SYSIBM.SYSCOPY C2
      WHERE C2.START_RBA = C1.START_RBA
      AND C2.DSNUM = 1
    )
  )
  AND (
    C1.DSNUM = 0
    OR EXISTS (
      SELECT * FROM SYSIBM.SYSCOPY C3
        WHERE C3.START_RBA = C1.START_RBA
        AND C3.DSNUM = ?
    )
  )
ORDER BY
  C1.TIMESTAMP DESC
FOR READ ONLY
```

- Makes sure that partition level copies are only picked up if a copy was made for all partitions

Allocate target objects

- PBG tablespaces often problematic since Db2 can add partitions
  - Might create additional LOBs (and indexes), XML tablespaces (and indexes)
- Target PBG has fewer parts: Use ALTER TABLE ADD PARTITION
- Target PBG has too many parts:
  - Either: Drop and recreate
  - Or in V12: REORG with DROP_PART YES
  - Or in V11: REORG_DROP_PBG_PARTS = ENABLE
  - Neat trick: Empty all target partitions using LOAD REPLACE with empty SYSREC before the copy, then ignore extra partitions

Allocate target objects

- Non-partitioned tablespaces: Up to 32 VSAMs, use IDCAMS
- # of pieces based on TYPE, DSSIZE, PGSIZE, NUMPAGESF:

```
/* Get piece size (non-LOBS) or DSSIZE (LOBs) */
IF TYPE = "O" THEN DSSIZE_IN_KB = DSSIZE * 1024 * 1024
ELSE DSSIZE_IN_KB = 2 * 1024 * 1024
/* Correction for LOBs with DSSIZE 4 G */
