
DB2 and PHP

In Depth on IBM i



seidengroup.com

Seiden Group and Club Seiden

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Seiden Group is a team of experts available for mentoring/troubleshooting/project advice/development.

Club Seiden, ZendCon 2015



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Today's discussion will include:

- **Uniqueness of DB2 for IBM i**
- **Which DB2-enabled middleware to use with PHP**
- **Securing your SQL with prepared queries**
- **Connection options for speed and reliability**
 - Persistent connections
 - Library lists
- **What's NEW in `ibm_db2`**
- **Connecting from “off the box”**
- **Many other tips**

Why learn DB2 best practices?

- **As chief database on IBM i, DB2 runs these:**
 - Most transaction processing systems
 - Stored procedures
 - “XMLSERVICE” Toolkit
 - Accessible with db2 stored procedures from PHP
- **DB2 knowledge will help you:**
 - Maximize speed
 - Reduce CPU usage
 - Maximize reliability
 - Avoid unexpected locking and other operational problems

Heart of IBM i is DB2

- **DB2 built in**
 - Transaction processing workhorse
 - Database implemented below operating system level!
 - IBM i's "Machine Interface (MI)" between OS and hardware
 - Journaling, auditing, commitment control very commonly used
 - Never corrupted
 - Doesn't lose data even if knock out power plug
- **Database often taken for granted**
 - So self-managing, DBAs are rare

Reliable

Nondisruptive business growth

- **Scales vertically**

- One system can handle large and diverse workloads
 - Total Cost of Ownership (TCO), including reduced operator costs, is said to be competitive or cheaper than assembling server farms
- Can activate additional processors without restarting system

- **Dependable**



Steve Pletcher @jloverpitcher

2,117

#IDM1 is impervious to viruses, malware, hackers, mother-in-laws and the zombie apocalypse. #powerSystems

- Resistant to viruses
 - Object-based system since the 1970s
- Journaling, commitment control, replication, high availability
- Security features galore
- Keeps on running
 - You will sleep soundly at night

IBM i can “phone home”

Additional Message Information

```
Message ID . . . . . : CPIEF03      Severity . . . . . : 40
Message type . . . . . : Information
Date sent . . . . . : 03/21/13      Time sent . . . . . : 00:12:15
```

```
Message . . . . . : Service Agent has sent a service request with service
assigned number 52369.
```

```
Cause . . . . . : A service request has been sent. No further action is
required. If this request was placed to IBM, an IBM Service representative
will be contacting you soon. If a PTF was downloaded for this problem, you
may not be contacted by IBM. If the request was sent to a service provider,
other than IBM, the service assigned number will be blank or contain <SVD>.
```

Queue .
Library
Severity

Type req
Writer
5 writ
Clean

```
Remote device rejected an attempt by the writer to open a connection.  
Remote device rejected an attempt by the writer to open a connection.  
Remote device rejected an attempt by the writer to open a connection.  
Message LPP2618 not monitored. Affected object name is TAPMLB02.  
Automatic configuration created device description TAPMLB02.  
Automatic configuration created device description TAP03.
```

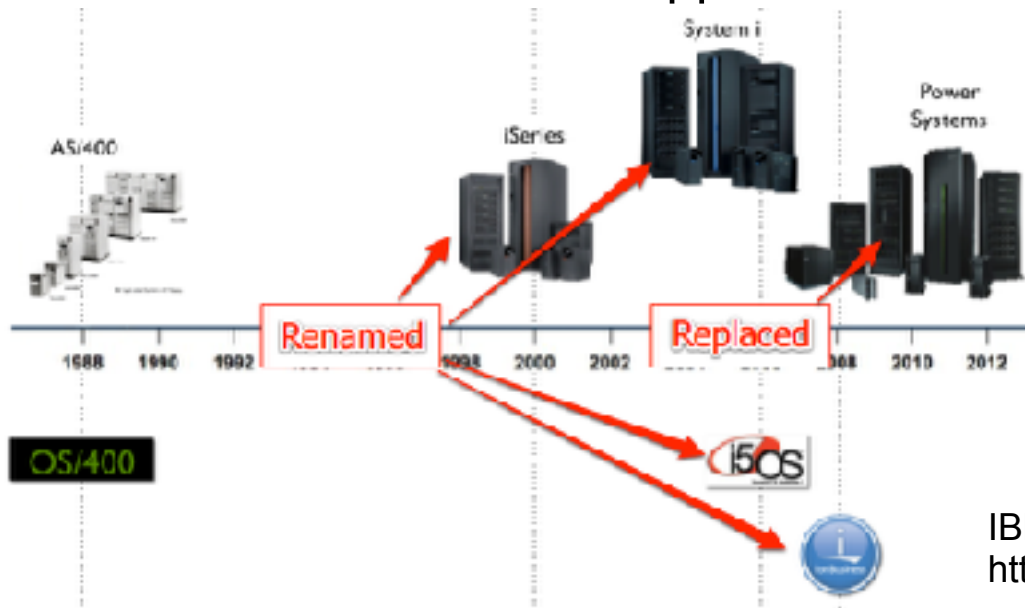
```
* *Attention* Contact your hardware service provider now.  
Service Agent is analyzing your system product activity log entries.  
Service Agent has sent a service request with service assigned number  
52369.
```

Bottom

```
F3=Exit          F11=Remove a message      F12=Cancel  
F13=Remove all   F16=Remove all except unanswered  F24=More keys  
* - Work with problem allowed for message.
```

Data and programs last forever

- **IBM has been dedicated to legacy app longevity and data longevity**
 - RPG (and occasionally COBOL) running for 30-40 years
 - DB2 data evolving 30-40 years
 - Middleware insulates applications from hardware changes



IBM i Heritage chart from Trevor Perry
<http://blog.angustheitchap.com/?p=415>

Long-serving back ends, new front ends

- **What does this mean to you?**
 - RPG and DB2, mature and evolving for years, can be part of your data model, accessed by PHP
 - Create web GUI interfaces and web services around these venerable resources
 - Business logic is encapsulated in RPG/COBOL/DB2
 - You can keep your hands somewhat clean of business details

DB2 on IBM i is...

- **Fully integrated business database**

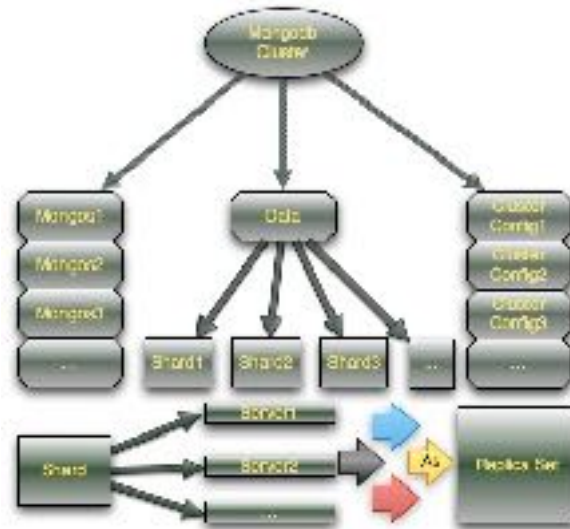
- Coded at the kernel level (below the OS)
 - Other database systems are .exe files
- User profiles = real IBM i user profiles
 - Security, logging, auditing consistent throughout the system
 - Other databases have “pretend” users whose security is enforced only by database code
- Always present and available
 - No daemon that can be ended or hacked
 - “Who shut down the database?” Not on IBM i!

DB2 on IBM i is...

- **Indestructible, low maintenance (cost-effective)**

- Data corruption almost unheard of
- 30+ years of work for reliability and throughput
- DBA-less operation. Scale vertically. Add disk and go!

- DB2 on i is **not** this:



Disclaimer: Not singling out other databases as “bad.” A NoSQL database such as Mongo prizes flexibility more than management ease

MongoDB @MongoDB

Sharding Pitfalls Part III: Chunk Balancing and Collection Limits buff.ly/1rgktMc

1rgktMc

Database jargon

Modern term	Traditional term or phrase
Schema	Library
Table	File or Physical File
Index	Logical File*
Row	Record
Column	Field

* a logical file resembles an “index + view”

Modern views, triggers, etc. are supported by DB2.

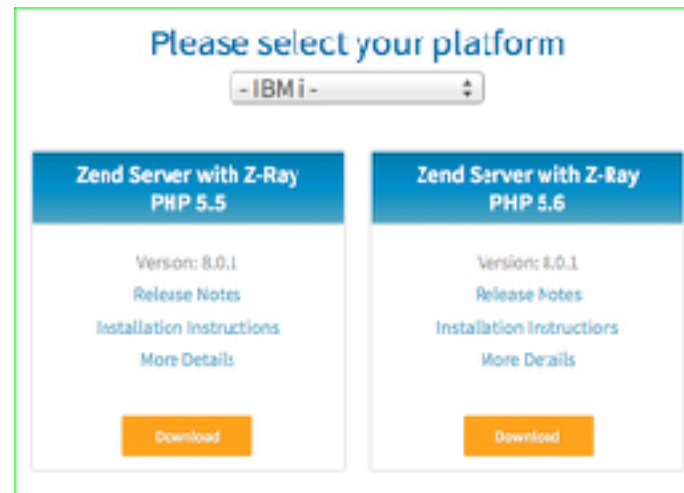
Tip: LF indexes used automatically

- **Logical file keys treated as indexes by SQL**
- **To take advantage of LF “indexes,” use ORDER BY, WHERE, and JOIN in your SQL as usual**
 - Indexes from LFs will be chosen automatically as appropriate
 - No need to specify LF in SQL: use physical file/table
- **If your preferred indexes aren’t selected by the optimizer, try Visual Explain to learn why.**
 - http://www.ibmssystemsmag.com/ibmi/developer/general/visual_explain/
 - Visual Explain runs in Access Client Solutions (ACS) and the older IBM i Navigator.

Prerequisites for DB2 with PHP

Zend Server for IBM i (8.x)

- **Download Zend Server 8.x**
 - <http://www.zend.com/en/products/server/downloads-ibmi>
 - Easy upgrade from 6.x
 - Includes ibm_db2 version 1.9.7 with many updates



- **Editions**
 - Basic (free), Professional, Enterprise
 - <http://www.zend.com/en/products/server/editions>
 - Same download, different license

Zend Server for IBM i (9.x)

- **Download Zend Server 9.x**
 - <http://www.zend.com/en/products/server/downloads-ibmi>
 - Includes PHP 7.1



- **Editions**
 - Basic (free), Professional, Enterprise
 - <http://www.zend.com/en/products/server/editions>
 - Same download, different license

Current PTFs within your release

- **Latest DB2 for IBM i group PTF level for your release**

- 7.1: WRKPTFGRP SF99701
- 7.2: WRKPTFGRP SF99702
- 7.3: WRKPTFGRP SF99703

- For the latest levels:

<http://www-01.ibm.com/support/docview.wss?uid=nas4PSPbyNum>

DB2 is an exciting growth zone for IBM i

- **Behooves you to stay on top of it**
- **Example of update:**
 - <http://www.mcpressonline.com/ibm-i-os/400-i5/os/step-right-up-and-hear-about-db2-and-tr9.html>
 - Regular expressions in WHERE clause
 - System info available via SQL...joblog, liblist, more

**Alan's current
favorite features**

A select list of features (1 of 2)

- **SQL Views**
 - Act like a table (SELECT) but implements “virtual” logic
- **User defined functions (UDF)**
 - Create your own scalar function
- **Stored procedures**
 - Efficient, flexible
 - Good place for business logic
 - Run multiple queries if desired

more...

