E82

HALDB Database Administration

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IMS

technical conference

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RETURN TO INDEX

Abstract and Trademarks

Abstract:

High Availability Large Database (HALDB) provides increased flexibility with IMS databases. Database administrators have new options and new tasks with HALDB. This session describes these options and tasks. The processes for adding, deleting, and modifying partitions are explained. The options and recommendations for reorganizations are covered. The requirements for backup and recovery, including time stamp recoveries, are described. Secondary indexes are given special emphasis. HALDB provides new performance options for many databases. These are explained. If you are planning to migrate databases to HALDB, you will want to attend this session.

Trademarks:

Agenda

- Review of database data sets
- Partitions
  - Initialization
  - Sizing
  - Adding, deleting, and modifying partitions
- Reorganizations
- Recoveries
  - Timestamp recoveries
- Test databases
- Secondary indexes
  - Sizing, recoveries, and reorganizations
- Performance

Other HALDB Sessions at This Conference

- E11: An Introduction to IMS HALDB
- C03:HALDB User Experiences at Telcordia

- E30: Application Design and Programming with HALDB
  - Partitioning
  - Order of segments in databases
  - Initial Loads
  - Processing Partitions in Parallel
  - Handling Unavailable Partitions
  - Processing Secondary Indexes as Databases
  - Converting from User Partitioning
- E81: Migrating to HALDB
  - DBDGENs
  - Defining partitions
  - Allocating database data sets
  - Migration unloads and reloads
  - Migrating secondary indexes
  - Migrating from PDB
  - Migrating user partitioned databases

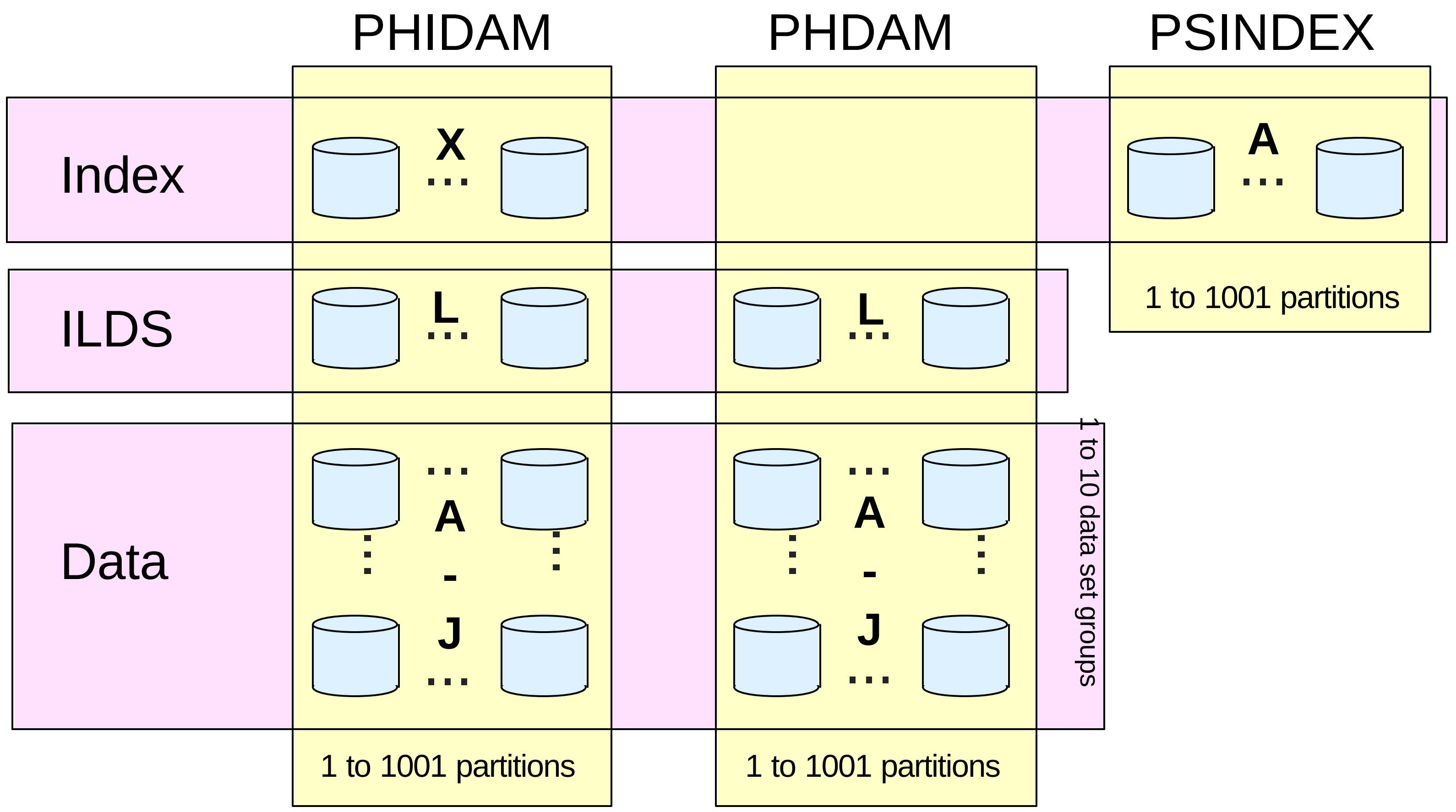
Versions of these presentations are also available on the web. The web versions include notes for each page. See www.ibm.com/support/techdocs and search on "HALDB" or see www.ibm.com/ims and click on "Presentations/papers".

