DB2 for z/OS Universal Table Spaces: The Whole Story

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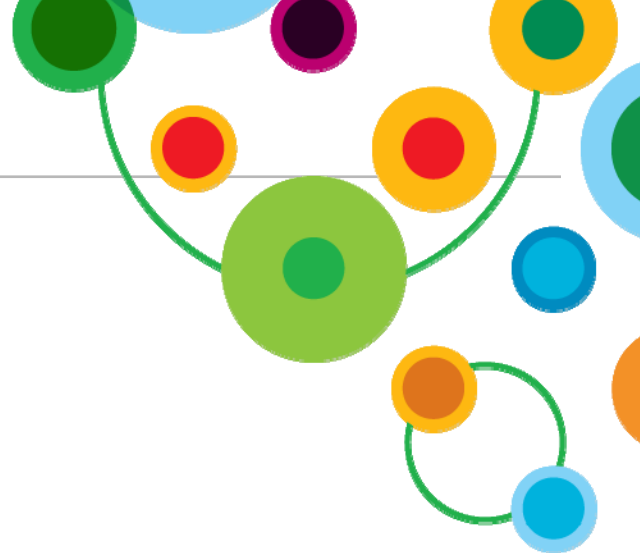


Review Today's Table Spaces

Actual Presentation start here

In the Beginning…

- There were simple table spaces
  - Multiple tables in the same table space
  - Multiple tables could occupy the same page
  - Simplistic space map
  - 64GB size limitation
  - Deprecated in DB2 9 for z/OS
  - DB2 Catalog still uses them

Note

- DB2 10 discontinues use of simple table spaces for DB2 Catalog

  - Customer really shouldn't be creating simple table spaces anymore in any DB2 Version

And There Were Also…

- Partitioned table spaces
  - Only one table allowed per table space
  - Table space is divided into multiple partitions, data sets
  - Requires a partitioning column
  - SQL and utilities have partition independence
  - Could be up to 128Tb
  - Customer must pick number of partitions

Note
- Deprecated in DB2 10 for z/OS

Then DB2 V2.1 Added…

- Segmented table spaces
  - Multiple tables per table space
  - Pages are organized into segments
  - Only one table per segment
  - Still 64GB size limitation
  - Better space maps, better DELETEs
  - And better INSERT processing
  - Customer choice, either segmented or partitioned
  - Of the three types, best performance in most cases
  - Default in DB2 9 when SEGSIZE, NUMPARTS, or MAXPARTITIONS options are not specified

Note

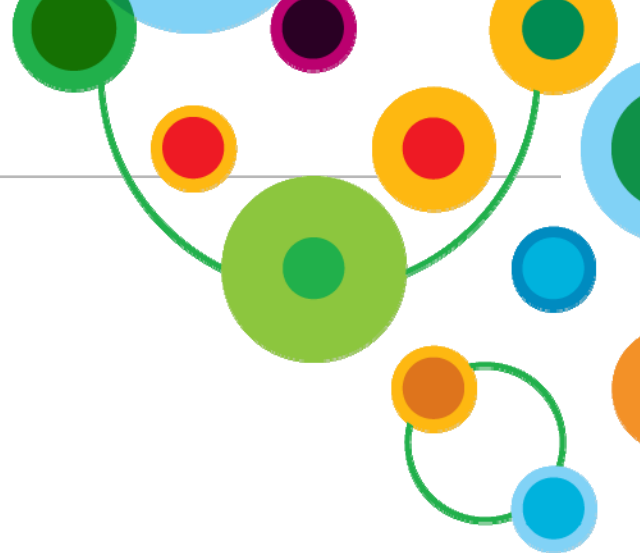
- No longer default in DB2 10 – partition-by-growth becomes default

Later, DB2 V6 Introduced…

- Large Object (LOB) table spaces

And Introduced with DB2 9…

- Universal Table Space (UTS)
- XML table spaces (discussion for another time)



Universal Table Space

What Was Needed

- A table space needs both partitioned and segmented organization:
  - A table's growth is unpredictable
  - How do you handle large without a convenient key for range partitioning
  - It needs to be larger than 64GB
  - Inter-partition parallelism or independent processing is necessary
  - Partition scope operations (ADD,ROTATE) apply
  - Rows are variable in length and a fast insert is required
  - Mass delete operations should be fast

What Was Needed

- Partitioning by a ROWID column introduces additional table space administration overhead:
  - estimating optimal number of partitions
  - ADDing partitions if necessary
  - less then optimal space utilization

The Solution…

- Universal table space
  - The very best of segmented and partitioned table spaces delivered in one object

What is a Universal Table Space?