A select list of features (2 of 2)

- **VARCHAR/Trim**
 - Avoid extra spaces caused by fixed-length strings
- **Web service support**
 - DB2 can retrieve/send HTTP data and parse XML

Views

- Like old “join logical” file and much more

create view presllmstj1

(programcode, programdesc, item, orderbydate, orderbydate_mmddy, expired) as
select trim(pccode), trim(pcdesc), pmprod, pmobdate,

mmddy_slashes(pmobdate),

CASE WHEN CURRENT_DATE > PMOBDATE THEN 1 ELSE 0 END as expired

from PRESLLMST left join PRESLLCDE on PMCODE = PCCODE

select * from presllmstj1

PROGRAMCODE	PROGRAMDESC	ITEM	ORDERBYDATE	ORDERBYDATE_MMDDYY	EXPIRED
HNRK	HENDRICKS GIN PRE-SELL	1306920	2015-06-26	6/26/15	1
HNRK	HENDRICKS GIN PRE-SELL	1306930	2015-06-30	6/30/15	1
HNRK	HENDRICKS GIN PRE-SELL	1306900	2015-06-26	6/26/15	1
BJNV	BEAUJOLAIS NOUVEAU15	6641041	2015-06-21	6/21/15	1
HH15	HEAVEN HILL 2015	1544340	2015-07-05	7/5/15	0
HH15	HEAVEN HILL 2015	1544540	2015-07-04	7/4/15	1
HH15	HEAVEN HILL 2015	1544240	2015-07-05	7/5/15	0
JPIN	JP INSIGNIA 15	8218050	2015-07-02	7/2/15	1

User-defined functions (UDF)

- **Create your own function in DB2**

e.g. 6 digit numeric date mmddyy to real date

old way:

```
select date(substr(digits(phdate),1,2) || '/' || substr(digits(phdate),3,2) || '/' ||
substr(digits(phdate),5,2)) as podate from podet inner join pohead on
pipo=phpo where piprod = 4317140;
```

```
CREATE FUNCTION mmddyy_to_date (thedata numeric(6,0))
RETURNS DATE LANGUAGE SQL DETERMINISTIC
BEGIN
    RETURN date(substr(digits(thedata),1,2) || '/' || substr(digits(thedata),
3,2) || '/' || substr(digits(thedata),5,2));
END
```

New way:

```
select MMDDYY_TO_DATE(phdate) as podate from podet
inner join pohead on pipo=phpo where piprod = 4317140
```

Stored procedures

- Most flexible.
- Multiple queries, resultsets, call RPG, SQL, all sorts of logic, parameters

OFFSET and LIMIT for Stateless Pagination

```
CREATE OR REPLACE PROCEDURE
TOYSTORE.FIND_EMPLOYEES
(IN P_PAGESIZE BIGINT, IN P_OFFSET BIGINT)
DYNAMIC RESULT SETS 1
LANGUAGE SQL
BEGIN
  DECLARE V_PREP_STMT1 VARCHAR(4096) ;
  DECLARE CEMP_RESULT_SET1 CURSOR
  WITH RETURN FOR PREP_STMT1;
  SET V_PREP_STMT1 =
  'SELECT EMPNO, HIREDATE, LASTNAME FROM
  TOYSTORE.EMPLOYEE
  ORDER BY HIREDATE DESC
  LIMIT ? OFFSET ?';
  PREPARE PREP_STMT1 FROM V_PREP_STMT1 ;
  OPEN CEMP_RESULT_SET1 USING P_PAGESIZE,
  P_OFFSET;

END;

CALL TOYSTORE.FIND_EMPLOYEES(10, 0);
CALL TOYSTORE.FIND_EMPLOYEES(10, 10);
```

Page 1

Page 2

EMPNO	HIREDATE	LASTNAME
000100	2013/01/01	SCOTT
000101	2013/01/01	FURNESS
000102	2013/01/01	FRANKS
000103	2013/01/01	ARMSTRONG
000104	2013/01/01	DEWETT
000105	2013/01/01	SMITH
000106	2013/01/01	WARD
000107	2013/01/01	WATSON
000108	2013/01/01	BLAKE
000109	2013/01/01	CLARK
000110	2013/01/01	ADAMS
000111	2013/01/01	JONES
000112	2013/01/01	SMITH
000113	2013/01/01	WARD
000114	2013/01/01	SCOTT
000115	2013/01/01	DEWETT
000116	2013/01/01	SMITH
000117	2013/01/01	WARD
000118	2013/01/01	SCOTT
000119	2013/01/01	DEWETT
000120	2013/01/01	SMITH

Varchar/trim

- **VARCHAR/Trim**
 - Avoid extra spaces caused by fixed-length strings
 - `<input type=text name='srvzip' size=9 value="43031 " id="srvzip" maxlength="9">`
- **Extra spaces caused by CHAR (fixed length strings)**
- **Use VARCHAR instead for automatic trimming or trim(MyField) in SQL**

Web services

- **DB2 can GET/POST HTTP**
- **Parse XML**
- **So DB2 can be a web service engine**

- **See my presentation on “PHP Tricks for RPG developers”**

DB2 drivers

Choice of middleware to access DB2

- **Zend Server includes at least three such extensions:**
- **odbc**
 - Less functionality than the others (generic)
 - “Free” connections from other platforms
- **IBM_PDO**
 - PDO = PHP Data Objects
 - Generic DB2. Experimental “/” separator and library lists
- **ibm_db2**
 - Provides IBM i-specific features such as library list support

ibm_db2 documentation

- **Manual page**
 - http://php.net/ibm_db2
- **Source code and additional documentation at the “PECL” PHP extension repository**
 - http://pecl.php.net/package/ibm_db2
 - Read the “C” source sometime—it’s educational
- **We will examine ibm_db2 in detail today**

Connect to DB2

Connect with `db2_connect()`

- **`db2_connect()` creates a database connection**
 - Accepts four parameters that you should master
 - Three string parameters
 - One array of optional options
- **`resource db2_connect (string $database, string $username, string $password [, array $options])`**
- **`db2_pconnect()` is similar**
 - `pconnect` creates persistent connections (more on that later)

db2_connect() string parameters

- **\$database**

- Leave blank (") for default local database
- Use a db name from WRKRDBDIRE for a choice of databases
 - Database name can be *LOCAL or that of an LPAR, IASP (Independent auxiliary storage pool), or another machine

- **\$username**

- Leave blank (") for default Apache user (QTMHHTTP)
 - Not recommended
- Use any valid user profile to associate queries with that user

- **\$password**

- Leave blank (") if \$database and \$username were blank
- Otherwise, provide password corresponding to \$username

db2_connect() basic examples

- **Empty params**

- `$conn = db2_connect(' ', ' ', ' ');`
- Connects to local database with web user QTMHHTTP
- Not recommended: may be disallowed in future release

- **Better: use specific values**

- `$conn = db2_connect('MYDB', 'MYUSER', 'MYPASS');`
- Connects to MYDB database (must be configured in WRKRDBDIRE) with user MYUSER

How to connect to remote DB or iASP

- **Connect to another partition, server, or iASP as if local**
- **Useful for testing PHP scripts against databases of multiple partitions (dev/test/production)**

- **Example: remote server is at IP 1.2.3.4 and has database named SANJOSE**
- **We will refer to it on our box with alias “DEVBOX”**
- **Use WRKRDBDIRE (Work with Relational Database Directory Entries) to create local alias to remote database**

WRKRDBDIRE to set up alias

Work with Relational Database Directory Entries

Option	Entry	Remote Location	Text
0	DEVBOX	1.2.3.4	
-	S105098	*LOCAL	Entry added by system

Display Relational Database Entry Detail

```
Relational database . . . . . : SANJOSE
  Relational database alias . . : DEVBOX
Remote location:
  Remote location . . . . . : 1.2.3.4
  Type . . . . . : *IP
  Port number or service name . : *DRDA
Remote authentication method:
  Preferred method . . . . . : *USRENCPWD
  Allow lower authentication . : *ALWLOWER
  Secure connection . . . . . : *NONE
  Encryption algorithm . . . . . : *DES
Text . . . . . :

Relational database type . . . . : *REMOTE
```

Now we can access “DEVBOX” database

- **User and password must be correct for the remote database**

```
$db = db2_connect('DEVBOX', 'DEVUSER', 'DEVPWD');
```

Fourth parameter (array \$options)

- **Optional array to fine-tune the connection**
- **Below are choices that are most relevant for IBM i**
- **Details as we go**
 - `i5_lib`
 - Set a single default library
 - `i5_naming`
 - Choose “system” or SQL naming
 - `i5_libl`
 - Set a library **list** (be sure to set `i5_naming` on)
 - `i5_commit`
 - Commitment control options
 - `autocommit`
 - `DB2_AUTOCOMMIT_ON` (default) or `_OFF`

- **Specify one library as default**
 - `'i5_lib'=>'MYLIB'`
- **Any unqualified files/tables will be assumed to use this library**

i5_naming for library lists

- **DB2_I5_NAMING_ON**

- A constant equal to 1 that turns on “system naming” mode
- Table files qualified using the slash (/) delimiter
- Unqualified files are resolved using the library list for the job

- **DB2_I5_NAMING_OFF**

- A constant equal to 0 (default) that enables “SQL naming” mode
- Table files qualified using the period (.) delimiter
- Unqualified files are resolved using either the default library (i5_lib) or the user profile name specified on db2_connect() (could be QTMHHTTP)
 - Message to watch for:
MYTABLE in YOURNAME type *FILE not found.
SQLCODE=-204”

User profile strategy

Three techniques (1 of 3)

- Small number of "system" user profiles. One user per library list. When "real" user signs in, authenticate against a database, LDAP, etc. Not against user profile list

Three techniques (2 of 3)

- db2_connect with real user profile
 - user can get disabled when wrong password is entered
 - revealing an actual user profile to end users (OK for internal. security problem if external)
 - benefit: authority, program logic, journal entries will work with "real" IBM i user profile
- db2_pconnect works the same except that the jobs stay semi-active, visible to operator

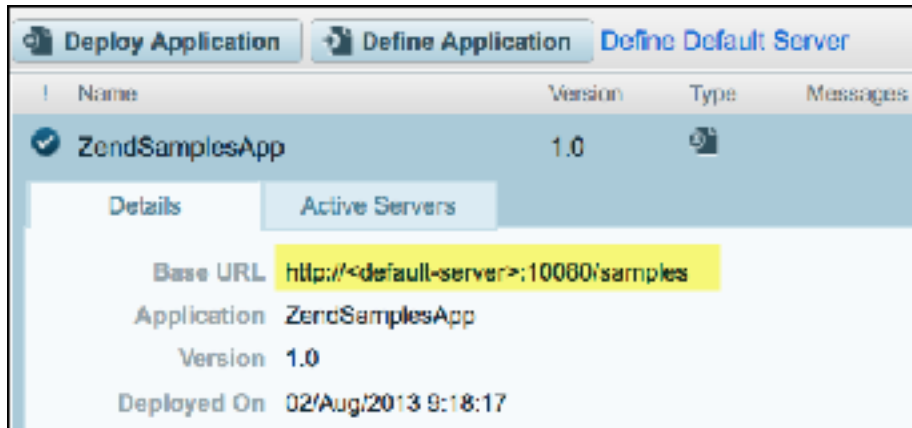
Three techniques (3 of 3)