IF DSSIZE_IN_KB = 4096 * 1024 THEN DSSIZE_IN_KB = 4095 * 1024
/* Calculate number of pieces */
SIZE_IN_KB = (NPAGESF * PGSIZE)
NUMPIECES = SIZE_IN_KB % DSSIZE_IN_KB
REMAINDER_IN_KB = SIZE_IN_KB // DSSIZE_IN_KB
IF REMAINDER_IN_KB > 0 THEN NUMPIECES = NUMPIECES + 1
```

Allocate target objects

- Popular choice PRIQTY -1 SECQTY -1 causes problems with copy programs that work outside of Db2
- Inspect actual HI-U-RBA or use SYSIBM.SYSCOPY.NPAGESF
  - Non-partitioned TS or partition level copy of partitioned TS:
    `NPAGESF * PGSIZE`
  - TS-level copy of range-partitioned TS (average size per partition):
    `((NPAGESF * PGSIZE) + NUMPARTS – 1) / NUMPARTS`
  - Non-partitioned TS with *n* pieces or TS-level copy of PBG with *n* partitions:
    Piece 1 to (*n*-1): **`DSSIZE`**
    Piece *n*: **`MOD(NPAGESF * PGSIZE, DSSIZE)`**

Allocate target objects

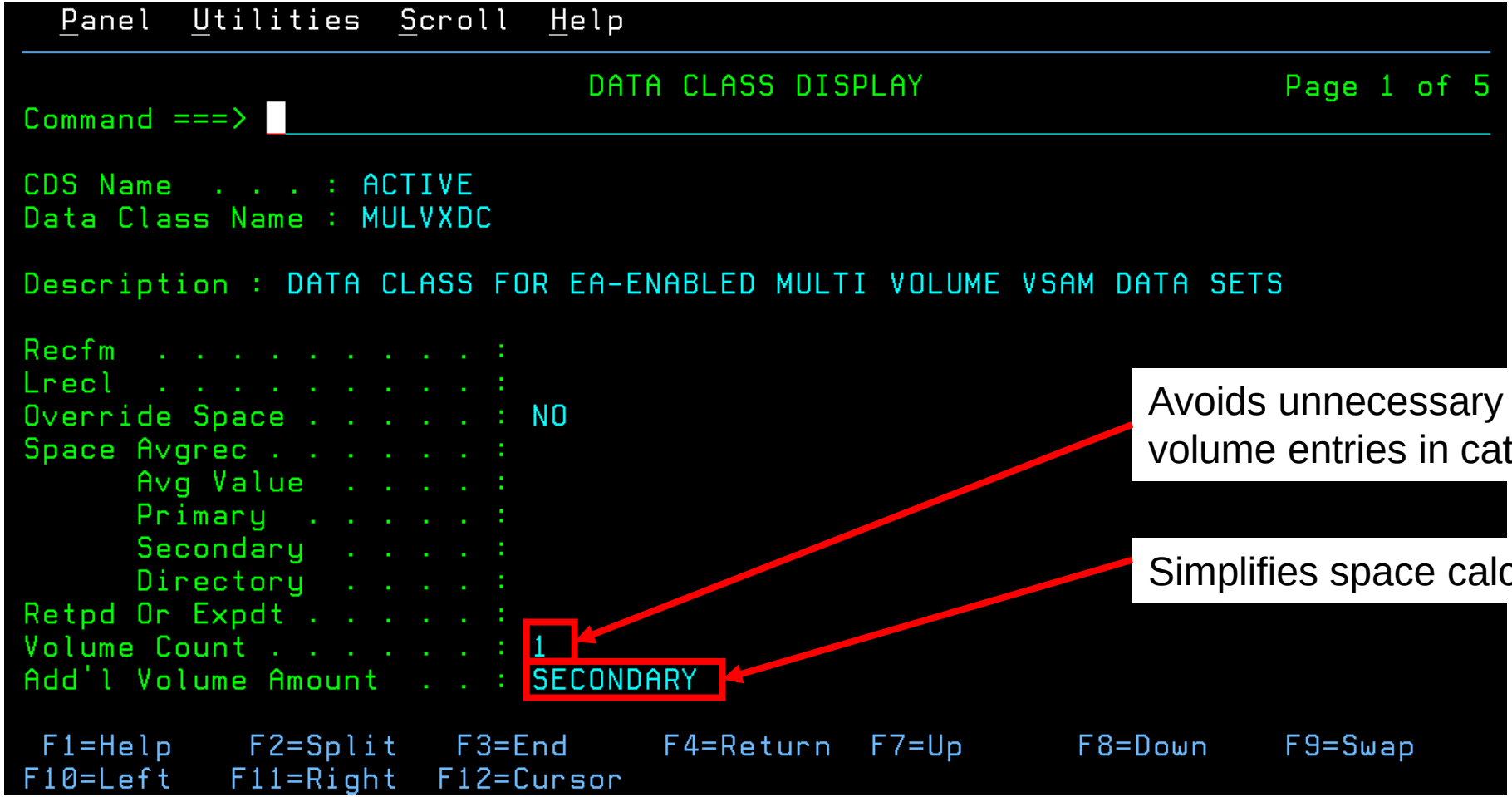
```
HI-A-RBA------4294377472
HI-U-RBA------4293918720
```

Allocated: 4,294,377,472 Bytes = 4,095.4375 MB
Used: 4,293,918,720 Bytes = 4,095.0000 MB

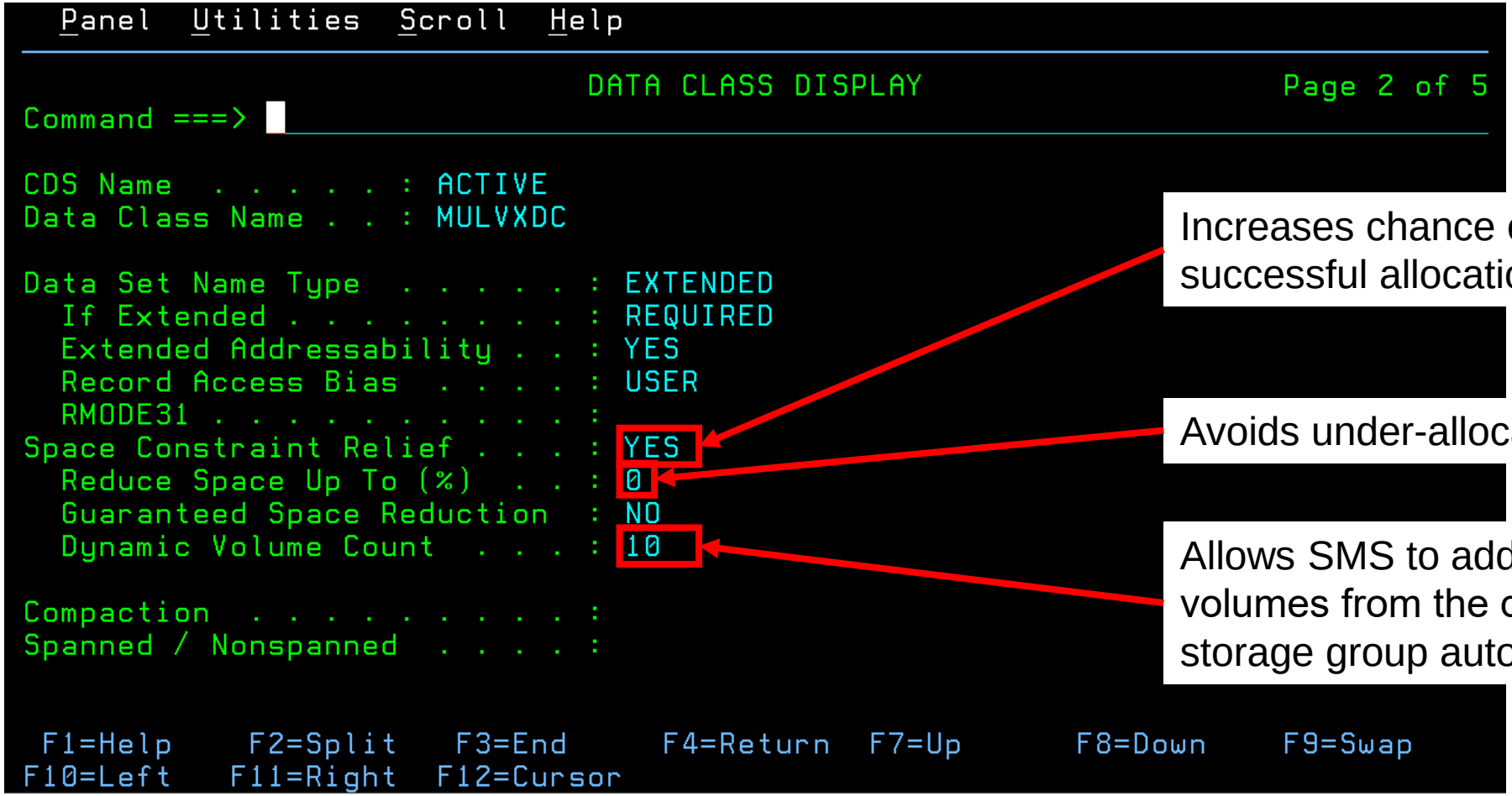
- LOBs with DSSIZE 4 G only use 4095 MB
  - When non-EA: Final HI-A-RBA must be between 4095 and 4096 MB
  - Use MEGABYTES(94, 200) in your IDCAMS statement (YMMV)
