
WDUG : Db2 Virtual Tech Conference
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Db2 BLU: Maximizing the Potential of Data
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Agenda

- Columnar Overview
- New Storage Enhancements for 11.5.4
- Compression Best Practices

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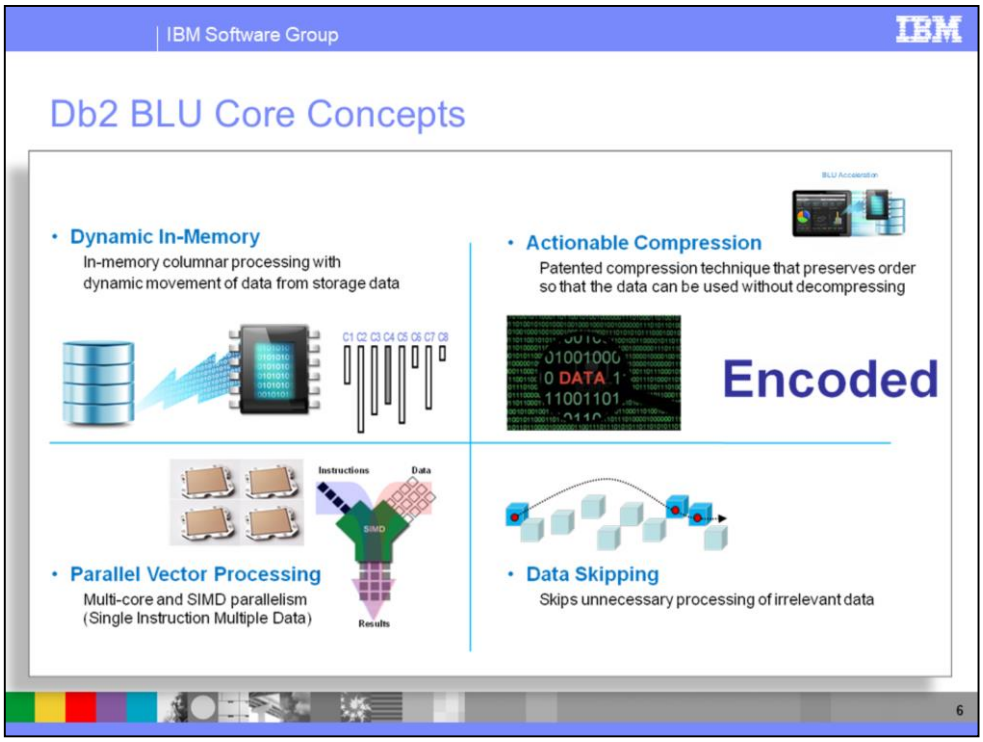
Columnar Overview



Easy to use – load and go!!

Improvements to all of I/O, RAM, and CPU. Maximizes cache and cacheline efficiency.

Only access required columns since each extent = 1 column.

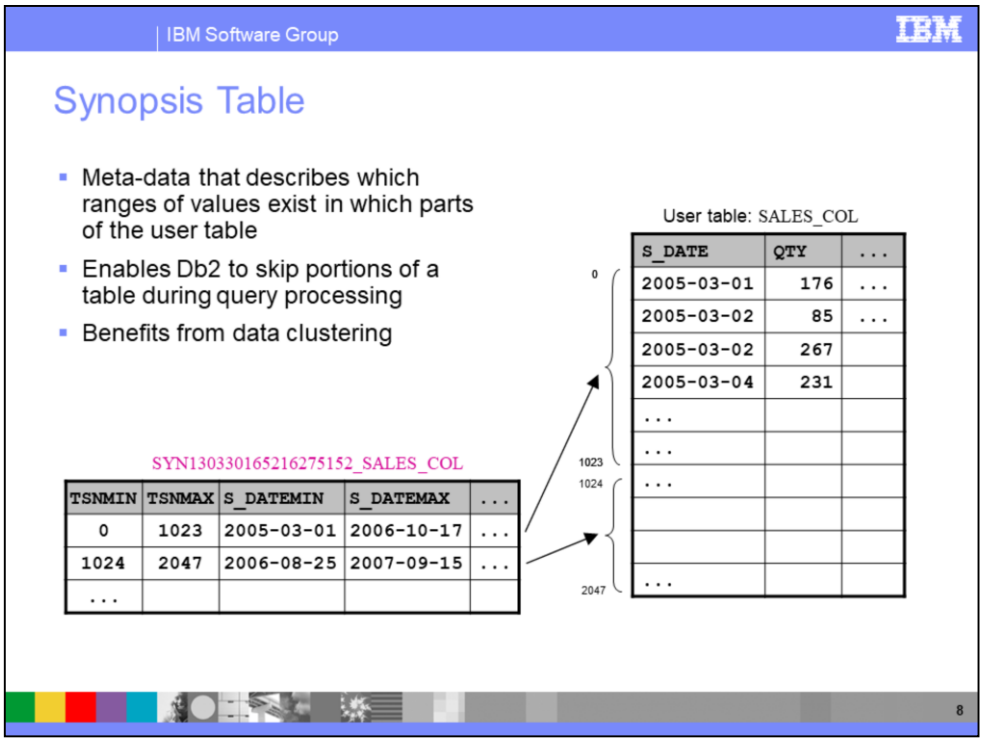
Deeper Look at Internals : Column Storage

BLU

- With BLU, each page and extent contains values for a single column

TSNs (a logical Row ID) are used to stitch together column values that belong in the same row during query processing

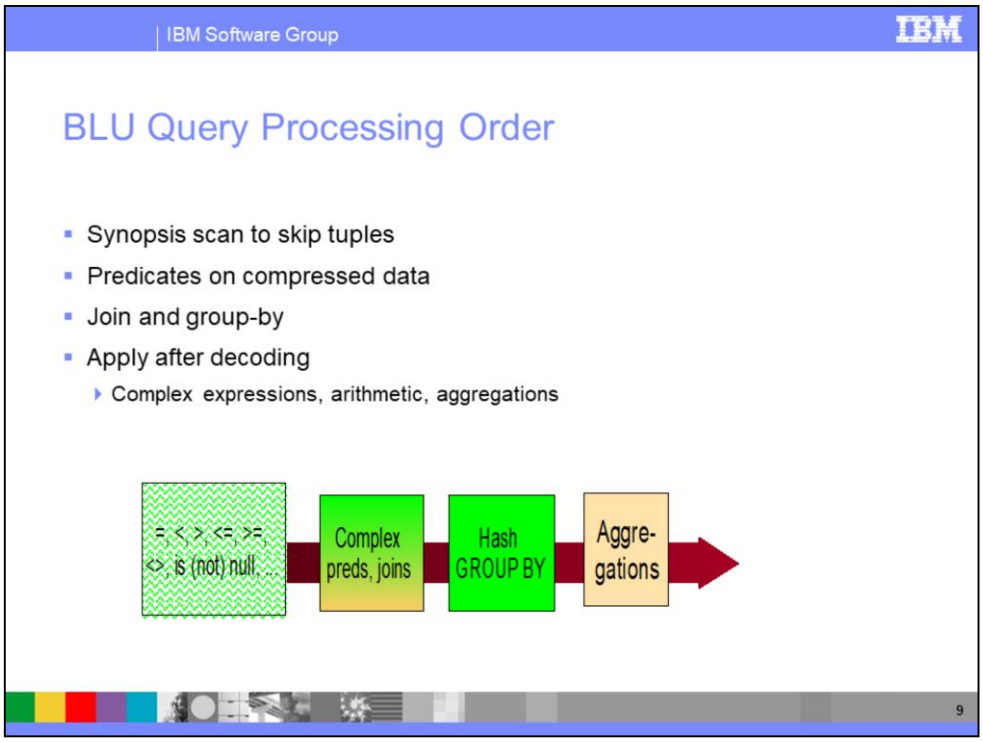
- eg. SELECT zipcode FROM t WHERE name="Mike Hernandez"
  - an internal 'page map index' allows Db2 to quickly find the page containing the zipcode for TSN 4



