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## DB2 for z/OS stored procedures: best practices & FAQ

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*Session 1700A Tuesday October 16, 2007 10:45-11:45am*

*Session 1700B Thursday October 18, 2007 2:30-3:30pm*



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**IBM INFORMATION ON DEMAND 2007**  
**October 14 - 19, 2007**  
**Mandalay Bay**  
**Las Vegas, Nevada**

## Topics

- Application architecture/design
- DBA stuff
- z/OS System Programmer stuff
- Common myths about basics of SPs
- Pitfalls to watch out for
- What's new you may have missed
- What's coming beyond V8
- Performance recommendations
- Java routines

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# IBM Data Servers

## **Reduce cost of deployment and management of data**

- *Innovation to reduce the cost of infrastructure*
- *Innovation to manage the lifecycle of data - from modeling and design through change management and sunsetting*

## **Enable rapid use of data throughout the enterprise**

- *Innovation that accelerates SOA and XML initiatives*
- *Innovation that leverages Web 2.0 and situational applications*

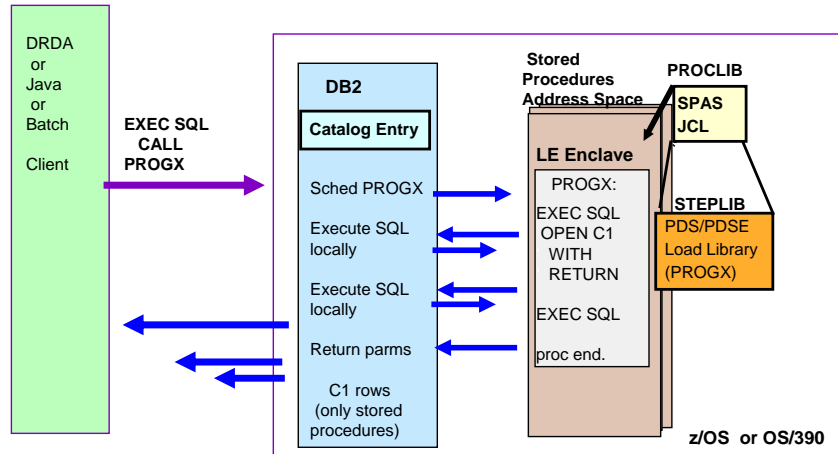
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## DB2 for OS/390 and z/OS Stored Procedures and User-Defined Functions execution



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This shows the environment. When the SP executes, the SQL access is via the local RRS attach, which is a very efficient API. If result sets are left open by the SP program, they are sent to the distributed user without any further network requests.

User-defined functions (UDFs) execute the same way, however they do not have the ability to return result set cursors.



# Application Design

TAKE BACK CONTROL



## SP Performance Checklist

- Consider pathlength of each invocation
  - Tune the SQL
  - Don't call the metadata SPs
  - Use PROGRAM TYPE SUB
  - Split up SUB to WLMENV by run options
  - Use STAY RESIDENT YES
  - Use SECURITY DB2
  - Don't println() / DISPLAY in production
  - Use the SP authorization cache
  - No more than 512 SPs in one WLMENV

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## FAQ : Should we use stored procedures locally ?

- When code reuse benefits outweigh additional overhead (additional 30K+ instructions)
- If executing from a high-overhead environment, such as Java on z/OS
- If executing from dynamic SQL (JDBC, ODBC) and prefer static SQL
- Other options for common or I/O modules:
  - Multiple linkedits for use as both SP and non-SP
  - Use DYNAM and entry point DSNHLI

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Application programmers often design to use stored procedures from local z/OS applications, even though the design point was for remote invocation. There are plenty of scenarios where this makes sense.

## FAQ: Nested and concurrent routines ?

- **Multiple stored procedures and UDFs require multiple times the resources**
  - One task per routine
  - Scheduling time for each routine
  - 2004 WLM and DB2 change for “dependent” routines: OA04555, PQ80631
- **Cancel scenarios become more complex**
  - Follow recommended order of events
  - Stay current on cancel maintenance
    - PK22811

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Bottom line here is when designing overall application performance, the invocation of each UDF and SP must be taken into account.