- All the best features from
  - Segmented table spaces and partitioned table spaces
    - Hybrid
  - Extra space maps and space map information
  - Multiple data sets (partitions)
  - Segmentation
- Plus a bunch of really cool new stuff
  - Better space management means less REORG
  - SQL TRUNCATE supported
  - ALTER TABLE ROTATE PARTITION supported
  - CLONE table supported (UTS required)
  - Improved insert performance

Things to Remember

- Only available AFTER upgrading to DB2 9 new function mode (NFM)
- Only one table per table space allowed
- Reordered Row Format (RRF) only
- Partition independence
- No longer has a 64GB limitation
  - Depending on DSSIZE and the number of partitions, the table space could grow up to 128 TB
- Incompatible with MEMBER CLUSTER
- DB2 10 allows MEMBER CLUSTER for universal table spaces

Note

Two Flavors are Available

- Universal table spaces are available in two flavors
  - Range-partitioned (PBR)
    - All the features of classic partitioning
    - Table controlled partitioning only
    - Using partition column
    - Partitioned and segmented
  - Partition-by-growth (PBG)
    - Partitions added as space is needed
    - No partitioning key
    - Partitioned and segmented

Common UTS Function limitations

- Cannot be used for the WORKFILE database

Note

  - Version 10 supports partition-by-growth table spaces in the WORKFILE database

- No LOCKSIZE TABLE (uses partitioned table space locking scheme)

Common UTS Function limitations

- No easy way to convert current type of table space to UTS
  - Required to use DROP/CREATE
  - DB2 10 ALTER TABLESPACE abc MAXPARTITIONS
    - Single table simple table space to partition-by-growth UTS
    - Segmented table space to partition-by-growth UTS
    - Plans and packages are invalidated
  - DB2 10 ALTER TABLESPACE abc SEGSIZE
    - Partition table space to range-partitioned UTS

Note

Common UTS Function limitations

- No MEMBER CLUSTER (not supported for segmented)

Note

  - DB2 10 allows MEMBER CLUSTER only for partition-by-growth or range-partitioned universal table space
    - ALTER MEMBER CLUSTER
      - Still not allowed for segmented, LOB, work file, or XML table spaces
      - If table space is a partitioned table space, partitioned table space is converted to range-partitioned universal table space
      - Altering MEMBER CLUSTER places table space in advisory REORG pending state (AREOR)
    - SYSIBM.SYSTABLESPACE.MEMBER_CLUSTER

- No ALTER SEGSIZE/DSSIZE
  - So get SEGSIZE/DSSIZE right or it is a DROP/CREATE

Note

  - DB2 10 allows ALTER SEGSIZE
    - If SEGSIZE is specified on ALTER, no other clause is allowed
    - ALTER SEGSIZE can only be specified for universal table space or partitioned table space that uses table-controlled partitioning
  - DB2 10 has ALTER DSSIZE also

DSNZPARM for SEGSIZE Default

- When SEGSIZE is NOT specified
- DB2 10 – The picture changes considerably
  - If ZPARM DPSEGSZ = 0
    - If MAXPARTITIONS is not specified
      - If NUMPARTS is not specified
        - » SEGSIZE 4 for segmented table space
      - If NUMPARTS is specified
        - » Classic partitioned table space
    - If MAXPARTITIONS is specified
      - With or without NUMPARTS being specified
        - » partition-by-growth table space w/ SEGSIZE = 32
  - If ZPARM DPSEGSZ > 0 (a greater than zero value)
    - If MAXPARTITIONS is not specified
      - If NUMPARTS is not specified
        - » SEGSIZE 4 for segmented table space
      - If NUMPARTS is specified
        - » Partitioned by range-partitioned table space w/ SEGSIZE = DPSEGSZ
    - If MAXPARTITIONS is specified
      - With or without NUMPARTS being specified
        - » partition-by-growth table space w/ SEGSIZE = DPSEGSZ

DB2 9
Default SEGSIZE 4

SYSIBM.SYSCOPY

- STYPE
  - CHAR(1) NOT NULL WITH DEFAULT
- When ICTYPE=A (ALTER) , the new/changed values are:
  - B The MEMBER CLUSTER value was changed
  - D The DSSIZE attribute of the table space was altered
  - M The MAXPARTITIONS attribute of the table space was altered
  - S The SEGSIZE attribute of the table space was altered

Other values were added/changed in SYSCOPY but are not affected by universal table spaces

Catalog Table SYSIBM.SYSCOPY

- TTYPE
  - CHAR(8) NOT NULL WITH DEFAULT
- When ICTYPE=A (ALTER) and STYPE=B
  - This column indicates if the previous value for the MEMBER CLUSTER attribute is being used:
  - Y
    - The previous member cluster attribute of the table space is being used
  - N
    - The previous member cluster attribute of the table space is not being used
- When ICTYPE=A (ALTER) and STYPE=D
  - This column indicates the previous DSSIZE attribute value for the table space in units of G, M, or K

Catalog Table SYSIBM.SYSCOPY

- TTYPE
  - CHAR(8) NOT NULL WITH DEFAULT
- When ICTYPE=A (ALTER) and STYPE=M
  - This column indicates either the previous value of the MAXPARTITIONS attribute for the table space or the type of table space conversion that was performed on the table space
  - I
    - The table space was converted from a single-table simple table space to a partition-by-growth universal table space
  - n
    - The previous value of the MAXPARTITIONS attribute for the table space
  - S
    - The table space was converted from single-table segmented table space to a partition-by-growth universal table space