- db2_pconnect with generic "system" profile but then switch to "real" profile after authentication
 - fast connection
 - limits number of active jobs
 - performance cost of the "switch"
 - security concerns about mixed generic/specific user profile attributes/authority in a job
 - need to "switch back" afterward

**Included
sample script**

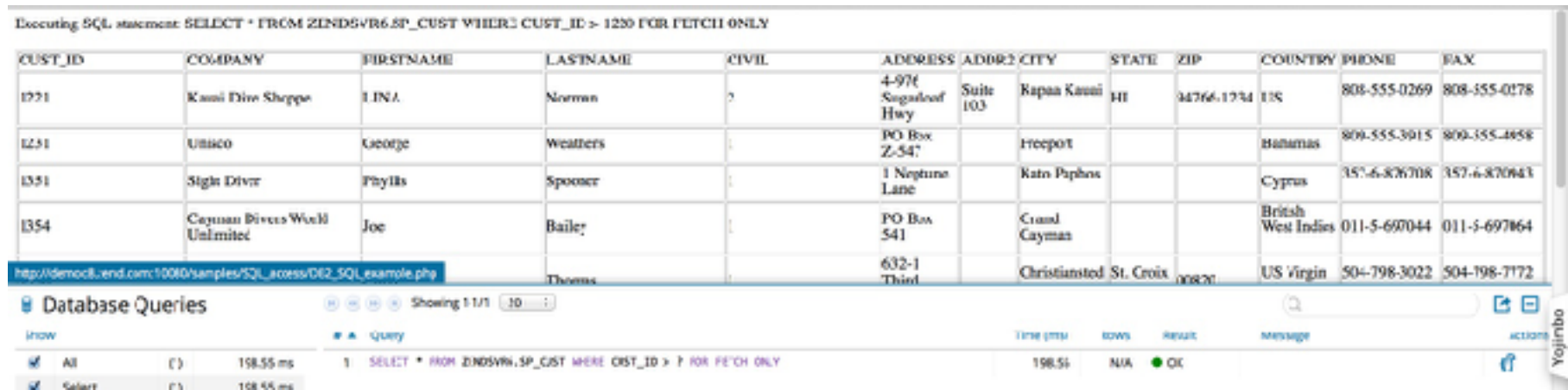
Included with Zend Server

“SQL Access” sample script illustrates several techniques from this talk



The screenshot shows the Zend Server management interface. At the top, there are three tabs: "Deploy Application", "Define Application", and "Define Default Server". Below the tabs is a table with columns "Name", "Version", "Type", and "Messages". The first row is "ZendSamplesApp" with version "1.0" and a status icon. Below the table, there are two sub-tabs: "Details" and "Active Servers". The "Details" tab is active, showing the following information:

- Base URL: `http://<default-server>:10080/samples`
- Application: ZendSamplesApp
- Version: 1.0
- Deployed On: 02/Aug/2013 9:18:17



The screenshot shows a web browser displaying a table of customer data. The table has the following columns: CUST_ID, COMPANY, FIRSTNAME, LASTNAME, CIVIL, ADDRESS, ADDR2, CITY, STATE, ZIP, COUNTRY, PHONE, and FAX. The data is as follows:

CUST_ID	COMPANY	FIRSTNAME	LASTNAME	CIVIL	ADDRESS	ADDR2	CITY	STATE	ZIP	COUNTRY	PHONE	FAX
1221	Kami Dive Shoppe	LINA	Norman	?	4-976 Sugarcreef Hwy	Suite 103	Rapa Kuni	HI	96766-1734	USA	808-555-0269	808-555-0178
1231	UBICO	George	Weathers	:	PO Box Z-547		Freeport			Bahamas	809-555-3915	809-555-4658
1331	Sight Diver	Phyllis	Sponser	:	1 Neptune Lane		Rato Paphos			Cyprus	357-6-876708	357-6-876943
1354	Cayman Divers World Unlimited	Joe	Bailey	:	PO Box 541		Grand Cayman			British West Indies	011-5-697044	011-5-697864
			Thomas	:	602-1 Third		Christiansted	St. Croix	00820	US Virgin	504-798-3022	504-798-7172

Below the table, there is a "Database Queries" section showing a log of queries. The first query is:

```
SELECT * FROM ZENDSVR6.SP_CUST WHERE CUST_ID > 1220 FOR FETCH ONLY
```

The query execution details are:

row	Query	Time (ms)	rows	Result	Message	actions
1	SELECT * FROM ZENDSVR6.SP_CUST WHERE CUST_ID > 1220 FOR FETCH ONLY	198.56	N/A	OK		

Snippet of sample script

```
/* Construct the SQL statement */
$sql = "SELECT * FROM ZENDSVR.SP_CUST WHERE CUST_ID > ? FOR FETCH ONLY";

/* Prepare, bind and execute the DB2 SQL statement */
$stmt= db2_prepare($conn_resource, $sql);
$lower_limit = 1220; //from the CUST_ID value
$fields = db2_num_fields($stmt);
if($fields > 0 )
{
//show Table Header (analyze result set)
echo "<table border=1>";
echo "<tr>";
for($i=0; $i<$fields; $i++)
{
    echo '<td width="20%">';
    $name = db2_field_name($stmt, $i);
    echo $name;
    echo "</td>";
}

echo "</tr>";

//Execute statement , uses a binding of parameters
db2_bind_param($stmt, 1, "lower_limit", DB2_PARAM_IN);
$result = db2_execute($stmt);
```


Commitment control

Assure data integrity

- **Commitment control allows “all or none” logic when running multiple update/insert/delete queries**
- **If one query fails, roll back previous related queries**
- **Example: If a detail record update fails, roll back the header update**
- **Requires that journaling be enabled on files/tables being written to**

Use commitment control for data integrity

- **Example: “all or none” for two INSERTS**

- with `ibm_db2.i5_allow_commit = 1`
- and `autocommit = DB2_AUTOCOMMIT_OFF`

```
$conn = db2_pconnect('', '', '', array('autocommit'=>DB2_AUTOCOMMIT_OFF));
$stmt=db2_prepare($conn,"INSERT INTO MYTABLE (IDNUM, NAME) VALUES(?, ?)");
$result1 = db2_execute($stmt, array(1, 'jane')); // should insert OK
$result2 = db2_execute($stmt, array('x', 'bob')); // not numeric!

// check if both INSERTs succeeded
if ($result1 && $result2) {
    // Success. Commit both inserts
    db2_commit($conn);
} else {
    // *** Error with one of the inserts; roll them both back ***
    db2_rollback($conn);
}
// Neither record will be in the table. We rolled back.
```

i5_commit

- **i5_commit**

- Options for isolation level
- Gives you fine-grained control (and ability to turn off altogether)
- Before Zend Server 8.5, must also enable commitment control system-wide
 - `ibm_db2.i5_allow_commit = 1` in INI file
- Choices:
 - `DB2_I5_TXN_NO_COMMIT` – turns off commitment control for this connection
 - `DB2_I5_TXN_READ_UNCOMMITTED`
 - `DB2_I5_TXN_READ_COMMITTED`
 - `DB2_I5_TXN_REPEATABLE_READ`
 - `DB2_I5_TXN_SERIALIZABLE`

autocommit

- **DB2_AUTOCOMMIT_ON**

- A constant equal to 1 (default)
- Turns autocommit on
 - End of script causes commit
- Only relevant when commitment control is used
- Convenient: insert/update/delete will work without `db2_commit()`

- **DB2_AUTOCOMMIT_OFF**

- A constant equal to 0
- Turns autocommit off
- Only relevant when commitment control is used
- Provides flexibility to ensure data integrity in multi-step transactions by using `db2_commit()/db2_rollback()` around groups of insert/update/delete queries

Commitment control tips

- **In php.ini:**

- To use commitment control before 1.9.6-sg25, set `ibm_db2.i5_allow_commit = 1`

- **In db2_connect() option array:**

- Modify default settings with 'i5_commit' option
- Choose 'autocommit' on or off

- **Turn on journaling for schemas (libraries)**

- Already on if schema created via "CREATE SCHEMA" (SQL/DDL)
- Extra step needed for libraries created via CRTLIB
 - Start Journal Library (STRJRNLIB, v6.1+) makes a library a journaled object. Any objects eligible to be journaled that are added to the library can be automatically journaled
 - <http://www.redbooks.ibm.com/abstracts/tips0662.html>

More about db2_connect, db2_pconnect

- **Manual pages**

- <http://www.php.net/manual/en/function.db2-connect.php>
- <http://www.php.net/manual/en/function.db2-pconnect.php>
- <http://www.php.net/manual/en/features.persistent-connections.php>

Security

Prepare queries

“Prepared” = safe and fast

- **Prepared queries help in several ways**
 - Eliminate errors due to un-escaped single quotes
 - Protect your data from SQL Injection attacks
 - Speed up repeated queries
- **They are also known as prepared statements**
- **Here’s an example of the mischief they prevent**

Apostrophes confuse query parsers

```
// mysite.com?name=whatever
$name = $_GET['name'];
$sql = "select custno from custfile
       where name = '$name' and status = 'ACTIVE' ";
```

- **Do you see any potential problems?**

- **What if the name is “O’Shea” ? Error!**

```
$sql = "select custno from custfile
       where name = 'O'Shea' and status = 'ACTIVE' ";
```

- **Single quotes confuse query parser when they serve two purposes**
 - Used as apostrophe in data
 - Delimiter of string literals in the SQL syntax

Malicious users can try “SQL Injection”

```
// mysite.com?name=whatever
$name = $_GET['name'];
$sql = "select custno from custfile
       where name = '$name' and status = 'ACTIVE' ";
```

- **What if the name is the weird-looking “x' OR 1=1--”**
(That is, a user typed: mysite.com?name=x' OR 1=1--)

```
$sql = "select custno from custfile
       where name = 'x' OR 1=1--' and status = 'ACTIVE' ";
```

- **Every record in the table will be selected**
 - OR 1=1 will always be true
 - -- turns subsequent ‘where’ criteria into a comment (ignored!)

