AUTOMATING Z/OS DB2 CHANGES WITH

REXX AND FLYWAY

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28th International Rexx Language Symposium, April 2017
The Open Source Deployment Pipeline
AUTOMATING DB2 Z/OS CHANGES WITH REXX AND FLYWAY

AGENDA

- The deployment pipeline
- Version management for DB2 objects
- Using Flyway on the command line
- Automating the process with NetRexx
- Using SQL based conversions
- Using Java based conversions
- Using DB2 z/OS Utilities
THE DEPLOYMENT PIPELINE
THE DEPLOYMENT PIPELINE
VERSION MANAGEMENT FOR DB2 OBJECTS
The problem with databases is that there is DATA in them.

In Dev, Test and Acc you can skirt this problem.

But in PROD you better keep the data and don’t lose it.

If the table structure changes, you need to either:

- alter and reorg

- unload, drop, define, reload, put back auth and FK’s

- a copy table, an “insert into ... from select” and a copy back

- the crossloader, that finally can handle most trouble
The easiest scenario is when you point Flyway to an empty database.

It will try to locate its metadata table. As the database is empty, Flyway won't find it and will create it instead.
WELL, NOT ALWAYS

- At this site, one may not use BP0 (only for DB2 catalog)
- BP0 (Buffer Pool Zero) is hardcoded in the definition
- No worries, we define it ourselves
- You cannot do this with flyway until you have modified flyway - this pays off the moment you have to do more databases, so invest in this small modification
CREATE TABLESPACE

Flyway will create this table when it does not find it. You only have to do this, once for every schema, if automatic creation fails

SET CURRENT SQLID="JANSR16";

CREATE TABLESPACE SFLYWAY
  IN JANSR16
  USING STOGROUP SGDB00
  PRIQTY -1 SECQTY -1
  ERASE NO
  FREEPAGE 0 PCTFREE 10
  GBPCACHE CHANGED
  TRACKMOD NO
  MAXPARTITIONS 4
  LOGGED
  DSSIZE 4 G
  SEGSIZE 32
  BUFFERPOOL BP1
  LOCKSIZE ANY
  LOCKMAX 0
  CLOSE YES
  COMPRESS YES
  CCSID UNICODE
  DEFINE YES
  MAXROWS 255;
CREATE TABLE schema_version (  "installed_rank"  INT NOT NULL,  "version"  VARCHAR(50),  "description"  VARCHAR(200) NOT NULL,  "type"  VARCHAR(20) NOT NULL,  "script"  VARCHAR(1000) NOT NULL,  "checksum"  INT,  "installed_by"  VARCHAR(100) NOT NULL,  "installed_on"  TIMESTAMP NOT NULL WITH DEFAULT,  "execution_time"  INT NOT NULL,  "success"  SMALLINT NOT NULL  )  IN JANSR16.SFLYWAY;
YOU CAN ALSO ADAPT FLYWAY TO YOUR (CUSTOMERS) SITE

- It is open source
- Git clone it from
  - git clone https://github.com/flyway/flyway.git
- Build it with Maven (will download the internet first time)
- This definition file (for DB2 z/OS) is in the jar at:
  - org/flywaydb/core/internal/dbsupport/db2zos/createMetaDataTable.sql
- I was lazy/efficient and just used zip to add the mod to the jar
You now have a database with a single empty table called SCHEMA_VERSION by default:

This table will be used to track the state of the database.
Automating DB2 Z/OS Changes with REXX and Flyway

How Does It Work

Immediately afterwards Flyway will begin scanning the filesystem or the classpath of the application for migrations. They can be written in either Sql or Java.

