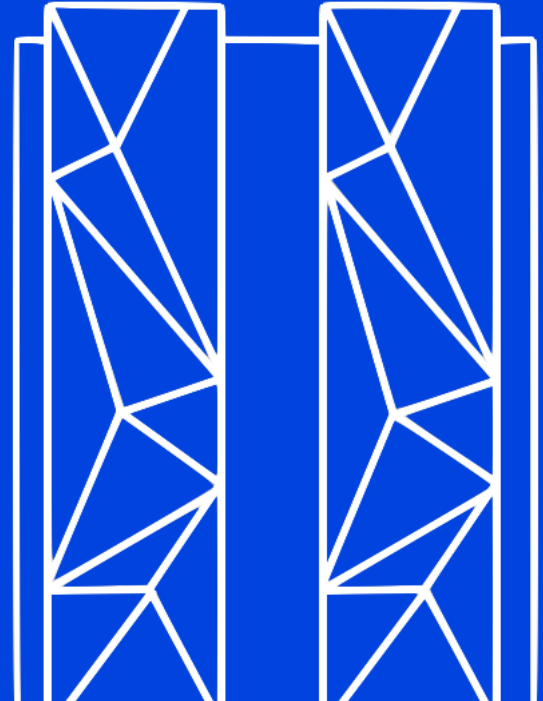


# Are you compatible?

Db2 12 for z/OS, Continuous Delivery,  
Function Levels and Application  
Compatibility (APPLCOMPAT)

April 13, 2021  
*Mark Rader*



# Agenda

## Review of continuous delivery

### Function level dependent **highlights**

- FL501 – May 2017
- FL502 – May 2018
- FL503 – October 2018
- FL504 – April 2019
- FL505 – June 2019
- FL506 – October 2019
- FL507 – June 2020
- FL508 – October 2020
- FL509 – February 2021

### Non-function level dependent **highlights**

- Distributed data facility (DDF)
- Utilities
- Analytics
- Z synergy
- Data sharing
- Usability
- Security

# Continuous delivery – feature categories

## Module level or code level dependent

Infrastructure changes, e.g.:

- Utility enhancements
- Parallel Sysplex exploitation
- Db2ZAI enablement

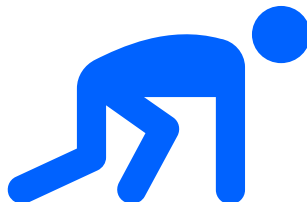


## Function level dependent

Significant system enhancements, e.g.:

- ENCRYPTION\_KEYLABEL in DSNZPARM
- HUFFMAN compression algorithm
- REBIND Phase-in