- E55: New News in IMS HALDB Tooling
- H04: HALDB Conversion and Maintenance Aid (hands on workshop)

Agenda

- **Review of database data sets**
- **Partitions**
  - Initialization
  - Sizing
  - Adding, deleting, and modifying partitions
- **Reorganizations**
- **Recoveries**
  - Timestamp recoveries
- **Test databases**
- **Secondary indexes**
  - Sizing, recoveries, and reorganizations
- **Performance**

HALDB Database Data Sets

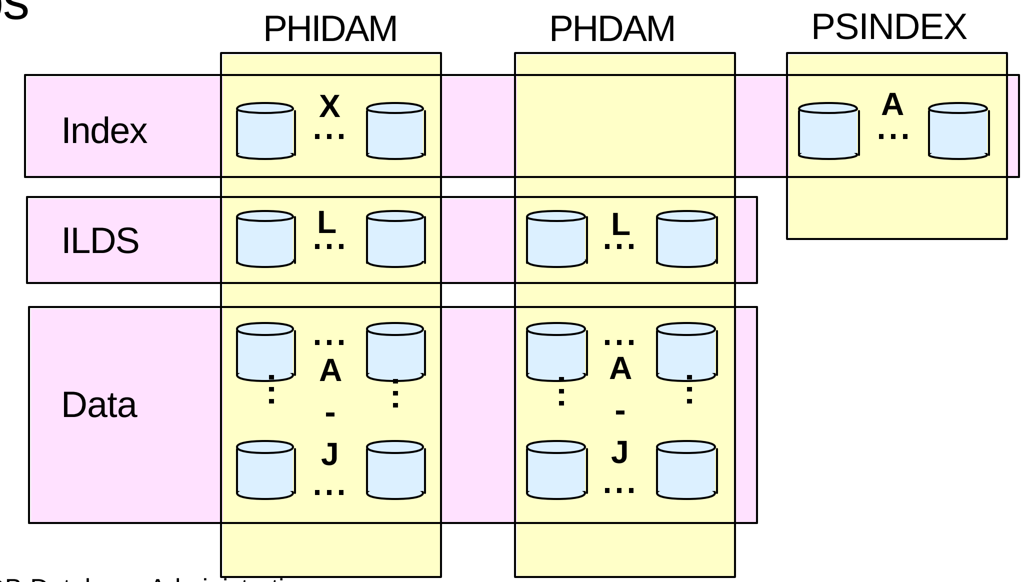


The data sets in a partition have generated data set names and DDNAMEs.
Letters are used to distinguish them.

- X - PHIDAM index
- L - ILDS
- A through J - Data data sets
- A - PSINDEX

HALDB Database Data Sets

- **Each PHDAM or PHIDAM partition requires an ILDS (L)**
  - ILDS is empty if there are no logical relationships or secondary index entries
- **Each PHIDAM partition has an index data set (X)**
- **Each PHDAM or PHIDAM partition has an A data set**
  - Root segments are in the A data sets
- **Each PHDAM or PHIDAM partition may have B-J data sets**
  - Used for multiple data set groups
- **Each PSINDEX partition has an A data set**



Partition Names and IDs

- **Each partition has a name**
  - Unique in the RECONs
    - Partitions in different databases cannot have the same name
    - Partitions cannot have the same name as a database
  - Choices:
    - Name signifies the data in the partition
      - Could cause problems when partitions are modified
    - Name is arbitrarily chosen
- **Each partition has an ID**
  - Number assigned by IMS when partition is created
    - Assigned in creation order
    - Not in key sequence
    - Not reused

HALDB Database Data Sets

Data set names

- Begin with data set name prefix for the partition
  - Up to 37 characters assigned by user
- Letter and Partition ID are used as suffix
  - X for PHIDAM index
  - L for ILDS
  - A for PSINDEX
  - A through J for data
- Example:
  - Partition data set name prefix IMP0.DB.INV23
  - Partition ID: 00004
  - Data set names:

► PHIDAM index:	IMP0.DB.INV23.X00004
► PHIDAM ILDS:	IMP0.DB.INV23.L00004
► PHIDAM first data data set:	IMP0.DB.INV23.A00004

- Each partition in a database may have the same data set name prefix.
  - Partition IDs make names unique.

HALDB DDNAMEs

DDNAMEs

- Begin with the partition name
  - Up to 7 characters assigned by user
- Letter is used as suffix
  - X for PHIDAM index
  - L for ILDS
  - A for PSINDEX
  - A through J for data
- Example:
  - Partition name LBAD112
  - DDNAME for PHIDAM Index: LBAD112X
  - DDNAME for PHIDAM ILDS: LBAD112L
  - DDNAME for first 'data' data set: LBAD112A

Dynamic Allocation

- **Dynamic allocation uses RECON information**
  - All HALDB databases are registered in RECONs
  - DFSMDA members are never used for HALDB
- **If you use a DD statement:**
  - If DD statement conflicts with RECON information, allocation fails
  - If DD statement matches RECON information, allocation succeeds
    - It works as if you had not used a DD statement
- **THEREFORE, do not include DD statements for HALDB**

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Partition Initialization

Partition initialization

- Prepares partition data sets for use
- Ensures that partitions with no data are usable
- Initialization is done either by
  - HALDB Partition Data Set Initialization utility (DFSUPNT0)
    or
  - Database Prereorganization utility (DFSURPR0)
- Database is specified to the utility
  - Partitions with 'partition initialization required' DBRC flag (PINIT) are initialized
    - Exception: DFSUPNT0 has unconditional partition initialization function
      - Invokes initialization for all partitions in the database with or without flag set
      - Specified with INITALL control statement in DFSOVRDS DD data set
      - Introduced by PQ49638 (IMS V7) and PQ55002 (IMS V8)

Partition Initialization

Partition initialization process

- Makes high-used RBA non-zero
  - Writes and erases a record in PSINDEX
- Writes reorg number and partition ID in PHDAM and PHIDAM
- Creates first bit map block in PHDAM and PHIDAM
- Writes high-key (x'FF...FF') record in PHIDAM
- Formats the root addressable area for PHDAM

Partition Initialization

- **Partition initialization is only required in three cases:**
  1. Before initial load (PROCOPT=L) of partition
  2. Before migration reload of partition
     - Input to reload was created by unload of non-HALDB database with MIGRATE=YES or MIGRATX=YES option
  3. Before a partition may be used without containing any data
     - Initial load or reload does not insert any segments in the partition
- **Partition initialization is not required with reorganizations**
  - Not required even when data sets are deleted and redefined
    - Unless the partition is empty
- **'Partition Initialization Required' flag in RECONs**
  - Turned 'on' by partition definition or DBRC command
  - Turned 'off' by partition initialization or DBRC command
  - Authorization fails if the flag is 'on'