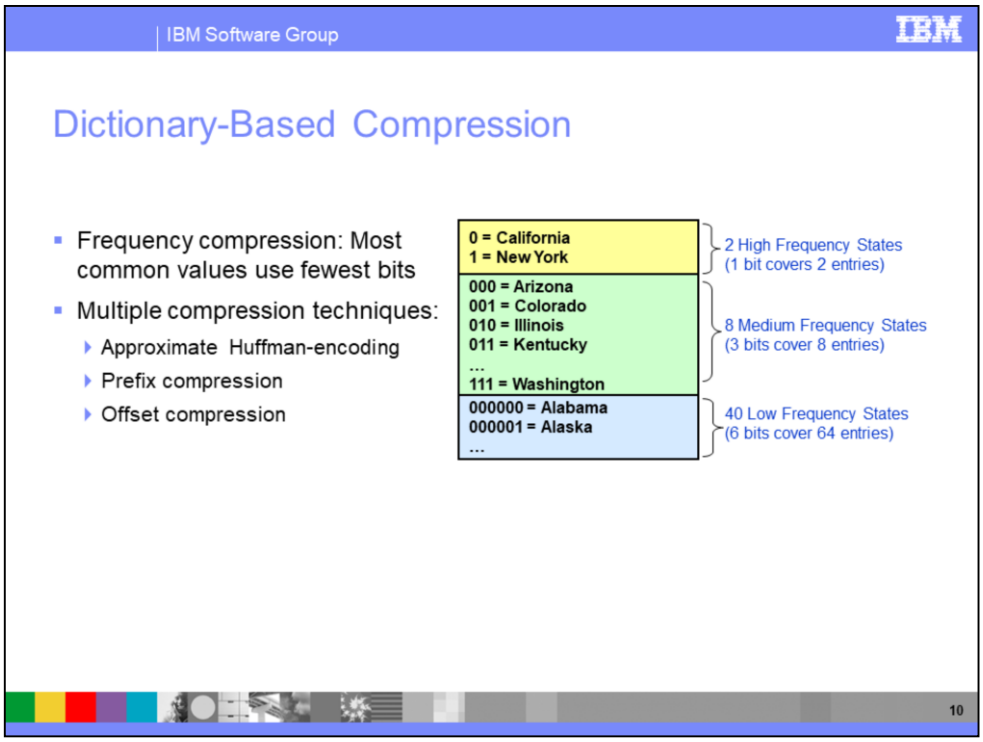
Predicate WHERE S_DATE = 2007-01-01 would skip first range.

Predicate WHERE S_DATE = 2006-09-12 would scan both ranges.

Each base table column has a synopsis min/max column.



Late materialization means we decode data only for operations that can not be executed on encoded values after other processing complete.



Exploiting skew in data distribution improves compression ratio

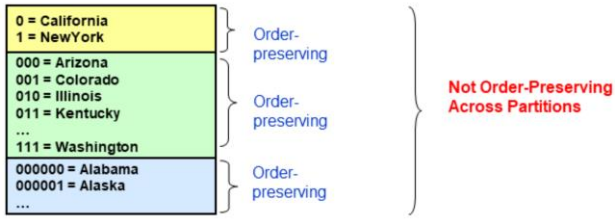
Very effective since all values in a column have the same data type

Maps entire values to compressed codes

Dictionary-Based Compression

- Prefix compression
  - Similar to approximate Huffman-encoding for common prefixes
  - Prefix bits for encoded prefixes concatenated with uncompressed suffix bits
  - Example values: MAR01, MAR02, JUN10, JUN15, etc.
  - 4 prefix bits, 16 suffix bits
- Offset compression
  - Dictionary includes base value and number of bits that define range of coverage
  - Example: Base value 0 and 10 offset bits (0-1023)
  - May include extended partition to provide some prediction for future values

Actionable Compression

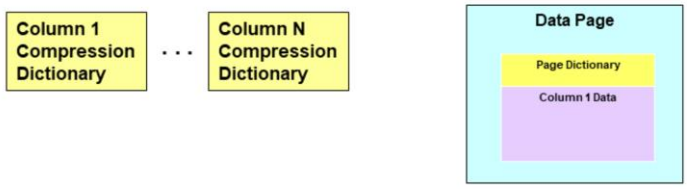


- **Actionable compression allows the following actions to be performed on compressed data**
  - Predicate evaluation (=, <, >, >=, <=, Between, LIKE)
  - Group by and Join processing on encoded data use global and On-The-Fly (OTF) encoding
- **Order-preserving encoding allows range predicates to be evaluated on compressed data**
  - Order is preserved within a dictionary partition but not across partitions
- **Avoiding decompression during predicate evaluation provides significant query performance gains**

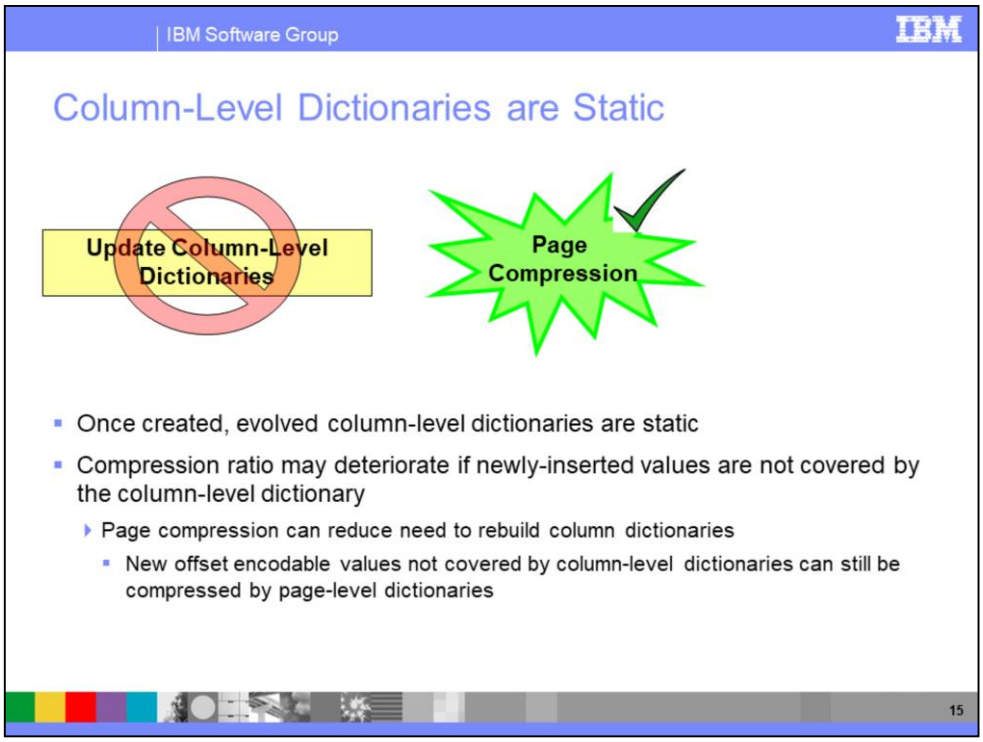
Dictionary Encoding Support by Data Type

Column Data Type	Pure Dictionary Coding	Minus Coding	Prefix Coding
Integer (2, 4, 8 bytes)	Yes	Yes	Yes
Decimal	Yes	Yes	Yes
Date/Time, Timestamp (precision <=6)	Yes	Yes	Yes
Double, Real	Yes	No	Yes
CHAR, VARCHAR, GRAPHIC, VARGRAPHIC	Yes	No	Yes
BINARY, VARBINARY	No	No	No
LOB and all variants (including inlined LOBs)	No	No	No

Compression Dictionaries for Column-Organized Tables

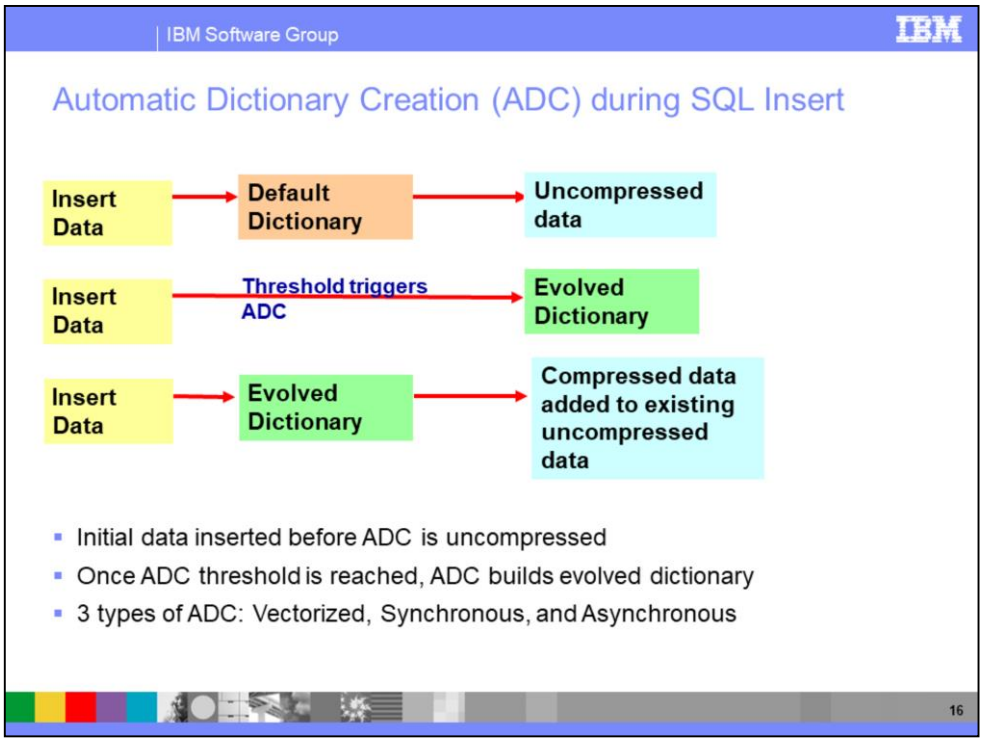


- Column-level dictionaries: **Always one per column**
  - Dictionary created during load replace, load insert, SQL insert/update
- Page-level dictionaries: **May also be created during load or insert**
  - Used if space savings outweighs cost of storing page-level dictionaries
  - Exploit local data clustering at page level



Offset encodeable = numeric datatypes such as integer, date, etc.