**Some function levels are catalog level dependent**



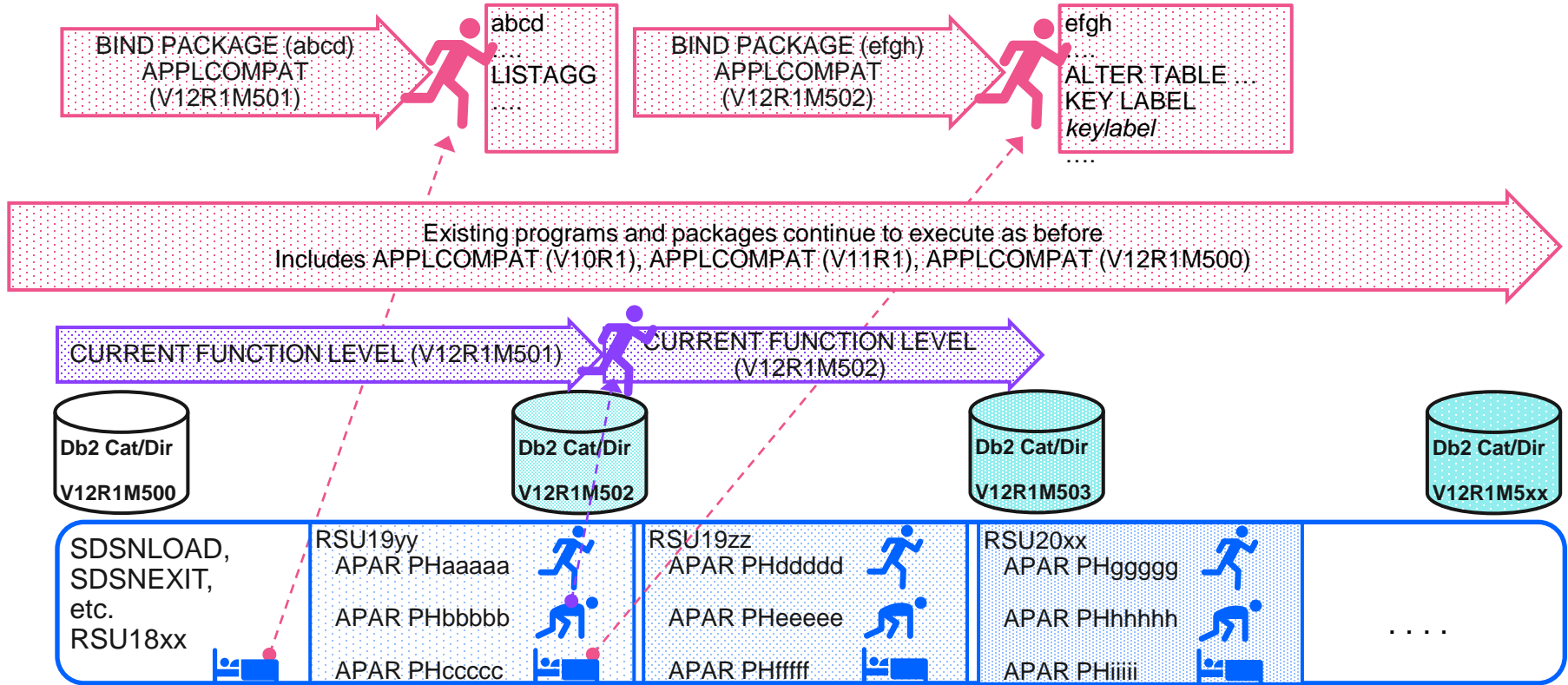
## APPLCOMPAT dependent

SQL-related changes: new or changed SQL or results, e.g.:

- LISTAGG
- KEY LABEL for STOGROUP, TABLE or TABLESPACE
- ENCRYPT\_DATAKEY, DECRYPT\_DATAKEY
- DECFLOAT columns in indexes



# Exploiting function levels



# What does DSNZPARM APPLCOMPAT do?

- This is the default APPLCOMPAT setting for packages that have not set APPLCOMPAT yet
  - BIND new package and 'forget' to specify APPLCOMPAT
  - REBIND pre-Db2 11 package without setting APPLCOMPAT
- Once a package has an APPLCOMPAT setting:
  - Changing the DSNZPARM value will not affect that package
- When should you change the DSNZPARM?
  - Recommendation: after you have issued -ACTIVATE FUNCTION LEVEL (V12R1M500) and are sure you are not going back to V12R1M100\* change to V12R1M500
  - Specific packages that want to take advantage of certain functions will specify the required APPLCOMPAT setting
  - Consider separate collections for IBM Data Server Driver packages (aka 'NULLID')
    - Each collection can have a different APPLCOMPAT setting
    - Can choose collection with SET CURRENT PACKAGE PATH explicitly or via System Profile Monitoring

# Function level 501

## PI70535

- Built-in function LISTAGG

One example - given this data in a table:

EMPNO	LASTNAME	WORKDEPT
0001	THOMAS	A01
0002	ROGERS	B01
0003	HONG	A01
0004	BARKER	B01
0005	KOHL	B01

```
SELECT WORKDEPT,  
LISTAGG(LASTNAME, ' , ' )  
WITHIN GROUP (ORDER BY LASTNAME)  
AS EMPLOYEES  
FROM EMPLOYEE  
GROUP BY WORKDEPT;
```

```
WORKDEPT    EMPLOYEES  
-----  
A01          HONG, THOMAS  
B01          BARKER, KOHL, ROGERS
```

# Function level 502

## PI95511

- Db2 interfaces to specify and report key labels for data set encryption
- System parameter for catalog and directory objects and archive logs on disk
- SQL data definition language (DDL) for tables or storage groups
- Db2 report and display options
- Explicit casting of numeric data types to strings with GRAPHIC or VARGRAPHIC functions

# Encrypting Db2 system objects



Security / System Admin / Storage Admin

In RACF, alter DFP segment in data set profile - DATAKEY()

– OR –

In Db2, set key label  
using system parameter  
OR  
IDCAMS DEFINE, etc.

– OR –

In DFSMS, assign  
to data class

1. Security admin sets key label via RACF
2. System admin can set a key label using Db2 system parameter (DSNZPARM)
  - ENCRYPTION\_KEYLABEL
  - Command –SET SYSPARM to enable parameter change
  - Applies to:
    - Catalog and directory objects
    - Disk archive logs
3. Storage admin can set key label in DFSMS data class

Numbers represent precedence order



# Encrypting Db2 user objects



Security / Database Admin / Storage Admin

In RACF, alter DFP segment in data  
set profile - DATAKEY()

– OR –

In Db2, set key label  
using SQL DDL interfaces  
OR  
IDCAMS DEFINE, etc.