## Using DSNHLI and DYNAM

- COBOL DYNAM is OK ( the DB2 book is wrong)
- COBOL dynamically loads modules that are external references, including DSNELI,/DSNHLI/DSNRLI/etc
- By default, DSNHLI
  - Not correct module for either CICS or stored procedures, so books should recommend NODYNAM.
- Options:
  - Using the ATTACH(RRSF) precompiler option
  - COPY DSNRLI module into a load library concatenated in front of the DB2 libraries and call it DSNHLI.

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### Note on DYNAM vs. NODYNAM compiler option

The *DB2 Universal Database for OS/390 and z/OS Version 7 Application Programming and SQL Guide*, SC26-9933-03 clearly states that you must use the NODYNAM option when coding COBOL programs that issue SQL statements under CICS or stored procedures. This is no longer strictly true, and we expect that the manual will be amended accordingly.

With the COBOL compile DYNAM option, COBOL will dynamically load modules that are external references, including the DB2 language interface code (DSNELI, DSNHLI, DSNRLI, etc.). By default, the DB2 precompiler will generate code that uses the external entry point name DSNHLI to invoke the DB2 language interface module. This is not the correct module for either CICS or stored procedures, hence the recommendation to use NODYNAM.

However, an enhancement to the precompiler allows to use a name other than DSNHLI in the precompiler generated code. This is true for the ATTACH(RRSF) keyword for the precompiler. With this enhancement, there is no issue in dynamically loading the RRS Attach DB2 language interface module.

DYNAM is supported for stored procedures, you just need to make sure that the correct DB2 language interface module is loaded dynamically by either:

Using the ATTACH(RRSF) precompiler option

or

Copying the DSNRLI module into a load library concatenated in front of the DB2 libraries using the member name DSNHLI.

Some CICS installations use this approach to get DYNAM to work with CICS. We provide a complete example in "Solution 2: Dynamic invocation of language interface module" on page129".

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## FAQ: Why SQL stored procedures ?

- Improve the development and usability of stored procedures
  - ▶ Stored Procedure Builder GUI instead of TSO
- Ensure portability of SQL SPs across DB2 platforms
  - ▶ Collaboration across the products
- Simplify migration to DB2
  - ▶ Migration tool (<http://www-306.ibm.com/software/data/db2/migration/mtk/>)
- DB2 9 eliminates C program requirement (native SQL procedures)

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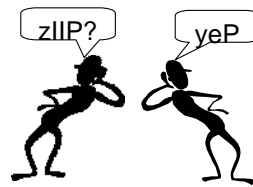
the new MTK 1.4 release (<http://www-306.ibm.com/software/data/db2/migration/mtk/>) now contains the Oracle to DB2 for z/OS support.

This is a no charge, the product is a supported download.

In a future version of DB2, we expect to remove the requirement for the C compiler and load modules, by providing native SQL procedures.

## DB2 9: Native SQL Procedure Language

- Eliminates generated C code and compilation
- Fully integrated into the DB2 engine
- Extensive support for versioning:
  - VERSION keyword on CREATE PROCEDURE
  - CURRENT ROUTINE VERSION special register
  - ALTER ADD VERSION
  - ALTER REPLACE VERSION
  - ALTER ACTIVATE VERSION
- BIND PACKAGE with new DEPLOY keyword



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### Native SQL stored procedures

Stored procedures written in SQL procedure language enhance portability and ease of use when using DB2 for z/OS as your enterprise information source. This language is an ANSI standard language. It is similar to the proprietary stored procedure languages of several competitive databases, which assists in migrating and porting to DB2 for z/OS. This is very similar to the changes in DB2 for LUW V8.2.

SQL stored procedures are supported by the DB2 Development Center tooling, providing an environment to code, test, and debug modules from your connected workstation. This language is currently converted to C when the CREATE PROCEDURE statement is executed. The C program is then automatically prepared, compiled, linked, and bound. The developer does not need to work with the C code.

SQL stored procedures code will be natively integrated into the DB2 engine, eliminating the conversion to C. Additionally, extensions to the bind command will allow for the promotion of the program and access paths between environments without needing to recreate the stored procedure.