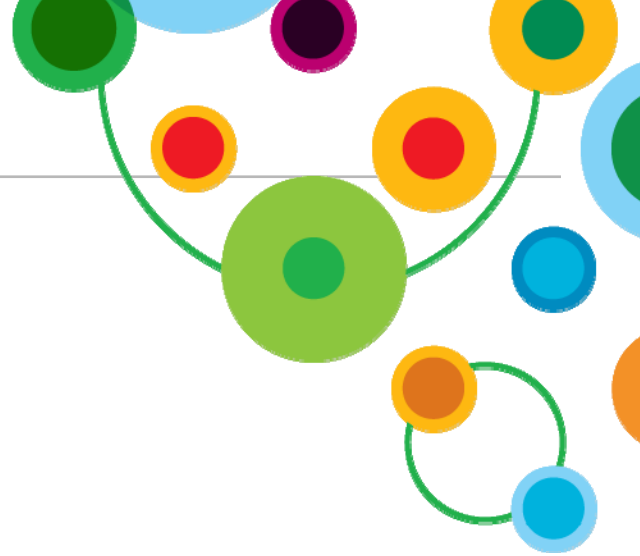
Catalog Table SYSIBM.SYSCOPY

- TTYPE
  - CHAR(8) NOT NULL WITH DEFAULT

- When ICTYPE=A (ALTER) and STYPE=S
  - This column indicates either the previous value of the SEGSIZE attribute for the table space or the type of table space conversion that was performed on the table space
  - n
    - The previous value of the SEGSIZE attribute for the table space
  - P
    - The table space was converted from a partitioned table space to a range-partitioned universal table space

Pause for Questions

(41 slides to go)



Partition-by-growth Universal Table Space

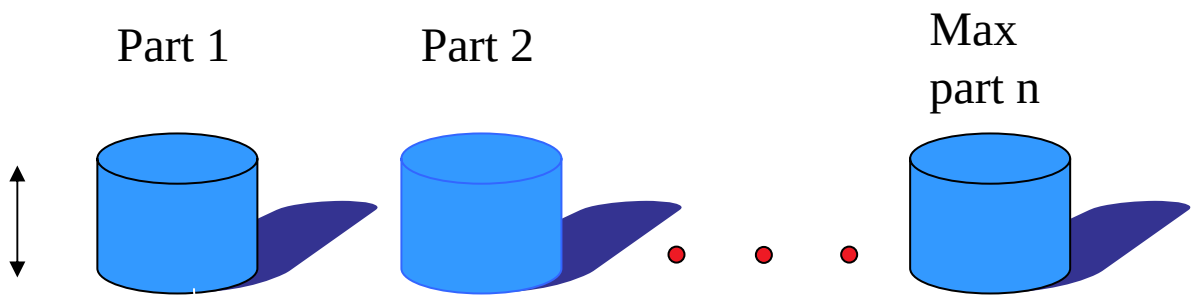
Partition-by-growth Table Space

explicit specification	`CREATE TABLESPACE …` `MAXPARTITIONS integer`
implicit specification	`CREATE TABLE …` `PARTITIONED BY SIZE EVERY integer G`

- ✓ Associated SYSTABLESPACES columns
  - MAXPARTITIONS =max number of partitions
  - PARTITIONS =actual number of partitions
  - TYPE =G
- ✓ Only single-table table space
- ✓ Universal table space organization: although the table space is partitioned, the data within each partition is organized according to segmented architecture
- ✓ Incompatible with MEMBER CLUSTER, ADD PARTITION, ROTATE PARTITION

How Partition-By-Growth Works

- The table space starts with one partition, additional partitions will be added on demand until the maximum partition is reached.



Partitioned Table Space (parts added on demand)

Partition-By-Growth CREATE

- SQL CREATE TABLESPACE statement for PBG

```
CREATE TABLESPACE TS1 IN DB1
    MAXPARTITIONS  55
    SEGSIZE 64
    DSSIZE 2G
    LOCKSIZE ANY;
```

Makes PBG

Partition size

- ✓A new key word MAXPARTITIONS - specifies the maximum # of partition for a table space.
- ✓Maxpartitions can be changed by ALTER TABLESPACE
  - Keep in mind that ALTER MAXPARTITIONS may require down time because it needs to physically close the datasets

Partition-By-Growth Create

- ✓SQL CREATE TABLE statement for PBG

```
CREATE TABLE Mytable
    PARTITION BY SIZE EVERY integer G;
```

where integer ≤ 64

- ✓Only available when you don't specify a table space name on the CREATE TABLE
- ✓Table space is implicitly created
- ✓ mG specifies DSSIZE of the table space

More on Implicitly Created PBG

- Implicitly created table space defaults to PBG
- It defaults to row locking
- The LOCKMAX defaults to SYSTEM
- Default value for MAXPARTITIONS = 256
- Default SEGSIZE = 4 if not specified on DDL

Note

- In DB2 Version 10, the default SEGSIZE value for universal table spaces has changed from 4 to 32
  - New DSNZPARM – DPSEGSZ (default 32) on DSN6SYSP macro
  - DPSEGSZ affects the SEGSIZE default chosen
  - DPSEGSZ becomes available in DB2 10 new function mode (NFM)