– OR –

In DFSMS, assign  
to data class

1. Security admin sets key label via RACF
2. Application database admin sets key label using SQL data definition language (DDL) interfaces
  - CREATE/ALTER STOGROUP
  - CREATE/ALTER TABLE
  - Note: requires APPLCOMPAT(V12R1M502)
3. Storage admin can set key label in DFSMS data class

Numbers represent precedence order

# Cast numeric values to GRAPHIC, VARGRAPHIC

In Db2 11 and prior, two step process

1. CAST (*numeric column* as CHAR(10) )
2. CAST (*character*) as GRAPHIC

Or

1. apply VARCHAR built-in function to *numeric column*, followed by
2. Apply VARGRAPHIC built-in function to resultant VARCHAR

Db2 12 solution, with APPLCOMPAT V12R1M502

- CAST(*numeric column* AS GRAPHIC(10) )

Or

- VARGRAPHIC(*numeric column*)

One step!



# Function level 503

## PH00506

- APAR PH00506 provides the code level which is the basis for Db2 AI for z/OS (Db2ZAI)
- Db2 AI for z/OS – product that applies machine learning capabilities to customize Db2 for z/OS for a client's workload
- Only FL500 required for Db2ZAI

### Temporal enhancements

- System time temporal: query correction
- System time temporal: replication enhancements

Because these change the effect of SQL operations, they require an application compatibility (APPLCOMPAT) bind/rebind setting change

# Function level 504

## PH07672

- Deprecated objects
- Huffman compression (with z14 or later)
- Built-in function (BIF) pass-through to Db2 Analytics Accelerator
- Syntax flexibility for special registers, NULL predicates

Deprecated objects cannot be created with package bound with APPLCOMPAT (V12R1M504) or higher

e.g. CREATE TABLESPACE	issued by application with APPLCOMPAT < V12R1M504	issued by application with APPLCOMPAT >= V12R1M504
SEGSIZE n	Segmented Table Space	UTS – PBG
SEGSIZE 0 & NUMPARTS p	Classic Partitioned Table Space	UTS – PBR
SEGSIZE n & MAXPARTITIONS p	UTS – PBG	UTS – PBG
SEGSIZE n & NUMPARTS p	UTS – PBR	UTS – PBR

# Huffman compression

New type of compression dictionary

Requirements:

- z14 or beyond
- Universal table space (UTS) only
- DSNZPARM: **TS\_COMPRESSION\_TYPE**
  - **FIXED\_LENGTH** (previous compression logic)
  - **HUFFMAN** (new compression; entropy encoding)
- Table space has COMPRESS YES attribute

Next dictionary build (REORG, LOAD REPLACE or INSERT) generates Huffman dictionary

Which compression algorithm was used?

- Use DSN1PRNT
- Check header page field HPGZLD
  - L or F indicates fixed-length dictionary
  - H indicates Huffman dictionary

# Built-in functions pass-through to Db2 Analytics Accelerator

- Db2 verifies the data types of the parameters are valid for the functions
- Accelerator engine does all other function resolution and validation
- Db2 Analytics Accelerator V7 or above

CUME\_DIST

FIRST\_VALUE

LAG

LAST\_VALUE

LEAD

NTH\_VALUE

NTILE

PERCENT\_RANK

RATIO\_TO\_REPORT

REGEXP\_COUNT

REGEXP\_INSTR

REGEXP\_LIKE

REGEXP\_REPLACE

## V12R1M504: New BIFs pass-through (reference)

**CUME\_DIST** : Returns a cumulative distribution of a row within an OLAP window

**FIRST\_VALUE** : Returns the expression value for the first row in an OLAP window

**LAG** : Returns the expression value for the row at offset rows before the current row

**LAST\_VALUE** : Returns the expression value for the last row in an OLAP window

**LEAD** : Returns the expression value for the row at offset rows after the current row

**NTH\_VALUE** : Returns the expression value for the nth-row row in an OLAP window

**NTILE** : Returns the quantile rank of a row

**PERCENT\_RANK** : Returns a relative percentile rank of a row within an OLAP window

**RATIO\_TO\_REPORT** : Returns the ratio of an argument to the sum of the arguments in an OLAP partition

**REGEXP\_COUNT** : Returns a count of the number of times that a regular expression pattern is matched in a string

**REGEXP\_INSTR** : Returns the starting or ending position of the matched substring, depending on the value of the return\_option argument

**REGEXP\_LIKE** : Returns an INTEGER value of 0 or 1 indicating if the regular expression pattern is found in a string

**REGEXP\_REPLACE** : Returns a modified version of the source string where occurrences of the regular expression pattern found in the source string are replaced with the specified replacement string

# Syntax flexibility for special registers, NULL predicates

- New syntax options make it easier to port applications and data to Db2 for z/OS from other platforms
- Example
  - SET :WS\_NAME = CLIENT WRKSTNNAME

## Special registers

Existing syntax	New syntax option
CURRENT CLIENT_ACCTNG	CLIENT ACCTNG
CURRENT CLIENT_APPLNAME	CLIENT APPLNAME
CURRENT CLIENT_USERID	CLIENT USERID
CURRENT CLIENT_WRKSTNNAME	CLIENT WRKSTNNAME
CURRENT SERVER	CURRENT_SERVER
CURRENT TIME_ZONE CURRENT TIMEZONE	CURRENT_TIMEZONE