Native SQL stored procedures are eligible for zIIP processors when they are invoked from a remote client.

## Stored procedure hot topics

- C compiler for SQL procs – gone in DB2 9
- zIIP processor
  - TCB execution is not eligible for offload
  - Stored procedure benefits still apply!
    - Less network trips
    - Better concurrency
    - Static SQL packages invoked from dynamic
  - Native SQL procs in V9 are zIIP eligible when invoked over DDF
  - Processing on DDF SRB is eligible
    - Commit, result sets
    - We Measured 10-13%

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## Interactive Debugging

- ▶ SQL procedures debugging in Version 8!
- IBM Debug Tool
  - ▶ Debug interactively from the workstation
  - ▶ How-to in the DB2 "Application Programming and SQL Guide"
  - ▶ See [www.software.ibm.com/awdtools/debugtool](http://www.software.ibm.com/awdtools/debugtool)
  - ▶ Works with COBOL, C/C++, PL/I
- ▶ Unified debugger support in DB2 9: SQL, Java

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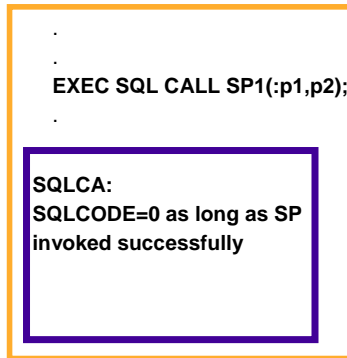
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The interactive debugger for SQL procedures is a huge improvement, available in V8.

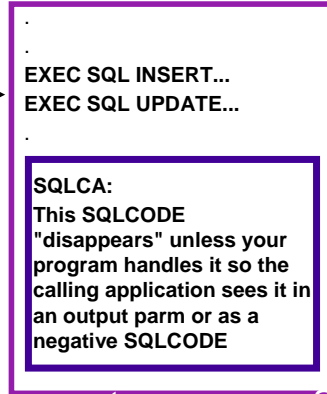
The IBM Debug Tool has been proven by many customers to be a good debugging solution for other languages.

## SPs need to signal failures

Calling application



Stored Procedure



“What happens in a stored procedure...”

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This is an application design issue. Errors must be reported back to the caller. This is what IBM-supplied stored procedures use.



## Parameter style SQL/DB2SQL

```
CREATE PROCEDURE(IN INT) PARAMETER STYLE SQL
```

```
CALL SP (:myint);
```

```
OUT SQLCODE=-443  
Tokens "BAD PARM"
```

DB2

SP:

Input parm parmint

DB2SQL input parms

DB2SQL output parm SQLSTATE

```
SQLSTATE='55555';
```

```
SQLERRM='BAD PARM'
```

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DB2SQL can be used instead of SQL

This illustrates how the SP program sets the output values that causes DB2 to report the error using the SQLCA and diagnostic work area. In V8, the GET\_DIAGNOSTICS statement can retrieve the complete text of the returned SQL error message.

Example 10-13 in the SP redbook is misleading regarding these extra parameters. We will get that corrected in the next redbook update.

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## SQLPROCEDURECOLS

- Metadata stored procedure supplied by server
- Invoked by V8 CLI client – initially always
- Not invoked by universal java driver
  - Legacy client java driver uses CLI
- Invoked if clp used to invoke SP
- Fixed in DB2 LUW client V8 Fixpack 4
  - Only invoked if first attempt to call fails, gets parm types
- Setting DescribeParam=0 in db2cli.ini eliminates call

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This little procedure has caused a lot of hub-bub. One key fact is that a properly coded CLI application should not cause this procedure to be invoked at the server. So if you are relatively current on LUW maintenance and you are still seeing invocations of this on CLI threads, then you should have the app programmers examine their data type assignments on invoking the SP.



# Database Administration

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## The dreaded -805 SQLCODE

(DB2 could not find package for the SQL)

- COLLID option on CREATE PROCEDURE
- CURRENT PACKAGESET special register
  - ▶ can be set from SP without a DB2 package
- **Local Invocation**
  - ▶ calling PLAN has PKLIST
    - As of V6, doesn't have to be there, but if it's there, it's found
- **Remote Invocation** (90+% ?)
  - ▶ There is no calling PLAN!!
  - ▶ V8 has current package path special register

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COLLID is the surest way to tell DB2 where to find the SP package. More complex stored procedure applications require more complex solutions.