The migrations are then sorted based on their version number and applied in order:

As each migration gets applied, the metadata table is updated accordingly:

<table>
<thead>
<tr>
<th>installed_rank</th>
<th>version</th>
<th>description</th>
<th>type</th>
<th>script</th>
<th>checksum</th>
<th>installed_by</th>
<th>installed_on</th>
<th>execution_time</th>
<th>success</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Initial Setup</td>
<td>SQL</td>
<td>V1__Initial_Setup.sql</td>
<td>1996767037</td>
<td>axel</td>
<td>2016-02-04 22:23:00.0</td>
<td>546</td>
<td>TRUE</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>First Changes</td>
<td>SQL</td>
<td>V2__First_Changes.sql</td>
<td>1279644856</td>
<td>axel</td>
<td>2016-02-06 09:18:00.0</td>
<td>127</td>
<td>TRUE</td>
</tr>
</tbody>
</table>
Out of the box, Flyways uses the convention

- V1.0__TableDefinition.sql
- V1.1__Add_index.sql
- V1.2__Drop_Recreate_and_Reload.sql
- V1.n__etcetera_ad_infinitum
V1.0__TABLE_DEFINITION.SQL

SET CURRENT SQLID='JANSR16';

CREATE TABLESPACE JANTST
  IN JANSR16
  USING STOGROUP SGDB00
  PRIQTY -1 SECQTY -1
  ERASE NO
  FREEPAGE 0 PCTFREE 10
  GBPCACHE CHANGED
  TRACKMOD NO
  MAXPARTITIONS 4
  LOGGED
  DSSIZE 4 G
  SEGSIZE 32
  BUFFERPOOL BP1
  LOCKSIZE ANY
  LOCKMAX 0
  CLOSE YES
  COMPRESS YES
  CCSID UNICODE
  DEFINE YES
  MAXROWS 255;

CREATE TABLE TSTFLYWAY
  (ID BIGINT NOT NULL,
   AUTHORIZED VARCHAR(255) FOR MIXED DATA,
   DISABLED VARCHAR(255) FOR MIXED DATA,
   ELEMENT VARCHAR(255) FOR MIXED DATA,
   ENTEREDAT TIMESTAMP (6) WITHOUT TIME ZONE,
   FORPROFILE_ID BIGINT WITH DEFAULT NULL,
   FORUSER_ID BIGINT WITH DEFAULT NULL,
   FUNCTIONALITY VARCHAR(255) FOR MIXED DATA,
   LASTMODIFIEDAT TIMESTAMP (6) WITHOUT TIME ZONE,
   NAME VARCHAR(255) FOR MIXED DATA,
   TARGET VARCHAR(255) FOR MIXED DATA,
   CONSTRAINT DATAACCESS_PK
     PRIMARY KEY (ID))
  IN JANSR16.JANTST
  PARTITION BY SIZE
  AUDIT NONE
  DATA CAPTURE CHANGES
  CCSID UNICODE
  NOT VOLATILE
  APPEND NO ;
SET CURRENT SQLID='JANSR16';

CREATE UNIQUE INDEX X1TSTFLW
ON TSTFLYWAY
  (ID ASC)
USING STOGROUP SGDB00
PRIQTY -1 SECQTY -1
ERASE NO
FREEPAGE 0 PCTFREE 10
GBPCACHE CHANGED
CLUSTER
COMPRESS NO
INCLUDE NULL KEYS
BUFFERPOOL BP2
CLOSE YES
COPY NO
DEFER NO
DEFINE YES
PIECESIZE 2 G;

Forgot the Primary Key index, you won’t get that for free on z/OS DB2

So there we have our first update/migration
AUTO-MIGRATION ON STARTUP

- It is possible (and recommended) to have your application check at startup if it speaks to the right database level
- There is an API for that
- More about that later
USING FLYWAY ON THE COMMAND LINE
AUTOMATING DB2 Z/OS CHANGES WITH REXX AND FLYWAY

THE MIGRATE COMMAND

$ flyway migrate

Example 1: We have migrations available up to version 9, and the database is at version 5. Migrate will apply the migrations 6, 7, 8 and 9 in order.