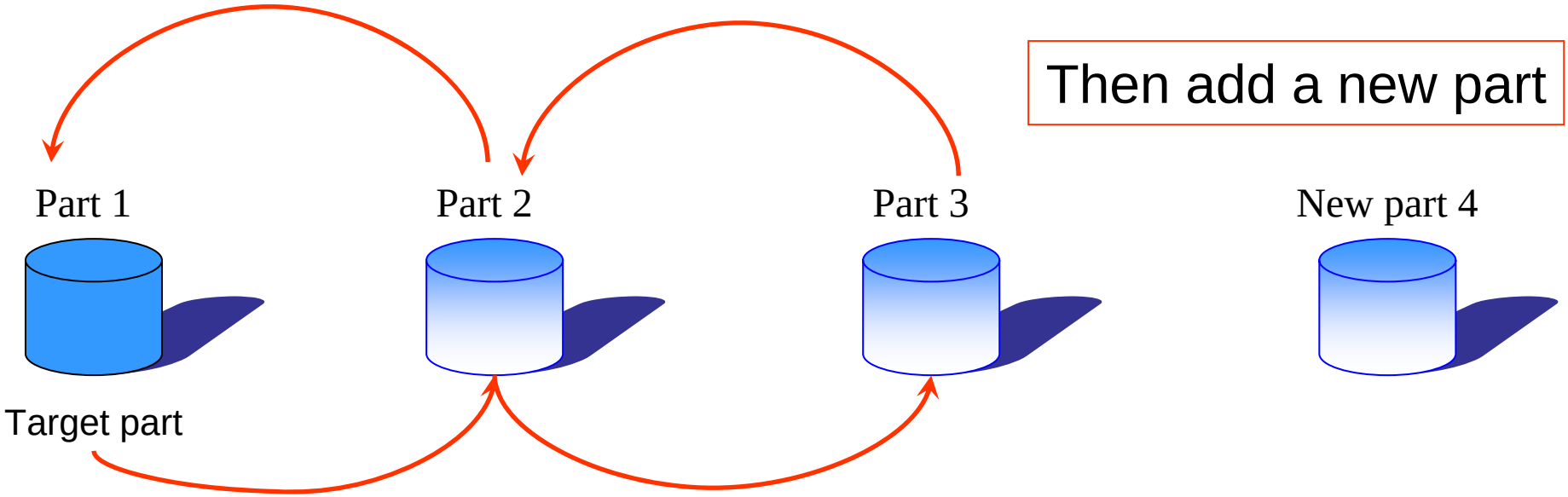
- Default DSSIZE = 4G if not specified on DDL
  - Note: DSSIZE and SEGSIZE require a DROP to change, no ALTER option

Note

- DB2 10 has ALTER DSSIZE/SEGSIZE

Partition-By-Growth Space Search

- ✓No more space in the partition…
  - Search forward to next partition if there is one
  - Search backward to previous partitions



Note: If there is any restricted DBET state of any part during the backward space search. New part will not be added.

PBG UTS and Catalog Table

- Catalog table SYSIBM.SYSTABLESPACE
- TYPE column value
  - “R” - Range-partitioned universal table space
  - “P” - Implicit table space created for pureXML columns
  - “O” - Table space is a LOB table space
  - “G” - Partitioned-by-growth table space
- MAXPARTITIONS (new column)
  - Maximum number of partitions
    - 0 (zero) if table space NOT partition-by-growth
- PARTITIONS
  - Column contains the number of physical partition (dataset) that currently exist

PBG UTS and Catalog Table

- Catalog table SYSIBM.SYSTABLEPART
  - When table space created, one partition created and one row inserted to SYSTABLEPART (assuming created with DEFINE YES)
  - Additional row added to SYSTABLEPART for each new partition required

Additional Characteristics of PBG

- PBG is partitioned according to space requirements
  - A partition is allocated when one is needed due to growth
- Each partition has a one-to-one correspondence to a VSAM data sets and MUST be DB2-managed
- No partitioning key to bound the data within a table space, so no PI index
- Only non-partitioned indexes can be created
  - No data-partitioned secondary index (DPSI)
- Only single table allowed per table space
  - can not totally replace segmented table space

Additional Characteristics of PBG

- When a partition fills and MAXPARTITIONS has not been reached
  - New partition created and catalog is updated
    - Even if unit of work adding a partition issues a rollback, new partition remains
  - Compression dictionary will be copied from previous partition to the new partition
  - Freespace, caching, define, logging and trackmod attributes are same for each partition
  - Drains and Claims of new partition are inherited from prior partition

Additional Characteristics of PBG

- Some DBET states are also inherited by the new partition from the previous partition
  - RO*, UTUT, UTRO for table space, PSRBD, ICOPY for NPI
- CLONE table can be created
  - Both CLONE and base table grow at the same time
- All utilities can operate at the partition level except LOAD utility

PBG – Additional Function Limitations

- No partition key range can be defined
- No ALTER ADD PART
- No ALTER ROTATE PART
- No ALTER Stogroup
- No LOAD PART
- No user-directed define partition
  - Required to use UNLOAD/LOAD instead of DSN1COPY for copying data between table space if source table space has more than 1 partition

Note

DB2 10 allows a partition to be added up to the value of MAXPARTITIONS

Practical Applications for PBG

- When no obvious partitioning column exists
- When a table requiring > 64G
  - Lift 64G size limitation of segmented table space
  - Increase overall size of table space on demand
- Space on Demand
- Large table space and manage utilities at a data subset is needed
  - Partition level utility
- There's a need for CLONE table

Note

- Planned hash table use (added in DB2 10)

