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Java stored procedures

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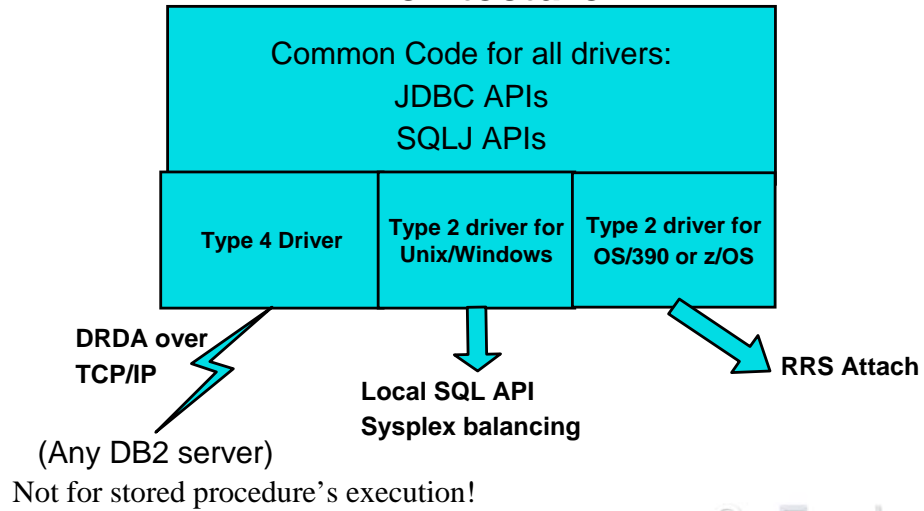
DB2 for z/OS

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Agenda

- **About Java on z/OS**
- **Writing Java stored procedures**
- **z/OS system setup for Java stored procedures**
- **Futures**
- **Summary of best performance practices**

DB2 Java Universal Client Internal Architecture



JDBC Overview

- Dynamic SQL access to database
- APIs are similar to ODBC
 - ODBC: Open Database Connectivity
 - Type 1 driver = ODBC bridge
- package java.sql
- Reference books at:
 - <http://java.sun.com/docs/books/jdbc/>

SQLJ Application Development

- 100% Java application process
 - ▶ eliminates DBRM files and .bnd files
- New SQLJ serialized profile format
 - ▶ fully portable to all platforms -- user can deploy on any server platform without running db2profc on the target system.
 - ▶ contains information needed for all BIND operations, without having to recustomize on each BIND
 - ▶ allow multiple class file to be bound into a single DB2 package
- Simplifies deployment of applications, but may require changes in existing procedures used by SQLJ users.

SQL Error Information

- DB2Diagnosable class for reporting contents of the SQLCA and SQL error message text
 - getSQLCode(),getSQLErrmc(),getSQLErrp(),
 - getSQLErrd(),getSQLState(),getSQLWarn(),
 - getSQLErrorMessage()
- Information is accessible for both JDBC and SQLJ whenever an SQL exception is thrown

DB2 provides a proprietary extension to JDBC and SQLJ that allows the Java application to request details about the content of the SQLCA when an SQLException is thrown. This enables the Java application to provide detailed feedback about SQL errors for use by application programmers and DBAs.

This enhancement includes the getSQLErrorMessage() method, which provides the DB2 server's native SQL error message text.

Java Stored Procedures

- Output parameters are one-element arrays
- Result sets are not in catalog definition
- Result sets are in java method signature as outputs
- Can be JDBC, SQLJ, or both
- JAR files stored in DB2 catalog
 - DB2-supplied SPs to put them in



Basics about Java stored routines.

Java Stored Procedures

- Requires the IBM Developer Kit for OS/390, Java(TM) 2 Technology Edition with Persistent Reusable Java Virtual Machines -(Integrated with SDK 1.3.1)
- Support for SDK 1.4.1 in APAR PQ76769
 - Support for universal driver in same APAR
- Support for IBM 31-bit SDK for z/OS, Java 2 Technology Edition, V5 in APAR PK09213
- New JVM coming... may require DB2 maintenance
- Language COMPJAVA is not supported in version 8 of DB2 for z/OS.
 - You should not be using this in V7 at this point

General information about support of Java routines and JDKs.