## NULL predicates

Existing syntax	New syntax option
IS NULL	ISNULL
IS NOT NULL	NOTNULL



# Function level 505

## PH09191

- REBIND phase-in
  - Db2 Analytics Accelerator hybrid transactional analytical processing (HTAP) phase 2
  - Built-in function (BIF) for column encryption
  - Indexes for DECFLOAT columns
  - Removal of trigger restrictions for temporal tables and for transparent archiving
  - RUNSTATS sampling simplification
- Note: PH28693 (January 2021) for REBIND phase-in

# REBIND phase-in

## Problem statement

- DBA cannot bind packages that are in use, for example
  - Cannot reoptimize
  - Cannot change bind options
  - Cannot switch to previous access path in case of regression
- 'in use' means use count is  $> 0$ 
  - Applies to RELEASE COMMIT until commit
  - Applies to RELEASE DEALLOCATE until thread termination

## Solution: REBIND phase-in

- Existing threads use current package copy
- DBA issues REBIND; Db2 creates new package copy
  - Db2 marks current copy 'do not use' in EDM pools
- New threads use new copy
  - Old copy deleted when no longer used

# REBIND phase-in example

Thread 1 – copy ID 0



Thread 2 – copy ID 0



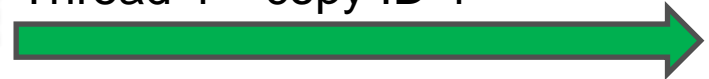
REBIND – copy ID 4: CURRENT



Thread 3 – copy ID 0



Thread 4 – copy ID 4



# REBIND phase-in sequence of events

- Threads executing CURRENT package-copy (copy ID n)
- REBIND
  - Create a next CURRENT copy of package with new copy ID (n+1)
  - Replicate old CURRENT copy (n) to PREVIOUS (copy ID 1) and ORIGINAL (copy ID 2)
    - If needed
  - Move copy ID n to SYSPACKCOPY as phased-out copy
- New threads load and execute new CURRENT copy (n+1) once the REBIND completes

# REBIND phase-in COPYID

COPYID column	in SYSIBM...	Remark
0, 4, 5, ... 16	SYSPACKAGE	CURRENT, used in wrap-around mode
1	SYSPACKCOPY	PREVIOUS
2	SYSPACKCOPY	ORIGINAL
3	-	reserved
0, 4, 5, ... 16	SYSPACKCOPY	Phased-out copies, until deleted

# REBIND phase-in details

- Current copy
  - 1 row in SYSPACKAGE, including COPYID column
  - Copy ID generated as 0, 4, 5, 6, ...16 then wrap back
    - 1 = PREVIOUS, 2 = ORIGINAL, 3 is reserved
- Phased-out copies
  - In SYSPACKCOPY (with COPYID other than 1, 2)
  - Cleaned up on subsequent REBIND
- EXPLAIN PACKAGE COPY copy-id
  - CURRENT: copy ID in SYSPACKAGE.COPYID column (0 or non-0)
  - Omit COPY clause: includes CURRENT, PREVIOUS, and ORIGINAL
  - Changed value in PLAN\_TABLE.HINT\_USED
- New copy ID field in IFCID 239 package accounting
  - Increased QPAC mapping size

# REBIND SWITCH phase-in

- Threads are executing CURRENT copy ID (n)
- REBIND SWITCH:
  - Copy PREVIOUS or ORIGINAL to new CURRENT copy ID (n+1)
  - Copy n becomes phased-out copy
  - Replicate phased-out copy (n) into PREVIOUS and ORIGINAL if needed
- New threads can execute new CURRENT (n+1)