Safeguard data with prepared queries

```
// mysite.com?name=whatever
$name = $_GET['name'];
$sql = "select custno from custfile
       where name = ? and status = 'ACTIVE' ";
```

- **Represent parameters with question marks (?) instead of literal values**
- **It's fine to retain hard-coded values in the query**
 - Such as 'ACTIVE' in the example above
- **Supply parameters in an array**
 - `$params = array("O'Shea");`
- **Full example on next slide**

db2_prepare() with db2_execute()

```
$name = $_GET['name'];
$conn = db2_connect('', '', '');
$sql = "select custno from custfile
       where name = ? and status = 'ACTIVE' ";
$params = array($name); // can be "O'Shea" for all we care
$stmt = db2_prepare($conn, $sql);
if ($stmt) { // prepared OK
    $result = db2_execute($stmt, $params);
    if ($result) { // ran query OK with parameters
        while ($row = db2_fetch_assoc($stmt)) {
            echo "$row['custno']\n";
        }
    }
}
```

Ordinary db2_exec() re-calcs plan

- **Ex. of non-prepared SQL repeated with different params**

```
$values = array('acme', 'shoprite', 'stop n shop');
foreach ($values as $value) {
    $sql = "select custno from custfile
           where name = '$value' and status = 'ACTIVE' ";
    // query gets re-optimized in each iteration
    $stmt = db2_exec($conn, $sql);
    if ($stmt) { // do something with $stmt }
}
```

- **The query plan will re-optimize on each db2_exec() because a new SQL string was supplied each time**
- **OK for one-off queries but not when repeated**

Prepared statement allows re-use of plan

- **Ex. of prepared SQL; execution with different params**

```
// prepare the query ONCE
$sql = "select custno from custfile
        where name = ? and status = 'ACTIVE' ";
$stmt = db2_prepare($conn, $sql);
// now execute with values only
$values = array('acme', 'shoprite', 'stop n shop');
foreach ($values as $value) {
    $result = db2_execute($stmt, array($value));
    if $result { // do something with $stmt }
}
}
```

- **The query plan is calculated ONCE and reused with each db2_execute(), saving time and CPU**

Prepared statements/queries are best

- **Replace `db2_exec()` with `db2_prepare()` and `db2_execute()`**
- **Benefits**
 - Queries will run as intended, with fewer surprises
 - Protection from a common form of hacking (SQL injection)
 - Performance will improve for repeated queries

RCAC

Db2 security technique

- **Row and Column Access Control (RCAC)**
 - In IBM i 7.2+
 - Implemented via additional SQL “WHERE” clauses and more
- **Row control: limit what rows can be selected, at the database level, depending on the user or any other criteria**
- **Column Access: mask or manipulate columns at the database level**
- **Will restrict in all applications**
- **More info**
 - <http://www.ibmssystemsmag.com/Blogs/i-Can/September-2014/IBM-i-7-2---Protect-Data-With-RCAC/>

Debug/diagnostics

Functions to get error codes/messages

- **db2_conn_error()** connection error code
- **db2_conn_errormsg()** connection error text
- **db2_stmt_error()** prepare/execute error code
- **db2_stmt_errormsg()** prepare/execute error text

Connections return a resource or false

```
$conn = db2_connect("*LOCAL", "MYUSER", "BADPASS");

// test for false
if (!$conn) {
    echo "Connection failed. SQL Err: ";
    echo db2_conn_error() . "<br>";
    echo db2_conn_errormsg();

    die();
} else {
    // use the connection....
}
```

An incorrect password will generate this output:

```
Connection failed. SQL Err: 08001
Authorization failure on distributed database
connection attempt. SQLCODE=-30082
```

Prepare/execute: resource or false

```
$sql = "SELECT * FROM BADLIB.SP_CUST WHERE CUST_ID > ?";  
  
$stmt= db2_prepare($conn, $sql);  
  
if (!$stmt) {  
    echo 'The db2 prepare failed. ';  
    echo 'SQLSTATE value: ' . db2_stmt_error() . '<BR>';  
    echo ' Message: ' . db2_stmt_errormsg();  
}
```

The error code and message might resemble:

```
SQLSTATE value: 42704
```

```
Message: SP_CUST in BADLIB type *FILE not found.  
SQLCODE=-204
```

Other trace/debug ideas

Advanced use only: special libdb400 tracing driver:

<http://yips.idevcloud.com/wiki/index.php/PASE/Service>

Configuration

Prestart jobs in QSYSWRK by default

DB2 queries run in separate prestart jobs

```
Subsystem . . . . . : QSYSWRK

Opt  Job      User      Type      Status
___  _____  _____  _____  _____
_    QSQSRVR  QUSER     PJ         ACTIVE
_    QSQSRVR  QUSER     PJ         ACTIVE
```

Prestart job optimization

- **QSQSRVR prestart jobs run in QSYSWRK**
- **Or, if remote DRDA, QRWTSRVR in QUSRWRK**
- **Configurable pool of jobs**

```
CHGPJE SBSD (QSYS/QSYSWRK) PGM (QSYS/QSQSRVR)  
STRJOBS (*YES) INLJOBS (xx) THRESHOLD (xx)  
ADLJOBS (xx) MAXUSE (xx or *NOMAX)
```

- **More on prestart db2 jobs and “server mode”**
 - <http://www.redbooks.ibm.com/abstracts/tips0658.html>
 - <http://www.mcpressonline.com/tips-techniques/database/techtip-grab-control-of-the-db2-qsqsrvr-jobs.html>
 - <http://www.mcpressonline.com/database/db2/finding-sql-server-mode-connecting-jobs.html>

**Tip on shared read
locks**

\$stmt = '' releases resources

- **End-of-script normally releases resources/memory**
- **For longer scripts, consider releasing these sooner**
 - Set statement to '' (empty string)
 - Releases memory, resources; closes cursor
 - Old way: db2_free_stmt(), now deprecated
 - Ensure that you don't need the \$stmt anymore

```
$stmt=db2_exec($conn,"SELECT * FROM MYTABLE");
while($row=db2_fetch_array($stmt)) {
    echo "\n<br>";
    var_dump($row);
}
// free statement resources
$stmt = '';
```

db2_free_result() clears “pseudo locks”

- **In persistent mode, SELECT statements can cause *SHRRD (shared read) pseudo locks**
 - See them in QSQSRVR jobs via the WRKOBJLCK command
 - Pseudo locks help retain performance-enhancing cursors
 - Normally, CLRPFM and other exclusive ops will clear the locks
- **If exclusive operations on your ‘i’ occur while your script is active, use db2_free_result() to release cursors**

```
$stmt=db2_exec($conn,"SELECT * FROM MYTABLE");  
while($row=db2_fetch_array($stmt)) {  
    echo "\n<br>";  
    var_dump($row);  
}  
db2_free_result ($stmt); // allow exclusive ops
```

Another way to clear “pseudo locks”

- **If persistent connections create “shared read locks”**

Run this command in your CL job stream before nightly exclusive lock attempts.

```
ALCOBJ OBJ ( (MYLIB/MYFILE *FILE *EXCL *N) )  
CONFLICT (*RQSRLS)
```

if a member:

```
ALCOBJ OBJ ( (MYLIB/MYFILE *FILE *EXCL MYMEMBER) )  
CONFLICT (*RQSRLS)
```

Make sure you add a MONMSG immediately after the ALCOBJ command to handle any messages such as "cannot allocate..." which may arise normally.

**Library list jubilee
(3 ways to set)**

1. Most efficient way to set library list

- **Let IBM i set library list based on user profile**
 - No extra program calls required
- **Use a user profile that has an “initial library list” in its job description (JOBDD)**
- **Specify the user profile and i5_naming=ON**
 - `$conn = db2_connect('*LOCAL', 'LIBLUSER', 'PASS', array('i5_naming' => DB2_I5_NAMING_ON));`

“JOB” technique in detail

Create job:

```
CRTJOB JOB (QGPL/APPROD)
      INLLIBL (LIB1 LIB2 LIB3 QGPL)
```

Set job in user profile (or create new profile):

```
CHGUSRPRF USRPRF (APPRODUSR)
          JOB (QGPL/APPROD)
```

- **In PHP, specify the user profile and `i5_naming=ON`**

- `$conn = db2_connect('*LOCAL', 'LIBLUSER', 'PASS', array('i5_naming' => DB2_I5_NAMING_ON));`

2. Middle ground: i5_libl

- **\$options array accepts 'i5_libl'**
 - **i5_libl is a space-delimited library list**
 - `'i5_libl'=>'MYLIB YOURLIB ANYLIB'`
- **Causes ibm_db2 to run CHGLIBL at the middleware level**
- **Example:**
 - ```
$conn = db2_connect('*LOCAL' , 'MYUSER', 'MYPASS',
 array('i5_naming' => DB2_I5_NAMING_ON,
 'i5_libl' => 'MYLIB1 MYLIB2'));
```
- **Note: with persistent connections, CHGLIBL only run the first time in, so be sure to distinguish different jobs by user profile**

# 3. Program call (not recommended)

- **If maximum flexibility required:**

- Run a command or program that sets up library list

```
$db = db2_connect ('*LOCAL', 'MYUSER', 'MYPASS',
 array('i5_naming' => DB2_I5_NAMING_ON));
```

```
$libl = 'CNXSRTQA QGPL QTEMP';
```

```
$sql = "call qsys2/qcmdexc('CHGLIBL LIBL($libl)')";
```

```
$stmt = db2_exec($conn,$sql);
```

# db2\_connect() example with \$options

```
$database = 'MYDB';
$user = 'MYUSER';
$password = 'MYPASS';

$options = array('i5_naming' => DB2_I5_NAMING_ON,
 'i5_lib1' => 'MYLIB1 MYLIB2'
);

$conn = db2_connect($database, $user, $password, $options);

if ($conn) {
 echo "Connection succeeded.";
} else {
 echo "Connection failed.";
}

// MYTABLE will be found, if in library MYLIB1 or MYLIB2
$stmt=db2_exec($conn,"SELECT * FROM MYTABLE");
```

# New Global settings

# Config file(s) for ibm\_db2

- **ibm\_db2.ini**

- Main location for these settings
- /usr/local/zendsvr6/etc/conf.d/ibm\_db2.ini
- A small file containing only ibm\_db2 settings
- Initial contents:  
`extension=ibm_db2.so`

```
*****Beginning of data*****
extension=ibm_db2.so
ibm_db2.i5_dbs_alloc=0
ibm_db2.i5_all_pconnect=0
ibm_db2.i5_max_pconnect=0
ibm_db2.i5_check_pconnect=2
ibm_db2.i5_job_sort=0
ibm_db2.i5_sys_naming=0
ibm_db2.i5_allow_commit=1
ibm_db2.i5_ignore_userid=0
```

- **php.ini**

- Less common location
- /usr/local/zendsvr6/etc/php.ini
- Large file containing hundreds of settings
- Add or modify settings under the section `[ibm_db2]`

# New ibm\_db2 config options

- **Shipped since Zend Server 7**
- **See change log for news**
  - **<http://www.youngiprofessionals.com/wiki/index.php/XMLSERVICE/PHPDB2ChangeLog>**
- **Highlights coming right up**



# Highlights new (slide 1 of 2)

| Setting                          | Default    | What it does                                                                                                                               |
|----------------------------------|------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| <b>ibm_db2.i5_sys_naming</b>     | <b>0,1</b> | 1 enables library lists by default (even in LUW DB2 Connect 10.5)                                                                          |
| <b>ibm_db2.i5_blank_userid</b>   | <b>0,1</b> | When 0, blank user id/ password become invalid                                                                                             |
| <b>ibm_db2.i5_max_pconnect</b>   | <b>0-n</b> | Cleans up persistent QSQSRVR jobs every so many connections                                                                                |
| <b>ibm_db2.i5_check_pconnect</b> | <b>0-4</b> | Checks pconnect job. 0 means no test; 1-4 progressively more robust to test for a valid connection. If connection invalid, reconnect fresh |

# Highlights new (slide 2 of 2)

| Setting                             | Values                                       | What it does                                                                                     |
|-------------------------------------|----------------------------------------------|--------------------------------------------------------------------------------------------------|
| ibm_db2.i5_log_verbose              | 0,1                                          | Log DB2 errors in /usr/local/zendsvr(6)/var/logs/php.log<br><b>Alan recommends 1</b>             |
| ibm_db2.<br>i5_servermode_subsystem | [empty],<br>*SAME,<br>subsystem<br>(QSYSWRK) | Exposes connection attribute SQL_ATTR_SERVERMODE_SUBSYSTEM to specify subsystem for QSQSRVR jobs |
| ibm_db2.i5_guard_profile            | 0,1                                          | Restore job's original "current user" at end of PHP request (this feature subject to change)     |

# Alan's recommended settings

**/usr/local/zendsvr6/etc/conf.d/ibm\_db2.ini**

```
extension=ibm_db2.so
```

```
; log db2 errors in PHP error log
```

```
ibm_db2.i5_log_verbose=1
```

```
; Reset persistent connection after every 200
connection requests
```

```
ibm_db2.i5_max_pconnect=200
```

```
; Quick check on each pconnect (conn. alive)
```

```
ibm_db2.i5_check_pconnect=1
```