NOTE while compression ratio is important, column-level dictionary coverage is critical to maximize query performance.

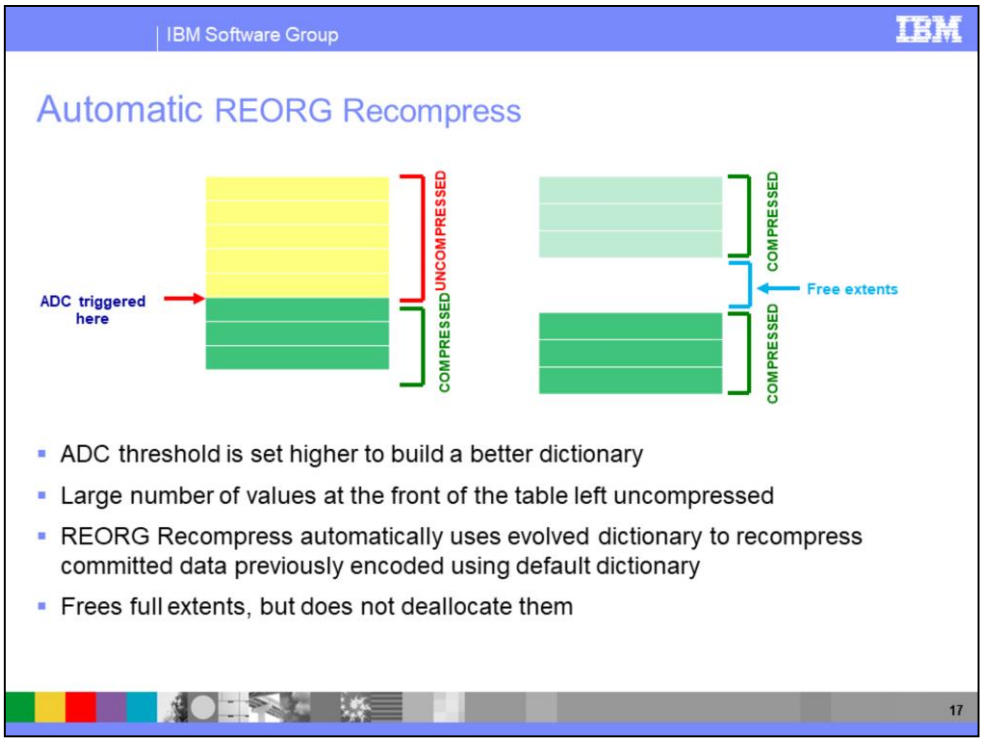


Per-MLN ADC threshold = 500K rows for one MLN, 1 million rows/# MLNs for multiple MLNs

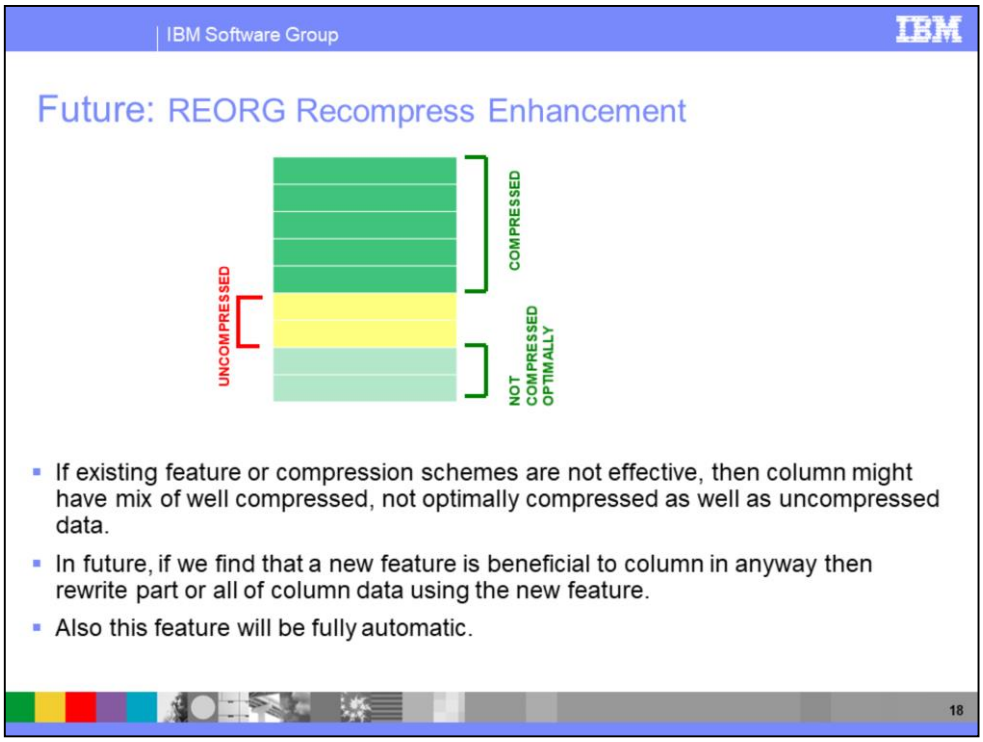
Vectorized ADC method designed for bulk insert.

Synchronous ADC is used for non-bulk insert cases where we have a Z-lock on the table or DGTTs. Examples may include CTAS, NLI tables, and inserting into an uncommitted table.

Asynchronous ADC is used in all cases where other ADC types are not available and builds column-level dictionaries in a background transaction.



Freed extents may be reused during future inserts to the same table.



Freed extents may be reused during future inserts to the same table.

New Storage Enhancements for 11.5.4

High Cardinality String Data Types Not Dictionary Encoded

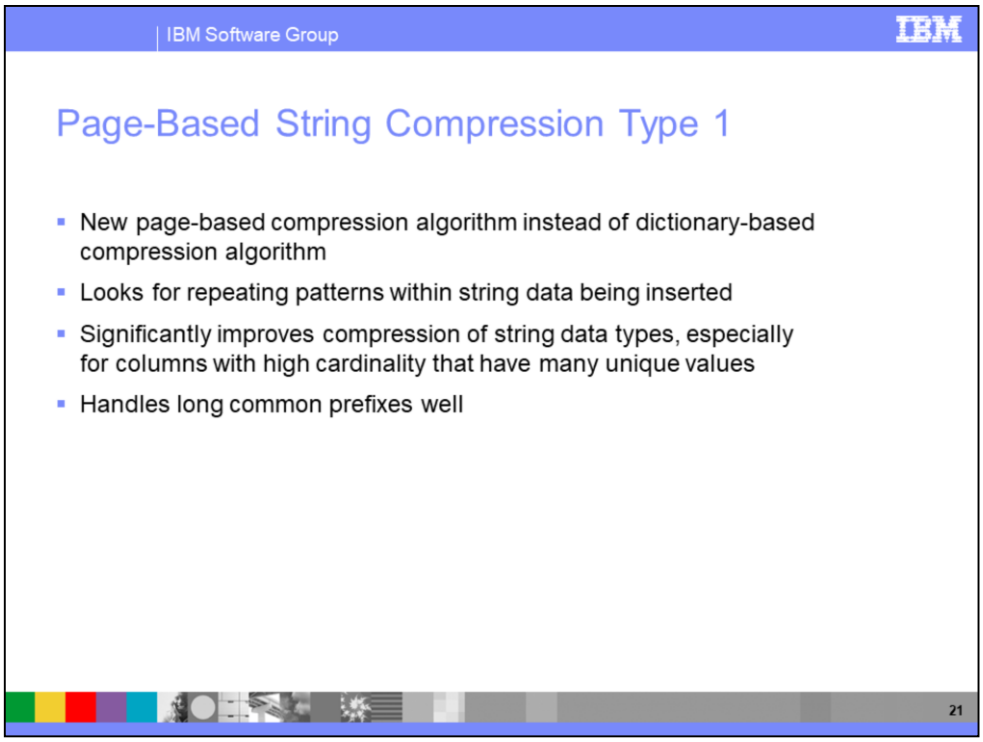
States VARCHAR
001 = Colorado
001 = Colorado
010 = Kentucky
001 = Colorado
011 = Illinois

States have high frequency so are encoded with dictionary

Product Description VARCHAR
Blue dress with unicorns girls size 6X
Red dress with hearts girls size 6X
Red dress with bears girls size 6X
Blue uniform shirt boys size 5
Red uniform shirt boys size 5

Free flowing text stored unencoded

- Frequency-based compression not effective for high cardinality string datasets so percentage of values encoded < 10%
- String data dominates storage cost