- Pitfall: Partitioned objects with DSSIZE 4 G use 4096 MB
- **Best way:** Total size as PRIQTY, let SMS handle the details
  - This minimizes the number of extents (good performance)

```
DEFINE CLUSTER(CISZ(32768) REUSE LINEAR SHR(3 3) -
   NAME(DSNC10.DSNDBC.BIGLOBDB.L1.I0001.A001)) -
   DATA(NAME(DSNC10.DSNDBD.BIGLOBDB.L1.I0001.A001) -
   KILOBYTES(4193280 419328))
```

SMS settings that make your life easier



SMS settings that make your life easier

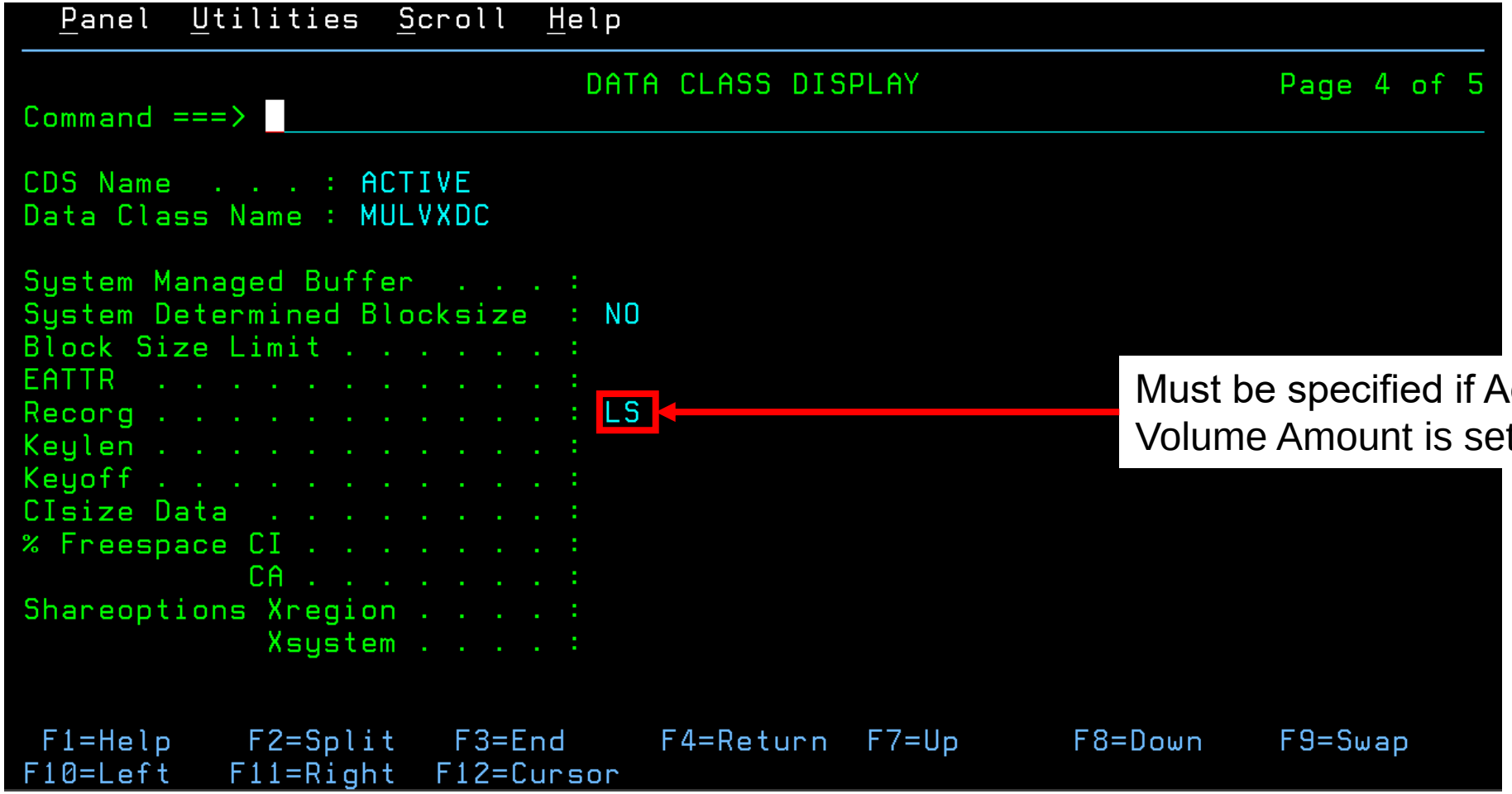


Increases chance of successful allocation

Avoids under-allocation

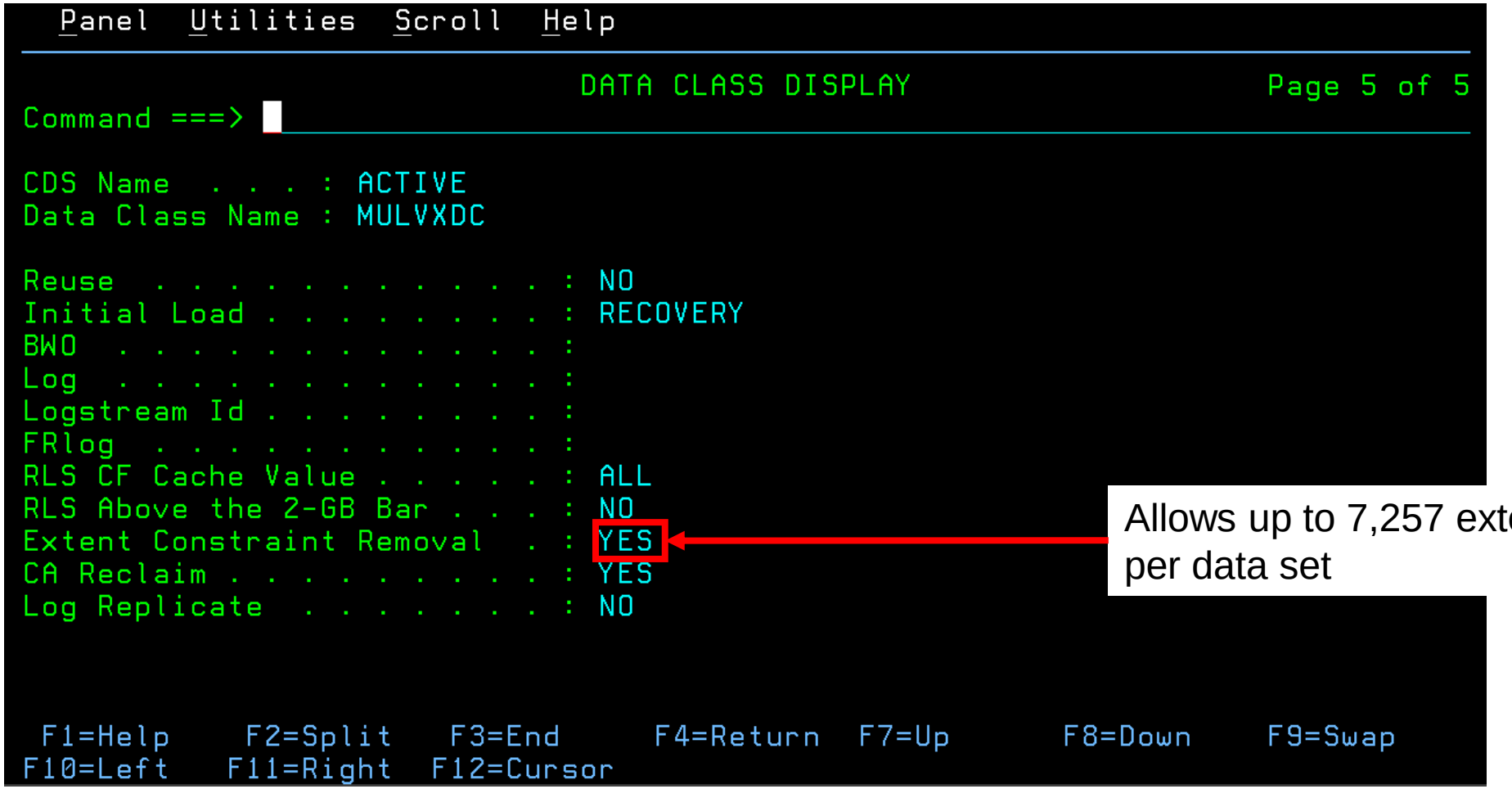
Allows SMS to add more volumes from the data set's storage group automatically

SMS settings that make your life easier

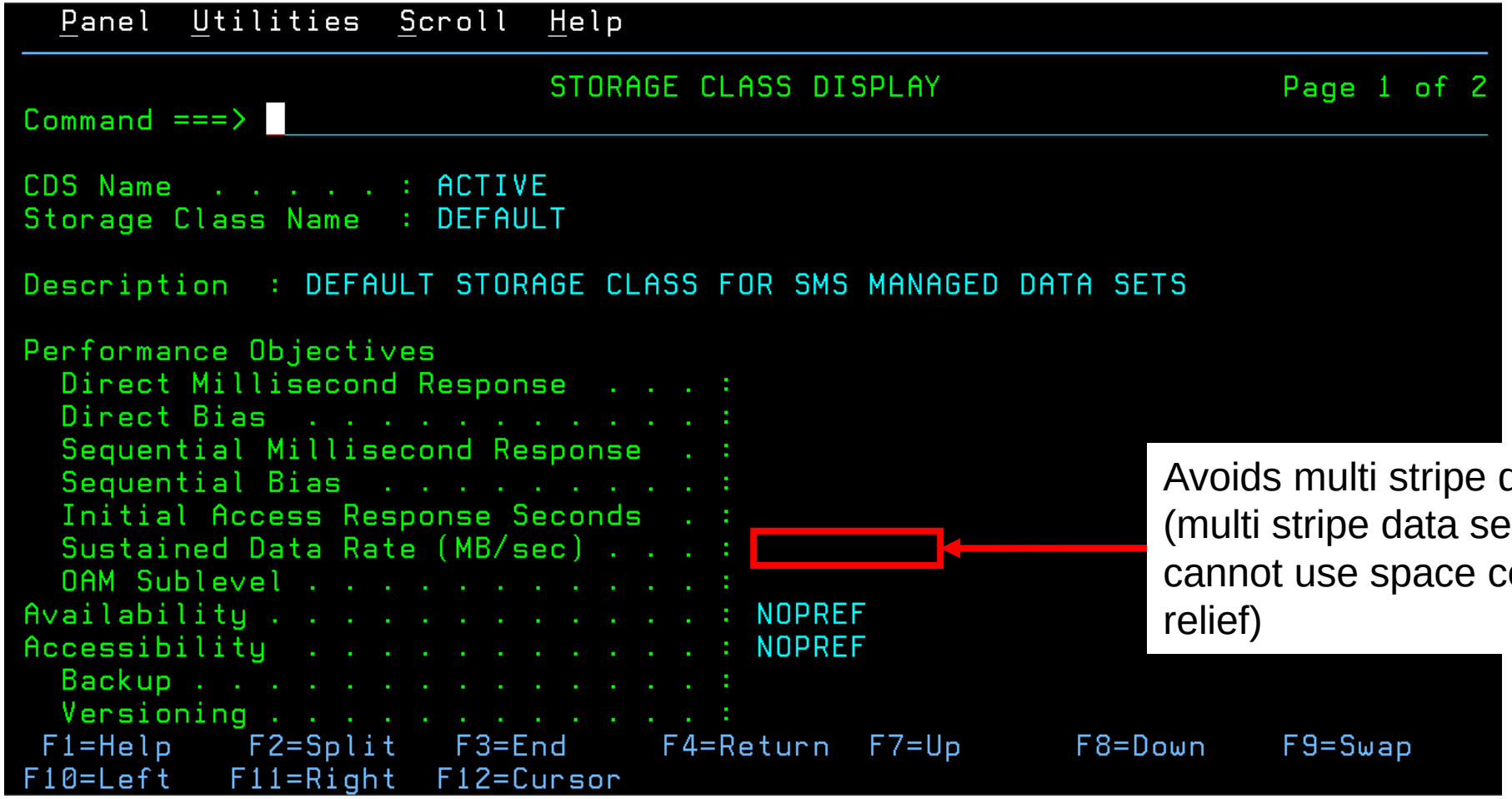


Must be specified if Add'l Volume Amount is set

SMS settings that make your life easier

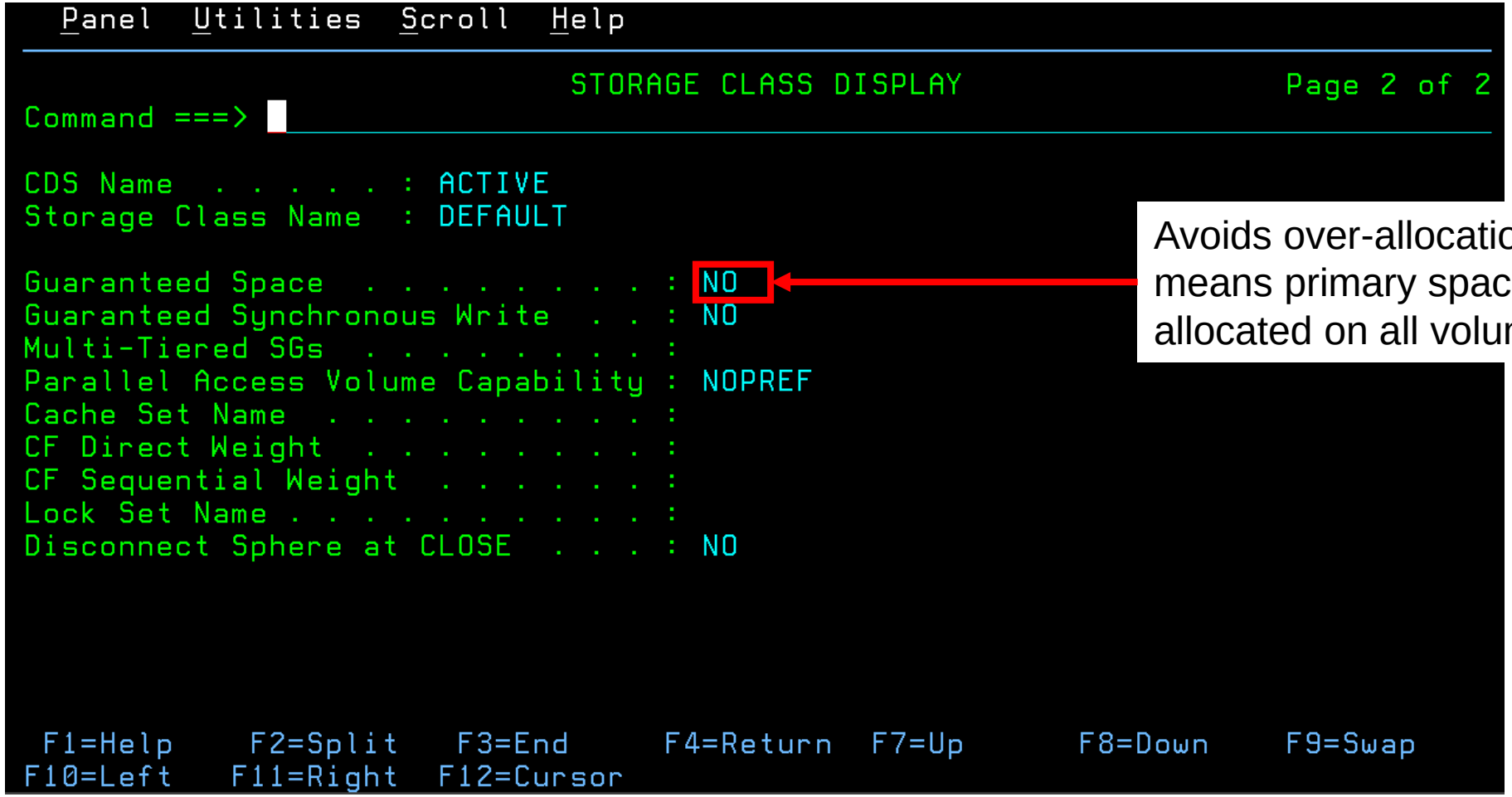


SMS settings that make your life easier



Avoids multi stripe data sets (multi stripe data sets cannot use space constraint relief)

SMS settings that make your life easier



Avoids over-allocation (YES means primary space is allocated on all volumes)

Copying the data with DSN1COPY