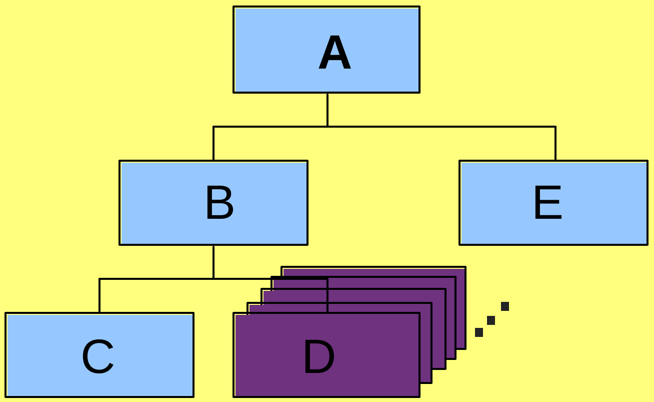
Number of Partitions and Their Sizes

- **Things to consider when choosing the number of partitions**
  - Number of partitions affects the sizes of partitions
  - Time required to reorg partitions in parallel
    - Smaller partitions shorten the process
  - Time required to image copy and recover partition data sets
    - Smaller partitions shorten these processes
  - Smaller partitions may avoid multivolume data sets
    - Especially important with OSAM
  - Management of the data sets
    - More data sets require more management
- **Multiple data set groups**
    - May be advantageous to have only one data set per partition
    - May be advantageous to have multiple data sets

Multiple Data Set Groups

- **HALDB supports multiple data set groups**
  - Multiple data set groups place different segment types in different data sets
  - Should you use them?
- **Multiple data set groups were used for two reasons with non-HALDB**
  1. Avoid data set size limitations
     - Not required with HALDB
  2. Place infrequently used segments in another data set
     - Also applies to HALDB

- Example:
  - Place D segments in a data set group
  - Increases likelihood that E will be in the same block with A



Database Compression

- **HALDB supports segment edit/compression routines**
  - Should you use them for compression?
- **Reasons to use compression with HALDB:**
  - Saves DASD space
  - May improve performance
    - Reduces I/Os required to retrieve and write data
- **Reasons not to use compression with HALDB:**
  - Not needed to avoid data set size limitation
  - May hurt performance
    - CPU costs for compression and expansion of segments
      - Probably not significant

Adding, Deleting, and Changing Partitions

- **Databases change over time**
  - The sizes of partitions may change over time
    - Data added and deleted
  - The high keys of partitions may need to be adjusted over time
    - Different amounts of data added or deleted to different partitions
      - Example: Root keys based on date
- **Databases need to be adjusted over time**
  - Partition may needed to be split, consolidated, created, or deleted
  - Partition boundaries (high keys) may need to be adjusted

HALDB Migration Aid Utility

HALDB Migration Aid utility (DFSMAID0)

- Reads HDAM, HIDAM, Secondary Index databases
  - Provides sizing and high key information for migration planning
  - Secondary index support
    - Provides key range boundaries and numbers of records
      - Secondary index 'bytes' and 'prefix-incr' information are inaccurate in the report!
      - Number of segments and high key values are accurate in the report
      - Sizes are easily calculated from the numbers of records
- Reads PHDAM, PHIDAM, and PSINDEX databases
  - Provides sizing and high key information for repartitioning planning

HALDB Migration Aid Utility

Sample report:

```
  partition 1 :

     minimum key =

        +0000  d2c1c1f1 f1f2f3f4    |KAA11234 |

     maximum key =

        +0000  d2f2f3f9 f9f2f3f4    |K2399234 |

                      segments         bytes   prefix-incr   length-incr
     1) 'PRODUCT '       31567       4040576        252536             0
     2) 'INVENT'        103781       8094918        830248             0
     3) 'ORDQTY'        171182      10955648       1369456             0
     4) 'MFGSPECS'       51115      10938610        408920             0
   SUM)                 357645      34029752       2861160             0
```

segments	- number of segments
bytes	- number of bytes for the segments
prefix-incr	- additional bytes due to increased prefix size
length-incr	- additional bytes required for paired logical relationships