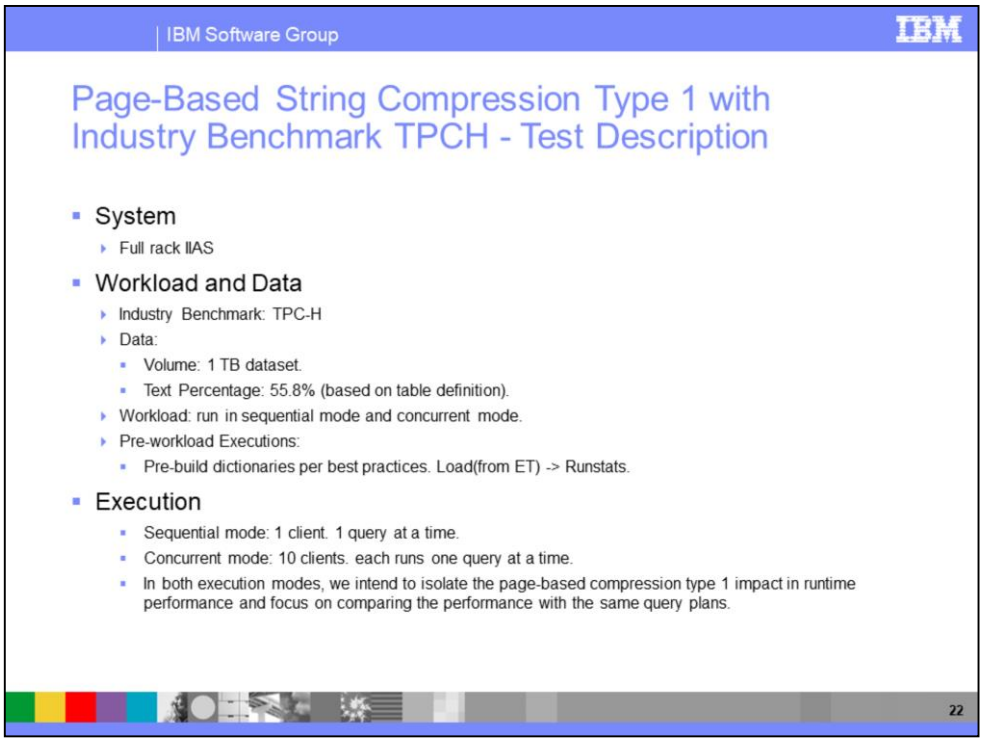


Frequency-based compression (even with our existing prefix compression) unable to provide coverage for some datasets.

- Geospatial data
- URLs
- Comments
- Etc.

String datatypes = CHAR, VARCHAR, GRAPHIC, VARGRAPHIC, BINARY, and VARBINARY

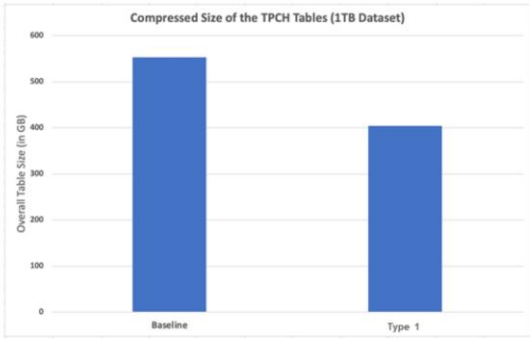
Enormous space savings possible for many such datasets!



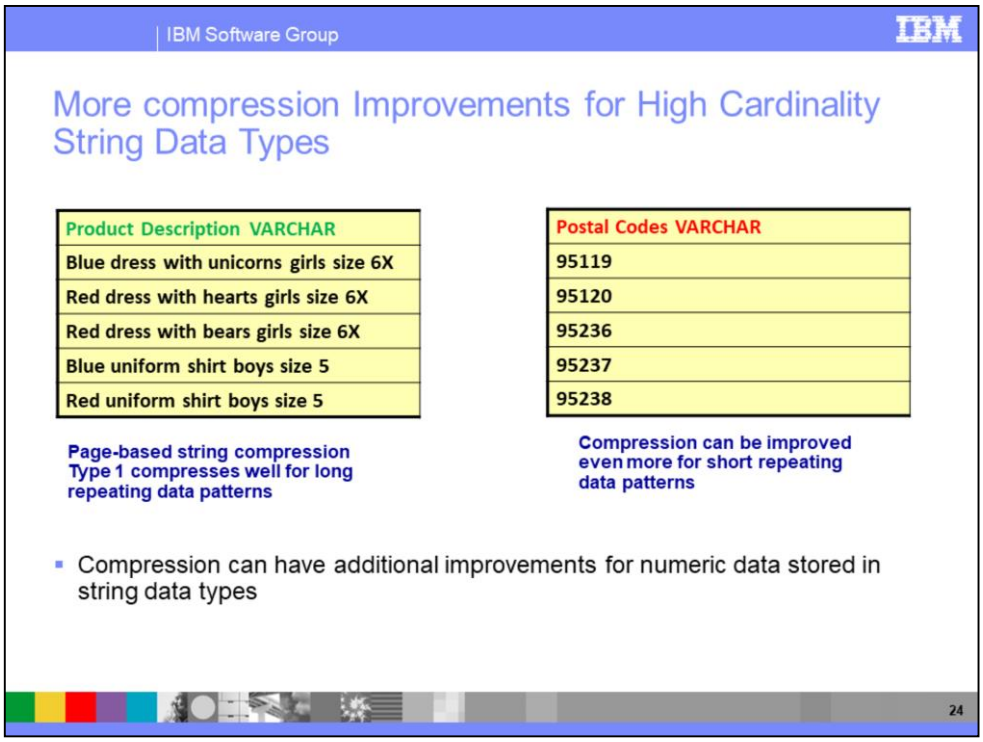
Concurrent Mode:
10 clients running concurrently executing the queries in sequential order. To avoid plan reuse different predicate values are used for the queries in each client.

The order of the queries were pre-generated (randomly) and stay unchanged for all iterations.

Compression Results with TPCH



- Overall compressed size of TPCH tables was reduced by 27% with Page based string compression Type 1.

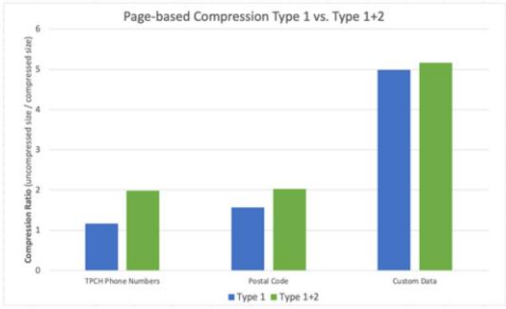


Page-Based String Compression Type 1 requires 4+ byte patterns to compress.

Page-Based String Compression Type 2

- Page-Based String Compression Type 2 very effective for compressing high cardinality hex, date, timestamp, numeric data stored in string data types
- Must have <= 16 distinct characters per compressed data page
- Sample data
  - HEX: 59721B038CB9AC5A5DD09055529A64CA4D000000
  - Postal-codes: 95133-7670
  - Telephone Numbers: 1-408-775-6978
  - Date:12/21/2003 (or other date formats)
  - Time:11:32:02 (or other time formats)
  - CDR (Call Detail Record for telecommunications):00650068D34B41799911903603
- Db2 automatically determines which compression scheme to use

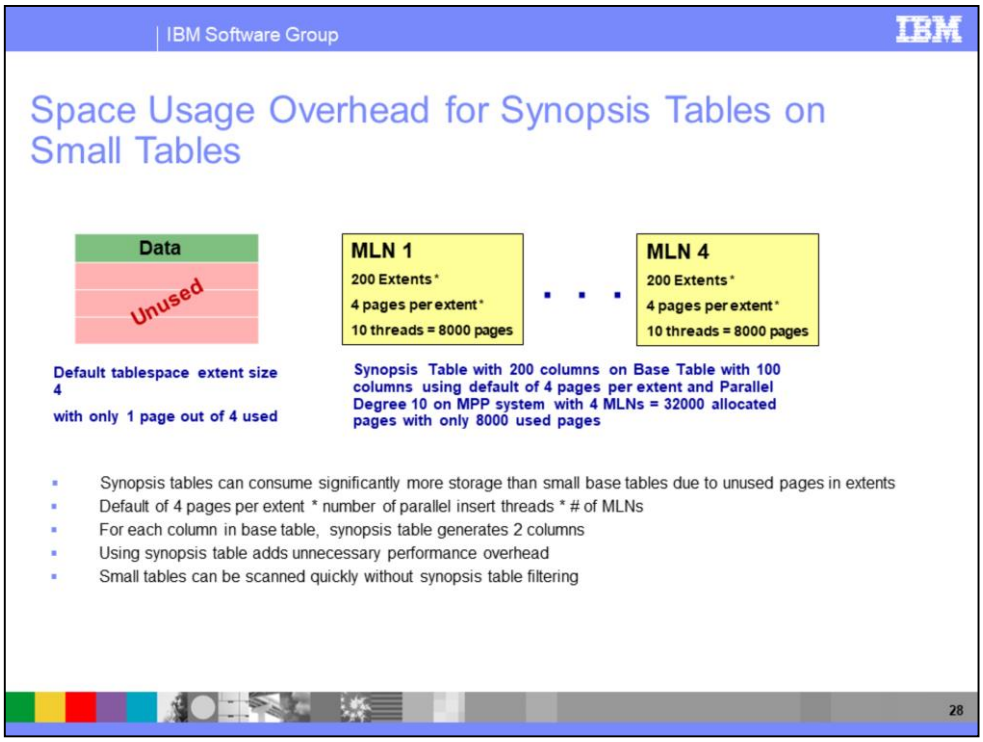
Compression Ratio with Page-based String Compression (Type 1 and 2)



- With Type 2, compression ratio for the phone numbers (stored as strings) of the TPCH benchmark was improved from 1.17 (Type 1) to 1.98.
- A custom workload also shows compression ratio for postal codes improves significantly with Type 2.
- Another custom workload shows compression ratio went from 4.99 (Type 1) to 5.17 (Type 1+2). It indicates that Type 2 can potentially increase the overall compression ratio for data that has been compressed considerably well by Type 1 already.