Partition-By-Growth and REORG

- Reorganization of data could result in more or less partitions
  - If n # of parts to start with will be n or more # of parts at the end of the REORG
  - No delete of existing partitions
  - If REORG is at the table space level, could result in empty partitions at the end of table space
  - Tables cannot contain LOB or XML columns
- If MAXPARTITIONS is reached, REORG will fail
- If new partition is added, dictionary pages are copied from the previous partition into the new partition

Partition-by-growth and REORG

- REORG SHRLEVEL CHANGE – new partition is added to both shadow and base (I and J data set)

Partition-By-Growth and REORG PART

- Data must fit back to original part or REORG will fail
  - To prevent failure, adjust space attributes (PCTFREE or PGFREE)
- If partition range level REORG, the data on one part can overflow to the other
- To avoid failure, run REORG for entire partitioned table space

Partition-by-growth and REORG

- Table has LOB column,
  - Holes within each partition will be eliminated
  - REORG does not move the data from one partition to another

Partition-By-Growth - REORG limitations

- No parallelism to ensure data reduced to minimum number of partitions
- No REBALANCE
- No shrinking of partitions even if there are only empty partitions at the end of table space
  - The empty partitions could have header, space map page, dictionary page and system pages

Partition-By-Growth and COPY

- Copies can be made at the part level or the table space level
- Will copy empty partition
- Will also pick up new partition added during COPY for COPY SHRLEVEL CHANGE at the table space level
  - Remember this is a fuzzy copy. It is not recommend to be used for RECOVER TOCOPY

Partition-By-Growth and RECOVER

- RECOVER to currency with image copy
  - Pick up new added parts since last copy via log apply.
- RECOVER to image copy, PIT or NOT LOGGED table space
  - The excess partitions (in base, LOB or XML) will be empty (header/space map/system pages).

Partition-By-Growth and LOAD

- Only support table space level operation
  - No partition level load
- No parallelism for Load Utility
- Can accommodate growth of table space
- Copy dictionary from previous partition to the new partition
- Excess partitions remain empty
- LOAD … COPYDICTIONARY not available
  - Keyword made available in DB2 9 by PK63324 and PK63325

Partition-By-Growth & Other Utilities

- CHECK INDEX SHRLEVEL CHANGE
  - Partition added during the course of the CHECK INDEX utility is NOT checked
- REBUILD INDEX SHRLEVEL CHANGE
  - Index for record inserted into new added partition during the course of the REBUILD is reflected in the index page set via log apply

Partition-By-Growth and DSN1COPY

- Partition number may be inconsistent between DSN1COPY and the target table space
  - If partition number of TARGET table space is greater than partition number of SOURCE table space:
    - Use TRUNCATE TABLE on the target table before DSN1COPY to make sure the target table is empty
  - If partition number of TARGET table space is less than partition number of SOURCE table space:
    - DSN1COPY cannot be used
    - Unload/Load may be used
  - Use NUMPARTS and SEGMENT keywords
    - NUMPARTS = MAXPARTITIONS for PbG

Pause

simply for effect

(17 slides to go)

Range-partitioned Universal Table Space

Create Range-partitioned UTS

- ✓ **SQL CREATE statement**

```
CREATE TABLESPACE PRB_TS1 IN UTS_DB1
    NUMPARTS 3
    SEGSIZE 64
    LOCKSIZE ANY;
```

Makes it PBR

- ✓ Create a partitioned table space and just add the SEGSIZE clause = Range-partitioned table space

Note

- Range-partitioned table space is now **DEFAULT in DB2 10**
  - Classic partitioned table spaces still supported
    - Create classic by specifying **SEGSIZE 0** on CREATE

Create Table in Range-partitioned UTS

```
CREATE TABLE MyTable
        ( C1  CHAR(4),
          C2   VARCHAR(20),
          C3   INTEGER )
    PARTITION BY (C1)
        ( PARTITION 1 ENDING AT ('DDDD'),
          PARTITION 2 ENDING AT ('HHHH'),
          PARTITION 3 ENDING AT ('ZZZZ') )
                    IN UTS_DB1.PRB_TS1 ;
```

- Must use table-controlled partitioning

Range-partitioned UTS and Catalog Table

- Catalog table SYSIBM.SYSTABLESPACE
- TYPE column value
  - "R" - Range-partitioned universal table space
  - "P" - Implicit table space created for XML columns.
  - "O" - Table space is a LOB table space
  - "G" - Partitioned-by-growth table space

Range-partitioned Aux Table Space

- LOB table space
  - Can be user defined via SQLRULES
- XML AUX table space
  - Its table space type is also Range-partitioned UTS
  - XML rows are in the same part as base row