## Using V8 current package path

- SP program made up of multiple parts
- Each could be in development/test/production
- Prior to V8:
  - Each program must try SET CURRENT PACKAGESET and handle -805
- In V8:
  - Invoker 1 : development,test,production
  - Invoker 2: test,production
  - Invoker 3: production
- In DB2 9: specified on CREATE PROCEDURE

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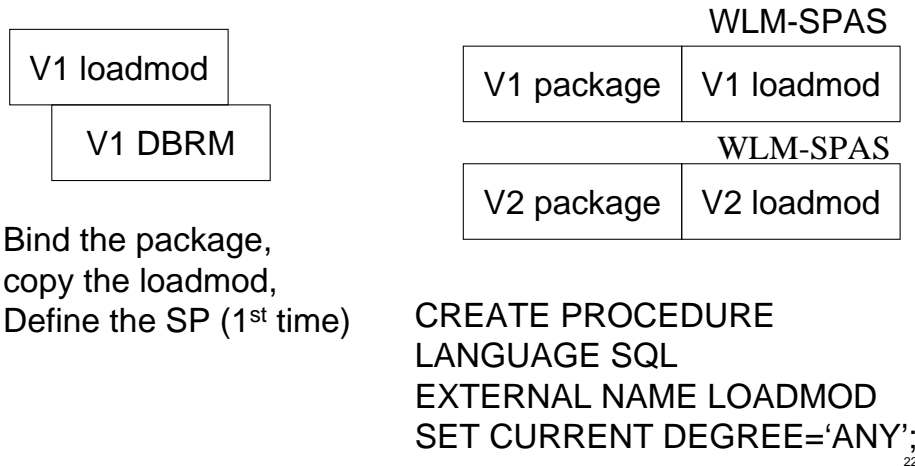


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The current package path special register provides a list of collection id's to be searched. This allows complex stored procedure applications to be bound in different collections, and the invoker to specify the search order.

## Promoting an SQL SP to production



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Q. How can I redeploy an SQL stored procedure without rebuilding it?

A. In order to copy any stored procedure to another system, three pieces need to be moved. These pieces are the load module, the SQL package, and the stored procedure definition. The load module can simply be copied. The SQL package can be generated on the target system by either copying the DBRM and issuing BIND, or by using the BIND COPY function. The stored procedure definition must be registered on the target system by issuing the CREATE PROCEDURE statement.

Please be aware that even though the load module is executed as a C load module, the stored procedure still must be defined as LANGUAGE SQL.

Some customers have fallen into a trap of redefining this generated C load module as an external C stored procedure since it seems natural when they re-deploy the SQL stored procedure to another system.

In V7, this will cause unpredictable results.. sometimes even it works.

In V8, the invocation of this C redefined stored procedure will almost certainly fail.

Some failures you will see are , SQLCODE450, LE user abend, or abend 0C4 in DB2.

The re-deployed stored procedure must continue to be defined to DB2 as LANGUAGESQL using CREATE PROCEDURE with LANGUAGE SQL

One stumbling point is that DDL for SQL stored procedure requires an SQL body. DB2 only uses this SQL body for preparation of the C load module and thus the SQL body can be changed to a single dummy statement when it is re-deployed.

A good choice for this dummy SQL body is SET CURRENT DEGREE ='ANY'

Here is a sample DDL statement for deployment of an SQL procedure.

```
CREATE PROCEDURE UPDATE1
(IN EMPLOYEE_NUMBER CHAR(10),
IN RATE DECIMAL(6,2))
LANGUAGE SQL
EXTERNAL NAME UPDATE1
MODIFIES SQL DATA
SET CURRENT DEGREE = 'ANY';
```

Please note that the rest of the CREATE PROCEDURE is your SQL stored procedure DDL and that you simply replace the entire SQL body with the single SET statement mentioned above.