Page-Based String Compression Type 1 and 2 Use Cases

- During bulk inserts and bulk updates, compression can be greatly improved for the following data types:
  - CHAR/VARCHAR
  - GRAPHIC/VARGRAPHIC
  - CHAR FOR BIT DATA/VARCHAR FOR BIT DATA
  - BINARY/VARBINARY

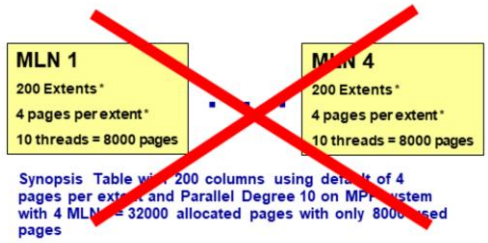


Space usage overhead may quickly become significant depending on number of concurrent streams used to populate a table.

Deferred Synopsis Tuple Creation for Small Base Tables

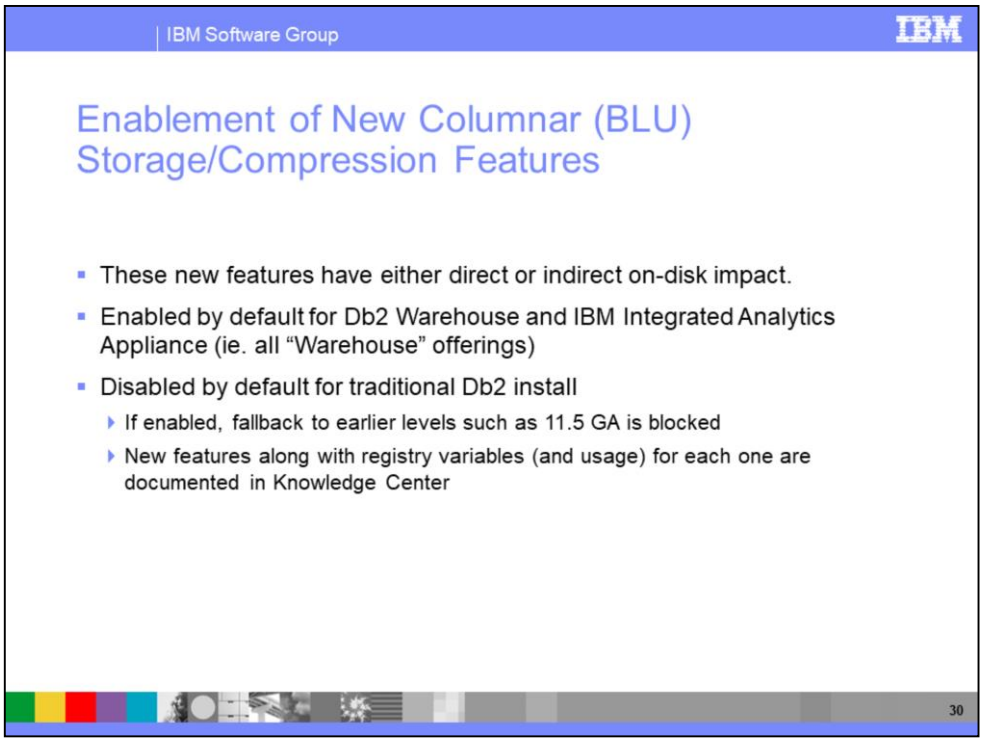
Default tablespace extent size 4

with only 1 page out of 4 used



Synopsis Table with 200 columns using default of 4 pages per extent and Parallel Degree 10 on MPP system with 4 MLNs = 32000 allocated pages with only 8000 used pages

- Defer creation of synopsis tuples until certain table size exceeded
- Avoids creating unnecessary synopsis tuples for small base tables
- Small tables don't need synopsis table for query performance



The following registry variable settings are used on-prem to enable the new 11.5.4 features discussed here. NOTE that Db2 must be restarted after these registry variables are set for them to take effect.

To enable Page-Based String Compression Types 1 and 2:

db2set DB2_COL_STRING_COMPRESSION="UNENCODED_STRING:ON"

To enable Deferred Synopsis Tuple Creation:

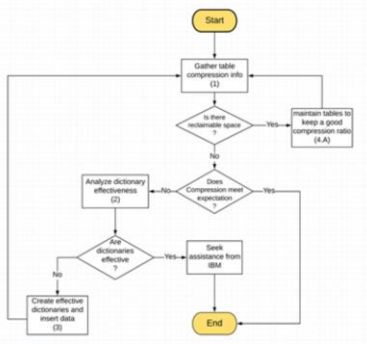
DB2_COL_SYNOPSIS_SETTINGS="DEFER_FIRST_SYNOPSIS_TUPLE:ON"

Compression Best Practices

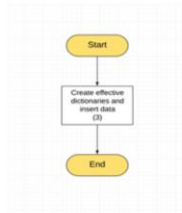
Best Practices Paper

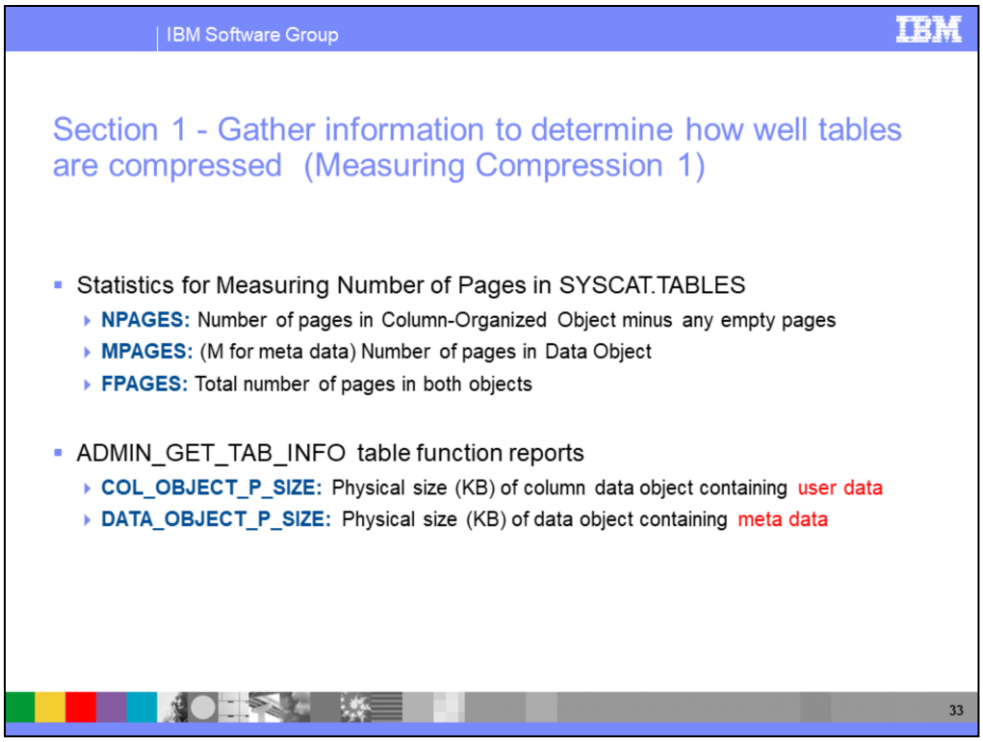
- The paper can be downloaded from:
  - IIAS: https://ibm.biz/BdqP2U
  - Other platforms: https://ibm.biz/BdqPGw