- You need a script to generate required jobs (could be several thousand job steps)
- Not very scheduler friendly
  - Can be invoked from REXX in one single job step via **`ADDRESS ATTCHMVS "DSN1COPY <parms>"`**
  - Requires dynamic allocation and error handling in REXX
- Read my rant at: http://ubs-hainer.com/solutions/bcv5/things-to-consider-when-using-dsn1copy-3

Adjust version numbers, RBA / row format

- Extremely important after DSN1COPY based copy
- Failure to do so can lead to INCORROUT, ABEND S04E, S04F
- Db2 V10: Use REPAIR VERSIONS
- Db2 V11, V12: Use REPAIR CATALOG
- Problem:
  - Adjusting version numbers requires system pages
  - No system pages if tables have never been altered
  - This is changing (PI86880, UI51746)

Copying catalog statistics and RTS

- Catalog statistics are important for the Db2 optimizer
  - Dynamic SQL: Copy statistics
  - Static SQL: Copy statistics, rebind plan
- Rebind after updating catalog statistics
- Do not forget to rebind implicit trigger packages
  - Basic triggers: REBIND TRIGGER PACKAGE (*creator*.*name*)
  - Advanced triggers: Basic triggers: REBIND PACKAGE (*creator*.*name*.(*))
- RTS are important when UTSORTAL = YES

Rebuild indexes

- Use dynamic allocation of sort work data sets