Built-in Stored Procedures for Java routines

- As per SQLJ specification
- Invoked with SQL CALL statement
 - ▶ INSTALL_JAR (file name in HFS)
 - Installs the Java ARchive file into the DB2 catalog
 - JAR file contains one or more Stored Procedures
 - ▶ REPLACE_JAR
 - ▶ REMOVE_JAR
 - ▶ LOB parameter support in Version 8
- JAR authorization
 - ▶ GRANT USAGE ON JAR

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These stored procedures are supplied by DB2 to allow a Java binary program to be stored in DB2. This provides actual “stored “ stored procedures.

Handy Java UDF

```
CREATE FUNCTION SYSADM.JAVDRVV ( )
  RETURNS VARCHAR(100)
  FENCED NO SQL
  LANGUAGE JAVA
  SPECIFIC JAVDRVV
  EXTERNAL NAME
    'com.ibm.db2.jcc.DB2Version.getVersion'
  WLM ENVIRONMENT WLMJAVA
  NO EXTERNAL ACTION
  NO FINAL CALL
  PROGRAM TYPE SUB
  PARAMETER STYLE JAVA;
SELECT SYSADM.JAVDRVV() FROM SYSIBM.SYSDUMMY1;
```

Returns: 2.7.72

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When you invoke this Java UDF, it returns the Universal Java Driver version being executed at the DB2 for z/OS server. It requires no user Java code to be written, so it is a handy way to test your setup for Java routines, as well as determine the exact release being run. Here is sample invocation and output:

```
SELECT SYSADM.JAVDRVV() FROM SYSIBM.SYSDUMMY1;
1_|2.7.72 |
```

You can look up what PTF the driver version corresponds to in RETAIN:

APAR - PK13108

Problem Summary:

```
*****
*****
* USERS AFFECTED: All Users of the DB2 Universal JDBC
Driver      *
*****
*****
* PROBLEM DESCRIPTION: DB2 Universal Driver Version
2.7.72 is  *
*
*                provided by this APAR. ( JCCV2772
)      *
```

CREATE PROCEDURE:
(DECIMAL(10,2) INOUT)
DYNAMIC RESULT SETS 1

Java SP source:

```
public static void getSals  
(BigDecimal[] AvgSalParm,  
ResultSet[] rs)
```

```
rs[0] = iter1.getResultSet();
```

This shows how to code a Java routine to match the DB2 definition of a SP. The output parm is a single-element array, and the result set shows up as a parameter.

COMPLETE SAMPLE SP

```
package s1;

#sql iterator NameSal(String LastName, BigDecimal Salary);
public class s1Sal
{
    public static void getSals(BigDecimal[] AvgSalParm, ResultSet[] rs)
    throws SQLException
    {
        NameSal iter1;
        try
        { #sql {SELECT AVG(SALARY) INTO :(AvgSalParm[0]) FROM DSN8510.EMP};

            #sql iter1 = {SELECT LASTNAME, SALARY FROM DSN8510.EMP
                WHERE SALARY > :(AvgSalParm[0]) ORDER BY SALARY DESC};
        }
        catch (SQLException e)
        { System.out.println("SQLCODE returned: " + e.getErrorCode());
            throw(e);
        }
        rs[0] = iter1.getResultSet();

    } //end getSals
} // end class s1Sal
```

This shows a complete sample SP that matches the examples explained on the previous page.

```
CREATE PROCEDURE SYSPROC.S1SAL  
(DECIMAL(10,2) INOUT)  
FENCED MODIFIES SQL DATA  
COLLID DSNJDBC -or- NULLID  
LANGUAGE JAVA  
EXTERNAL NAME  
'PEG.MYJAR: s1.s1Sal.getSals'  
READS SQL DATA  
WLM ENVIRONMENT WLMENVJ  
DYNAMIC RESULT SETS 1  
PROGRAM TYPE SUB  
PARAMETER STYLE JAVA;
```

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This is the complete DDL to define the sample stored procedure.

