DB2 for i → 7.2 Overview
for SEMIUG and WMSUG

Power Systems 2014
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DB2 for i Business Architect
DB2 for i
- Standard compliant
- Secure
- Scalable
- Functionally Advanced
- Excellent Performance
- Easier to use
- Easier to maintain

Continual Investment and Innovation

DB2 for i – 7.2 Overview

7.1
- XML Support
- Encryption enhancements (FIELDPROCs)
- Result set support in embedded SQL

CURRENTLY COMMITTED
- MERGE
- MQ Functions
- SQE Logical file support
- SQE Adaptive Query Processing
- EVI enhancements
- Inline functions

CREATE OR REPLACE

V5R4
- WebQuery
- SSD Memory Preference
- On Demand Performance Center
- Health Center
- Completion of SQL Core
- Scalar fullselect
- Recursive CTE
- INSTEAD of triggers

ROW CHANGE TIMESTAMP
- Statistics catalog views
- CLIENT special registers
- SQE Stage 6
- Deferred Restore of MQT and Logicals

Environmental limits

V5R3
- Partitioned tables
- UFT-8 and UTF-16 ICU sort sequence
- MQTs
- Sequences
- Implicit char/numeric
- BINARY/VARBINARY
- GET DIAGNOSTICS
- DRDA Alias
- DECIMAL(63)
- SQE Stage 3
- Ragged SWA
- ODBRPLAY
- Online Reorganize

V5R2
- SQE Stage 1
- IASPs
- Identity columns
- Savepoints
- UNION in views
- Scalar subselect
- UDTFs
- DECLARE GLOBAL TEMPORARY TABLE
- Catalog views
- JDBC V3.0
- DRDA Kerberos
- Journal Standby

V5R1
- SQL triggers
- Java Functions
- DRDA DUW TCP/IP
- 2 GB LOBs
- 1 Terabyte Table
- Journal Minimal Data
- Two-phase over TCP/IP
- DDL Journaling
- Database Navigator
- Generate SQL

6.1
- Omnifind
- MySQL storage engine
- DECIMAL
- Grouping sets/super groups
- INSERT IN FROM VALUES
- Extended Indicator Variables
- Expression in Indexes
- ROW CHANGE TIMESTAMP
- Statistics catalog views
- CLIENT special registers
- SQE Stage 6

Deferred Restore of MQT and Logicals

Environmental limits

7.2
- Row and Column Access Control
- XMLTABLE
- CONNECT BY
- TRANSFER OWNERSHIP
- Named arguments and defaults for parameters
- Obfuscation of SQL routines & triggers
- Array support in UDFs
- Timestamp precision
- Multiple-action Triggers
- Built-in Global Variables
- Record movement between partitions on UPDATE

1.7 Terabyte Indexes
- Health Center – Non-database limits
- Navigator Graphing and Charting
- SQE I/O Costing model improvement
- TRUNCATE

IBM Information Management software

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DB2 for i – Enhancements delivered via DB2 PTF Groups

IBM i 7.1

Entrainments delivered by PTF are documented here:
www.ibm.com/developerworks/ibmi/techupdates/db2
& in this article “A Hit Parade of DB2 for i Enhancements”
http://iprodeveloper.com/database/hit-parade-db2-i-enhancements
DB2 for i – Enhancements delivered via DB2 PTF Groups
IBM i 7.1 & 7.2

2014

TR7

2015

7.1 - TR9
7.2 – TR1

7.1 - TR8 timed Enhancements:
• Faster JDBC Toolbox
• Use SQL to programmatically analyze performance
• Generate SQL procedure
• Program & Package statement level statistical catalogs
• Procedural alternative for Analyze Plan Cache Snapshot
• And more…

7.2 – TR2

SF99701 Level 26
SF99702 Level 1

SF99701 Level 29
SF99702 Level 30

SF99702 Level 3
SF99702 Level ??

SF99702 Level 1
SF99701 Level ??