A. For existing tables compression. Numbers corresponding to section numbers in the paper



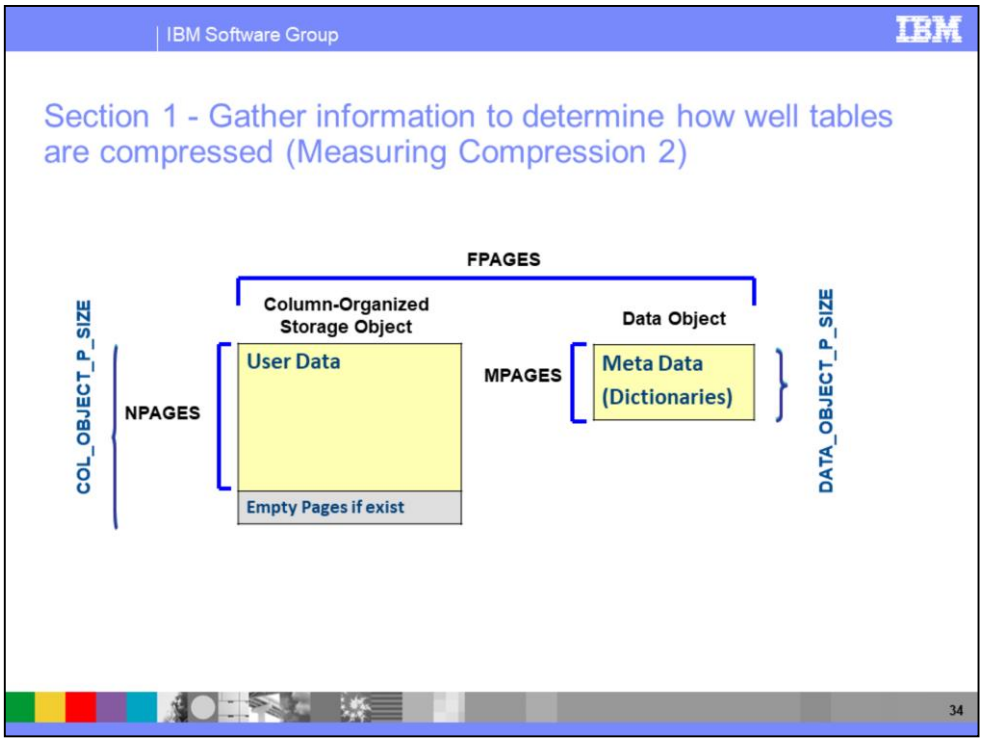
B. For database migrations from Netezza to IIAS.





COL_OBJECT_P_SIZE : The size returned takes into account full extents allocated for the table and includes the EMP extents for objects created in DMS table spaces. This size represents the physical size of the base columnar data only. Space consumed by LOB data, Long Data, Indexes and XML objects are reported by other columns.

DATA_OBJECT_P_SIZE : For column-organized tables, the data object physical size is the amount of disk space that is physically allocated for the table metadata only, which is relatively small.



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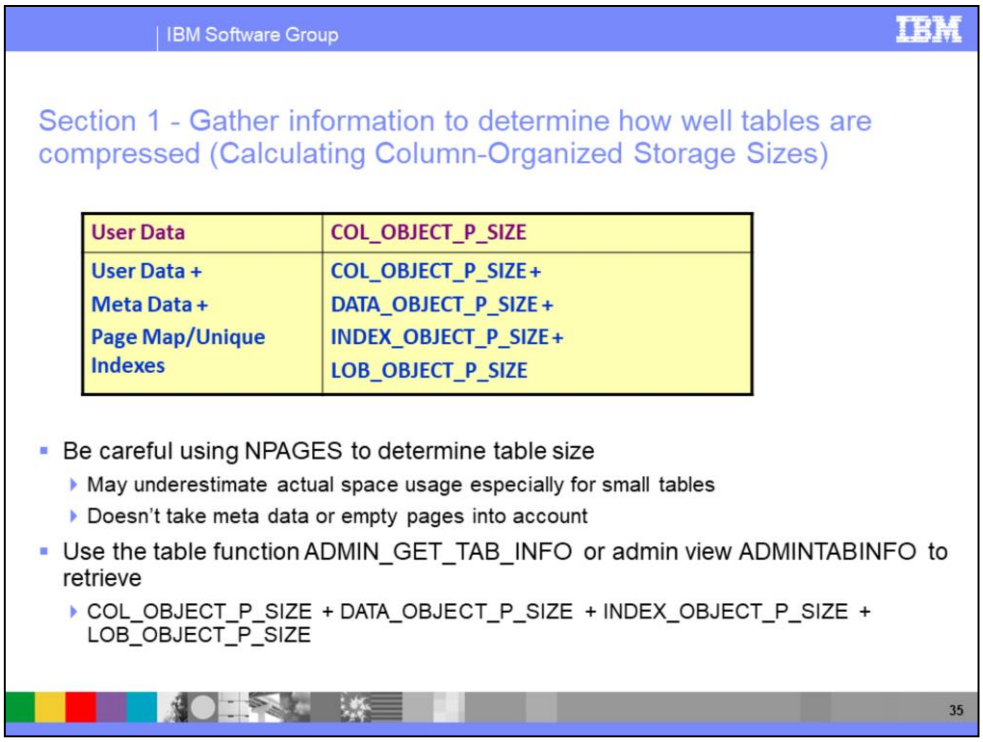
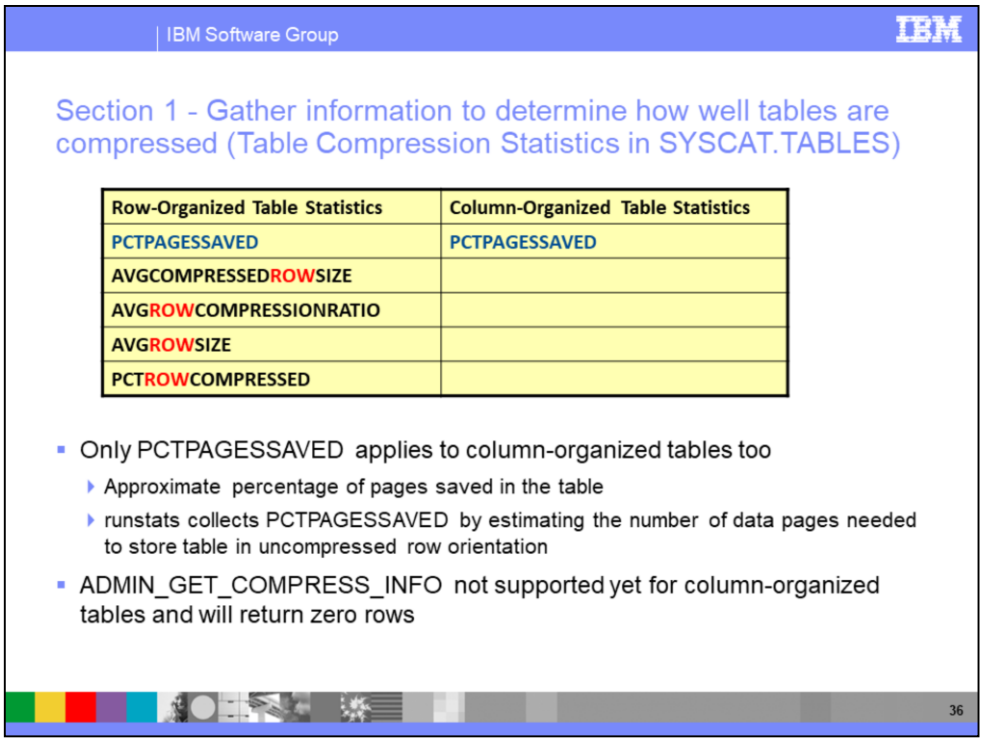


You may want to run RUNSTATS first to ensure statistics are up to date.

Here is a sample query to compute storage sizes for all tables within a given tablespace (substitute the appropriate tablespace name for BLYLE):

```
SELECT CAST(TABSCHEMA as char(16)) TABSCHEMA,
                    CAST(TABNAME as char(20)) TABNAME,
                    DBPARTITIONNUM,
                    (DATA_OBJECT_P_SIZE+COL_OBJECT_P_SIZE+INDEX_OBJECT_P_SIZE)/1024 AS PHYSICAL_SIZE_MB,
                    RECLAIMABLE_SPACE AS RECLAIMABLE_SPACE
FROM TABLE (SYSPROC.ADMIN_GET_TAB_INFO('BLYLE','T1') ) ;
```



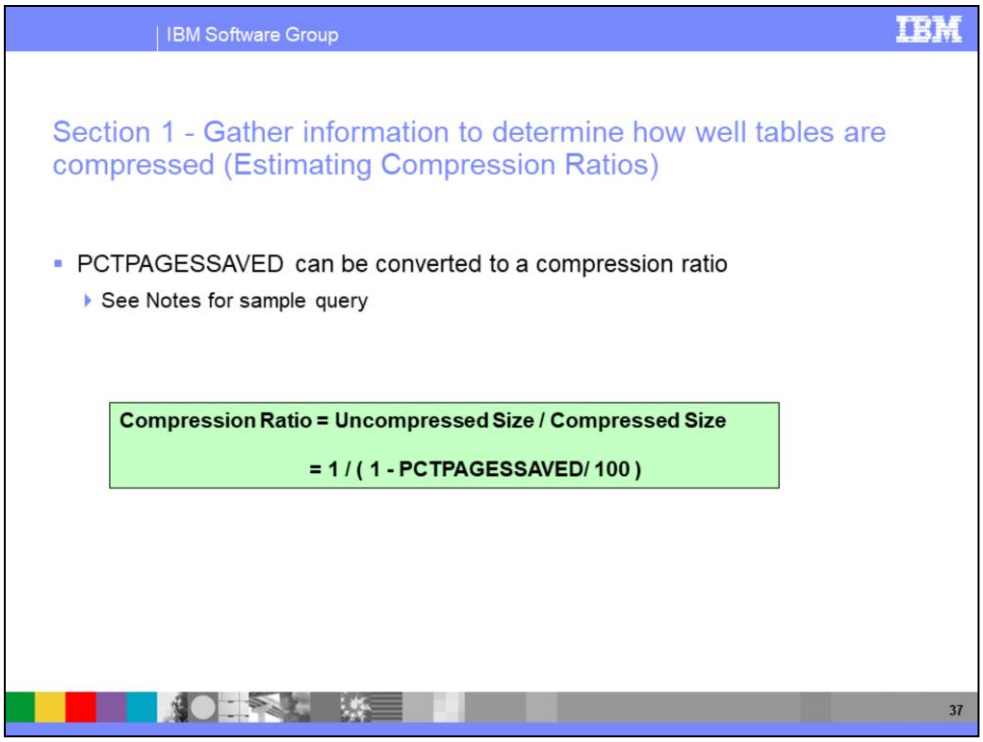
For column-organized tables, the following compression statistics will all have the value of -1 for Not Applicable:

•AVGCOMPRESSEDROWSIZE

•AVGROWCOMPRESSIONRATIO

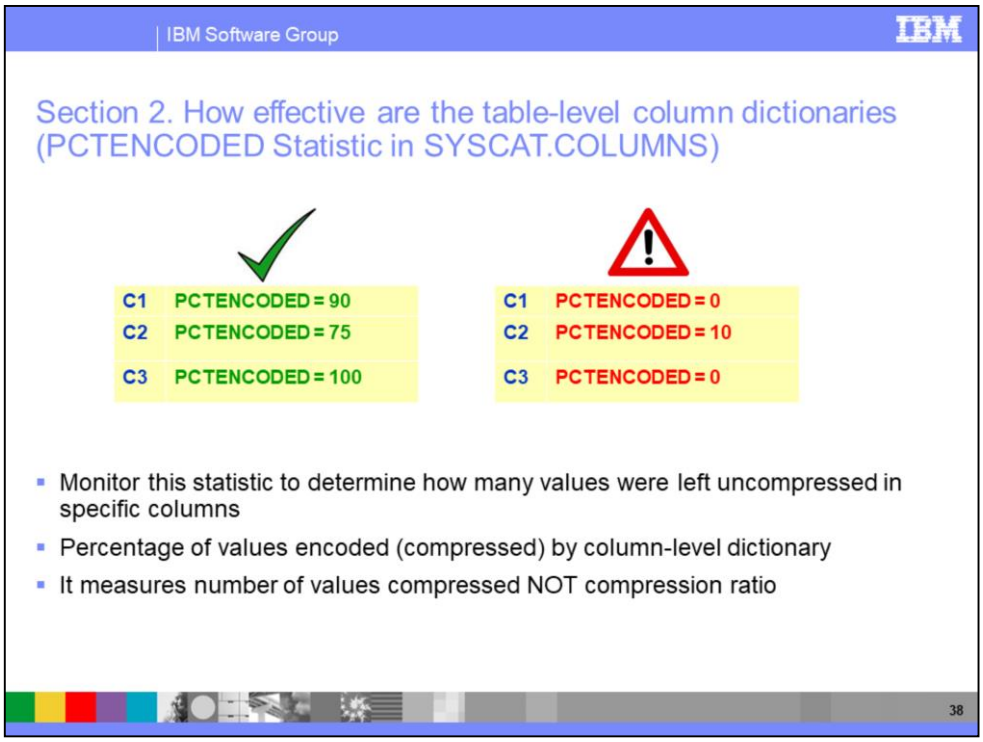
•AVGROWSIZE

•PCTROWCOMPRESSED



Here is a sample query to compute the compression ratio for a specific table:

```
SELECT CAST(TABSCHEMA as char(16)) TABSCHEMA,
                    CAST(TABNAME as char(20)) TABNAME,
                    PCTPAGESSAVED,
                    DEC(1.0/(1.0-(PCTPAGESSAVED*1.0)/100.0),31,2) AS compression_ratio
FROM SYSCAT.TABLES tab
WHERE TABSCHEMA = 'BLYLE' AND TABNAME = 'T1' with UR;
```



Each column could have a different encoded percentage.

WARNING: PCTENCODED does not include page compression since it is used in heuristic decisions for performing join or group by on either encoded or unencoded data. PCTENCODED = 0 could actually have many values compressed at page level.

Would like to have better statistics in future such as PCTCOMPRESSED per column.

If you suspect a problem with the compression ratio after the initial load, check PCTENCODED to make sure the columns were compressed. If you see many columns where PCTENCODED = 0, then something could have gone wrong with the load such as the util_heap_sz value set too small and the AUTOMATIC option wasn't specified. PCTENCODED = 0 means that the values were not encoded using the table-level dictionary but they still could have been compressed using the page-level dictionaries for minus coded values.

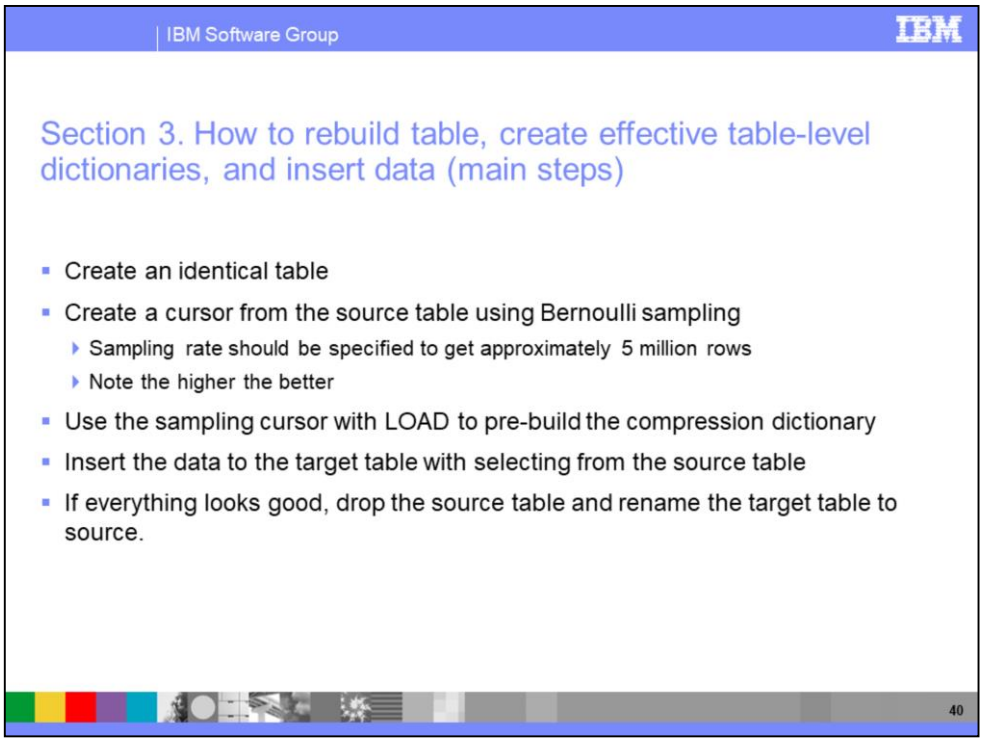
Here is a sample query to find the PCTENCODED values for the columns of a specific table:

```
SELECT CAST(COLNAME AS CHAR(20)) COLNAME, CAST(TYPENAME AS CHAR(16)) TYPENAME, PCTENCODED, COLCARD FROM
SYSCAT.COLUMNS WHERE TABSCHEMA = 'TPCH' AND TABNAME = 'ORDERS'

COLNAME         TYPENAME        PCTENCODED COLCARD
```

```
-------------------- ---------------- ---------- --------------------
O_ORDERKEY           BIGINT                  100            150007839
O_CUSTKEY            INTEGER                 100             77594624
O_ORDERSTATUS        CHARACTER               100                    3
O_TOTALPRICE         DECIMAL                 100             36438016
O_ORDERDATE          DATE                    100                 2400
O_ORDERPRIORITY      CHARACTER               100                    5
O_CLERK              CHARACTER               100              1003520
O_SHIPPRIORITY       INTEGER                 100                    1
O_COMMENT            VARCHAR                   1             58982400

  9 record(s) selected.
```

Section 2. How effective are the table-level column dictionaries (PCTENCODED for string data types)

- PCTENCODED does not reflect page level encoding or correlate with page level compression.
- Low PCTENCODED does not necessarily mean poor compression for columns of string data types (CHAR, VARCHAR, GRAPHIC, VARGRAPHIC, BINARY, VARBINARY, CHAR FOR BIT DATA, VARCHAR FOR BIT DATA)