  - Specify SORTDEVT, do not specify SORTNUM (or set IGNSORTN=YES)
  - Remove DFSORT related DDs from utility jobs
- Make sure to copy RTS for index first
- If RTS for index is unavailable:
  - Make sure you have good RTS for associated tablespace
  - REPAIR OBJECT SET INDEXSPACE (*dbname*.*spacenam*) RBDPEND
  - Then rebuild index

Identity columns and sequences

- Must be adjusted in target
- Use MAXASSIGNEDVAL + INCREMENT value
- Sequence objects: Use A TART WITH
- Identity co OLUMN RESTART WITH
- Implicit XML sequences: Query repeatedly to increase value
  - Cannot be altered directly
  - SQLCODE = -20142, ERROR: SEQUENCE CANNOT BE USED AS SPECIFIED

Same as for Unload/Load

Copying the data with DSN1COPY

- DOs and DON'Ts:
  - Pre-allocate all target VSAMs with the correct size
  - Check for restricted states in the source
  - Don't copy XML tablespaces into another Db2 subsystem
  - Don't copy from an object that has not been reorganized after the most recent ALTER TABLE or DROP TABLE
  - Don't copy partitioned tablespaces if partitions have been rotated, or if partitions have been inserted at any position other than the end
    - You'd think that „Relative Page Numbering" helps, but it does not

Why do DSN1COPY based copies fail?