# REBIND phase-in eligibility

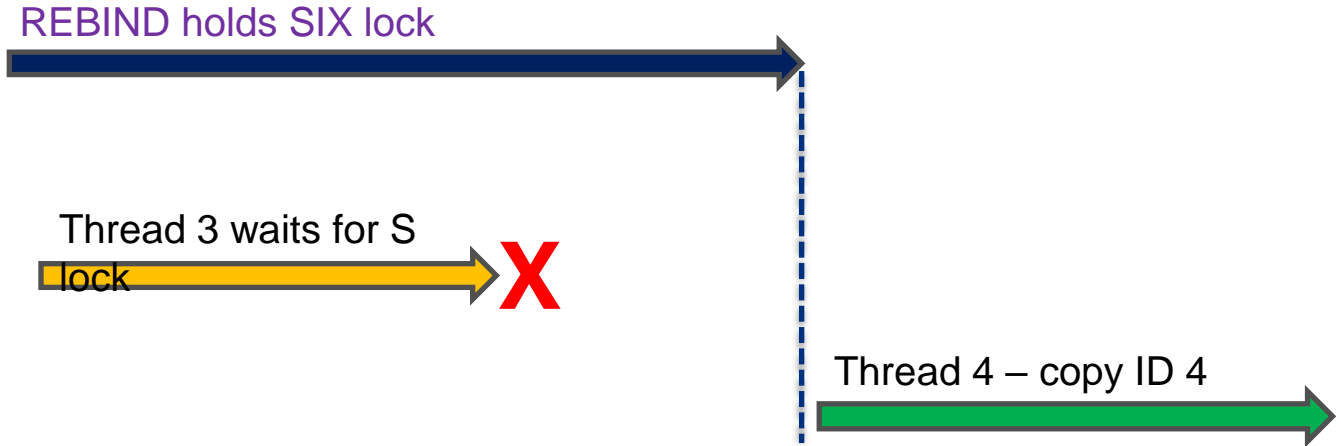
- Phase-in occurs only when current copy is in use
- Initial support:
  - PLANMGMT(EXTENDED) APREUSE(NO)
  - PLANMGMT(EXTENDED) APREUSE(WARN|ERROR) APREUSESOURCE(CURRENT)
- Packages for native SQL routines or advanced triggers do not currently support REBIND phase-in
- REBIND phase-in is an always-on feature in function level 505
  - No APPLCOMPAT requirement



# FREE phased-out copy

- Phased-out copy clean up on REBIND
  - Query package lock holders
  - Compare oldest thread's package allocation time to the time a copy becomes phased-out
    - DSNT500I message with reason code 00E30307 to show thread blocking FREE
  - New IFCID 393 to indicate long running thread RELEASE(DEALLOCATE), uncommitted thread