SF99701 Level ??
SF99702 Level ??

7.2 – TR3

Enhancements delivered by PTF are documented here:
www.ibm.com/developerworks/ibmi/techupdates/db2

IBM i 7.1 TR8 – Landing page for all 7.1 TR8 enhancements:

IBM i 7.2 – Landing page for all 7.2 enhancements:
www.ibm.com/developerworks/ibmi/techupdates/i72
**DB2 for i - 7.2 Enhancements by role - Security**

Security & DB2 for i

- Column Masks
  - Deploy “need to know” logic

- Row Permissions
  - Simpler & safer security

- Violation clause for CHECK constraints
  - Protect data integrity

- Secure remote journal using SSL
  - Achieve HA & DR objectives without exposure

- SQL alternative to CHGOBJOWN
  - Embrace separation of duty, using SQL

- Use adopted authority identity within business logic
  - “Who am I?” conditional code using SQL

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**Data-Centric Security**

- Comprehensive
- Auditable
- Sustainable
- Scalable
- Manageable

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Data is an asset… what’s your data worth?
DB2 for i - 7.2 Enhancements by role - Performance

Database Performance
  – **SQE enhancements:**
    • Support for Native Queries
    • Improved I/O Costing Model
    • Enhanced implementation for IN list processing
  – **Navigator enhancements:**
    • New PDI perspectives
    • Native Queries in the SQL Plan Cache
    • Enhanced SQL Plan Cache detail and tuning
  – New system level resource…
    **Temporary Storage** consumption
  – And other enhancements that were brought back to IBM i 7.1 alongside Technology Refreshes

Out of the Box… what’s **faster?**
  ✓ **OPNQRYF & Query/400 complex queries**
  ✓ **I/O intensive queries**
  ✓ **Queries with long IN lists**

**Disclaimer: Realized performance gains depends upon many factors**

New Services
  – QSYS2/SYSTMPSTG catalog
  – QSYS2/DUMP_SNAP_SHOT_PROPERTIES() procedure
DB2 for i - 7.2 Enhancements by role – App Dev

Database Application Development

- Increased timestamp precision
- Named and Default parameter support on UDF/UDTFs
- Use of ARRAYs within UDF/UDTFs
- Obfuscation of SQL triggers
- Built-in Global Variables
- Expressions on PREPARE & EXECUTE IMMEDIATE
- Autonomous procedures
- CURRENT USER special register
- Constants in LANGUAGE SQL routines
- Unified debugger support for SQL functions
- Datetime scalar function improvements
- And other enhancements that were brought back to IBM i 7.1 alongside Technology Refreshes

New SQL Statement

- TRUNCATE

New Built-in Functions

- LPAD()
- RPAD()
SQL Query Engine (SQE) – Progression

SQE Characteristics
- Object Oriented Design
- Enhanced Performance for complex queries
- Enhanced Optimization Engine
- Separate Statistics Management
- Maintained Temporary Indexes
- Encoded Vector Indexes Enhancements
- Single, System-wide Plan Cache
- and much more...

6.1 → SQE
- Translation support
- Lateral Correlation
- UDTF support
- Optimization time improvements
- Other miscellaneous performance
- Simple Logical File support

7.1 → SQE
- Logical File support
- Adaptive Query Processing (AQP)
- EVI Aggregate capability
- Global Statistics Cache
- Other miscellaneous performance

7.2 → SQE
- Native Opens including:
  - Open Query File (OPNQRYF)
  - Query/400 commands
- Improved I/O costing
- Other miscellaneous performance
DB2 for i & IBM i 7.2 – Other enhancements

DBA/DBE
• Queued exclusive locks control
• SQL Server Mode detail in collection services
• SQL Details for Jobs enhancement
• Improved VARCHAR & LOB space management
• Automatic record movement between partitions

Navigator for DBA/DBE
• Performance Data Investigator (PDI)
  - Investigate Data – DB2 category
  - SQL Plan Cache perspectives
  - Physical vs Logical I/O breakdowns
  - And more...
• On Demand Performance Center
  - Observance of Native Queries
  - Advanced Monitor Compare

Navigator for DB App Dev
• Support of all new SQL features
  - Permissions
  - Masks
  - Named and default parameters
  - Obfuscation of Triggers
  - Arrays in UDFs/UDTFs
  - Create based ON
DB2 for i & IBM i 7.2 – Reasons to Upgrade

Why move to 7.2?