Setup Errors

- SQLCODE trying to invoke the routine
 - Couldn't find user class
 - -20212
 - Additional SQLCA information has class name that couldn't be found
 - WLM-SPAS will start and get control
 - ➔ Make sure all classes included in JAR, or in common CLASSPATH

If DB2 can't find a java class that it needs to run the routine, it needs to search the JVM to figure that out, so this error is returned after the WLM-SPAS gets control to look. It may be a class referenced by the Java routine, so make sure it is available in the z/OS WLM-SPAS JVM environment.

Setup Errors - con't

- Couldn't find user method
 - -20204
 - Additional SQLCA information has signature generated from SQL types
- ➔ Make sure PARAMETERS column maps to JDBC types
- ➔ Can check java signature
 - ➔ javap -s -private <classname>
- ➔ Remember, result sets in java method signature, but not in PARAMETERS column

Runtime errors

- Uncaught SQL Exceptions:
 - Stored Procedure is not put in STOPABN
 - Additional information in SQLCA
- ➔ Java programmer should use try/catch logic
- Other uncaught Java Exceptions
 - -4302 SQLCODE
 - Console message DSNX961
 - Stored Procedure put in STOPABN
- ➔ print stack trace, fix problem

Tasks for z/OS System Programmer

- Install JDBC/SQLJ drivers
- Set up WLM ENV, address space JCL
- Set up JAVAENV with classpath, etc.
- Consider USS .profile for users
 - Can build/deploy from workstation in V8.

- **How to display current version (hint for .profile)**

```
#-----  
# print out java and jdbc versions  
#-----  
java -version  
java com.ibm.db2.jcc.DB2Jcc -version
```

- **Results:**

```
java version "1.4.2"  
Java(TM) 2 Runtime Environment, Standard Edition (build 1.4.2)  
Classic VM (build 1.4.2, J2RE 1.4.2 IBM z/OS Persistent Reusable  
VM build cm142-20040917 (JIT disabled))
```

```
IBM DB2 JDBC Universal Driver Architecture 2.5.46
```

The system programmer will probably be logging onto Unix Systems Services. These are some handy steps to put in the .profile, which is automatically executed at logon. These commands display the version of the JVM and DB2 Java driver, and make sure they are available.

Stored Procedures Address Space JCL

```
/**
*****
/* THIS PROC IS USED TO START THE WLM-ESTABLISHED SPAS
/* ADDRESS SPACE FOR THE WLMCJAV APPLICATION ENVIRONMENT.
*****
//ENV4JAV PROC SUBSYS=V81A,NUMTCB=5,APPLENV=WLMCJAV
//X9WLM EXEC PGM=DSNX9WLM,TIME=1440,
// PARM='&SUBSYS,&NUMTCB,&APPLENV',
// REGION=0M
//STEPLIB DD DSN=USER.RUNLIB.LOAD,DISP=SHR
// DD DSN=USER.TESTLIB,DISP=SHR
// DD DSN=DB2A.TESTLIB,DISP=SHR
// DD DSN=DSN810.SDSNLOAD,DISP=SHR
// DD DSN=DSN810.SDSNLOAD2,DISP=SHR
// DD DSN=CEEA.SCEERUN,DISP=SHR
//JAVAENV DD DSN=WLMCJAV.JSPENV,DISP=SHR
//JSPDEBUG DD SYSOUT=A
//CEEDUMP DD SYSOUT=A
//SYSPRINT DD SYSOUT=A
```

The JCL for the WLM-SPAS where the Java routines executes has some special setup required.

JAVAENV DD STATEMENT

- Dataset containing RUNOPTS
 - Applies to entire WLMENV, not individual SPs
- Where to find JVM: JAVA_HOME
- Where to find Universal driver: JCC_HOME
- May set CLASSPATH for common classes
- Can set TZ, LC_LANG, etc for localization

Usability Enhancements

- JVM property startup options – in ENVAR
 - Heap size example
 - "**JVMPROPS=/u/<filename>**"
 - create a text file in USS
 - add this line to the file: **-Xmx100M**
- Support for envvars > 254 chars in a separate file:
 - ENVAR("_CEE_ENVFILE=/u/<filename>",**