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- **Use the SP authorization cache**
  - No more than 512 SPs in one WLMENV

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## SP Authorization Cache

- ZPARM
- ROUTINE AUTH CACHE option on the INSTALL DB2 PROTECTION panel (DSNTIPP).
- If set to zero no caching is done.
- Default is 100KB, maximum is 5MB
- Field name is CACHERAC
- Maximum of 5 authorization IDs cached for each routine

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## Changes in V8

- MAX\_ST\_PROC zparm (2000 per thd)
  - Causes -904 if exceeded without commit
  - PK08328 provided relief
- Specify number of allowed abends per procedure
- WLM management of tasks, not address spaces
- Can't create DB2-managed stored procedures
  - After V8, no execution either

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New stored procedure capability in V8.

SP definition can include how many times a SP can abend, which now is a system parm. The system parm becomes the default, and a SP definition can be altered to use the default.

WLM will manage the number of tasks, so NUMTCB becomes a maximum.

APAR PK08328 closed to help with MAX\_ST\_PROC -904, count is not incremented if no open result sets.

You can re-linkedit load modules that implemented DB2-managed SPs by using:

```
REPLACE DSNALI
```

```
INCLUDE SYSLIB(DSNRLI)
```

The version of DB2 after Version 8 will not allow execution of DB2-managed stored procedures.

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## FAQ: What about subroutines?

- Not affected by STAY RESIDENT YES option
- Therefore, may see many loads of subroutines
- PROGRAM TYPE SUB helps stay in storage
  - use of COBOL dynamic call may affect
  - Local variables must be initialized each invocation
    - SQL-INIT-FLAG for COBOL
- Programs in LPA is another option

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We are adding this to APSG section 6.2.4.4 Writing a stored procedure as a main program or subprogram: If stored procedure parameters are used in host variables for a COBOL SP that is defined as PROGRAM TYPE SUB and STAY RESIDENT YES then the DB2 precompiler-generated variable SQL-INIT-FLAG must be set to 0 on each invocation to ensure that the SQLDA is updated with the current addresses.

And reword this one:

If you pass host variables with address changes into a program more than once, then the called program must reset SQL-INIT-FLAG.

to say this:

If your program uses parameters defined in the LINKAGE SECTION as host variables to DB2, your program must reset the DB2 precompiler-generated variable SQL-INIT-FLAG if it is possible for the address of the input parameter to change on subsequent invocations of your program.

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## SP Performance Checklist

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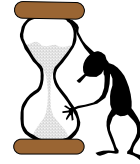
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## Control runaways

- Use ASUTIME to control looping
  - Specified on CREATE PROCEDURE
  - Only monitored every 20 seconds
- If no ASU limit specified and looping:
  - Cancel Thread (doesn't do anything if program is processing outside DB2)
  - Refresh WLM environment
  - Cancel of WLM-SPAS address space is effective as a **last resort**



In  
This  
Order!



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Put this chart on your wall, and copy it to your hand held device. If you get a call in the middle of the night to cancel a looping stored procedure, everyone will be much happier if you follow these steps to cancel it.



# System Programming

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## WLM-SPAS Considerations

- When modify code, need to refresh
  - 'V WLM,APPLENV=<env>,REFRESH'
  - DB2 supplies a WLM\_REFRESH SP
    - Uses RACF authority check
    - Can be invoked remotely !
- STOP PROC/START PROC do not affect load modules in WLM-SPAS
- Pre-V8: Enough storage in the address space?
  - Too many tasks on NUMTCB?
    - Many customers successful with 40-60
    - If CPU-starved, may need to use less
  - V8 – tasks are managed by WLM, NUMTCB is max

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CPU-starved means that when WLM takes into account the weight of a WLM-SPAS, the higher the NUMTCB, the heavier it looks. In that case, 4 WLM-SPAS with 10 TCBs each may look better than one WLM-SPAS with 40.

WLM REFRESH must be part of any change control process. If you know you are the only developer working on a SP and nobody else could be invoking it, you may get away with STAY RESIDENT NO.

Do not use the STOP PROCEDURE /START PROCEDURE commands as part of change control, unless you want to stop invocations of the SP for a short time. They do not affect load modules in WLM-SPAS.