1. Major improvements for SQL & Native DB users
   - Improved database performance, out of the box
   - New capabilities to protect business critical data
   - Improved insight into database workloads

2. Major improvements for SQL application development
   - User defined function advancements
   - New DB2 built-in global variables, special register and more
   - Enhanced SQL behavior
   - Extended capabilities in Navigator & PDI

3. Position your company to receive future DB2 for i enhancements
   - DB2 for i enhancements on the Technology Refresh (TR) cadence
     Note: While 7.2 will include all enhancements, some will also be PTF’d to previous releases

“faster”
“safer”
“easier to maintain”

“sustainable solutions for business computing”

“stay current, value extended”
DB Security – 7.2 Enhancements
DB2 for i - 7.2 Enhancements by role - Security

New SQL Statements for security
- CREATE PERMISSION
- ALTER PERMISSION
- CREATE MASK
- ALTER MASK
- ALTER TRIGGER
- TRANSFER OWNERSHIP

New Boss Option
IBM Advanced Data Security for i
(Boss option 47)
No Charge

New Built-in Function
- VERIFY_GROUP_FOR_USER()

New Function Usage ID
- QIBM_DB_SECADM

New Catalogs
- QSYS2/SYSCONTROLS
- QSYS2/SYSCONTROLSDEP

New tools in the toolbox…

New Journal Entry Types
For journal code D - Database file:
- M1, M2, M3 for create/drop/alter mask
- P1, P2, P3 for create/drop/alter permission

For journal code T – Audit trail:
- AX for Row and Column Access Control
- X2 for Query manager profile changes
Before 7.2
In order to grant or revoke privileges, a user must have one of the following:
1. Object ownership
2. Object management (*OBJMGT) authority for the specified object.
   Note: A user with object management authority can grant to other users any authority that the user has, except object management authority
3. All object (*ALLOBJ) user special authority

Problem: If you are allowed to grant the SELECT privilege, you are also allowed to query the data.

IBM i 7.2
A user with security administration function usage (QIBM_DB_SECADM) will be able to grant or revoke privileges on any object to anyone, even if they do not have the SELECT privilege.

This enables the management of security, without exposing the data to be read or modified.

Note that:
• Audit the SECADM users for *SECURITY to ensure they are not granting themselves privileges to access the data
• Only QSECOFR or someone with *SECADM authority can grant the security administrator function usage.
Meet the users:

- **MARYSEC** – A Security Officer responsible for granting and revoking security, including data security

  ```
  CRTUSRPRF USRPRF(MARYSEC) PASSWORD(xxxxxxxx)
  USRCLS(*SECADM) TEXT('Security Officer')
  GRTOBJAUT OBJ(<data-libraries>) OBJTYPE(*LIB)
  USER(MARYSEC) AUT(*USE)
  CHGFCNUSG FCNID(QIBM_DB_SECADM)
  USER(MARYSEC) USAGE(*ALLOWED)
  ```

- **FRANKDBA** – A Database Administrator with authority to do everything but change security settings

  ```
  CRTUSRPRF USRPRF(FRANKDBA) PASSWORD(xxxxxxxx) USRCLS(*USER)
  TEXT('Database Administrator')
  SPCAUT(*ALLOBJ *JOBCTL *SAVSYS *SPLCTL)
  ```

- **JOEUSER** – An end user with no special authority (manager)

  ```
  CRTUSRPRF USRPRF(JOUEUSER) PASSWORD(xxxxxxxx)
  USRCLS(*USER) TEXT('User with no special authorities')
  ```
Separation of Duty & DB2 for i - Use case exploration