# Default values to examine

```
/usr/local/zendsvr6/etc/conf.d/ibm_db2.ini
```

```
; no commitment control
```

```
ibm_db2.i5_allow_commit=0
```

```
; allow blank user/pw (change to 0 if you can)
```

```
ibm_db2.i5_blank_userid=1
```

Note: Do not update these values directly in INI files. Go to PHP section of Zend Server admin web interface to update (see next slides)

# i5\_check\_pconnect in Zend Server admin

Save Enable Disable

| <input type="checkbox"/>                                                                                                                                      | Name                                                                                                                                                         | Status | Version | Description                                               | Messages |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|---------|-----------------------------------------------------------|----------|
| These functions enable you to access the IBM DB2 Universal Database, IBM Cloudscape, and Apache Derby databases using the DB2 Call Level Interface (DB2 CLI). |                                                                                                                                                              |        |         |                                                           |          |
|                                                                                                                                                               | <b>ibm_db2.binmode</b><br>This option controls the mode used for connecting to and from binary data in the PHP application.                                  |        |         | DB2_BINARY                                                |          |
|                                                                                                                                                               | <b>ibm_db2.i5_allow_commit</b><br>This option controls the commit mode used for i5 schema collections in the PHP application.                                |        |         | 0 - DB2_I5_TXN_NO_COMMIT - Commitment control is not used |          |
|                                                                                                                                                               | <b>ibm_db2.i5_check_pconnect</b><br>Advanced db2_pconnect monitor                                                                                            |        |         | 1 - try conn get an attribute (check attribute)           |          |
|                                                                                                                                                               | <b>ibm_db2.i5_guard_profile</b><br>Guard profile                                                                                                             |        |         | 0 - normal no monitor use db2 connection                  |          |
|                                                                                                                                                               | <b>ibm_db2.i5_job_sort</b><br>This option turns DB2 UDB CLI job sort mode on/off                                                                             |        |         | 0 - normal sort order                                     |          |
|                                                                                                                                                               | <b>ibm_db2.i5_max_pconnect</b><br>Max use count db2_pconnect to recycle                                                                                      |        |         | 999                                                       |          |
|                                                                                                                                                               | <b>ibm_db2.i5_servermode_subsystem</b><br>start servermode jobs to subsystem                                                                                 |        |         |                                                           |          |
|                                                                                                                                                               | <b>ibm_db2.instance_name</b><br>On Linux and UNIX operating systems, this option defines the name of the instance to use for cataloged database connections. |        |         |                                                           |          |

# i5\_log\_verbose in Zend Server admin

| <input type="checkbox"/> | Name ↵                                                                                                                                     | Status | Version | Description                             |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|--------|---------|-----------------------------------------|
|                          | <p>This option controls the internal <code>ibm_db2</code> allocation scheme for large DBCS column buffers.</p>                             |        |         | 0 - default allocations ▼               |
|                          | <p><b>ibm_db2.i5_ignore_userid</b><br/>This option overrides <code>i5 db2_(p)connect userid</code> and password in the PHP application</p> |        |         | 0 - normal user/pwd using QSQSRVR jol ▼ |
|                          | <p><b>ibm_db2.i5_log_verbose</b><br/>DB2 error log verbose</p>                                                                             |        |         | 1 - expanded php.log messages ▼         |
|                          | <p><b>ibm_db2.i5_override_ccsid</b><br/>force PASE CCSID (utf-8 1208)</p>                                                                  |        |         | 0                                       |
|                          | <p><b>ibm_db2.i5_sys_naming</b><br/>System naming mode</p>                                                                                 |        |         | 0 - sql naming, schema.table ▼          |

**Set up DB2/i  
in  
Zend Framework**

# IBM i configuration change

In `application.config.php`, add `__DIR__`

```
'config_glob_paths' => array(
 __DIR__ . '/autoload/{,*.}
{global,local}.php',
),
```

This is because IBM i normally starts searching at the IFS root. Must tell it to start at `__DIR__`.



# Set up IBM i DB2 connection

## In local.php (or combination global and local)

```
return array(
 'db' => array(
 'driver' => 'IbmDb2',
 'database' => '*LOCAL',
 'username' => 'MYUSER',
 'password' => 'MYPASS',
 'persistent' => true, // true or false. Update your ZF2 for this
 'driver_options' => array(
 'autocommit' => 'DB2_AUTOCOMMIT_OFF',
 'i5_lib' => 'MYLIB', // for example. Could also specify i5_lib1
),
),
 'service_manager' => array(
 'factories' => array(
 'db-adapter' => 'Zend\Db\Adapter\AdapterServiceFactory',
),
),
);
```

**Local development  
(on your PC)**

# “How do I develop on non-i, deploy on i?”

- **Developer goal:**

- Develop IBM i-based PHP code on a non-i machine (Linux, Windows)
- Connect to DB2 on IBM i using code that will also work on ‘i’ later in production

- **Requires a separate product from IBM**

# IBM DB2 Connect from Windows/Linux

- **Purchase IBM’s “DB2 Connect”**
  - <https://www.ibm.com/ms-en/marketplace/db2-connect>
  - Not free. We’ll see how this develops (no more Personal Edition)
- **Your non-i computer will host a local “dummy” DB2 database that actually accesses DB2 on your IBM i**
  - Use the same `ibm_db2` functions that you normally do
  - Configuration tips: <http://yips.idevcloud.com/wiki/index.php/Tier2/DB2Connect>
- **Library lists (system naming) available in DB2 Connect 10.5 on IBM i 7.1+**

# ODBC alternative to DB2 Connect

- **ODBC: no charge**
- **Not optimized for IBM i, minimally maintained/ supported**
- **Some have had success with it**
- **I don't recommend for mission-critical systems but you are welcome to try it, especially if your software already supports ODBC**
- **Less portable than DB2 Connect in moving app to/ from IBM i**

# Future options

- **db2sock project**

db2sock

Welcome to db2sock project. Goal is PASE DB2 CLI asynchronous API driver and more (libdb400.a).

A vast number of features have been added to new libdb400.a, async CLI, ILE direct CLI APIs, Unicode CLI "Unix" API (UTF-8), Unicode CLI "wide" APIs (UTF-16), and more. These additions should make DB2 language extension writing easier.

Run time, libdb400.a should fit seamlessly under any existing scripting language db2 extension. That is to say, new libdb400.a exports everything old PASE libdb400.a, same synchronous CLI APIs, but providing new advanced functions (above). At this time, new libdb400.a driver is designed to augment current PASE libdb400.a, therefore both must be on the machine. However, eventually new libdb400.a driver may replace PASE version entirely. You do NOT have to recompile your language extension, simply set PASE LIBPATH for new libdb400.a. Possible configuration new/old libdb400.a (see Run below)

### design goals (the list)

- **(available)** No impact - libdb400.a should fit seamlessly under any existing scripting language db2 extension.
- **(available)** Service driver - provide good PASE side TRACE capabilities for service
- **(available)** Traditional APIs - provide all current libdb400.a CLI APIs

Make connection using ODBC  
Issue #5 commented on in itmis/db2s  
Tony Cairns - 4 days ago

Make connection using ODBC  
Issue #5 commented on in itmis/db2s  
Teemu Helmele - 4 days ago

1 commit  
Pushed to itmis/db2sock  
7ad877: toolkit - add db2user custom  
Tony Cairns - 5 days ago

1 commit  
Pushed to itmis/rh2rack  
57d0e1: toolkit - reading ILE-PROC-1  
Tony Cairns - 5 days ago

1 commit  
Pushed to itmis/db2sock  
f85c1fd: toolkit - reading ILE-PROC  
Tony Cairns - 5 days ago

1 commit  
Harvest

# Pagination (LIMIT/OFFSET)

# Email from a PHP fan

“I’ve run into a little problem with DB2. I’m used to being able to use the **LIMIT option in MySQL** to set a **range of records** I want to view, perhaps the 20-29 records for instance.

“Could you tell me if there is or is not a way to do that on IBM i? My boss and I are beginning to think that such an option does not exist for use on the AS400 IBM i.”

- Yes, it can be done via a choice of two techniques
- Useful for pagination (page-at-a-time logic)
- LIMIT and OFFSET are non-standard, not in DB2



# 1. ibm\_db2 middleware technique

```
// specify DB2_SCROLLABLE in db2_exec or db2_execute
$startingRow = 20;
$endingRow = 29;
$stmt = db2_execute($stmt,
 array('cursor' => DB2_SCROLLABLE));
$currentRow = $startingRow;
while (($currentRow <= $endingRow) &&
 $row = db2_fetch_array($stmt, $currentRow)) {
 print "$row[0]\n";
 $currentRow++;
}
```

Note additional param for row number:

```
array db2_fetch_array (resource $stmt [, int $row_number = -1])
```

Disadvantage: middleware-dependent (only works with ibm\_db2)

## 2. Old SQL technique

- DB2's `row_number()` and `over()` functions can select records by number in a recordset
- This simulates `LIMIT` and `OFFSET`
- Example coming up

# Record range selection in DB2

## Start with this:

```
$queryString = "SELECT CUST_ID, COMPANY FROM SP_CUST
order by CUST_ID"
```

## Use row\_number() and over() to limit the record selection:

```
$queryString = "SELECT CUST_ID, COMPANY FROM
 (select row_number() over (order by CUST_ID) as rowid,
CUST_ID, COMPANY
 from SP_CUST) as t
 where t.rowid between 20 and 29";
```

# Or let Zend Framework handle it

- Use ZF's Zend Db component from regular PHP
- Builds SQL, hiding complexity of LIMIT/OFFSET implementation, with cross-database code
- **Full script:** <https://github.com/alanseiden/Code-Examples/blob/master/IBMi/DB2/ZF2LimitOffset.php>

// works with v2.3.2 of ZF2.

```
$sql = new Sql($adapter);
$select = $sql->select();
$select->from('SP_CUST')
 ->where('CUST_ID > 1220')
 ->order('CUST_ID ASC')
 ->limit(10)
 ->offset(20);
```