PBR – Additional Function Limitations

- No index-controlled partitioning definition

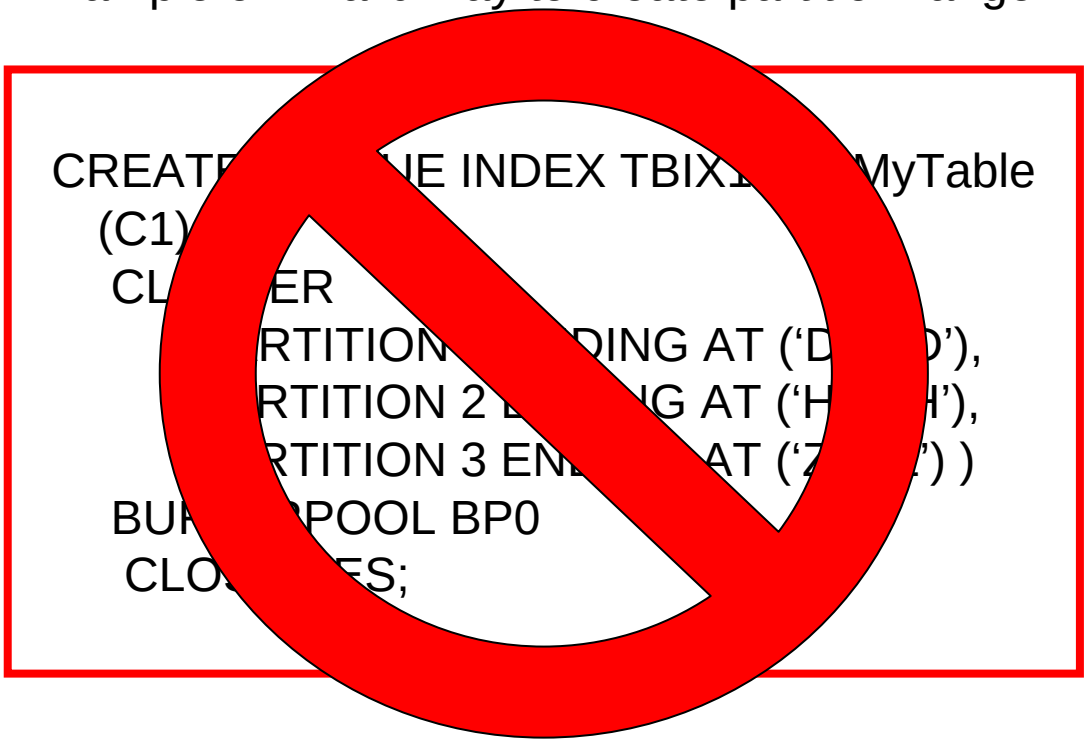
Example of invalid way to create partition range:

```
CREATE UNIQUE INDEX TBIX1 ON MyTable
   (C1)
    CLUSTER
        (PARTITION 1 ENDING AT ('DDDD'),
         PARTITION 2 ENDING AT ('HHHH'),
         PARTITION 3 ENDING AT ('ZZZZ') )
    BUFFERPOOL BP0
     CLOSE YES;
```

PBR – Additional Function Limitations

- No index-controlled partitioning definition

Example of invalid way to create partition range:



SQLCODE = -662

A PARTITIONED INDEX CANNOT BE CREATED ON A NON-PARTITIONED, PARTITION-BY-GROWTH, OR RANGE-PARTITIONED UNIVERSAL TABLE SPACE

Range-partitioned Practical Applications

- When a partitioned table space and a partitioning key is required
- When better performance than classic partitioned table space is required
- Parallelism and partition-independence capabilities
- When a CLONE table is required

Note

- Hash table use (added in DB2 10)

Conclusion

(10 slides to go)

What Can You Have?

- Partition-by-growth universal table space
  - MAXPARTITIONS
- Range-partitioned universal table space
  - SEGSIZE and NUMPARTS
- Classic partitioned table space
  - NUMPARTS, no SEGSIZE
- Segmented table space
  - SEGSIZE, no NUMPARTS, no MAXPARTITIONS
- Simple table space
  - Not allowed

Universal Table Spaces are Very Cool

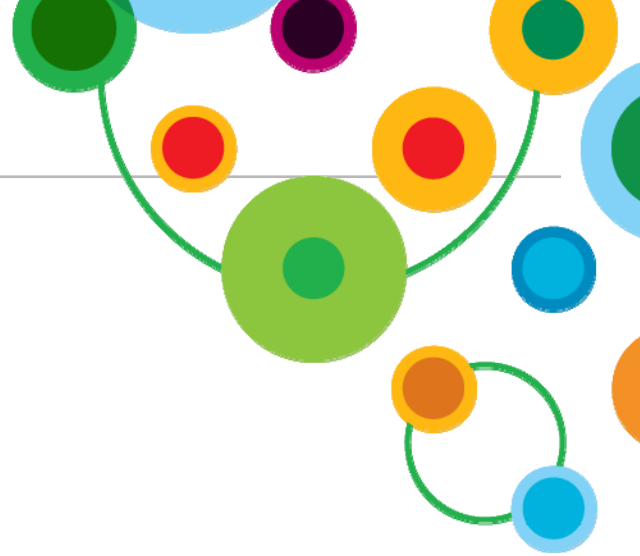
- Only one table per table space
  - Possibly more VSAM data sets
  - DSMAX may have to be increased