• **Database security can be managed on 7.2 without having *ALLOBJ**

  **Commands:**
  - CHGOBJOWN
  - CHGOBJPGP
  - GRTOBJAUT
  - RVKOBJAUT
  - EDTOBJAUT
  - DSPOBJAUT
  - WRKOBJ
  - WRKLIB
  - ADDAULTLE
  - CHGAULTLE
  - RMVAULTLE
  - RTVAULTLE
  - DSPAUTL
  - DSPAUTLOBJ
  - EDTAULTL
  - WRKAULTL

  **APIs: (also used by Navigator)**
  - qsyrtvua - retrieve users authorized to an object
  - qsylusra - list users authorized to an object
  - qsylatlo - list objects secured by an autl
  - qsyrautu - retrieve users authorized to an object
  - qsyau - list authorized users
  - qsyrsri - retrieve user information
  - quslobj - list objects
  - qgyolobj - open list of objects

  **MARYSEC can manage database security (and more) without *ALLOBJ or specific authorization**

• **Other aspects of managing security don’t have this alternative authorization method for security officers**
## RCAC terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base Table</strong></td>
<td>The table (physical file) containing business critical data.</td>
</tr>
<tr>
<td><strong>Dependent Object</strong></td>
<td>Any object (file, schema, function, or other object) the permission or mask references.</td>
</tr>
<tr>
<td><strong>Permission</strong></td>
<td>A row permission defines a row access control rule for rows of a table by setting an SQL search condition that describes the set of rows a user can access.</td>
</tr>
<tr>
<td><strong>Mask</strong></td>
<td>A column mask defines a column access control rule for a specific column in a table by using an SQL CASE expression that describes what column values a user is permitted to see and under what conditions.</td>
</tr>
<tr>
<td><strong>RULETEXT</strong></td>
<td>The expression to be used by the permission (WHERE clause predicates) or mask (selection CASE expression)</td>
</tr>
</tbody>
</table>

0 to many ➔ permissions allowed per table

0 or 1 ➔ masks allowed per column
IBM Advanced Data Security for i (Boss Option 47)

- **Option 47 must be installed** to:
  - CREATE PERMISSION and CREATE MASK (RCAC)
  - Open a file that has RCAC activated

- **RCAC is applied after checking object authorization** requirements
  - If you pass the object authorization check:
    - Row permissions reduce the set of rows returned
    - Column Masks limit full or partial access to sensitive column data

- **RCAC constructs exist within the table** (*FILE*)
- When ENABLED & ACTIVATED, **RCAC is automatically applied by SQE**
- **RCAC is comprehensive** and applies to every database interface (Native DB, SQL, RPG, APIs, Commands, etc)
- Only users with **QIBM_DB_SECADM** authority can manage RCAC
Row and Column Access Control (RCAC)

CREATE MASK SSN_MASK ON EMPLOYEE
FOR COLUMN SSN RETURN
CASE
    WHEN (VERIFY_GROUP_FOR_USER(SESSION_USER, 'PAYROLL') = 1)
    THEN SSN
    WHEN (VERIFY_GROUP_FOR_USER(SESSION_USER, 'MGR') = 1)
    THEN 'XXX-XX-' CONCAT SUBSTR(SSN, 8, 4)
    ELSE NULL
END
ENABLE;
ALTER TABLE EMPLOYEE ACTIVATE COLUMN ACCESS CONTROL;

CREATE PERMISSION PATIENT_TABLE_HMO_PERMISSION
ON HOSPITAL.PATIENT_TABLE
FOR ROWS
WHERE ((VERIFY_GROUP_FOR_USER(SESSION_USER, 'PCP') = 1 AND
    HOSPITAL.PATIENT_TABLE.PCP_ID = SESSION_USER) OR
    VERIFY_GROUP_FOR_USER(SESSION_USER, 'ACCTGROUP') = 1 OR
    VERIFY_GROUP_FOR_USER(SESSION_USER, 'RESGROUP') = 1)
ENFORCED FOR ALL ACCESS
ENABLE;
ALTER TABLE HOSPITAL. PATIENT_TABLE ACTIVATE ROW ACCESS CONTROL;