# Sample DB2 on i pagination script

coded by Zend's Clark Everetts

<https://github.com/clarkphp/Code-Examples/tree/master/IBMi/pagination>

Showing ALL the THINGZ! Page 1 of 3 (54 total records)

| CUST_ID | COMPANY                       | FIRSTNAME | LASTNAME    | ADDRESS                | ADDR2     | CITY           | STATE     | ZIP        | COUNTRY             | PHONE        | FAX          |
|---------|-------------------------------|-----------|-------------|------------------------|-----------|----------------|-----------|------------|---------------------|--------------|--------------|
| 1221    | Kauai Dive Shoppe             | LINA      | Norman      | 4-976 Sugarloaf Hwy    | Suite 103 | Kapaia Kauai   | HI        | 94766-1234 | US                  | 808-555-0259 | 808-555-0273 |
| 1231    | Unisco                        | George    | Weathers    | PO Box Z-547           |           | Freeport       |           |            | Bahamas             | 809-555-3915 | 809-555-4953 |
| 1351    | Sight Diver                   | Phyllis   | Spooner     | 1 Neptune Lane         |           | Kato Paphos    |           |            | Cyprus              | 357-6-876708 | 357-6-870943 |
| 1354    | Cayman Divers World Unlimited | Joe       | Bailey      | PO Box 541             |           | Grand Cayman   |           |            | British West Indies | 011-5-697044 | 011-5-697064 |
| 1356    | Tom Sewyer Diving Centre      | Chris     | Thomas      | 632-1 Third Frydenhoj  |           | Christiansted  | St. Croix | 00820      | US Virgin Islands   | 504-798-3022 | 504-798-7772 |
| 1380    | Blue Jack Aquic Center        | Ernes     | Barrat      | 23-738 Paddington Lane | Suite 310 | Waipahu        | HI        | 99776      | US                  | 401-609-7623 | 401-609-9403 |
| 1384    | VIP Divers Club               | Russdl    | Christopher | 32 Maia St.            |           | Christiansted  | St. Croix | 02800      | US Virgin Islands   | 809-453-5976 | 809-453-5932 |
| 1510    | Ocean Paradise                | Paul      | Gardner     | PO Box 8745            |           | Kailua-Kona    | HI        | 94756      | US                  | 808-555-8231 | 808-555-8450 |
| 1513    | Fantastique Aquatica          | Susan     | Wong        | Z32 999 #12A-77 A.A.   |           | Bogota         |           |            | Columbia            | 057-1-773434 | 057-1-773421 |
| 1551    | Marmot Divers Club            | Joyce     | Marsh       | 872 Queen St           |           | Kitchener      | Ontario   | G3N 2E1    | Canada              | 416-698-0330 | 416-698-0390 |
| 1560    | The Depth Charge              | Sam       | Witherspoon | 15243 Underwater Fwy.  |           | Marathon       | FL        | 35003      | US                  | 800-555-3798 | 800-555-0353 |
| 1563    | Blue Sports                   | Theresa   | Kunec       | 203 12th Ave. Box 746  |           | Giribaldi      | OR        | 91187      | US                  | 610-772-6734 | 610-772-6893 |
| 1624    | Makai SCUBA Club              | Donna     | Siaus       | PO Box 8534            |           | Kailua-Kona    | HI        | 94756      | US                  | 317-649-9098 | 317-649-6787 |
| 1645    | Action Club                   | Michael   | Spurling    | PO Box 5451-F          |           | Sarasota       | FL        | 32274      | US                  | 813-870-0239 | 813-870-0282 |
| 1651    | Jamaica SCUBA Centre          | Barbara   | Harvey      | PO Box 68              |           | Negril         | Jamaica   |            | West Indies         | 011-3-697043 | 011-3-697043 |
| 1680    | Island Finders                | Desmond   | Ortega      | 6133 1/3 Stone Avenue  |           | St Simons Isle | GA        | 32521      | US                  | 713-423-5675 | 713-423-5675 |
| 1984    | Adventure Undersea            | Gloria    | Gonzales    | PO Box 744             |           | Belize City    |           |            | Belize              | 011-34-09054 | 011-34-09064 |
| 2118    | Blue Sports Club              | Harry     | Bathbone    | 63365 Nez Perce Street |           | Largo          | FL        | 34684      | US                  | 612 897 0342 | 612 897 0343 |
| 2135    | Frank's Divers Supply         | Lloyd     | Fellows     | 1455 North 44th St.    |           | Eugene         | OR        | 90427      | US                  | 503-555-2778 | 503-555-2769 |
| 2156    | Davy Jones' Locker            | Tanya     | Wagner      | 246 South 16th Place   |           | Vancouver      | BC        | K8V 9P1    | Canada              | 803-509-0112 | 803-509-0553 |

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## 3. “Real” LIMIT and OFFSET

- Recent: LIMIT and OFFSET support in TR11 (7.1) and TR3 (7.2)
- <https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/IBM%20i%20Technology%20Updates/page/OFFSET%20and%20LIMIT>
- From Scott Forstie’s wiki page:
  - LIMIT: alternative to FETCH FIRST x ROWS ONLY
  - OFFSET: skip rows in the query result
- Addition to Zend Framework to use real LIMIT and OFFSET:
  - <https://github.com/zendframework/zend-db/pull/275>




# Stored procedure from Scott Forstie

## OFFSET and LIMIT for Stateless Pagination

```
CREATE OR REPLACE PROCEDURE
TOYSTORE.FIND_EMPLOYEES
(IN P_PAGESIZE BIGINT, IN P_OFFSET BIGINT)
DYNAMIC RESULT SETS 1
LANGUAGE SQL
BEGIN
 DECLARE V_PREP_STMT1 VARCHAR(4096) ;
 DECLARE CEMP_RESULT_SET1 CURSOR
 WITH RETURN FOR PREP_STMT1;
 SET V_PREP_STMT1 =
 'SELECT EMPNO, HIREDATE, LASTNAME FROM
 TOYSTORE.EMPLOYEE
 ORDER BY HIREDATE DESC
 LIMIT ? OFFSET ?';
 PREPARE PREP_STMT1 FROM V_PREP_STMT1 ;
 OPEN CEMP_RESULT_SET1 USING P_PAGESIZE,
 P_OFFSET;

END;

CALL TOYSTORE.FIND_EMPLOYEES(10, 0);
CALL TOYSTORE.FIND_EMPLOYEES(10, 10);
```



The screenshot shows a window titled 'EMPNO, HIREDAT...' containing a table of employee data. The table has three columns: EMPNO, HIREDATE, and LASTNAME. The data is sorted by HIREDATE in descending order. Two green brackets on the left side of the table indicate pagination: 'Page 1' covers the first 10 rows (EMPNO 000270 to 000140), and 'Page 2' covers the next 10 rows (EMPNO 000140 to 000020).

| EMPNO  | HIREDATE | LASTNAME      |
|--------|----------|---------------|
| 000270 | 01/30/80 | PEREZ         |
| 000070 | 08/30/80 | PULASKI       |
| 000100 | 05/19/80 | SPENCER       |
| 000290 | 05/30/80 | PARKER        |
| 000240 | 12/01/79 | MONTMURCE     |
| 000240 | 12/05/79 | MARDINO       |
| 000210 | 04/11/79 | JONES         |
| 000170 | 08/15/78 | YAMAMOTO      |
| 000130 | 03/14/78 | WONG-ONG P.A. |
| 000060 | 12/11/77 | PIANKA        |
| 000140 | 12/15/76 | NATZ          |
| 000140 | 12/15/76 | NICHOLLS      |
| 000090 | 02/03/76 | WONG          |
| 000330 | 02/03/76 | LEE           |
| 000260 | 08/11/75 | JOHNSON       |
| 000030 | 04/05/75 | KIRIAN        |
| 000130 | 07/04/74 | WALKER        |
| 000020 | 12/30/73 | THOMPSON      |
| 000060 | 08/14/73 | STERN         |
| 000180 | 07/07/73 | SCOUTTBN      |
| 000300 | 06/20/72 | SMITH         |
| 000120 | 05/05/72 | ORLANDO       |
| 000150 | 02/12/72 | ADAMSON       |
| 000130 | 07/28/71 | QUINTANA      |
| 000090 | 08/15/70 | HENDERSON     |
| 000250 | 12/30/69 | SMITH         |
| 000220 | 08/29/68 | JOHN          |
| 000220 | 08/29/68 | LUTZ          |
| 000280 | 03/24/67 | SCHWARTZ      |
| 000280 | 03/24/67 | SCHNEIDER     |
| 000230 | 11/21/66 | JEPPERSON     |
| 000200 | 03/03/66 | BROWN         |
| 000320 | 07/07/65 | MEHTA         |

# Performance tips



# Performance tips

- **Use persistent connections (see next slides)**
- **Optimize SQL**
  - A few specific tips (there are so many ways):
    - Avoid scalar functions (such as UPPER) in WHERE clause
    - OPTIMIZE FOR n ROWS (when know how many rows)
    - Check out IBM Rochester's DB2 SQL performance class
- **Index properly**
  - Refer to Plan Cache and Index Advisor
  - Try Encoded Vector Indexes when appropriate
- **System configuration**
  - More memory, more memory!
  - Consider separate memory pool to keep data together

# System specs

- **Memory and CPU make a big difference**
- **So will more disk arms, write cache, SSD**
- **Old story: earlier in the decade, a friend of mine upgraded his customer from a Power 5 to a Power 6. A process that had taken 30 seconds, requiring a complex programming workaround, now took 0.5 seconds.**
- **Power 8 machines even better**

# More about specs

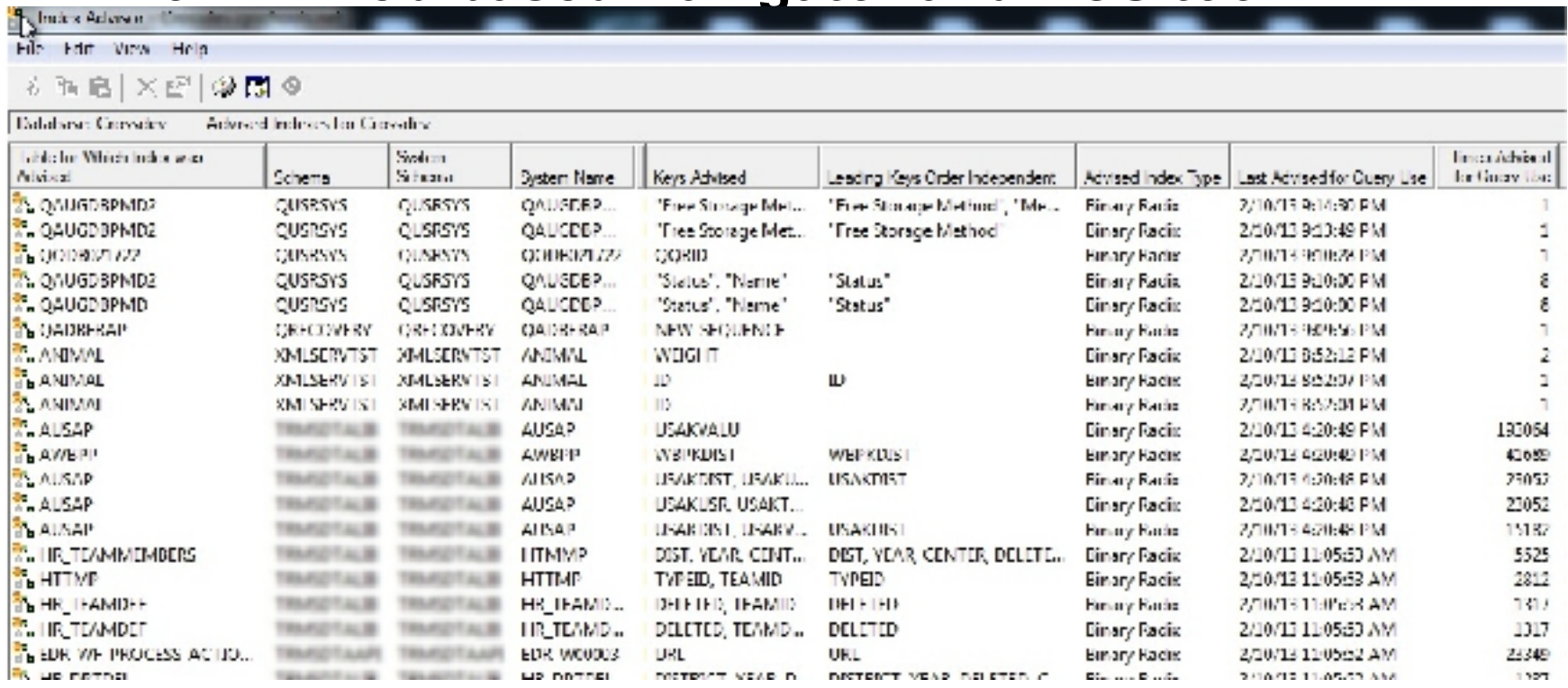
- **OS matters: newer releases speed up complex DB2 queries with a smarter query optimizer**
- **IBM i is built to scale as large as its resources**
  - ▶ Example: IBM i's query optimizer will choose the best plan it can, given the amount of memory available to it. More memory, a more intelligent plan.