# REBIND phase-in holds SIX lock, existing scenario 1



# REBIND phase-in wait for SIX lock, existing scenario 2

Thread 1 – copy ID 0 holds S lock



Thread 2 – copy ID 0



REBIND – copy ID 4: CURRENT



REBIND waits for SIX lock **X** holds U lock

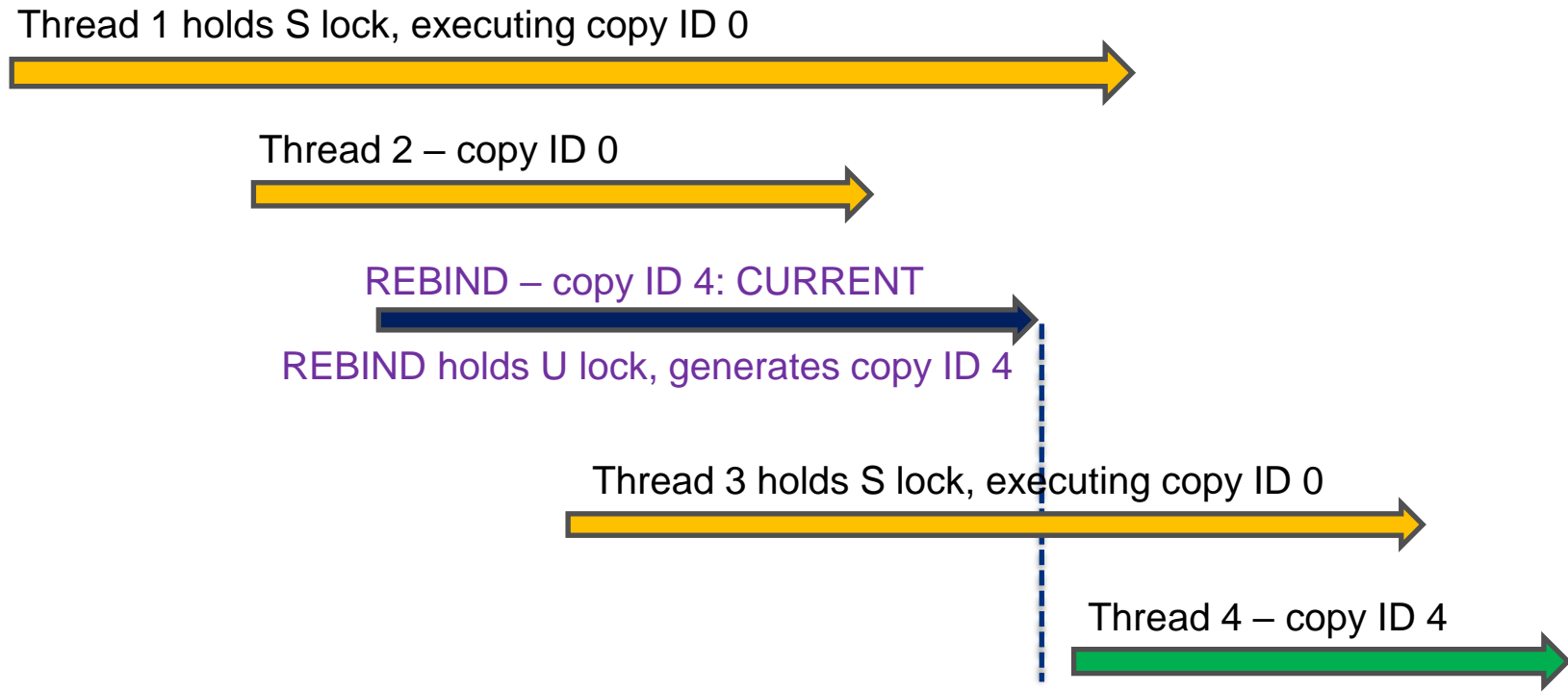
Thread 3 waits for S



Thread 4 – copy ID 4



# REBIND phase-in without SIX lock ([PH28693](#))



# Db2 Analytics Accelerator HTAP phase 2

- Data coherency between Db2 and Accelerator
  - No concern about latency of committed data
    - Queries run when data available
- No longer need to explain to users why committed data not seen
  - Data used by SELECT contains corresponding commits
- Exploits integrated synchronization
  - Special log processing technology



# BIF for column encryption



## ENCRYPT\_DATAKEY (data string, keylabel, algorithm)

- Column-based encryption of security-sensitive data
- String and numeric datatypes are supported
  - Resulting datatype is VARBINARY for any non-LOB and BLOB for any LOB input value
  - Schema change required for cipher text column
- Use of ICSF protected keys and RACF keylabel protection
  - Primary authid requires permit for keylabel defined in CSFKEYS class
- **AES256D|R** – 256-bit AES CBC mode encryption **algorithm**
  - 'D' – fixed initialization vector to generate a cipher text
  - 'R' – random initialization vector to generate a cipher text

## DECRYPT\_DATAKEY\_xxxx (encrypted data)

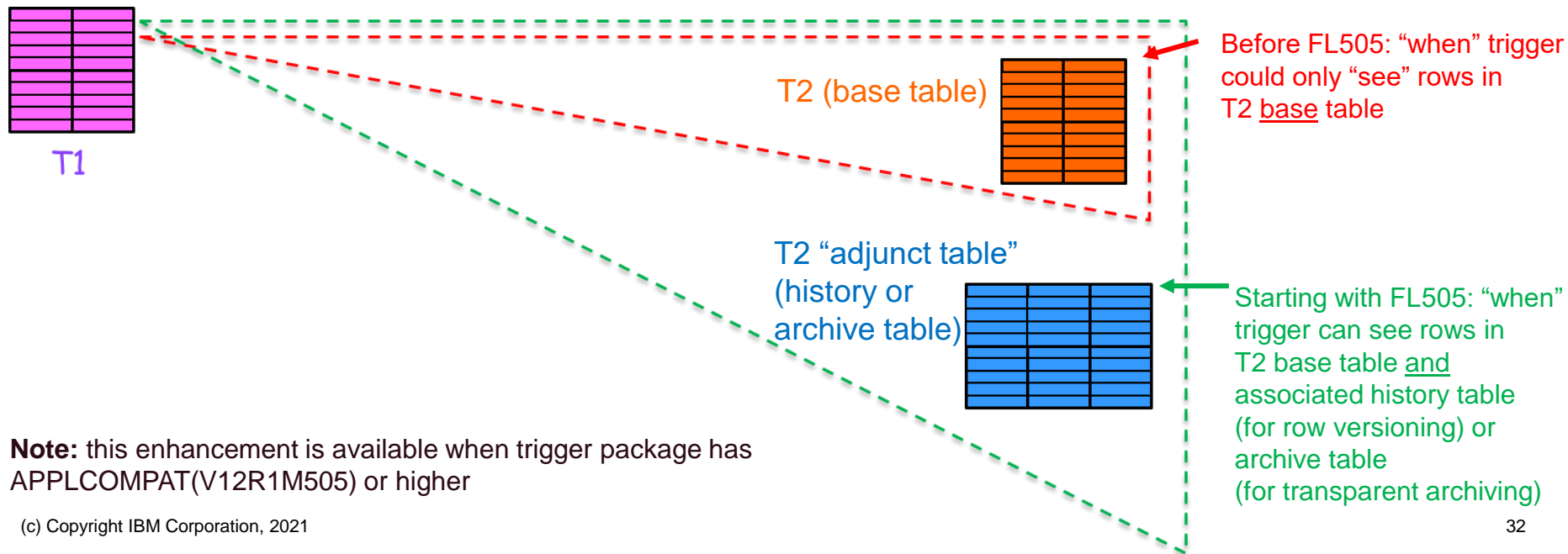
- Datatype dependent BIFs: xxxx = BIGINT or CHAR or INTEGER, etc.