- During file system level copy:
  - Missing target page set
  - Cannot extend target page set or grow beyond 4 GB if non-EA
  - Remains of dropped tables in source causes OBID translation errors

Why do DSN1COPY based copies fail?

- Post file system level copy:
  - Did not include all source data sets
  - Incorrect sequences and identity columns
  - Did not take care of restricted states
  - Did not rebuild all target indexes
  - Incorrect OBID translation, log RBA, level ID
  - Did not do REORG before, REPAIR CATALOG after copy
  - Versioning problems / did not run REPAIR CATALOG in target
  - Copy was made despite structural incompatibilities

Fun with versions after APAR PI57004

- REPAIR CATALOG can have unexpected results:
  - Source tablespace and table are both version *x*, freshly reorged
  - Tablespaces and tables are 100% compatible
  - You run DSN1COPY, REPAIR CATALOG
  - You check the target catalog and it says version *x+1*
- Reason: TIMESTAMP or DECIMAL columns in the source table
  - TIMESTAMP columns problematic if source was created in V10 or older
  - DECIMAL columns problematic if source was created in V7 or older

My biggest problem with DSN1COPY

- There are situations where the copy process itself succeeds, and the target objects *look* OK, and *seem* to be accessible, but on occasion accessing the target tables will produce abend S04E with reason 00C90101 or similar reason codes.
- It’s usually caused by missing REORGs / wrong SYSXLAT
- It can still be very hard to detect

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- ADRDSSU always available, can trigger FlashCopy2

	Ease of use	Automation	Flexibility	Speed	Aware of Db2
Unload/Load	Good	Fair	Good	Bad	Yes
DSN1COPY	Bad	Bad	Bad	Good	Yes
ADRDSSU / FlashCopy2	?	?	?	?	?
Vendor solutions	?	?	?	?	?

What about ADRDSSU / FlashCopy2?

- NOT a good tool to copy one tablespace to another
- Does not translate DBID, PSID, OBIDs
  - Some people think they can use the REPAIR utility to fix DBID and PSID, but this is not always true.
- Does not reset log RBAs
- Does not set the PG1COPY flag bit, which is used by REPAIR CATALOG to trigger schema checking
- Read my other rant at: http://ubs-hainer.com/solutions/bcv5/copying-db2-objects-with-flashcopy

After ADRDSSU, use REPAIR to fix Level ID, DBID, PSID, versions.

Table OBID is identical. We change the DBID from 012B to 012C, we change the PSID from 0004 to 0002.

```
DSNU050I    219 22:49:34.20 DSNUGUTC -  REPAIR
DSNU650I  -DBBG 219 22:49:34.21 DSNUCBLI -    LEVELID TABLESPACE TVERSIDX.T1
DSNU683I  -DBBG 219 22:49:34.57 DSNUCBRP - REPAIR LEVELID OPERATION SUCCESSFUL
DSNU050I    219 22:49:34.57 DSNUGUTC -  REPAIR OBJECT
DSNU650I  -DBBG 219 22:49:34.58 DSNUCBRL -    LOCATE TABLESPACE TVERSIDX.T1 PAGE X'00'
DSNU650I  -DBBG 219 22:49:34.86 DSNUCBRP -    VERIFY OFFSET X'000C' DATA X'012B0004'
DSNU652I  -DBBG 219 22:49:34.86 DSNUCBRR - VERIFY OPERATION SUCCESSFUL
DSNU650I  -DBBG 219 22:49:34.86 DSNUCBRP -    REPLACE OFFSET X'000C' DATA X'012C0002'
DSNU656I  -DBBG 219 22:49:34.91 DSNUCBRR - REPLACE OPERATION SUCCESSFUL, DATA WAS X'012B0004'
DSNU050I    219 22:49:34.94 DSNUGUTC -  REPAIR
DSNU650I  -DBBG 219 22:49:34.95 DSNUCBVR -    CATALOG TABLESPACE TVERSIDX.T1
DSNU675I  -DBBG 219 22:49:35.27 DSNUCBVR - HIGH VERSION FOR DBID=X'012C' PSID=X'0002' IN THE
                    Db2 CATALOG IS 0, BUT IN THE PAGE SET IS 1.
DSNU675I  -DBBG 219 22:49:35.27 DSNUCBVR - LOW VERSION FOR DBID=X'012C' PSID=X'0002' IN THE
                    Db2 CATALOG IS 0, BUT IN THE PAGE SET IS 1.
DSNU671I  -DBBG 219 22:49:35.27 DSNUCBVR - DBID=X'012C' PSID=X'0002' OBID=X'07D0'
                    TABLE VERSION IN THE CATALOG DOES NOT MATCH THE PAGE SET
DSNU695I  -DBBG 219 22:49:35.29 DSNUCBVR - INFORMATION IN THE CATALOG WAS UPDATED
                    TO MATCH THE PAGE SET
```

Then run REBUILD INDEX. It works, so the tablespace is OK, right?