Usability Enhancements – Con't

- **Support to direct output to dataset or HFS file**
 - **For println() debugging statements**

```
//JAVAOUT DD  PATH='/u/javasp/out/javaout.txt',  
// PATHOPTS=(ORDWR,OCREAT,OAPPEND),  
// PATHMODE=(SIRUSR,SIWUSR,SIRGRP,SIWGRP,SIROTH, SIWOTH)  
//JAVAERR DD  PATH='/u/javasp/out/javaerr.txt',  
// PATHOPTS=(ORDWR,OCREAT,OAPPEND),  
// PATHMODE=(SIRUSR,SIWUSR,SIRGRP,SIWGRP,SIROTH, SIWOTH)
```

Java SP Hot Topics

- Persistent Reusable JVM topics
 - Gone from JVM 5!!
 - Never used in DB2 9
 - Optional in V8 with PK09213
 - RESET_FREQ=-1 envar setting
- Java Shared Classes
- Deployment development/production
- DB2 9: Multiple/common Jars for an application
- DB2 9: Debugging

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GoFurther

The most questions come in from these topics.

V8 APAR PK09213 closing text describes how to avoid running with the resettable JVM.

JVM 5 feature Java Shared Classes show much promise for overcoming storage constraints in the WLM-SPAS and avoiding long startup times. It can be configured with JVM startup options and no DB2 changes are required.

Deploying a Java SP to production requires the same general steps as any other language program – the binary and package need to be promoted together. Package versioning can be used for Java packages, and WLM REFRESH to pick up the new code.

DB2 9 for z/OS has enhancements in allowing multiple JARs to be searched for an application, as well as remote debugging with the Universal debug client.

Java Shared Classes – Java 5

- Uses z/OS Shared memory segments
- Java configuration parameter
 - -Xscmx4M
 - -Xshareclasses:name=myCache
- Utilities
 - Statistics:
`java -Xshareclasses:name=myCache,printStats`
 - Destroy
`java -Xshareclasses:name=myCache,destroy`



Improves memory usage and JVM startup time

DB2 9: Common JARs for a SP

- V8: Common routines had to either be included in each JAR that referenced them, or stored in the HFS and added to CLASSPATH
- DB2 9: Can install a common JAR once, and then specify that other JARs can reference it



Simplified administration and maintenance

Java SP Performance Checklist

1. Consider pathlength of each invocation
2. Tune the SQL
3. Don't call the metadata SPs
4. Use the SP authorization cache
5. Don't println() / DISPLAY in production

Java-only below this line

6. Make sure the JVM is not destroyed between invocations
 1. Test it out with JSPDEBUG
7. Don't use JSPDEBUG in production
8. Use a non-resettable JVM

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Items 1-5 are common with non-Java SPs.

Items 6-8 are unique to Java SPs.

DB2 UDB for z/OS Support



- Search APARs
- Find presentations, Redbooks, and white papers
- Read technotes for hints and tips

ibm.com/software/data/db2/zos/support.html

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The DB2 for z/OS Support page provides the following features:

- Self help through vehicles such as technotes, APARs, product documentation, Redbooks, white papers, presentations, and forums and discussion groups
- Flashes
- Problem submission and tracking capabilities (if you have a maintenance contract)
- Links to related products, support sites, and so on

DB2 for z/OS

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Forums

DB2 for OS/390 and z/OS

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DB2 for z/OS Redbooks

- Powering SOA with IBM Data Servers, SG24-7259-00
- DB2 9 for z/OS Performance Topics, SG24-7473-00
- DB2 for z/OS Stored Procedures: Through the CALL and Beyond, SG24-7083-00

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List of Links

- DB2 for z/OS product page
- DB2 for z/OS V8 Library
- DB2 9 for z/OS library
- Willie Favero's Blog
- DB2 Database Discussion list at IDUG
- International DB2 User's Group (IDUG)

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Blogs

Martin Packer

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Summary

- **About Java on z/OS**
- **Writing Java stored procedures**
- **z/OS system setup for Java stored procedures**
- **Futures**

Conclusion:

Still evolving to meet our customer's needs, not as popular as COBOL but a different set of users, as was expected.

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