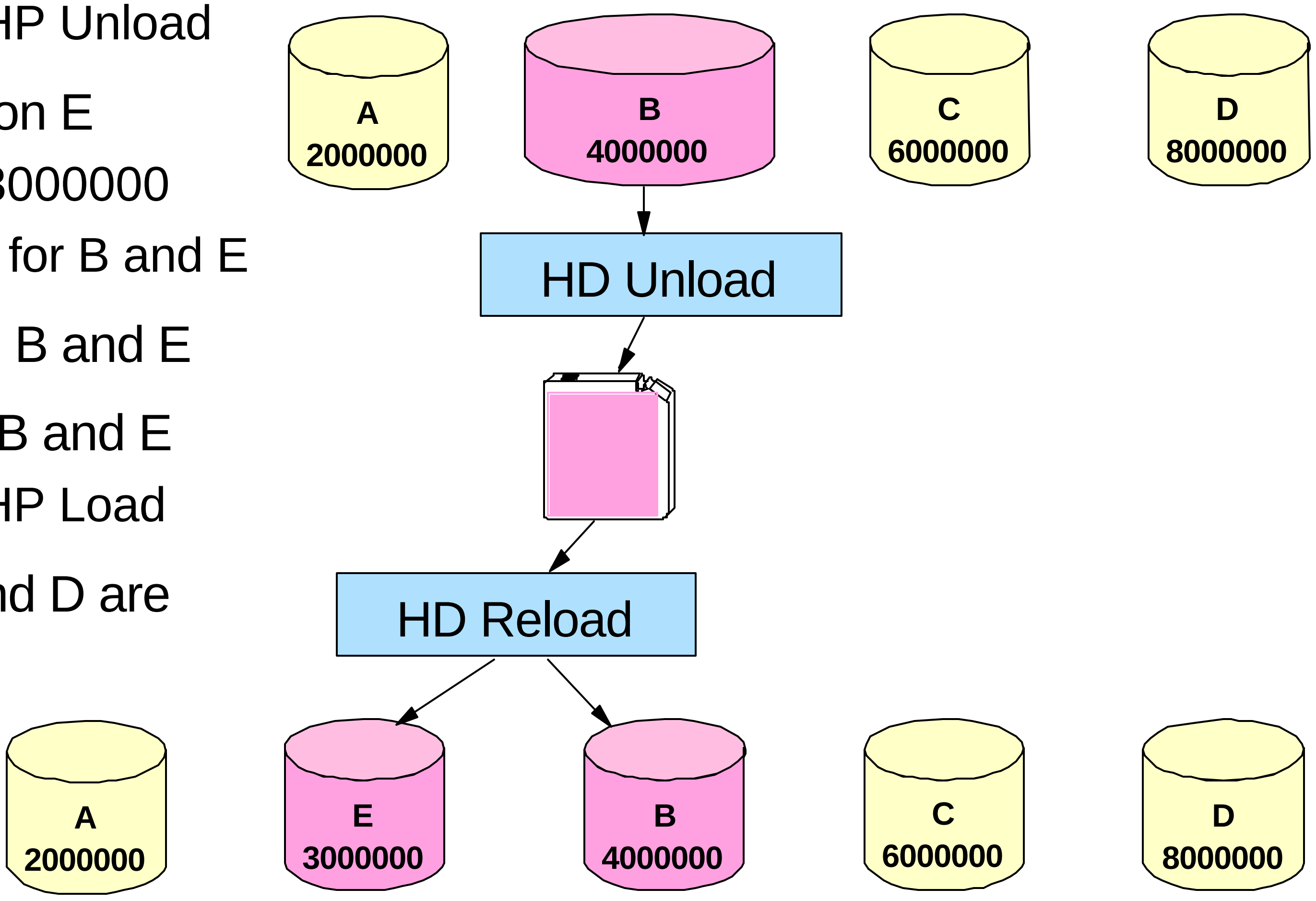
HALDB Migration Aid Utility

Using the Migration Aid utility

- You may specify one of the following:
  - Number of equal sized partitions
  - Number of segment bytes per partition
  - High keys for partitions
- Report for each partition and the entire database
- Bytes in reports do not include free space, bit maps, RAPs, or FSEAPs
  - You must adjust for these!

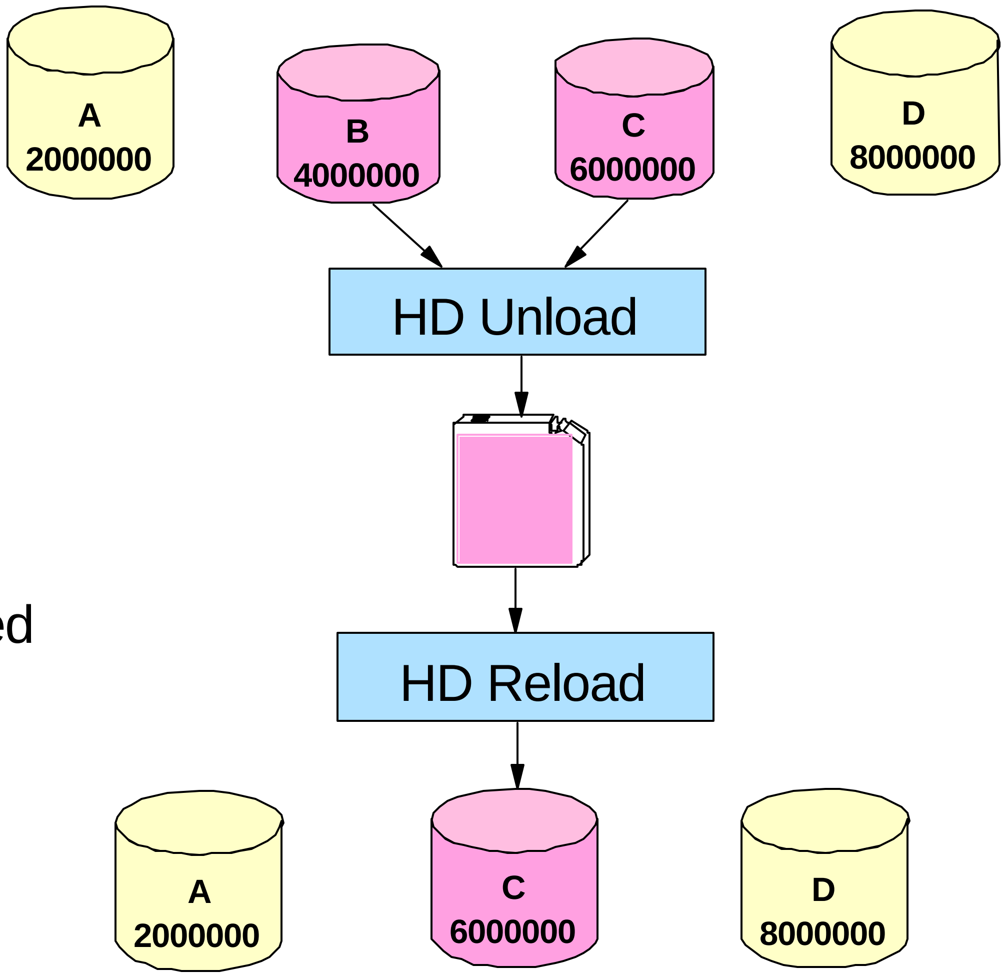
Splitting a Partition

- **If partition B with high key 4000000 needs to be split**
  - Unload partition B
    - HD Unload or HP Unload
  - Define new partition E
    - With high key 3000000
    - Sets PINIT flag for B and E
  - Initialize partitions B and E
  - Reload partitions B and E
    - HD Reload or HP Load
  - Partitions A, C, and D are not affected