# DB2 query optimization

- **IBM i has great tools**
- **I'll share a couple of favorites**
  - ▶ Index Advisor
  - ▶ SQL Plan Cache
- **See IBM's book**
  - IBM i Database Performance and Query Optimization
  - [https://www.ibm.com/support/knowledgecenter/ssw\\_ibm\\_i\\_73/rzatd/rzatdprintable.htm?view=kc](https://www.ibm.com/support/knowledgecenter/ssw_ibm_i_73/rzatd/rzatdprintable.htm?view=kc)

# Index Advisor

- Recommends indexes across all queries
- Now in web-based Navigator and ACS too



The screenshot shows the Index Advisor interface with a table titled "Advised Indexes for Crossfire". The table lists various databases and their recommended indexes, including schema names, system names, keys advised, leading keys, order independence, index type, last advised date, and the number of queries using the index.

| Table for Which Index is Advised | Schema     | System Schema | System Name  | Keys Advised         | Leading Keys Order Independent | Advised Index Type | Last Advised for Query Use | Times Advised for Query Use |
|----------------------------------|------------|---------------|--------------|----------------------|--------------------------------|--------------------|----------------------------|-----------------------------|
| QAUGD8PMD2                       | QUSRSYS    | QUSRSYS       | QAUGD8P...   | "Free Storage Met... | "Free Storage Method", "Me...  | Binary Facit       | 2/10/13 9:14:30 PM         | 1                           |
| QAUGD8PMD2                       | QUSRSYS    | QUSRSYS       | QAUGD8P...   | "Free Storage Met... | "Free Storage Method"          | Binary Facit       | 2/10/13 9:14:49 PM         | 1                           |
| QJ00R0777                        | QUSRSYS    | QUSRSYS       | QJ00R0777    | QJ00R0...            |                                | Binary Facit       | 2/10/13 9:10:29 PM         | 1                           |
| QAUGD8PMD2                       | QUSRSYS    | QUSRSYS       | QAUGD8P...   | "Status", "Name"     | "Status"                       | Binary Facit       | 2/10/13 9:10:00 PM         | 6                           |
| QAUGD8PMD                        | QUSRSYS    | QUSRSYS       | QAUGD8P...   | "Status", "Name"     | "Status"                       | Binary Facit       | 2/10/13 9:10:00 PM         | 6                           |
| QADRFRAP                         | QRFCOVERY  | QRFCOVERY     | QADRFRAP     | NEW SEQUENCE         |                                | Binary Facit       | 2/10/13 8:09:56 PM         | 1                           |
| ANIMAL                           | XMLSERVIST | XMLSERVIST    | ANIMAL       | WEIGHT               |                                | Binary Facit       | 2/10/13 8:52:13 PM         | 2                           |
| ANIMAL                           | XMLSERVIST | XMLSERVIST    | ANIMAL       | ID                   | ID                             | Binary Facit       | 2/10/13 8:52:09 PM         | 1                           |
| ANIMAL                           | XMLSERVIST | XMLSERVIST    | ANIMAL       | ID                   |                                | Binary Facit       | 2/10/13 8:52:01 PM         | 1                           |
| AUSAP                            | TRADTALB   | TRADTALB      | AUSAP        | USAKVALU             |                                | Binary Facit       | 2/10/13 4:20:49 PM         | 13054                       |
| AWBFP                            | TRADTALB   | TRADTALB      | AWBFP        | WBPKDIS1             | WBPKDIS1                       | Binary Facit       | 2/10/13 4:20:49 PM         | 42899                       |
| AUSAP                            | TRADTALB   | TRADTALB      | AUSAP        | USAKTST, USAKL...    | USAKTST                        | Binary Facit       | 2/10/13 4:20:48 PM         | 29052                       |
| AUSAP                            | TRADTALB   | TRADTALB      | AUSAP        | USAKUSR, USAKT...    |                                | Binary Facit       | 2/10/13 4:20:48 PM         | 23052                       |
| AUSAP                            | TRADTALB   | TRADTALB      | AUSAP        | USAKDIS1, USAKV...   | USAKDIS1                       | Binary Facit       | 2/10/13 4:20:48 PM         | 15182                       |
| HR_TEAMMEMBERS                   | TRADTALB   | TRADTALB      | HTMMP        | DIST, YEAR, CONT...  | DIST, YEAR, CENTER, DELETE...  | Binary Facit       | 2/10/13 11:05:53 AM        | 5525                        |
| HTTMP                            | TRADTALB   | TRADTALB      | HTTMP        | TYPED, TEAMID        | TYPED                          | Binary Facit       | 2/10/13 11:05:53 AM        | 2812                        |
| HR_TEAMIDF                       | TRADTALB   | TRADTALB      | HR_TEAMID... | DIFFID, TEAMID       | DIFFID                         | Binary Facit       | 2/10/13 11:05:43 AM        | 1411                        |
| HR_TEAMDET                       | TRADTALB   | TRADTALB      | HR_TEAMD...  | DELETED, TEAMID...   | DELETED                        | Binary Facit       | 2/10/13 11:05:53 AM        | 1317                        |
| EDR_WF_PROCESS_ACTIO...          | TRADTALB   | TRADTALB      | EDR_WOODS    | URL                  | URL                            | Binary Facit       | 2/10/13 11:05:52 AM        | 24348                       |
| HR_PARTNER                       | TRADTALB   | TRADTALB      | HR_PARTNE... | DETRECT YEAR, D...   | DETRECT YEAR, DELETED, C...    | Binary Facit       | 2/10/13 11:05:53 AM        | 1397                        |



# Persistent connections

- **Create a pool of database jobs**

- Known as a “connection pool”
- You will connect quickly because a job is waiting for you
- DB2 will...
  - Choose a QSQRVR job when your PHP job first connects
  - Create new jobs to handle high workload

```
Subsystem : QSYSWRK
Opt Job User Type Status
— — — — —
— QSQRVR QUSER PJ ACTIVE
— QSQRVR QUSER PJ ACTIVE
```

- **The word “persistent” may be misleading**

- No guarantee that a browser session reconnects to same job
- Between requests, cannot rely on maintaining state (QTEMP, library lists). OK within a request, though

# db2\_pconnect() to connect persistently

- `resource db2_pconnect ( string $database , string $username , string $password [, array $options ] )`
- **Persistent is much faster than non-persistent**
  - db2\_pconnect can reuse connections, reducing the time needed to connect (after the first time) to almost zero
  - SQL statement objects can also be reused, speeding queries
- **How db2\_pconnect() reuses connections**
  - Connections defined by *database*, *username*, and *password*
  - Tries to reuse an existing connection matching these 3 params
  - db2\_close() on a persistent connection does nothing
  - db2\_pclose() forces the conn to close



# Tools for testing/ development

# There's more than STRSQL

- **Operations Navigator (old reliable, but Windows only)**
- **Web-based navigator**
  - Starting to get quite good, with Run SQL window just added
  - <http://myibmi:2001>
- **IBM i Access Client Solutions**
  - New client for Mac, Linux, Windows 10+
  - <http://www-03.ibm.com/systems/power/software/i/access/>
- **Other tools such as SQL Workbench/J, Data Studio**
  - <http://www.sql-workbench.net/>, <https://www.ibm.com/developerworks/ibmi/library/i-debugger-db2-i/>

# SQL Workbench/J

The screenshot displays the SQL Workbench/J application window. The title bar reads "SQL Workbench/J - A&G - Default.wksp". The interface includes a toolbar with navigation and execution icons, and a status bar at the bottom showing "Ready, if you are", "L:13 C:39", "6.43s Timeout:", "0 Max. Rows:", and "5000 71-88/5000".

The main window is divided into two panes. The top pane, labeled "Statement 1", contains the following SQL script:

```
1set schema sbststdta;
2select * from qs36f.poopen;
3select date(substr(digits(phdate),1,2) || '/' || substr(digits(phdate),3,2) || '/' || substr(digits(phdate),5,2)) as podate, pi
4select sbststdta.empnoy_to_date(podate) as podate, pipe from podat inner join potead on pipeatpo where pipred = 4337140;
5set schema qs36f;
6select * from presllmst where pmprod = 3839800;
7with EXPIRING_PRODUCTS as (select PMPROD as expiring_product_code, PMSODATE as order_by_date from PRESLLMST where PMSODATE < '20
8
9with EXPIRING_PRODUCTS as (select PMPROD as expiring_product_code, PMSODATE as order_by_date from PRESLLMST where PMSODATE < '20
10 select PMSODATE as ORDERNUM, min(order_by_date) as EARLIEST_ORDER_BY_DATE from PRESLLDT inner join EXPIRING_PRODUCTS on PMPR
11 group by PMSODATE
12 order by PMSODATE;
13select * from presllhd order by phnum;
14select * from presllot order by PMSODATE;
15select * from pconkey;
```

The bottom pane, labeled "Result 1", displays the execution results in a table format. The table has 11 columns: PMPROD, PMSOCDN, PMSOBT, PMSOPN, PMSOPN, PMSODATE, PMSOTCS, PMSOTBT, PMSOTCG, PMSOTBG, and PMSOTB2. The data is as follows:

| PMPROD | PMSOCDN | PMSOBT | PMSOPN | PMSOPN | PMSODATE | PMSOTCS | PMSOTBT | PMSOTCG | PMSOTBG | PMSOTB2     |
|--------|---------|--------|--------|--------|----------|---------|---------|---------|---------|-------------|
| 216052 | 5       |        | 0      | 38     | 100815   | 0       | 0       | 0       | 0       | 0151008 ... |
| 216053 | 5       |        | 0      | 0      | 0        | 0       | 0       | 0       | 0       | 0000000 ... |
| 216091 | 5       |        | 0      | 0      | 0        | 0       | 0       | 0       | 0       | 0000000 ... |
| 216340 | 5       |        | 0      | 0      | 0        | 0       | 0       | 0       | 0       | 0000000 ... |
| 218020 | 5       |        | 0      | 85     | 112015   | 0       | 0       | 0       | 0       | 0151120 ... |
| 218030 | 5       |        | 0      | 0      | 0        | 0       | 0       | 0       | 0       | 0000000 ... |
| 218040 | 5       |        | 0      | 14     | 112015   | 0       | 0       | 0       | 0       | 0151120 ... |
| 220020 | 4       |        | 0      | 0      | 0        | 78      | 0       | 0       | 0       | 0000000 ... |
| 220020 | 5       |        | 0      | 327    | 50115    | 0       | 0       | 0       | 0       | 0150501 ... |
| 220030 | 5       |        | 0      | 55     | 110615   | 0       | 0       | 0       | 0       | 0151106 ... |
| 220040 | 5       |        | 0      | 210    | 110615   | 0       | 0       | 0       | 0       | 0151106 ... |
| 221020 | 4       |        | 0      | 546    | 110615   | 312     | 0       | 0       | 0       | 0151106 ... |
| 221020 | 5       |        | 0      | 1170   | 110615   | 0       | 0       | 0       | 0       | 0151106 ... |
| 221022 | 5       |        | 0      | 0      | 0        | 0       | 0       | 0       | 0       | 0000000 ... |
| 221030 | 5       |        | 0      | 220    | 110615   | 0       | 0       | 0       | 0       | 0151106 ... |
| 221040 | 4       |        | 0      | 0      | 0        | 0       | 0       | 0       | 0       | 0000000 ... |
| 221040 | 5       |        | 0      | 350    | 110615   | 0       | 0       | 0       | 0       | 0151106 ... |