## Workload Manager APPLENVs

- How many Application Environments do we need to define?
  - ▶ Separate one for any super-sensitive application
  - ▶ TYPE SUB with special RUNOPTS
  - ▶ Test/Development regions
  - ▶ Separate one for Stored Procedure Builder service routine (DSNTPSMP)
  - ▶ REXX needs to be NUMTCB=1
  - ▶ Separate one for Java
  - ▶ Separate JDBC drivers – Universal and Legacy

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Besides these, DB2 and IBM ship many stored procedures. The Application Programming and SQL Guide gives some guidance as to which can be run in the same APPLENV. In general, any SP that requires special JCL should be executed in its own APPLENV. Also, some such as WLM\_REFRESH need to be APF-authorized.

## WLM environments and DB2 subsystems

- WLM will start one address space per APPLENV, service class, and DB2 subsys
- To use same WLM APPLENV for different datasharing members or subsystems
  - ▶ **DB2SSN=&IWMSSNM** on WLM ISPF panel
  - ▶ Same JCL
  - ▶ Address space will identify to the member that is processing the SQL CALL statement

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Many astute customers will notice that more than one WLM-SPAS will start up for the same SP when it is invoked by a batch program and a DDF thread, even though there should be plenty of WLM-SPAS TCBs. This is because the batch program and DDF thread execute in different WLM service classes, and WLM needs to manage them by address space.

The min/max WLM-SPAS is a WLM requirement for the ability to specify this on their WLM application environment definition panel, where the current allowed values are 1 and “unlimited”.

## FAQ: How to min,max WLM-SPAS?

- 1 per system vs. NO LIMIT ?
  - “Managed by WLM
- One TCB per concurrent SP/UDF request?
  - No - “Managed by WLM” (they queue)
- Eeeek! How can I stop them?
  - -STOP PROC/FUNC, -CANCEL THD,  
WLM QUIESCE
- Manual Control



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The details for this are on the DB2 z/OS support site

<http://www-1.ibm.com/support/docview.wss?uid=swg21239743>

General link:

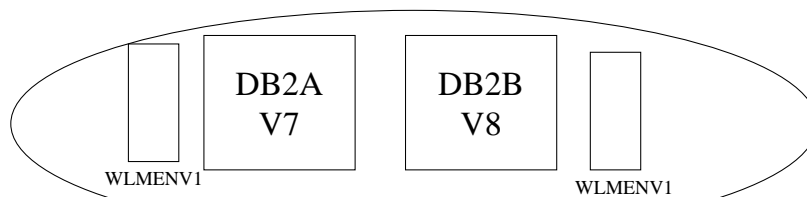
[www.software.ibm.com/db2zos](http://www.software.ibm.com/db2zos) Click ‘support’ on the left side for FAQs, etc.

## Datasharing Coexistence

- Example of JCL used after one member of a datasharing group has migrated, so the same DSN needs to refer to different datasets

```
//STEPLIB DD DISP=SHR,DSN=DSNT2.&DB2SSN..SDSNEXIT
// DD DISP=SHR,DSN=DSNT2.&DB2SSN..SDSNLOAD
// DD DISP=SHR,DSN=DSNT2.&DB2SSN..SDSNLOD2
// DD DISP=SHR,DSN=DSNT2.RUNLIB.LOAD
```

```
DSNT2.DB2A.SDSNLOAD          *ALIAS
DSNT2.DB2B.SDSNLOAD          *ALIAS
```



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### Special Considerations for WLM-managed stored procedures in coexistence.

When running in a data sharing group, each member has a different DBM1 address space. This means that the DB2 code in the WLM-SPAS will have to match more than one DB2 release level. This can cause a problem when it is desirable to use a single JCL definition for the procedure name listed in the WLM definition.

In the following example, the DB2SSN parameter is used as a part of the dataset name in STEPLIB. This allows redirection to a dataset name based on the SSN of the member that is invoking the Stored Procedure or UDF.

In the WLM definition;

```
Start Parameters . . . . . DB2SSN=&IWMSSNM
```

The special keyword &IWMSSNM in the WLM definition causes WLM to send the subsystem name as the DB2SSN parm when the address space is started.