```
 LISTDEF L1 INCLUDE INDEXSPACES DATABASE TVERSIDX
LISTDEF STATEMENT PROCESSED SUCCESSFULLY
 REBUILD INDEX LIST L1 SHRLEVEL REFERENCE
PROCESSING LIST ITEM: INDEXSPACE TVERSIDX.TVERSIDX
INDEXES WILL BE BUILT IN PARALLEL, NUMBER OF TASKS = 3
MAXIMUM INDEX PARALLELISM IS 3 BASED ON NUMBER OF INDEXES
DSNUCRUL - UNLOAD PHASE STATISTICS - NUMBER OF RECORDS PROCESSED=100000
UNLOAD PHASE COMPLETE - ELAPSED TIME=00:00:00
SORT TASK SW01: 100000 RECORDS SORTED, ESTIMATED 0, VARIATION -1 PERCENT
SORT TASK SW01: USED DFSORT
SORT TASK SW01: MEMORY BELOW THE BAR: OPTIMAL 6 MB, USED 6 MB
DSNURBXC - SORTBLD PHASE STATISTICS - NUMBER OF KEYS=100000 FOR INDEX KAI.TVERSIDX_IX1
SORTBLD PHASE STATISTICS. NUMBER OF INDEXES = 1
SORTBLD PHASE COMPLETE, ELAPSED TIME = 00:00:00
MAXIMUM SORT AMOUNT ESTIMATION VARIATION WAS 0 PERCENT
TOTAL SORT MEMORY BELOW THE BAR: OPTIMAL 6 MB, USED 6 MB
UTILITY EXECUTION COMPLETE, HIGHEST RETURN CODE=0
```

Verify that the data is OK using SELECT *, all is good.

```
PAGE    1
***INPUT STATEMENT:
  SELECT * FROM KAI.SVERSIDX_TB1;
              +-------------------------------------------------------------------------------------------+
              |     COL01      |     COL02      |     COL03      |     COL04      |     COL05      |     COL06      |
              +-------------------------------------------------------------------------------------------+
            1_|              1 |         114921 |         624590 |         550815 |         939021 | ?              |
            2_|              2 |         724429 |         839504 |         684609 |         635107 |         181827 |
            3_|              3 |         552245 |         750931 |         245715 |         751530 |         724362 |
            4_|              4 |         612184 |         519980 |         182482 |         817834 |            464 |
            5_|              5 |         988725 |         654720 |         336550 |         924940 |         426401 |
            6_|              6 |         341380 | ?              |         118057 | ?              |          35152 |
            7_|              7 |         203656 |         182620 |         505645 |         698866 |          45088 |
            8_|              8 |          88569 |         214801 |         809647 |         318800 |         931594 |
            9_|              9 |         308779 |          77896 |         786255 |         919866 |         639709 |
           10_|             10 |         176410 |         847833 |           9513 |         749993 |         675077 |
           11_|             11 |         515483 |         139905 |         555669 |         683022 |         869535 |
```

[many more rows]

```
        99997_|          99997 |         857691 |         335066 |         729772 |          35849 |          22198 |
        99998_|          99998 |          46105 |         953504 |         617066 |         275336 |         766092 |
        99999_|          99999 |         361769 |         913569 | ?              |         819001 |         892942 |
       100000_|         100000 |          35631 |         989423 |         536785 |         986317 |         251987 |
              +-------------------------------------------------------------------------------------------+
SUCCESSFUL RETRIEVAL OF     100000 ROW(S)
```

Wrap things up by running RUNSTATS. Wait a second…

```
 LISTDEF L1 INCLUDE TABLESPACES DATABASE TVERSIDX BASE
LISTDEF STATEMENT PROCESSED SUCCESSFULLY
 LISTDEF L2 INCLUDE INDEXSPACES DATABASE TVERSIDX
LISTDEF STATEMENT PROCESSED SUCCESSFULLY
 RUNSTATS TABLESPACE LIST L1 SHRLEVEL REFERENCE REPORT NO UPDATE ALL HISTORY ALL
TABLE(ALL)
PROCESSING LIST ITEM: TABLESPACE TVERSIDX.T1
UTILITY DATA BASE SERVICES MEMORY EXECUTION ABENDED, REASON=X'00C9021C'
```

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00C9021C

While running a utility, the data manager detected an inconsistent data condition. A row was encountered that is not represented by a record OBD in the database descriptor (DBD). This abend may indicate an internal Db2® error, but most likely occurs due to a user error. Possible user errors may include:

- Data from a Db2 subsystem was copied to another Db2 subsystem incorrectly. This is the most common error.
- DSNDB01.DBD01 was regressed to a time prior to a table being created.

What happened?

DBID X'012B' PSID X'0004'
Table OBID X'07D0'

```
  Jobs  Resources  Devices  Tools  Filter  View  Options  Help
 ------------------------------------------------------------------------------
 DSN1PRNT JOB07063                          <        .DSN1PRNT.SYSPRINT>
 Command ===>
 Current Find Text:
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+---10----+---11-
 PARTITION: # 0002
 PAGE: # 00040000 ------------------------------------------------------------------------------------------
 HEADER PAGE:  PGCOMB='10'X  PGRIGRBA='00000000000000000000'X  PGNUM='00040000'X  PGFLAGS='38'X
               HPGOBID='012B0004'X  HPGHPREF='00042792'X  HPGCATRL='00'X  HPGREL='D7'X  HPGZLD='D3'X
               HPGCATV='00'X  HPGTORBA='000000000000'X  HPGTSTMP='2017072113353763983 7'X
               HPGSSNM='DBBG'  HPGFOID='0003'X  HPGPGSZ='4000'X  HPGSGSZ='0040'X  HPGPARTN='000A'X
               HPGZ3PNO='000000'X  HPGZNUMP='10'X  HPGTBLC='0001'X  HPGROID='07D0'X
               HPGZ4PNO='00040002'X  HPGMAXL='0120'X  HPGNUMCO='0009'X  HPGFLAGS='010C'X
               HPGFLAGS2='00'X  HPGFLAGS3='80'X  HPGCONTM='20170721133806624835'X
               HPGSGNAM='SYSDEFLT'  HPGVCATN='DSNB10  '  HPGRBRBA='000000000000'X
               HPGLEVEL='000000000000'X  HPGPLEVL='000000000000'X  HPGCLRSN='000000000000'X
               HPGSCCSI='0417'X  HPGDCCSI='0000'X  HPGMCCSI='0000'X  HPGPARTNUM='0000'X
               HPGDSSZ='00400000'X  HPGFLAG2='00'X  HPGEPOCH='0001'X  HPGRBLP='000000000000'X
               HPGMASSDELETETIMESTAMP='000000000000'X  HPGDNUMB='01'X  HPGDNUMC='0100'X
               HPGDFSG='00000002'X  HPGDLSG='00000002'X  HPGSISP='00000000'X
               HPGBIGTORBA='00000000000000000000'X  HPGBIGRBRBA='00000000004CD235F77A'X
               HPGBIGLEVEL='00000000004CD235F77A'X  HPGBIGPLEVL='00000000004CD22A43A8'X
               HPGBIGCLRSN='00000000004CD22B7BE7'X  HPGBIGRBLP='00000000000000000000'X
               HPGBIGMASSDELETETIMESTAMP='00000000000000000000'X  FOEND='52'X
 DVI HASH BUCKET:  HPGDBKT#='01'X  HPG1BEYE='4E'X
  F1=Help    F3=Exit    F5=Rfind   F6=Info    F7=Up      F8=Down    F9=Swap   F10=Left   F11=Right  F12=Cancel
```

What happened?