# SQL Workbench/J

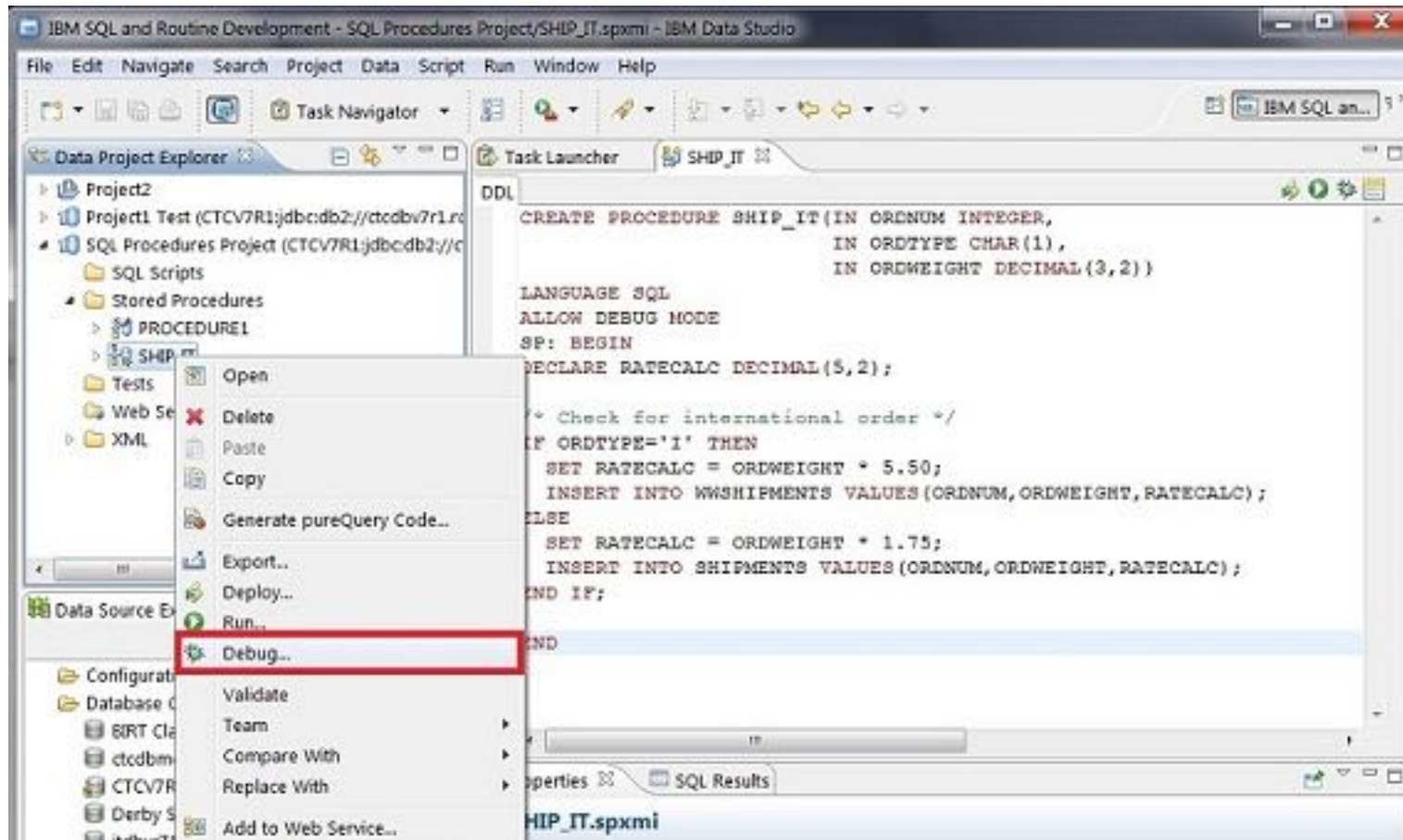
The screenshot shows the SQL Workbench/J interface. At the top, the title bar reads "SQL Workbench/J - ABC - Default.wksp". Below it, the connection information is "User=aseiden, System=AP400, URL=jdbc:as400://192.168.99.1/AP400". The main window has tabs for "Statement 1", "PRESLDT 2", "Statement 3", and "Database Explorer 4". The "Database Explorer" tab is active, showing a tree view of the database structure. The "Library" is set to "SBSTSTDTA". The "Objects" tab is selected, displaying a list of tables. The table "ARFILE" is selected, and its details are shown in the "Columns" tab. The "Columns" tab displays a table with the following columns: COLUMN\_NAME, DATA\_TYPE, PK, NULLABLE, DEFAULT, and AUTOINC. The table contains 349 rows of data.

| NAME       | TYPE  | SYSTEM | LIBRARY   | REMARKS |
|------------|-------|--------|-----------|---------|
| ARCWOP     | TABLE | AP400  | SBSTSTDTA |         |
| ALANTES    | TABLE | AP400  | SBSTSTDTA |         |
| ALANTEST   | TABLE | AP400  | SBSTSTDTA |         |
| ACRDIRHF   | TABLE | AP400  | SBSTSTDTA |         |
| ARFILE     | TABLE | AP400  | SBSTSTDTA |         |
| BHCLNTOJST | TABLE | AP400  | SBSTSTDTA |         |
| BHCLNTRLP  | TABLE | AP400  | SBSTSTDTA |         |
| BHCLNLSLS  | TABLE | AP400  | SBSTSTDTA |         |
| BIDETAIL   | TABLE | AP400  | SBSTSTDTA |         |
| BILLHDF    | TABLE | AP400  | SBSTSTDTA |         |
| BILLHDFU31 | TABLE | AP400  | SBSTSTDTA |         |
| BILLHDS    | TABLE | AP400  | SBSTSTDTA |         |
| BILLHDSL1  | TABLE | AP400  | SBSTSTDTA |         |
| BILLHDSH   | TABLE | AP400  | SBSTSTDTA |         |
| BILLHDSH01 | TABLE | AP400  | SBSTSTDTA |         |
| BILLHDSH02 | TABLE | AP400  | SBSTSTDTA |         |
| BUSYFLAG   | TABLE | AP400  | SBSTSTDTA |         |
| CBDEPLP    | TABLE | AP400  | SBSTSTDTA |         |
| CBDEPLQ01P | TABLE | AP400  | SBSTSTDTA |         |
| CBTEMP     | TABLE | AP400  | SBSTSTDTA |         |
| CBTEMPADD  | TABLE | AP400  | SBSTSTDTA |         |
| CBTEMPLT   | TABLE | AP400  | SBSTSTDTA |         |
| CBTEMPORG  | TABLE | AP400  | SBSTSTDTA |         |
| CBTXR1     | TABLE | AP400  | SBSTSTDTA |         |
| CBTXR1SAV  | TABLE | AP400  | SBSTSTDTA |         |
| CBTXR1WRK  | TABLE | AP400  | SBSTSTDTA |         |
| CBTXR2     | TABLE | AP400  | SBSTSTDTA |         |
| CBTXRP     | TABLE | AP400  | SBSTSTDTA |         |

| COLUMN_NAME | DATA_TYPE    | PK  | NULLABLE | DEFAULT | AUTOINC |
|-------------|--------------|-----|----------|---------|---------|
| ARNOST      | NUMERIC(1)   | NO  | NO       | 0       | NO      |
| ARCUST      | NUMERIC(6)   | NO  | NO       | 0       | NO      |
| ARINVP      | NUMERIC(6)   | NO  | NO       | 0       | NO      |
| ARIDAT      | NUMERIC(6)   | NO  | NO       | 0       | NO      |
| ARCOMM      | DECIMAL(7,2) | NO  | NO       | 0       | NO      |
| ARTERM      | NUMERIC(1)   | NO  | NO       | 0       | NO      |
| ARCCLR      | NUMERIC(1)   | NO  | NO       | 0       | NO      |
| ARIAM1      | NUMERIC(8,2) | NO  | NO       | 0       | NO      |
| AR1YFA      | CHAR(1)      | NO  | NO       | ' '     | NO      |
| AR1AX       | DECIMAL(7,2) | NO  | NO       | 0       | NO      |
| ARCLID      | CHAR(2)      | NO  | NO       | ' '     | NO      |
| ARPAID      | CHAR(1)      | NO  | NO       | ' '     | NO      |
| ARSLSP      | NUMERIC(3)   | NO  | NO       | 0       | NO      |
| ARHOLS      | NUMERIC(2)   | NO  | NO       | 0       | NO      |
| ARSPLC      | NUMERIC(2)   | NO  | NO       | 0       | NO      |
| ARIOLC      | NUMERIC(2)   | NO  | NO       | 0       | NO      |
| ARPLC       | NUMERIC(2)   | NO  | NO       | 0       | NO      |
| AR1CH#      | CHAR(3)      | NO  | NO       | ' '     | NO      |
| ARCRCO      | CHAR(1)      | NO  | NO       | ' '     | NO      |
| ARCRCO      | NUMERIC(6)   | NO  | NO       | 0       | NO      |
| ARMSG       | CHAR(17)     | NO  | NO       | ' '     | NO      |
| ARFKFP      | CHAR(1)      | NO  | NO       | ' '     | NO      |
| AR1KST      | NUMERIC(10)  | YES | NO       | 0       | NO      |
| AR1KSFQ     | NUMERIC(4)   | YES | NO       | 0       | NO      |
| AR1CHK      | CHAR(5)      | NO  | NO       | ' '     | NO      |
| AR1SHSE     | NUMERIC(2)   | NO  | NO       | 0       | NO      |
| AR1PAPQ     | NUMERIC(9)   | NO  | NO       | 0       | NO      |
| AR1PSPQ     | NUMERIC(9)   | NO  | NO       | 0       | NO      |

# Data Studio



# DB2 and PHP Resources

- **IBM**

- IBM\_DB2 manual and open source repository
  - [http://php.net/ibm\\_db2](http://php.net/ibm_db2), [http://pecl.php.net/package/ibm\\_db2](http://pecl.php.net/package/ibm_db2)
- DeveloperWorks wiki
  - <http://ibm.com/developerworks/ibmi>
- Many details about PHP and DB2 connections
  - <http://www.youngiprofessionals.com/wiki/index.php/PHP/DB2Connection>

- **Zend**

- Zend Server for IBM i
  - <http://www.zend.com/en/products/server/zend-server-ibm-i>
- Forums for PHP on IBM i
  - <http://forums.zend.com/viewforum.php?f=67>

# Resources

# For more info and learning

- **DB2 for i SQL reference**

- [http://www-01.ibm.com/support/knowledgecenter/ssw\\_ibm\\_i\\_72/db2/rbafzintro.htm?lang=en](http://www-01.ibm.com/support/knowledgecenter/ssw_ibm_i_72/db2/rbafzintro.htm?lang=en)

- **Young i PHP/Db2 page**

- <http://www.youngprofessionals.com/wiki/index.php/PHP/DB2Documents>

- **IBM DB2 forum**

- <https://www.ibm.com/developerworks/community/forums/html/forum?id=11111111-0000-0000-0000-000000000292&ps=50>



# Questions

# Contact and tips

**Alan Seiden**

Seiden Group

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Free newsletter:

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