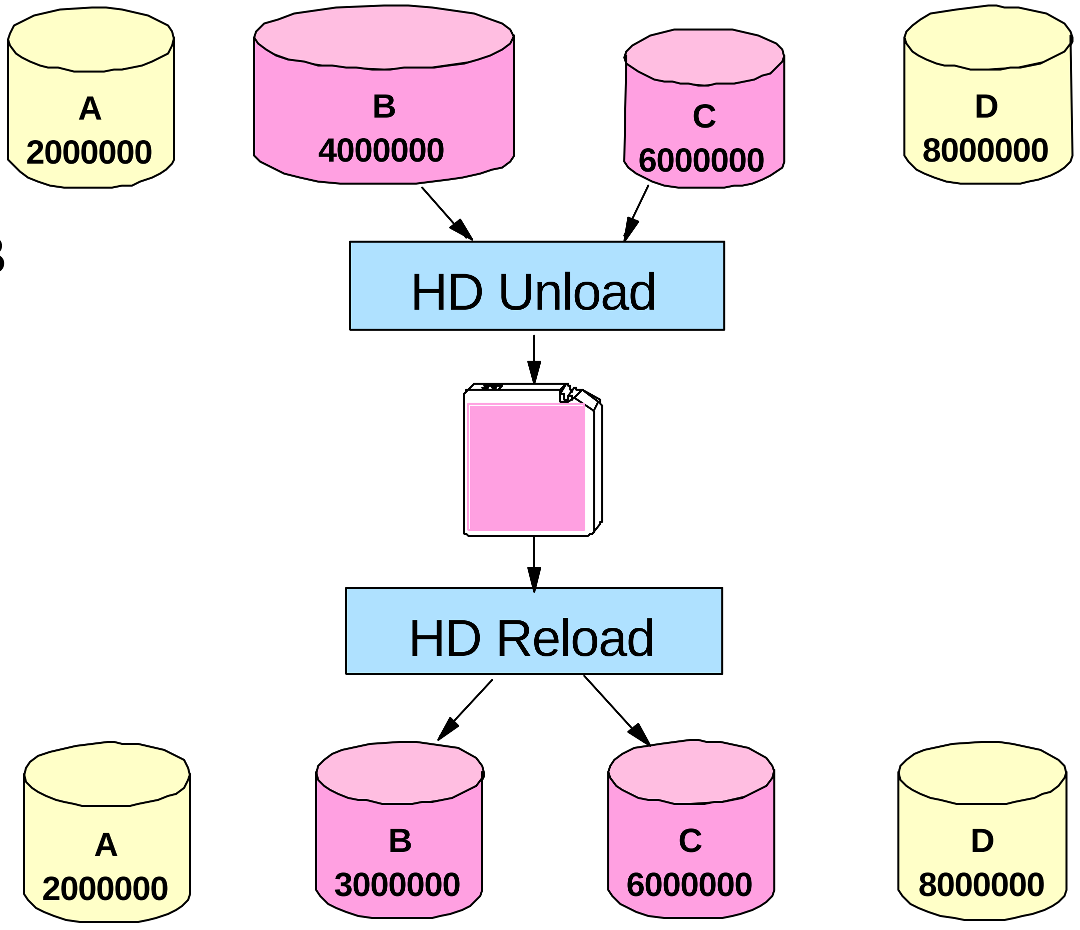
Combining Partitions

- **If partitions B and C with high keys 4000000 and 6000000 need to be combined**
  - Unload partitions B and C
    - HD Unload or HP Unload
  - Delete definition of partition B
    - Sets PINIT flag for C
  - Initialize partition C
  - Reload partition C
    - HD Reload or HP Load
  - Partitions A and D are not affected



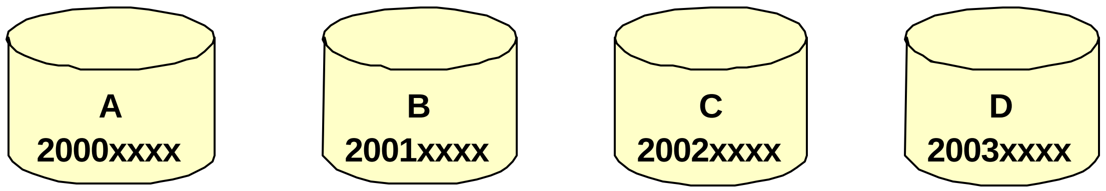
Modifying Partition Boundaries

- **If records need to be moved from partition B to C**
  - Unload partitions B and C
    - HD Unload or HP Unload
  - Change high key for partition B
    - From 4000000 to 3000000
    - Sets PINIT flag for B and C
  - Initialize partitions B and C
  - Reload partitions B and C
    - HD Reload or HP Load
  - Partitions A and D are not affected

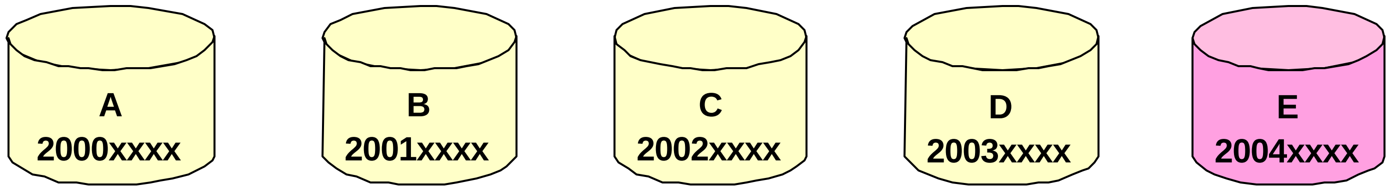


Databases with Dates for Keys

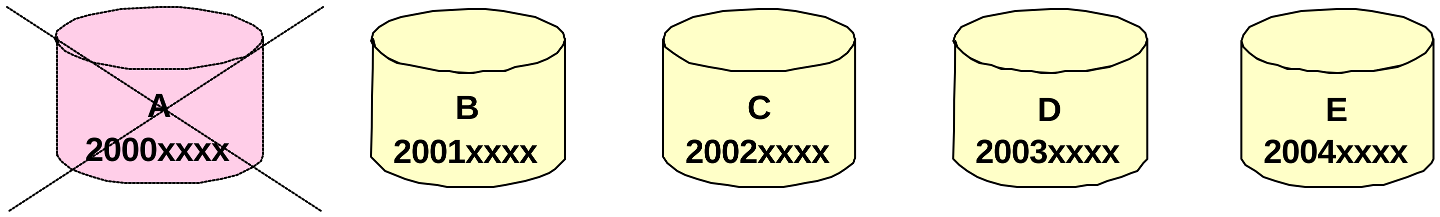
Some databases have dates as the high-order part of the key