IBM Advanced Data Security for i (Boss option 47)
No Charge
Row Permission – Employee table example

- Many users have access to the employee table
- A row permission can be used to reduce access to data

```
CREATE OR REPLACE PERMISSION toystore7.permission_on_employee ON toystore7.employee FOR ROWS WHERE

(TOystore7.manager_of_department = WORKDEPT)
  /* Managers see their department members */

  OR (USER_PROFILE_NAME = USER)
  /* Random users can see their own row */

  OR (VERIFY_GROUP_FOR_USER(SESSION_USER, 'DBATEAM') = 1)
  /* DBA's see every row */

ENFORCED FOR ALL ACCESS ENABLE;
```

An enabled and activated RCAC rule is automatically applied by SQE.
Row Permission – Employee table example

- FRANKDBA – what data does he see?

SELECT SESSION_USER, A.* FROM toystore7.employee A

VERIFY_GROUP_FOR_USER(SESSION_USER, 'DBATEAM') = 1) /* DBA's see every row */
Row Permission – Employee table example

- MARYSEC – what data does she see?

```sql
SELECT SESSION_USER, A.* FROM toystore7.employee A
```

<table>
<thead>
<tr>
<th>EMPNO</th>
<th>FIRSTNAME</th>
<th>LASTNAME</th>
<th>W0</th>
<th>P0</th>
<th>HIRE</th>
<th>JOB</th>
<th>E</th>
<th>BI</th>
<th>SALARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>0001</td>
<td>MARYSEC</td>
<td>SCOUTTEN</td>
<td>D11</td>
<td>1682</td>
<td>1973</td>
<td>17F</td>
<td>194</td>
<td>21340.00</td>
<td></td>
</tr>
</tbody>
</table>

(USER_PROFILE_NAME = USER)
/* Random users can see their own row */
Row Permission – Employee table example

- JOEUSER – what data does he see?

```
SELECT SESSION_USER, A.* FROM toystore7.employee A
```

```
(ToyStore7.manager_of_department = WORKDEPT)
/* Managers see their department members */
OR
(ToyStore7.USER_PROFILE_NAME = USER)
/* Random users can see their own row */
```
### Contrasting DB2 for i - Data Security

<table>
<thead>
<tr>
<th>Use case</th>
<th>Technology Use Case</th>
<th>Field Procedures</th>
<th>Column Masks</th>
<th>Row Permissions</th>
<th>Views &amp; Logical Files</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supported IBM i OS releases</td>
<td>7.1, 7.2</td>
<td>7.2</td>
<td>7.2</td>
<td>6.1, 7.1, 7.2</td>
<td></td>
</tr>
<tr>
<td>Limit access to some/all data within a column</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Limit access to rows</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Security logic payload (customer experience)</td>
<td>External program (complex)</td>
<td>SQL rule (simple)</td>
<td>SQL rule (simple)</td>
<td>DDS or SQL (varies)</td>
<td></td>
</tr>
<tr>
<td>Software Vendor component</td>
<td>Townsend Security</td>
<td>None at this time</td>
<td>None at this time</td>
<td>N/A</td>
<td></td>
</tr>
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<td></td>
<td>Linoma</td>
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<td></td>
<td>Enforcive</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data encrypted at rest</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Data encrypted in journal</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Masked values apply to selection criteria</td>
<td>Yes</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Data-Centric Solution</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Success factors include: Strategy, Tuning &amp; Consulting</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

- **Field Procedures**: Yes
- **Column Masks**: Yes
- **Row Permissions**: No
- **Views & Logical Files**: Yes

Success factors include: Strategy, Tuning & Consulting
Other security oriented SQL statements