# Indexes for DECFLOAT columns

- DECFLOAT columns can now:
  - be part of an index (unique or non-unique)
  - be specified in a unique constraint
  - be specified in a primary key constraint
- Other restrictions remain
  - DECFLOAT columns can neither be specified in referential constraints nor be part of a partitioning key
  - No support for DECFLOAT columns in INCLUDE indexes nor in indexes on expression
- Note: implicit casting to DECFLOAT data type is still stage 2 in Db2 12, regardless of index support

# Removal of trigger restrictions for temporal tables and for transparent archiving

Scenario: “when” trigger on update to T1 when condition true for T2  
(T2 is archive-enabled table in this example)





# Removal of trigger restrictions for temporal tables and for transparent archiving

- Problem: WHEN clause of trigger could not be applied to data in history table (system-time temporal) or archive table
  - In more technical terms: WHEN clause of trigger could not reference...
    - ...table for which row versioning has been enabled, if trigger package bound with SYSTIMESENSITIVE(YES)
    - ...archive-enabled table, if trigger package bound with ARCHIVESENSITIVE(YES)
  - Trigger packages could be bound or rebound with SYSTIMESENSITIVE(NO) or ARCHIVESENSITIVE(NO), but that means no trigger access to data in history or archive table
- Db2 12 function level M505 removes these restrictions when trigger package bound with APPLCOMPAT(V12R1M505)

# Function level 506

## PH16829

- DROP TABLE: automatic DROP of explicit table spaces
- SQL syntax compatibility for scalar functions
- Explicitly created table spaces are dropped as part of DROP TABLE processing
  - For UTS and LOB table spaces
  - DROP TABLE no longer fails with -669

# SQL syntax compatibility for scalar functions

Current name	Alternate name
COVARIANCE or COVAR	COVAR_POP
CHARACTER_LENGTH	CHAR_LENGTH
CLOB	TO_CLOB
HASH_MD5, HASH_SHA1, HASH_SHA256	HASH with different integer constants as second argument
LEFT	STRLEFT
POSSTR	STRPOS
POWER	POW
RAND	RANDOM
RIGHT	STRRIGHT
TIMESTAMP_FORMAT or TO_DATE	TO_TIMESTAMP

# Function level 507

## PH24371

- Application granularity for locking limits
  - NUMLKUS and NUMLKTS
  - New global variables
    - `SYSIBMADM.MAX_LOCKS_PER_TABLESPACE`
    - `SYSIBMADM.MAX_LOCKS_PER_USER`
    - Can be set for DDF applications with system profile monitoring tables
- Deletion of old statistics when using statistics profiles (PH16345)
- `CREATE OR REPLACE` for procedures
- New pass-through expressions with IBM Db2 Analytics Accelerator

# Application granularity for locking limits

- Before FL507, lock limits for application processes set at Db2 level via two ZPARMs
  - **NUMLKTS**: max locks (page, row or LOB) that a single application process can hold at one time for one table or table space
  - **NUMLKUS**: max locks (page, row or LOB) that a single application process can hold at one time on all table spaces
- Different application processes have different locking requirements
  - If ZPARM values too low, processes that need to hold many locks at once can fail
  - If ZPARM values too high, poor application design can be tolerated unknowingly
- New built-in global variables
  - **SYSIBMADM.MAX\_LOCKS\_PER\_TABLESPACE**
  - **SYSIBMADM.MAX\_LOCKS\_PER\_USER**
- Example: TS1 has LOCKSIZE ROW and LOCKMAX SYSTEM and NUMLKTS = 2000; process inserts 4000 rows into TS1 in a single unit of work
  - Result: lock escalation occurs at insert of 2000<sup>th</sup> row, and no other processes can access the table space until X-lock released (generally at commit)
- Same situation, but app issues this before inserts:
  - SET SYSIBM.MAX\_LOCKS\_PER\_TABLESPACE = 4000;
  - Result: app successfully insert s4000 rows without triggering lock escalation

# CREATE OR REPLACE for procedures

- Goal: consistent deployment of Db2 objects, including stored procedures
  - BIND subcommand with DEPLOY option is not ideal
  - DROP and re-CREATE is not ideal
- **CREATE OR REPLACE PROCEDURE**
  - Native SQL or external stored procedures
    - For native SQL procedure, can specify VERSION
      - If exists, replaced
      - If does not exist, new version added
  - Unlike DROP and re-CREATE:
    - Existing authorizations preserved
    - Not blocked of procedure called by SQL procedure language (SQLPL) routine

# CREATE OR REPLACE PROCEDURE examples


## Create procedure MYPROC1

```
CREATE PROCEDURE MYPROC1
  ( IN  P1 CHAR(5) ,
    OUT P2 DECIMAL(15,2) )
BEGIN
  SELECT AVG(SALARY) INTO P2
    FROM DSN8C10.EMP
    WHERE WORKDEPT = P1;
END
```