- To add a partition for a set of dates (higher keys)
  - Define it and initialize it



- To delete the partition with the lowest dates (keys) and all of its data
  - Delete the partition definition



- Unloads and reloads are not required for these changes

Disabling and Enabling Partitions

- **Disabling and enabling of partitions was introduced by APARs**
  - PQ48421 for IMS V7
  - PQ73858 for IMS V8
- **Disabling partitions**
  - Definitions and information remain in RECONs
    - Includes partition IDs, DSN prefixes, and recovery information
  - Partitions are not used
    - Partitions are ignored
- **Disabled partitions may be enabled**
  - Enabled partitions are made active
  - Enabled partitions are marked 'recovery needed'

Enabling and Disabling Partitions

Use of disabling and enabling of partitions

- Disabling is normally done prior to deleting a partition
  - Keeps recovery information, partition ID, DSN prefix, etc.
- If testing is successful, partition is deleted
  - Deletion removes all information
- If testing is not successful, partition is enabled
  - Partition is recovered and becomes active
    - Other partitions may require timestamp recovery

PDU support for disabling and enabling

- New 'Partition status' field on 'Change Partition' panel

DBRC commands for disabling and enabling

```
CHANGE.PART DBD(dname) PART(pname) DISABLE
CHANGE.PART DBD(dname) PART(pname) ENABLE
```

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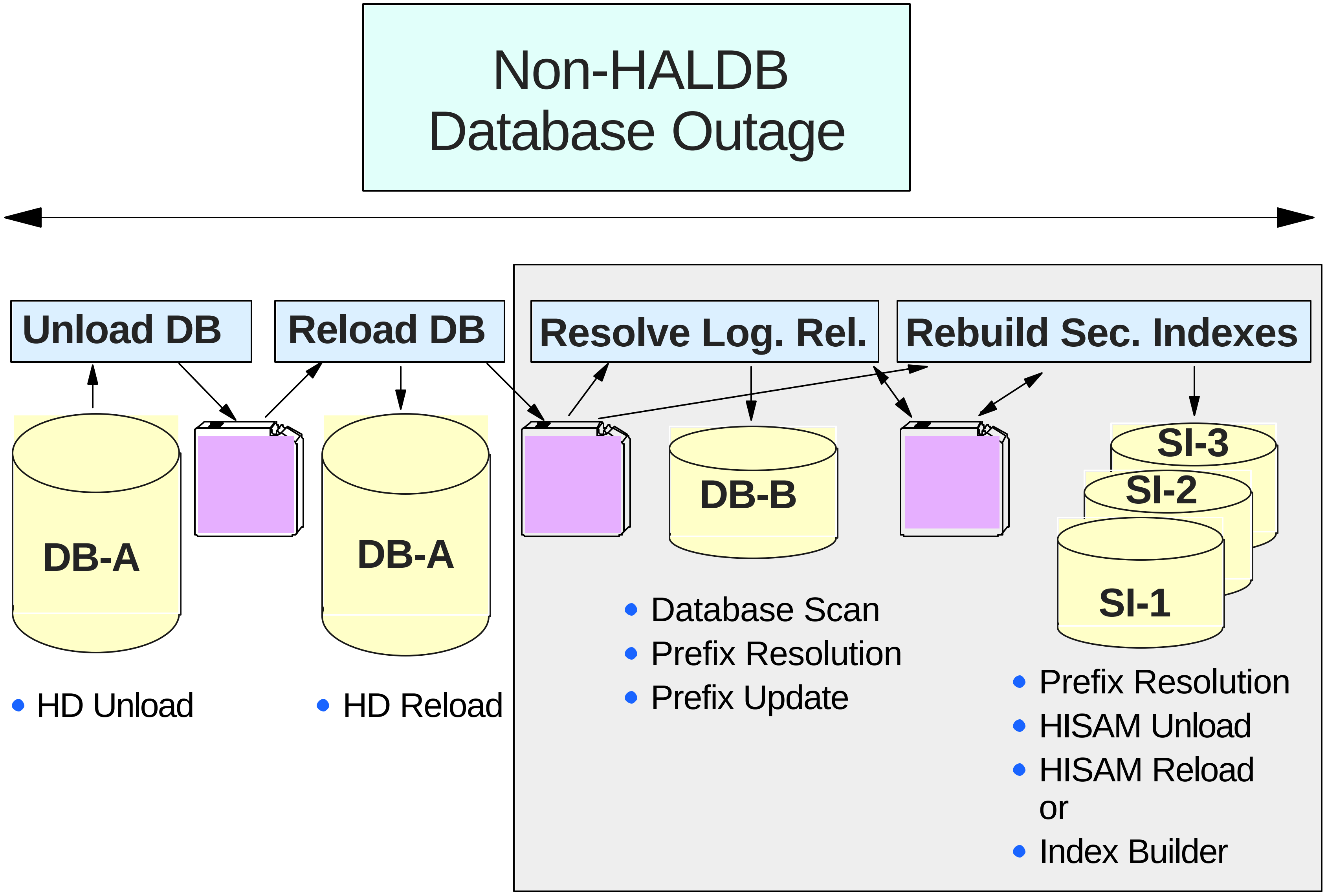
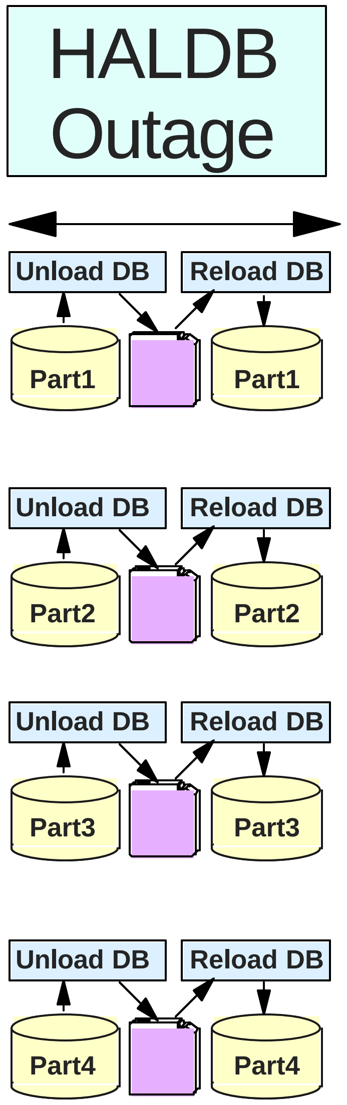
Non-HALDB Reorganizations