Example 2: We have migrations available up to version 9, and the database is at version 9. Migrate does nothing.
AUTOMATING DB2 Z/OS CHANGES WITH REXX AND FLYWAY

WHERE IT FINDS WHAT – FOR COMMAND LINE USAGE
In the mainframe world, a DB2 subsystems contains numerous databases.

Generally, naming conventions are used to separate concerns: for database, stogroup, buffer pools, and authorisations.

Also, different DTAP environments have different dimensioning: PRIQTY, SEQTY, LOCKSIZE, LOCKMAX.

But you want to keep one copy of DDL, DCL, DML in version management.

Yes, you do.
PARAMETERS

- The solution is a set of substitutable parameters
- Flyway supports these
- They can be specified on the command line
- Standard convention is `${parm}` but configurable using API
  - for example `<parm>` works fine
CLEAN

- $ flyway clean
  - cleans out the schema (drops everything)
  - good for development
  - scary for other environments

- Limited usefulness: does not work when dropping a table in an explicitly defined tablespace with

-669  THE OBJECT CANNOT BE EXPLICITLY DROPPED. REASON 001
AUTOMATING THE PROCESS WITH NETREXX
WHY DO THIS

- have a look at the Flyway script and ask yourself if this is going to work on all shells that you are using (think of USS with ksh or tcsh in EBCDIC)
- The answer is probably: Nah
- Also, the script counts on a specific layout for the directory structure
- Instead of layout, .conf file, jars lookup, just one nrx script
- Why NetRexx: Flyway is a Java Jar. All methods can be seamlessly called by NetRexx
- We are using NetRexx scripting mode: no need to use the compiler
- You can use the generated Java for the customer
import org.flywaydb.core.Flyway

fw = Flyway()
fw.setDataSource("jdbc:db2:xxxxxxxx/LOCDB00","xxxxxx","xxxxxx", null)
fw.setTable("SCHEMA_VERSION")
fw.setBaselineOnMigrate(1)
fw.migrate()
AUTOMATING DB2 Z/OS CHANGES WITH REXX AND FLYWAY

OOOREXX

fw = .bsf~new("org.flywaydb.core.Flyway")
fw~setDataSource("jdbc:db2:xxxxxxx/LOCDB0O","xxxxxx","xxxxxx",.nil)
fw~setTable("SCHEMA_VERSION")
fw~setBaselineOnMigrate(1)
fw~migrate

::requires "BSF.CLS"
import org.flywaydb.core.Flyway

parms = TreeMap()
parms.put("SQLID", "JANSR16")
parms.put("DB2DBNAME", "JANSR16")
parms.put("DB2TSSTOGROUP", "SGDB00")

fw = Flyway()
fw.setDataSource("jdbc:db2:xxxxxxx/LOCDB00", "xxxxxx", "xxxxxx", null)
fw.setTable("SCHEMA_VERSION")
fw.setBaselineOnMigrate(1)
fw.setPlaceholderPrefix('<')
fw.setPlaceholderSuffix('>')
fw.setPlaceHolders(parms)
fw.migrate()}
parms = .bsf~new("java.util.TreeMap")
parms~put("SQLID", "JANSR16")
parms~put("DB2DBNAME", "JANSR16")
parms~put("DB2TSSTOGROUP", "SGDB00")

fw = .bsf~new("org.flywaydb.core.Flyway")
fw~setDataSource("jdbc:db2:xxxxxxx/LOCDB00","xxxxxx","xxxxxx", .nil)
fw~setTable("SCHEMA_VERSION")
fw~setBaselineOnMigrate(1)

fw~setPlaceholderPrefix('<')
fw~setPlaceholderSuffix('>')
fw~setPlaceHolders(parms)

fw~migrate

::requires "BSF.CLS"
CONVERSIONS: SQL BASED
The simplest way, and lots of people do it always like this, is to make a copy or rename the old table and insert the data back into the newly defined new table; then drop the old one.