```
  Jobs  Resources  Devices  Tools  Filter  View  Options  Help
 ──────────────────────────────────────────────────────────────────────────────
 DSN1PRNT JOB07063                          <        .DSN1PRNT.SYSPRINT>
 Command ===> 
 Current Find Text:
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+---10----+---11-
   HPGDCOLL#='0100'X  HPG1OBID='07D0'X  HPG1V='01'X  HPG1RID='0004004201'X
 SI HASH BUCKET:  HPGDBKT#='01'X  HPGS1BEYE='E2'X  HPGS1OBI='07D0'X  HPGS1FSG='00000003'X
                  HPGS1CSG='00000003'X  HPGS1LSG='0000009F'X


 PAGE: # 00040001 ------------------------------------------------------------
 SEGMENTED SPACEMAP PAGE:  PGCOMB='00'X  PGBIGRBA='00000000000000000000'X  PGNUM='00040001'X
                           PGFLAGS='30'X  SEGNUM='015B'X  SEGFREE='00BC'X  SEGENT='00A0'X
                           SEGSIZE='0040'X  SEGLENT='00002790'X  SEGBFMEM='00'X  FOEND='42'X
 FIRST PART OF SEGMENTED SPACE MAP:
 SEG 0001   0000000[0004]8 FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
 SEG 0002   00000000001E0 F0000000000000000000000000000000000000000000000000000000
 SEG 0003   0000000407D0C0 FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
 SEG 0004   0000000507D080 FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
 SEG 0005   0000000607D080 FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
 SEG 0006   0000000707D080 FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
 SEG 0007   0000000807D080 FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
 SEG 0008   0000000907D080 FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
 SEG 0009   0000000A07D080 FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
 SEG 000A   0000000B07D080 FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
  F1=Help    F3=Exit    F5=Rfind   F6=Info    F7=Up      F8=Down    F9=Swap   F10=Left   F11=Right  F12=Cancel
```

The PSID appears on the space map page to identify the segment that contains the compression dictionary

Anything else?

- Space map pages and system pages contain PSID and OBIDs
- Number and locations of these pages varies (and so does the offset of the PSID/OBID fields on these pages)
- In the future, there will be system pages even if objects have never been altered
- Remember PI86880, UI51746?

What about ADRDSSU / FlashCopy2?

- DOs and DON'Ts:
  - Don't use ADRDSSU / FlashCopy2 to make a copy from one Db2 tablespace to another
  - No really, don't.

What are our options to copy data?

- Every Db2 shop has Unload/Load (either from IBM or vendor)
- Every Db2 shop has DSN1COPY
- ADRDSSU always available, can trigger FlashCopy2

	Ease of use	Automation	Flexibility	Speed	Aware of Db2
Unload/Load	Good	Fair	Good	Bad	Yes
DSN1COPY	Bad	Bad	Bad	Good	Yes
ADRDSSU / FlashCopy2	Bad	Bad	Bad	Good	No
Vendor solutions	?	?	?	?	?

Conclusion

Conclusion

- Db2 itself does not provide a good mechanism to copy objects
- Problems mainly stem from:
  1. Missing tools for DDL generation
  2. Dependencies between Db2 catalog and contents of page sets
  3. Concept of version numbers after online schema changes
  4. Quirks of the native z/OS file system
- Unload/Load solves problems 2, 3, 4, but is too slow
- DSN1COPY lacks automation, is error prone

Conclusion

- Many Db2 shops simply use Unload/Load
- Some Db2 shops try to automate DSN1COPY
  - Works reasonably well for simple environments
  - Problems arise when newer Db2 features are exploited (table versioning, universal PBG tablespaces, partition rotation, clone tables, adding partitions in the middle of a tablespace, XML, etc.)
  - DSN1COPY may end with return code 0 even if the target is broken

Is there a better way?

- Vendor tools provide a degree of automation that is very hard to achieve manually
- UBS Hainer offers BCV5, which can do everything that was discussed today and more
- It combines unmatched flexibility with a very high copy speed
- BCV5 is easy to use, setting up a copy process takes mere minutes
- BCV5 is very scheduler friendly (fixed number of jobs, static JCL)
- BCV5 can also make consistent copies without stopping the source

UBS HAINER

What are our options to copy data?

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	Ease of use	Automation	Flexibility	Speed	Aware of Db2
Unload/Load	Good	Fair	Good	Bad	Yes
DSN1COPY	Bad	Bad	Bad	Good	Yes
ADRDSSU / FlashCopy2	Bad	Bad	Bad	Good	No
Vendor solutions	We certainly think so.				Yes

Questions or comments?

Thank you for your attention!

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