A. Create identical table.

```
create table T1 like exttable organize by column;
```

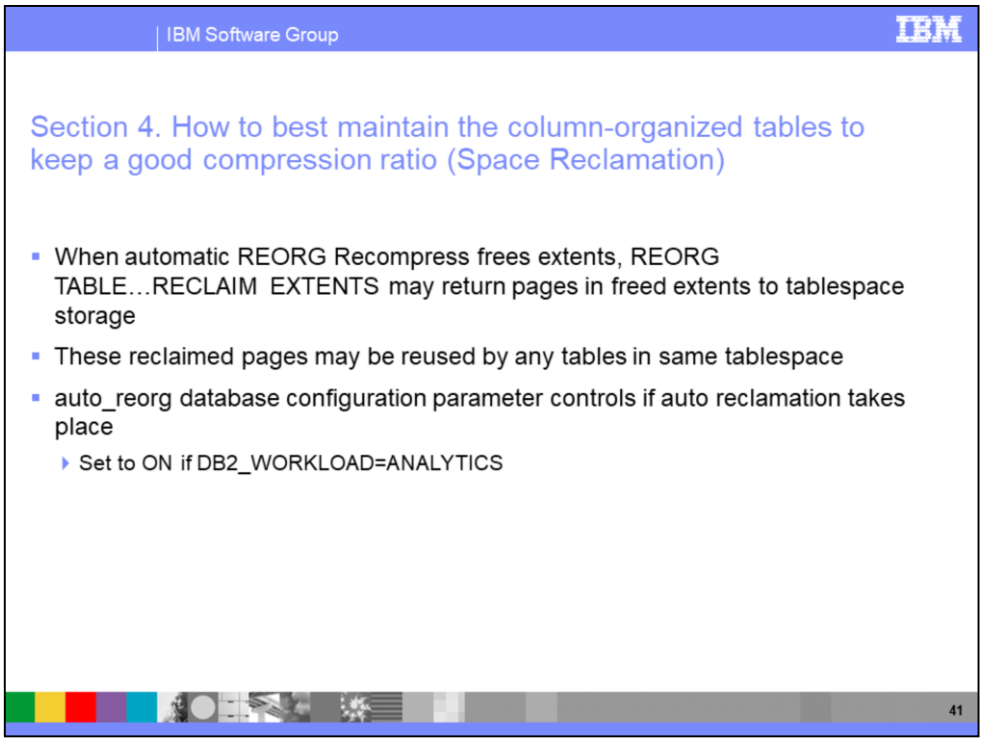
B. Create a sampling cursor from the source table.

```
declare cursor1 CURSOR FOR select * from exttable tablesample bernoulli(1);  -- <== 1% sample rate to get 5M of 500M rows
```

C. Use the sampling cursor with LOAD to pre-build the compression dictionary.

```
load from cursor1 OF CURSOR  MODIFIED BY CDEANALYZEFREQUENCY=100 replace resetDictionaryOnly into T1;  -- <== Load has its own internal sampling, turn it off to avoid double sampling....
```

```
insert into T1 select * from exttable;
```



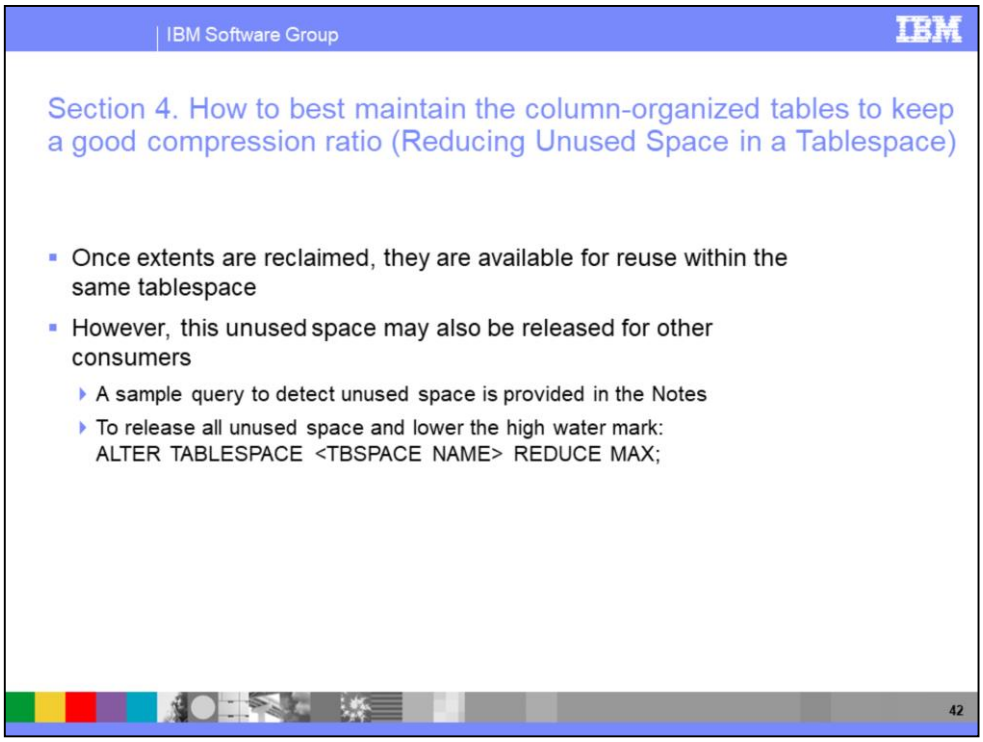
To manually check for reclaimable space (update schema value as appropriate):

SELECT substr(tabname,1,10) as tabname , substr(tabschema,1,10) as tabschema, reclaimable_space as reclaimable_space_KB FROM SYSIBMADM.ADMINTABINFO WHERE tabschema = 'CDREXELI' order by tabname WITH UR;

If you locate tables with high amounts of reclaimable space, you may manually run REORG RECLAIM EXTENTS manually. Here is a sample command:

REORG TABLE <tabname> RECLAIM EXTENTS;

Once this is complete, you may rerun RUNSTATS to verify that statistics are up to date.



Here is a sample query to examine your tablespaces for unused space:

select substr(TBSP_NAME,1,14) as TS_NAME , TBSP_TOTAL_PAGES as Total_pages, TBSP_USED_PAGES as Used_pages , TBSP_PAGE_TOP as High_water_MARK , reclaimable_space_enabled from table (MON_GET_TABLESPACE (NULL , -1)) as ts where TBSP_NAME NOT LIKE ('SYS%') and TBSP_TYPE = 'DMS' ;

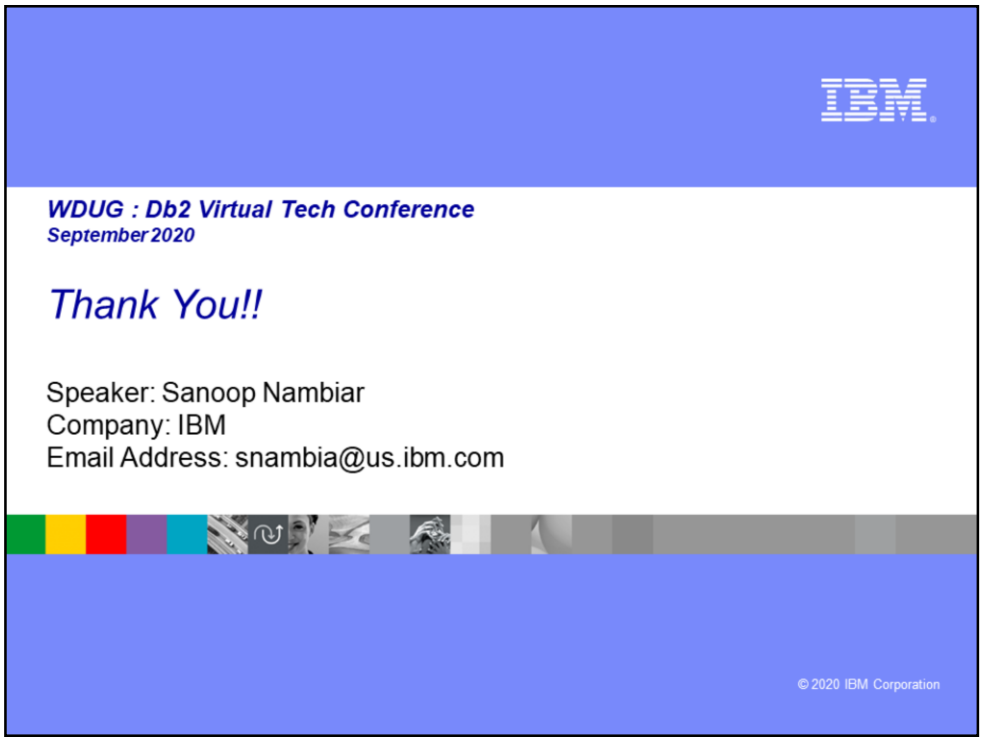
When considering reducing tablespace usage:

- Look for tablespaces with total pages and/or HWM that is much higher than the number of used pages
- Look for tablespaces with reclaimable space attribute of '1'

REDUCE MAX command is asynchronous, user needs to wait it completes to do a RUNSTATS

The max should be only used if no concurrent INSERTs are running

The MON_GET_EXTENT_MOVEMENT_STATUS table function can be used to return the status of the extent movement operation


WDUG : Db2 Virtual Tech Conference
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