If you cannot switch off logging this is not a good idea for those very large tables.

Also, you can alter tables, add or delete (novelty for DB2 V11) columns - but your tablespace enters Advisory Reorg status.

But an SQL-based conversion looks like this:
SET CURRENT SQLID = '<schema>';  

CREATE TABLESPACE SFLYWAY  
    IN '<schema>'  
    SEGSIZE 4  
    BUFFERPOOL BP0  
    LOCKSIZE PAGE  
    LOCKMAX SYSTEM  
    CLOSE YES  
    COMPRESS YES  
;

CREATE TABLE '<schema>.' 'TMP_<table>' (  
    'installed_rank' INT NOT NULL,  
    'version' VARCHAR(50),  
    'description' VARCHAR(200) NOT NULL,  
    'type' VARCHAR(20) NOT NULL,  
    'script' VARCHAR(1000) NOT NULL,  
    'checksum' INT,  
    'installed_by' VARCHAR(100) NOT NULL,  
    'installed_on' TIMESTAMP NOT NULL WITH DEFAULT,  
    'execution_time' INT NOT NULL,  
    'success' SMALLINT NOT NULL,  
    CONSTRAINT '<table>_S' CHECK ('success' in(0,1))  
)  
IN '<schema>.' SFLYWAY;

INSERT INTO '<schema>.' 'TMP_<table>'(  
    'installed_rank',  
    'version',  
    'description',  
    'type',  
    'script',  
    'checksum',  
    'installed_by',  
    'installed_on',  
    'execution_time',  
    'success'  
)  
FROM '<schema>.' '<table>' ;

--drop old tablespace  
DROP TABLESPACE '<schema>.' SDBVERS;  

RENAME TABLE '<schema>.' 'TMP_<table>' TO '<table>';  

UPDATE '<schema>.' '<table>' SET  
    'type'='BASELINE' WHERE 'type'='INIT';  

CREATE UNIQUE INDEX  
    '<schema>.' '<table>_IR_IDX' ON  
    '<schema>.' '<table>';  

CREATE INDEX '<schema>.' '<table>_S_IDX' ON  
    '<schema>.' '<table>' ('success');
CONVERSIONS: JAVA BASED
### Java Based Conversions

- Mostly used for BLOB or CLOB handling, Java based conversions give more freedom over the workflow.
- You can open and close cursors, read and write files, insert (and validate) XML columns from files.
AUTOMATING DB2 Z/OS CHANGES WITH REXX AND FLYWAY

LOCATION AND DISCOVERY

Naming
In order to be picked up, the Java Migrations must implement `JdbcMigration`. A Java Migration automatically
• wraps the migration in a transaction
• extracts the version and the description from the class name

Repeatable Migrations are always run
### You can use callbacks

<table>
<thead>
<tr>
<th>Name</th>
<th>Execution</th>
</tr>
</thead>
<tbody>
<tr>
<td>beforeMigrate</td>
<td>Before Migrate runs</td>
</tr>
<tr>
<td>beforeEachMigrate</td>
<td>Before every single migration during Migrate</td>
</tr>
<tr>
<td>afterEachMigrate</td>
<td>After every single migration during Migrate</td>
</tr>
<tr>
<td>afterMigrate</td>
<td>After Migrate runs</td>
</tr>
<tr>
<td>beforeClean</td>
<td>Before Clean runs</td>
</tr>
<tr>
<td>afterClean</td>
<td>After Clean runs</td>
</tr>
<tr>
<td>beforeInfo</td>
<td>Before Info runs</td>
</tr>
<tr>
<td>afterInfo</td>
<td>After Info runs</td>
</tr>
<tr>
<td>beforeValidate</td>
<td>Before Validate runs</td>
</tr>
<tr>
<td>afterValidate</td>
<td>After Validate runs</td>
</tr>
<tr>
<td>beforeBaseline</td>
<td>Before Baseline runs</td>
</tr>
<tr>
<td>afterBaseline</td>
<td>After Baseline runs</td>
</tr>
<tr>
<td>beforeRepair</td>
<td>Before Repair runs</td>
</tr>
<tr>
<td>afterRepair</td>
<td>After Repair runs</td>
</tr>
</tbody>
</table>
CONVERSIONS:
DB2 Z/OS UTILITIES
A z/OS DB2 DBA will want to use DB2 utilities in a number of cases:

- LOAD LOG(NO) instead of SQL INSERT
- LOAD Replace to clear out a partition
- REORG and RUNSTATS
- The Crossloader
- IMAGECOPY for recoverability
DB2 UTILITIES

- But ... don’t you need JCL to start a DB2 utility?
  - You cannot make a Rexx exec to start pgm DSNUTILB
    - Because it runs in storage key 7
    - Believe me, it has been tried
  - There are two stored procedures, however:
    - DSNUTILS (EBCDIC only, deprecated)
    - DSNUTILU (EBCDIC and Unicode, supported)
import java.sql.
class.forName("com.ibm.db2.jcc.DB2Driver")

con = java.sql.Connection -
    java.sql.DriverManager.getConnection(-
    "jdbc:db2://xxx.xxxxx.xxxxx.xxxx.xxx/xxxx", "xxxxxx", "xxxxxxxxx")

cstmt = con.prepareCall("CALL DSNUTILU(?,?,?,?,?)")

cstmt.setString(1, "JANSR16");
cstmt.setString(2, "NO")
cstmt.setString(3, "TEMPLATE TEMPL01 "-
    " DSN 'XXXXXX.&DB..&SN..P&PA(2,4)..T&TIME.' " -
    " UNIT SYSDA DISP(NEW,CATLG,DELETE) " -
    " REORG TABLESPACE XXXXXX.XXXXX COPYDDN (TEMPL01) " -
    " SHRLEVEL REFERENCE NOSYSREC SORTDEVT SYSDA SORTNUM 64 " -
    " STATISTICS INDEX TABLE SAMPLE 25")

cstmt.setString(4, "")

cstmt.execute()

rs = cstmt.getResultSet()
loop while rs.next()
    say rs.getString(2)
end
cstmt.close()
call bsf.loadClass "com.ibm.db2.jcc.DB2Driver"

con = bsf.loadClass("java.sql.DriverManager") ~getConnection("jdbc:db2://xxx.xxxxx.xxxx.xxxx.xxx/xxxx", "xxxxxx", "xxxxxxxxxx")

cstmt = con~prepareCall("CALL DSNUTILU(?,?,?,?,?)")

cstmt~setString(1, "JANSR16")
cstmt~setString(2, "NO")
cstmt~setString(3, "TEMPLATE TEMPL01 
  DSN 'XXXXXX.&DB..&SN..P&PA(2,4)..T&TIME.' 
  UNIT SYSDA DISP(NEW,CATLG,DELETE) 
  REORG TABLESPACE XXXXXX.XXXXXX COPYDDN (TEMPL01) 
  SHRLEVEL REFERENCE NOSYSREC SORTDEVT SYSDA SORTNUM 64 
  STATISTICS INDEX TABLE SAMPLE 25")
cstmt~setString(4, "")

cstmt~execute

rs = cstmt~getResultSet
loop while rs~next
  say rs~getString(2)
end
rs~close

cstmt~close
::requires "BSF.CLS"
DSNUTILU

- Note that DSNUTILU can reside in a package that has been bound with ENCODING(EBCDIC) or ENCODING(UNICODE).

- When a Unicode space (X’20’) is recognised, the output for the SYSPRINT resultset is Unicode.

  - So when you start the command with a quote, it goes terribly wrong. Well, not terribly, and not wrong, but you cannot read the output from the DB2 utility, IDCAMS, DFSORT, and the rest.