- HD Unload
- HD Reload
- Database Scan
- Prefix Resolution
- Prefix Update
- Prefix Resolution
- HISAM Unload
- HISAM Reload
  or
- Index Builder

HALDB Reorganizations



- **Shorten the reorg time to <u>your window</u>**
- **Reorg partitions in parallel**
  - Create enough partitions to meet your requirement
- **Eliminate rebuilds of secondary indexes**
  - Prefix Resolution, HISAM Unload, HISAM Reload, or Index Builder are not required
- **Eliminate updates to logical relationships**
  - DB Scan, Prefix Resolution, and Prefix Update are not required

Healing Pointers After Reorgs

- **After a reorganization sec. index and log. rel. pointers are "broken"**
  - Normal processing heals them efficiently
    - Only heals pointers that are used
    - Reads of pointers are "free"
      - They are being read for normal processing
    - ILDS reads are efficient
      - ILDS CIs hold many entries
      - ILDS CIs are maintained in the buffer pools
  - Optionally, you can heal them
    - Extends the reorganization process
    - Typically, uses more resources
      - Heals all pointers
      - More total I/Os
    - HALDB Conversion and Maintenance Aid includes pointer healing utility
- **My recommendation: Let normal processing heal the pointers**

Data Set Delete and Define for Reorgs

- **HALDB database data sets may be reused**
  - Delete and redefine are not required for reorganization
    - VSAM REUSE attribute is honored by HD Reload
      - Non-HALDB VSAM required DELETE and DEFINE
    - OSAM allows reuse with both HALDB and non-HALDB
  - Delete and define are required to move data sets
- **REUSE attribute is required for HALDB VSAM data sets**
  - Except ILDS
    - Parameter is allowed but not honored for ILDS
      - ILDS will not be reused

Partition Initialization During Reorgs

- **Partition initialization is not required during reorganizations**
  - Data sets may be deleted and redefined without partition initialization
    - Exception: A partition which contains no data must be initialized

- **Reorganization steps:**
  - Unload partition
  - Delete partition data sets (optional)
  - Define partition data sets (optional)
  - Reload partition

Reorganizations and Secondary Indexes

- **Reorganization of a HALDB database does not require rebuild of its secondary indexes**
  - Self-healing pointer scheme eliminates this requirement

Good!

- **Many installations never reorganize non-HALDB secondary indexes**
  - They are rebuilt (and organized) with every reorg of the indexed databases
- **HALDB secondary indexes may become disorganized**
  - They may require reorganization

This is a change in procedures!

Reorganization Alternatives

HD Unload and HD Reload

- Utilities provided with IMS
- PHDAM, PHIDAM, and PSINDEX
  - Also non-HALDB support
- Partitions must be offline

High Performance Unload and High Performance Load

- Tools from IBM
- PHDAM, PHIDAM, and PSINDEX
  - Also non-HALDB support
- Partitions must be offline

Reorganization Alternatives

- **IMS Online Reorganization Facility (ORF)**
  - IBM tool
  - PHDAM, PHIDAM, PSINDEX
    - Also non-HALDB support
  - Short outage during rename of database data sets
  - Limitations: no data sharing, no XRF, no external logical relationships
- **IMS V9 Online Reorganization (OLR)**
  - Utility provided with IMS V9
  - PHDAM and PHIDAM
  - Absolutely no outage
    - Data is available throughout the reorg process
  - Supports: data sharing, XRF, logical relationships, secondary indexes, ...

Eliminating the Need for Reorgs

- **Free space**
  - Rule of thumb of 20% free space is 25+ years old
    - Developed when DASD was very expensive
    - Developed when the nightly window was 12 hours
    - Out of date?
  - HALDB allows you to have as much free space as you need (and can afford)
    - DASD space is cheap
    - Reorganizations are expensive
  - More free space could eliminate the need for some reorganizations!

Reorganization Summary

- **Size partitions to meet reorganization window needs**
  - Reorganize partitions in parallel
  - Largest partition determines reorganization time
- **Pointer healing**
  - Typically, normal processing heals pointers most efficiently
- **Database data sets may be reused**
  - VSAM REUSE attribute is honored
- **Partition initialization is not required for reorganizations**
  - Even when data sets are redefined
- **Secondary indexes are not rebuilt**
  - May need to be reorganized

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Backup and Recovery

HALDB A-J data sets (not the ILDS or PHIDAM index)

- Backup
  - Image Copy utility (DFSUDMP0)
    - Including CIC option
  - Image Copy 2 utility (DFSUDMT0)
- Updates are logged
  - Change Accum may be used
- Recovery
  - Database Recovery utility (DFSURDB0)
  - Online Recovery Service (ORS) tool
  - Database Recovery Facility (DRF) tool
- DBRC
  - GENJCL.IC
  - GENJCL.CA
  - GENJCL.RECOV