In the WLM-SPAS JCL:

As members are migrated the ALIAS can be changed to reflect the new release the member is running.

## Java SP Hot Topics

- IBM's zAAP processor  
<http://www-1.ibm.com/servers/eserver/zseries/zaap/>
- Persistent Reusable JVM topics
  - Gone from JVM 5!!
- Java Shared Classes – shared memory
- Build for Universal Driver and DB2 z/OS V7
- Deployment development/production
- DB2 9: Multiple/common Jars for an application
- DB2 9: Debugging

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The most questions come in from these topics.

## 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. Don't use JSPDEBUG in production
7. Make sure the JVM is not destroyed between invocations
  1. Test it out with JSPDEBUG
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.

## Summary

- Key Rules:
  - Consider pathlength of each invocation
  - Use WLM environments
  - Specify ASUTIME LIMIT
  - Cancel following prescribed order
- Closing thoughts :
  - ▶ Many large companies in very high production environments
  - ▶ Pitfalls are mostly when getting started

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## SP Performance Checklist

1. Consider pathlength of each invocation
2. Tune the SQL
3. Don't call the metadata SPs
4. Use PROGRAM TYPE SUB
5. Split up SUB to WLMENV by run options
6. Use STAY RESIDENT YES
7. Use SECURITY DB2
8. Don't println() / DISPLAY in production
9. Use the SP authorization cache
10. No more than 512 SPs in one WLMENV

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## References

- **Redbooks**
  - [www.redbooks.ibm.com](http://www.redbooks.ibm.com)
  - **SG24-7083 Through the call and beyond**
  - **Scheduled for update this fall**
- **New! Collaboration site**
  - [www.developerworks.com/spaces/db2zos](http://www.developerworks.com/spaces/db2zos)
- **DB2 for z/OS:**  
[www.ibm.com/software/db2zos](http://www.ibm.com/software/db2zos)
  - Follow 'support' link for FAQ's
- **DB2 Developer Domain:**  
[www.ibm.com/software/data/developer](http://www.ibm.com/software/data/developer)

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## DB2 for z/OS information resources

Take advantage of the following information resources available for DB2 for z/OS:

- **Information center**  
<http://publib.boulder.ibm.com/infocenter/dzichelp/index.jsp>
- **Information roadmap**  
[ibm.com/software/data/db2/zos/roadmap.html](http://ibm.com/software/data/db2/zos/roadmap.html)
- **DB2 UDB for z/OS library page**  
[ibm.com/software/data/db2/zos/library.html](http://ibm.com/software/data/db2/zos/library.html)
- **Examples trading post**  
[ibm.com/developerworks/exchange/dw\\_categoryView.jsps?categoryID=25](http://ibm.com/developerworks/exchange/dw_categoryView.jsps?categoryID=25)
- **DB2 for z/OS support**  
[ibm.com/software/data/db2/zos/support.html](http://ibm.com/software/data/db2/zos/support.html)
- **Official Introduction to DB2 for z/OS**  
[ibm.com/software/data/education/bookstore](http://ibm.com/software/data/education/bookstore)

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Overview of the key information resources available.

### Information center

- Access the entire DB2 UDB for z/OS library in a single location
- Search across all DB2 for z/OS, IMS, QMF, and Tools documentation
- Search messages and codes easily using the LookAt tool

### Information roadmap

Take advantage of an anchor site that provides links to a wide variety of useful information resources about DB2 UDB for z/OS, Version

### DB2 UDB for z/OS library page

The DB2 UDB for z/OS library page offers a complete range of product information resources, including:

- Product documentation for all supported versions of DB2 UDB for z/OS
- Announcement letters
- Presentations
- Important technical tips

### Examples trading post

- Share examples of actual code
- Learn how customers are using the product

### Support

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

### Official Introduction to DB2 for z/OS

- Get started with DB2 Version 8
- Prepare for the DB2 Family Fundamentals certification exam
- Practice with sample questions

Session: 1700A or 1700B  
Stored Procedures: Futures, Best Practices and FAQs

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*Thank You!!*



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