- For debugging this, you need to convert EBCDIC strings to Unicode with `String.getBytes(“Cp1047”)` and `String(var,”UTF-8”)`. 
You don’t have DDnames. So use the TEMPLATE utility that generates and dynamically allocates datasets for you.

When using GDG’s, which is possible, you need to have a preallocated model DCB dataset cataloged - then you can use it from a TEMPLATE.
When you have seen that DSNUTILU is working, it is time to have these Stored Procedure calls in your conversion scenario.

- Make sure your class inherits from `JdbcConversion`.
- Make sure to replace the `.` in the class name with a `_`.
  - So `V1.2__Reorg.sql` becomes class `V1_2__Reorg`.
- Put it in a package `db.migrations` and leave the `.class` file in the same directory next to the other, sql-based migration files.
V1_2__REORG.NRX

package db.migration

import java.sql.*
import org.flywaydb.core.*

class V1_2__Reorg implements JdbcMigration

    method migrate(con=Connection) signals Exception

        cstmt = con.prepareCall("CALL DSNUTILU(?,?,?,?,?)")

        cstmt.setString(1, "<SQLID>REO");
        cstmt.setString(2, "NO")
        cstmt.setString(3, "TEMPLATE TEMPL01 -
                        " DSN 'A21G089.<SQLID>..&DB..&SN..P&PA(2,4)..T&TIME.' " -
                        " UNIT SYSDA DISP(NEW,CATLG,DELETE) " -
                        " REORG TABLESPACE <DB2DBNAME>.JANTST COPYDDN (TEMPL01) " -
                        " SHRLEVEL REFERENCE NOSYSREC SORTDEVT SYSDA SORTNUM 64 " -
                        " STATISTICS INDEX TABLE SAMPLE 25")

        cstmt.setString(4, "")

        cstmt.execute()

        rs = cstmt.getResultSet()
        loop while rs.next()
            say rs.getString(2)
        end
        cstmt.close()
return BSFCreateRexxProxy(.V1_2__Reorg~new, "db.migration.JdbcMigration")

::requires "BSF.CLS"

::class V1_2__Reorg

::method migrate
  use arg con

  cstmt = con~prepareCall("CALL DSNUTILU(?,?,?,?,,?)")

  cstmt~setString(1, "<SQLID>REO")
  cstmt~setString(2, "NO")
  cstmt~setString(3, "TEMPLATE TEMPL01 
                   DSN 'A21G089.<SQLID>..<DB>..<SN>.P&PA(2,4)..T&TIME.' 
                   UNIT SYSDA DISP(NEW,CATLG,DELETE) 
                   REORG TABLESPACE <DB2DBNAME>.JANTST COPYDDN (TEMPL01) 
                   SHRLEVEL REFERENCE NOSYSREC SORTDEVT SYSDA SORTNUM 64 
                   STATISTICS INDEX TABLE SAMPLE 25")
  cstmt~setString(4, "")
  cstmt~execute

  rs = cstmt~getResultSet
  loop while rs~next
    say rs~getString(2)
  end
  cstmt~close
AUTO-MIGRATION ON STARTUP
THE EASY CASE

▸ Have your code and migrations in Git, and deploy always the corresponding migrations (as the highest level) with the application

▸ Start the application with a

▸ fw.migrate()

▸ It will migrate, but only the first time

▸ Subsequently, it will check and do nothing

▸ Always cater for quick fallback - you never know
THE NOT-SO-EASY CASE

- In testing and acceptance/certification environments, you need repeatable conversions, and not always to the highest available database level.
ROLL-BACK AND RECOVERY

- On z/OS DB2, DDL updates are atomic within a transaction
- Failed migrations are properly rolled back
- (this works for DB2, PostgreSQL, Derby, EnterpriseDB and to a certain extent SQL Server); Oracle surreptitiously sneaks in commits between DDL statements, invalidating the transaction concept
THANK YOU
Q?
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