→ **Just Remember…**

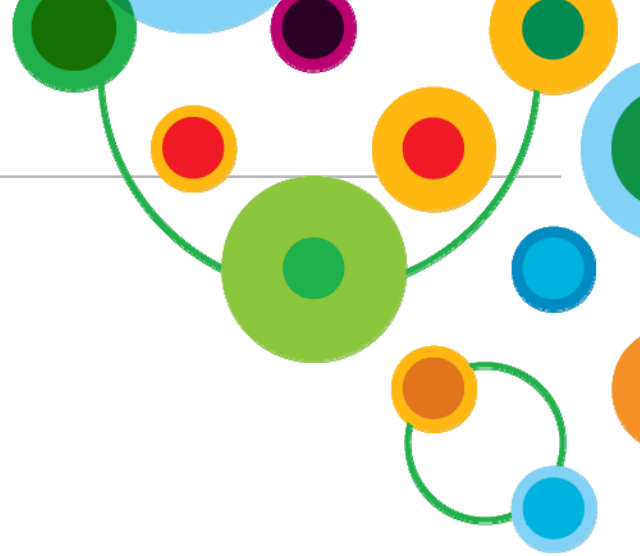
- No member cluster
  - Could be a concern if you are using data sharing
  - Allowed in DB2 10
- No migration
  - Must DROP and re-CREATE
  - ALTER in DB2 10

Pause

simply for effect



Questions



Additional Information

No-charge Certification Testing

- DB2 for z/OS Certifications
  - IBM Certified Database Associate - DB2 9 Fundamentals
    - Exam 730
  - IBM Certified Database Administrator - DB2 9 for z/OS
    - Exam 732
  - IBM Certified System Administrator - DB2 9 for z/OS
    - Exam 737
  - IBM Certified Database Administrator - DB2 10 for z/OS
    - Exam 612
  - IBM Certified System Administrator - DB2 10 for z/OS
    - Exam 617

All links (Exam xxx) are live.

No-charge Certification Testing

- DB2 9.7 for Linux, UNIX, and Windows (LUW)
- IBM Certified Database Associate, DB2 9 Fundamentals, Exam 730
- IBM Certified Database Administrator, DB2 9.7 for LUW, Exam 541
- IBM Certified Application Developer, DB2 9.7 for LUW, Exam 543
- IBM Certified Solution Developer, DB2 9.7 SQL Procedure Developer, Exam 545, Coming soon!
- IBM Certified Advanced Database Administrator, DB2 9.7 for LUW, Exam 544
- Upgrade Exam for DB2 9.7 for LUW, Exam 546

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- IBM Certified Database Administrator, DB2 9 for LUW, Exam 731
- IBM Certified Application Developer, DB2 9, Exam 733
- IBM Certified Advanced Database Administrator, DB2 9 for LUW, Exam 734
- IBM Certified Solution Developer, DB2 9.5 SQL Procedure Developer, Exam 735
- Upgrade Exam for DB2 9 for LUW, Exam 736

Shameless Self promotion

My DB2 for z/OS blog…

http://blogs.ittoolbox.com/database/db2zos

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August/September 2007

Redbooks -- http://www.ibm.com/redbooks

SG24-7330 - DB2 9 for z/OS Technical Overview (8.2MB)
SG24-7473 - DB2 9 for z/OS Performance Topics (6.5 MB)

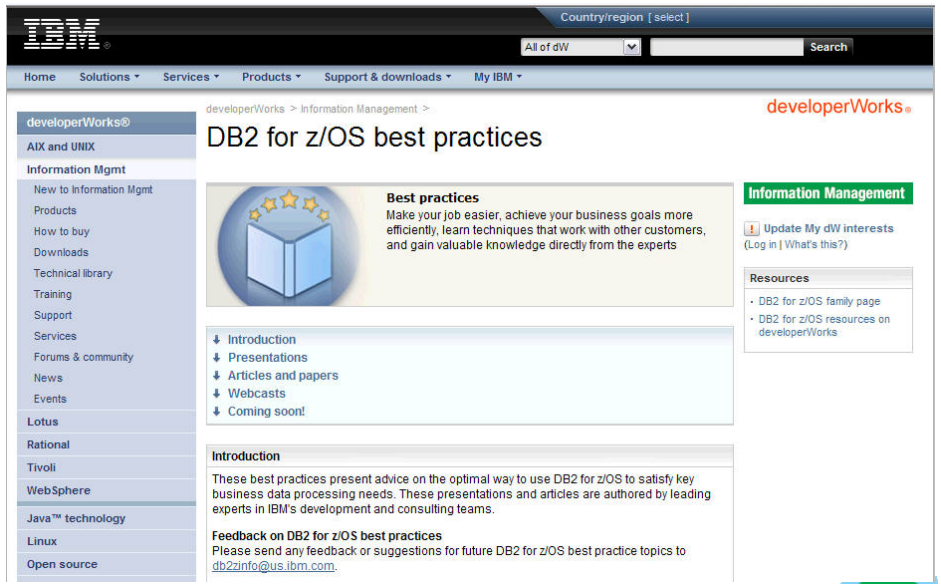
NEW

DB2 for z/OS Best Practices

www.ibm.com/developerworks/data/bestpractices/db2zos/

- Watch recorded presentations and read articles from your favorite DB2 experts.
- Get practical recommendations for areas such as:
  - Virtual storage tuning
  - Security
  - Software maintenance strategies
  - Migration
  - Setting up application servers to access DB2 for z/OS
  - Partitioning table spaces
  - Debugging stored procedures

  And more!