## Replace MYPROC1 with new definition

```
CREATE OR REPLACE PROCEDURE MYPROC1
  ( IN  P1 CHAR(5) ,
    OUT P2 DECIMAL (15,2) )
BEGIN
  SELECT AVG(SALARY + 1000) INTO P2
    FROM DSN8C10.EMP
    WHERE WORKDEPT = P1;
END
```

Change  
body of  
procedure



## Add version V2 of MYPROC1

```
CREATE OR REPLACE PROCEDURE MYPROC1
  ( IN  P1 CHAR(5) ,
    OUT P2 DECIMAL (15,2) )
  VERSION V2
BEGIN
  SELECT AVG(SALARY + 5000) INTO P2
    FROM DSN8C10.EMP
    WHERE WORKDEPT = P1;
END
```

## Replace version V2 of MYPROC1

```
CREATE OR REPLACE PROCEDURE MYPROC1
  ( IN  P1 CHAR(5) ,
    OUT P2 DECIMAL (15,2) )
  VERSION V2
BEGIN
  SELECT AVG(SALARY + 9000) INTO P2
    FROM DSN8C10.EMP
    WHERE WORKDEPT = P1;
END
```

# New pass-through expressions for accelerator

- ADD\_DAYS
- BTRIM
- DAYS\_BETWEEN
- NEXT\_MONTH
- Regression functions (REGR\_AVGX, REGR\_AVGY, REGR\_COUNT, ...)
- ROUND\_TIMESTAMP if invoked with a date expression



# Function level 508

## PH29392

- Migration of multi-table table space to partition by growth (PBG) universal table space (UTS)
- Prior to FL 508, an outage required to migrate to UTS PBG from multi-table table space
- For each table in the table space
  - Create target PBG UTS
  - ALTER table as pending change
- REORG TABLESPACE to materialize pending ALTER statements
  - Possibly REBIND
- ALTER TABLESPACE now has **MOVE TABLE** clause
- NOTE: in most cases, the number of open data sets will increase, potentially substantially

# Function level 509

## PH33015

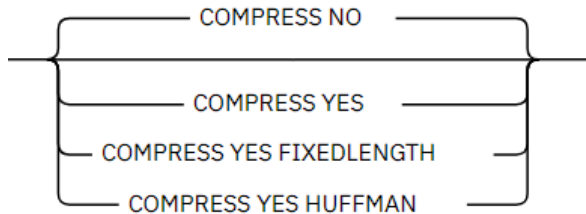
- Huffman compression: specify compression algorithm at table, table space, or partition level
- Tamper-proof audit policies
- Temporal RI allows UPDATE or DELETE on parent table
- High availability for accelerator-only tables (IDAA: HA for IOT)

# Huffman Compression (M509)



## What is different?

- Choose compression type at the table space or partition level for UTS table spaces



- For COMPRESS YES default is TS\_COMPRESSION\_TYPE



## How do you specify?

- CREATE TABLESPACE
- ALTER TABLESPACE
- CREATE TABLE
  - For implicitly created table spaces
  - Default specified by DSNZPARM IMPTSCMP (NO, YES)



## V12R1M509 Catalog level

- SYSTABLEPART columns
  - COMPRESS\_USED** (new)
    - F, H, ' ' or NULL
  - COMPRESS** (changed)
    - Y, F, H, ' '
- SYSTABLESPACE column
  - COMPRESS** (changed)
    - Y, F, H, ' ' or NULL

# Non-function level dependent highlights

- **Db2 distributed data facility (DDF)**
  - System profile monitoring
    - Set limit of queued or inactive threads
  - MONITOR ALL CONNECTIONS, MONITOR ALL THREADS
  - Data server drivers – JDBC, ODBC, .net
    - Continuous delivery enhancements
    - Enhanced messaging
  - REST services command, versioning
  - Transport layer security-only access
- **Utilities**
  - Redirected recovery
  - Usability
  - Performance
  - zIIP exploitation
  - FlashCopy
- **DevOps**
  - Developer Extension for VS Code
- **Security**
  - Dump diagnostics
- **Analytics**
  - Accelerator related enhancements
  - Db2 AI for z/OS (Db2ZAI)
- **Z synergy**
  - zHyperLink: database read, log write
  - Compression performance
  - Encryption performance
- **Data sharing**
  - Asynchronous group buffer pool cross invalidation
  - Messaging for auto recovery of LPL/GRECP
- **Usability**
  - Transparent archiving parameter setting
  - System parameter (DSNZPARM) simplification

# Summary: Db2 12 for z/OS latest features

Continuous delivery is here

Function level enhancements

- Numerous benefits
- Control with ACTIVATE command, APPLCOMPAT setting on package
- Application behaviors

Non-function level enhancements

- Numerous benefits (over 100 so far)
- Control with maintenance stream

# Thank you!

Mark Rader  
*ATG Db2 for z/OS Specialist*  
[mrader@us.ibm.com](mailto:mrader@us.ibm.com)

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