**ALTER TRIGGER**

Triggers over files with active RCAC must be identified as SECURED

**ALTER TRIGGER Employee_Insert_Trigger <SECURED | NOT SECURED>**

Pre-req for deployment of RCAC

**ALTER TRIGGER Employee_Insert_Trigger <ENABLE | DISABLE>**

Alternative to CL command for enabling / disabling triggers

Operations can be run under commitment control and rolled back

**ALTER FUNCTION**

Functions can be used in an RCAC rule, but they must be analyzed and approved by the Security administrator

**ALTER FUNCTION Return_Name_Function <SECURED | NOT SECURED>**

Pre-req for deployment of RCAC

Only the QIBM_DB_SECADM user can do these steps
Other security oriented SQL statements

TRANSFER OWNERSHIP
SQL statement that is similar to the CL command CHGOBJOWN

TRANSFER OWNERSHIP OF TABLE mjatst.t1 TO USER paul
   PRESERVE PRIVILEGES

Operation can be run under commitment control and rolled back

Grant to GROUP and USER

Compatibility with DB2 Family

GRANT ALL ON council TO USER frank WITH GRANT OPTION

GRANT ALL ON council TO GROUP marketing WITH GRANT OPTION

Identifies whether the ID is a group or a user
DB Application Development
7.2 Enhancements
Named Arguments & Defaults for User-Defined Function Parameters

- Similar to Named & Default parameters for procedures (IBM i 7.1 → TR5), IBM i 7.2 adds support for SQL and External User Defined Functions (UDFs)
- This enhancement brings the usability found with CL Commands to UDFs/UDTFs
- Extend existing functions without fear of breaking existing callers!

CREATE OR REPLACE FUNCTION DEPTNAME (P_EMPID VARCHAR(6), P_REQUESTED_IN_LOWER_CASE INTEGER DEFAULT 0) RETURNS VARCHAR(30) LANGUAGE SQL D: BEGIN ATOMIC
DECLARE V_DEPARTMENT_NAME VARCHAR(30);
DECLARE V_ERR VARCHAR(70);
SET V_DEPARTMENT_NAME = (SELECT CASE WHEN P_REQUESTED_IN_LOWER_CASE = 0 THEN D.DEPTNAME ELSE LOWER(D.DEPTNAME) END CASE FROM DEPARTMENT D, EMPLOYEE E WHERE E.WORKDEPT = D.DEPTNO AND E.EMPNO = P_EMPID);
IF V_DEPARTMENT_NAME IS NULL THEN
    SET V_ERR = 'Error: employee ' CONCAT P_EMPID CONCAT ' was not found';
    SIGNAL SQLSTATE '80000' SET MESSAGE_TEXT = V_ERR;
END IF;
RETURN V_DEPARTMENT_NAME;
END D;

VALUES (DEPTNAME('000110'), DEPTNAME('000110', 1), DEPTNAME('000110', P_REQUESTED_IN_LOWER_CASE=>1))

VALUES (DEPTNAME('000110'), DEPTNAME('000110', 1), DEPTNAME('000110', P_REQUESTED_IN_LOWER_CASE=>1))

00001 | 00002 | 00003
SPIFFY COMPUTER SERVICE DIV. spiffy computer service div. spiffy computer service div.
Named Arguments and Defaults for User-Defined Function Parameters