Like other IMS database data sets

Backup and Recovery

HALDB ILDS (L) and PHIDAM Index (X) data sets

- Backup
  - No image copies
- Updates are not logged
  - ILDS is only updated by reorganization reload
  - PHIDAM Index is treated like a non-recoverable database
- Recovery
  - Index/ILDS Rebuild utility (DFSPREC0)
    - Rebuilds the data set(s) from the database
- DBRC
  - GENJCL.USER MEMBER(DSPUPJCL)
    - May be used to generate DFSPREC0 JCL to rebuild an ILDS or PHIDAM index

Timestamp Recoveries

- **All data sets of a partition must be recovered to the same time**
  - PHIDAM index must be rebuilt
    - A data set must be recovered first
    - Rebuild with Index/ILDS Rebuild utility (DFSPREC0)
  - ILDS may need to be rebuilt
    1. If secondary indexes or logical relationships are used and
    2. If recovery is to time before last reorganization
       - ILDS is only changed by reorganizations
    - May be rebuilt with Index/ILDS Rebuild utility (DFSPREC0)
  - Alternative for ILDS
    - After reorganization
      - Copy ILDS with REPRO
    - If ILDS needs to be restored
      - Use copy produced by REPRO

Timestamp Recoveries

- **Must all partitions of a database be recovered to the same time?**
  - Almost always
  - User must understand when this is not required
    - For example, offending program updated only one partition
- **Secondary index implications**
  - Usually, database with secondary index forces recovery of all partitions to the same time
    - All partitions of the indexed database
    - All partitions of its secondary indexes
- **Logical relationship implications**
  - Usually, database with logical relationships forces recovery of all partitions to the same time
    - All partitions in the logically related databases

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Test Databases

- **Non-HALDB test databases**
  - Often, not registered in RECONs
  - Each programmer may have one or more versions of a database
- **All HALDB databases are registered in RECONs**
  - Multiple versions of a database must be defined in different RECONs
    - DBRC does not allow multiple databases with the same name
  - Multiple test versions of a database require multiple RECONs
  - Plan your batch test environments

Defining Test Databases

- **Use the same DBD as production**
  - DBD does not include partition or data set information
  - Place in test DBDLIB and ACBLIB

- **Create test partition definitions**
  - Define partitions for test environment

    or
  - Use Partition Definition Utility EXPORT and IMPORT functions
    - Moves partition definitions between RECONs
      - They may be modified after IMPORT
        - Data set name prefix, RAA, etc.
      - APARs PQ48421 (V7) and PQ73858 (V8) maintain partition IDs

Creating Test Databases

Alternatives for creating a test database from a production database

- Unload and Reload
  - HD Unload (HP Unload) of production
  - HD Load (HP Load) to test
    - You may create a different partition configuration
      - Partition IDs will generally be different
      - Partition names may be changed
      - Partition boundaries may be changed
- Image Copy and restore
  - Export and import partition definitions
    - Maintains partition IDs (with APARs PQ48421 or PQ73858)
  - Image copy production database data sets and restore to test
    - Partition IDs are stored in database data sets
  - Change database data set names of test database
    - Change data set name prefixes
- Use application programs

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Secondary Indexes

- **Plan the partitions for the secondary indexes**
  - How many partitions do you need?
    - Space requirements
      - HALDB secondary index entries are much larger than those for non-HALDB sec. ind.
        - Pointers are larger
        - Root key of target is stored in the entry
    - Reorganization requirements
  - Will they need to be adjusted during life of the database?
    - Keys based on date, etc.
- **Plan to reorganize them**
  - They are not rebuilt with each reorganization of their indexed databases
- **Don't make them non-recoverable**
  - Unless you have a tool to rebuild them (e.g. Index Builder)
  - They are not rebuilt by IMS utilities

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Performance

- **HALDB processing is tuned like other full function database processing**
  - Buffer pools
    - ILDSs also use buffer pools
  - Reorganizations and free space
  - OSAM sequential buffering
  - PHDAM root addressable area (RAA) and RAPs
    - Make your RAA large enough to hold all of your data with free space
      - In each partition
    - Give yourself a lot more RAPs than roots
      - In each partition
- **HALDB has some new options**
  - Parallel processing of partitions

Assigning Data Sets to Buffer Pools

- **HALDB database data sets may be assigned to separate buffer pools**
  - DFSVSMxx member or DFSVSAMP data set

```
DBD=dbdname(data set identifier,id)
```

dbdname - partition name or master database name

data set identifier - Letter A-J, L, or X

A-J for user data sets
A for secondary index
L for Indirect List Data Set (ILDS)
X for PHIDAM primary index

id - subpool id

Parallel Processing of Partitions

Parallel processing of partitions

- Different jobs may process different partitions
- Could shorten elapsed times
- Control statement may be used to limit PCB access to one partition
  - Batch (DLI or DBB), BMP, or JBP region
  - DFSHALDB DD statement:

```
HALDB PCB=(nnn|dddddddd,ppppppp)

   nnn - DBPCB number
   dddddddd - DBPCB label or name
   ppppppp - partition name
```

HALDB Database Administration

- **Partitioning**
  - Sizing, naming, and modifying
- **Reorganization**
  - Parallel processing and alternatives
- **Backup and recovery**
  - Special considerations for ILDSs and PHIDAM indexes
- **Secondary indexes**
  - Partition sizing and reorganization requirements
- **Redbook:**
  - *The Complete IMS HALDB Guide: All You Need to Know to Manage HALDBs*, SG24-6945

Things to Remember

- **HALDB Migration Aid utility can analyze existing HALDB databases**
  - Useful when planning repartitioning
- **Deleting a partition definition deletes its recovery information**
  - Disabling a partition keeps its recovery information
- **Secondary indexes may require reorganizations**
  - They are not rebuilt when the indexed database is reorganized
- **Secondary index cannot be rebuilt from database with IMS utilities**
  - Don't make them non-recoverable unless you have a tool like the IBM Index Builder
- **PHIDAM indexes and ILDSs have a different recovery process**
  - They are rebuilt with Index/ILDS Rebuild Utility (DFSPREC0)
- **Plan your scheme for creating HALDB test databases**
  - DBRC registration is required for all databases