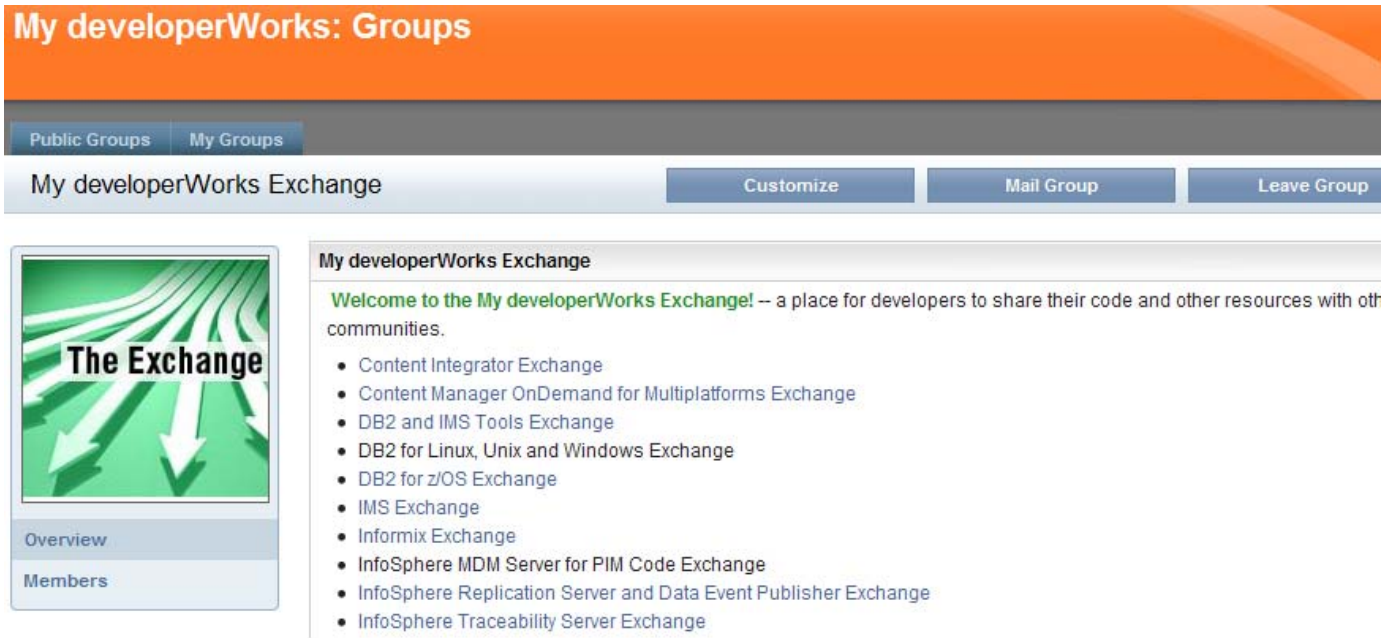


Send feedback and topic suggestions to db2zinfo@us.ibm.com

The Exchange on My developerWorks

www.ibm.com/developerworks/software/exchange

- Download samples from IBM and fellow users, or share your own code
- Subscribe to updates; tag, comment on, and recommend samples
- Be part of the My developerWorks community: read or write blogs, join in message board discussions, find useful links and answers



Useful DB2 for z/OS URLs

- **DB2 10 Launch Website** http://bit.ly/DB210Launch
- **DB2 for z/OS Website** http://www-01.ibm.com/software/data/db2/zos/
- **DB2 Product Library** http://www.ibm.com/software/data/db2/zos/library.html
- **DB2 Newsletter** http://www.ibm.com/vrm/newsletter/11065

- **Latest Whitepapers**
  - Business Value of DB2 10 – Julian Stuhler
  - A Matter of Time: Temporal Data Management
  - Why DB2 for z/OS is BETTER than Oracle RAC ?
- **DB2 for z/OS e-Kit** http://bit.ly/DB210e-Kit
- **Upcoming Conferences/Events**
  - **IDUG DB2 Tech Conference EMEA Prague - 13th -18th Nov 2011**
  - **DB2 10 Migration Planning Workshop Prague - 13th November 2011**
  - **IDUG DB2 Tech Conference AG Denver - 14th -16th May 2012**
  - **IDUG 10 Migration Planning Workshop Denver - 13th May 2012**

Top DB2 for z/OS e-Communities

- **World of DB2 for z/OS - 1700+ members** — http://db2forzos.ning.com/
- **DB2 10 LinkedIn - 1000+ members** — http://linkd.in/IBMDB210
- **DB2 for z/OS What's On LinkedIn – 2000+ members** — http://linkd.in/kd05LH
- **DB2 for z/OS YouTube** — http://www.youtube.com/user/IBMDB2forzOS
- **WW IDUG LinkedIn Group - 2000 +members** — http://linkd.in/IDUGLinkedIn
- **IBM DeveloperWorks** — http://www.ibm.com/developerworks/data/community/

Thank You for Attending!

Willie

Willie Favero

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Data Warehousing for System z Swat Team

IBM Silicon Valley Laboratory

IBM Academic Initiative Ambassador for System z
IBM Certified Database Administrator - DB2 Universal Database V8.1 for z/OS
IBM Certified Database Administrator – DB2 9 for z/OS
IBM Certified Database Administrator – DB2 10 for z/OS
IBM Certified DB2 9 System Administrator for z/OS
IBM Certified DB2 10 System Administrator for z/OS
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