Before 7.2 (must specify 15 parameters):

```sql
SELECT journal_code, journal_entry_type, object, object_type, X.*
FROM TABLE (QSYS2.Display_Journal('PRODDATA', 'QSQRJRN',"
CAST(null as TIMESTAMP),
CAST(null as DECIMAL(21,0)),"
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Function resolution using casting rules

• Prior to 7.2, function resolution looked for an exact match
  – Match on function name
  – Match on # of parameters
  – Match on data type of parameters

• With 7.2, if DB2 for i doesn’t find an exact match, it looks for the “best fit”
• Read the SQL Reference rules for details
• Basic rule, if CAST() is supported for the parameter data type mismatch, the function will be found
• Prior to this support, you would observe SQL0204 – Function not found

For example:
CREATE OR REPLACE FUNCTION MY_CONCAT ( FIRST_PART CHAR(10),
   SECOND_PART CHAR(50))
RETURNS VARCHAR(60)
LANGUAGE SQL
BEGIN
RETURN(FIRST_PART CONCAT SECOND_PART);
END;
VALUES(MY_CONCAT(123, 456789))
Function resolution using casting rules

- Character literal values are considered VARCHAR
- Passing character literal values to functions prior to 7.1 was difficult/annoying

For example:
CREATE FUNCTION How_Long(NAME CHAR(30))
RETURNS INT
RETURN LENGTH(NAME);

Prior to 7.2
VALUES(How_Long('a b c'))

With 7.2
VALUES(How_Long('a b c'))
Array Support in User-Defined Functions

Create a type that is an array

```
CREATE TYPE INTARRAY AS INTEGER ARRAY[20]
```

Create an SQL function that uses an the array type.

```
CREATE FUNCTION myfunction1 (Input_Identifiers INTARRAY) RETURNS INTARRAY 
BEGIN 
    DECLARE ids intArray;
    DECLARE c2 CURSOR FOR SELECT * FROM UNNEST(Input_Identifiers) AS x;
    ...
    SELECT ARRAY_AGG (name ORDER BY id) INTO ids FROM persons;
    SET ids = ARRAY[5,6,7];
    SET ids[4] = 8;
    SET (maxcardo, cardo) = (MAX_CARDINALITY(ids), CARDINALITY(ids));
    ...
    RETURN ids;
END
```
**Timestamp Precision**

**Provides the ability to specify between 0 and 12 digits of precision**

- Prior to IBM i 7.2, we only support 6 digits of timestamp precision
- For some applications this is no longer sufficient as systems get faster with many more processors.
- In other cases, this is more than needed
- Use ALTER TABLE to adjust existing tables
- Any precision between 0 and 12 is allowed

**CREATE TABLE**

(C1 **TIMESTAMP(12)**, \(\rightarrow\) Additional precision when 6 is not enough
(moving from 6\(\rightarrow\)12 consumes 3 additional bytes)

C2 **TIMESTAMP(0)** \(\rightarrow\) Less precision (and storage) when 6 isn’t needed
(moving from 6\(\rightarrow\)0 eliminates 3 bytes)
Example: Compare the results of mixed precision time

create table corpdb.time_travel (  
  old_time timestamp,          /* identical to timestamp(6) */  
  new_time timestamp(12),     /* maximum precision */  
  no_time  timestamp(0),  
  Last_Change TIMESTAMP NOT NULL IMPLICITLY HIDDEN FOR EACH ROW ON UPDATE AS ROW CHANGE TIMESTAMP)  
insert into corpdb.time_travel values(current timestamp, current timestamp, current timestamp)  
insert into corpdb.time_travel values(current timestamp, current timestamp(12), current timestamp)  

select old_time, new_time, no_time, last_change from corpdb.time_travel

<table>
<thead>
<tr>
<th>OLD_TIME</th>
<th>NEW_TIME</th>
<th>NO_TIME</th>
<th>LAST_CHANGE</th>
</tr>
</thead>
</table>

select new_time - last_change as new_minus_last,  
new_time - old_time as new_minus_old,  
new_time - no_time as new_minus_no from corpdb.time_travel

<table>
<thead>
<tr>
<th>NEW_MINUS_LAST</th>
<th>NEW_MINUS_OLD</th>
<th>NEW_MINUS_NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.024476000000</td>
<td>0.000000000000</td>
<td>0.591834000000</td>
</tr>
<tr>
<td>-0.012983433055</td>
<td>0.000000566894</td>
<td>0.560759555894</td>
</tr>
</tbody>
</table>

The last change time occurs after the current timestamp is captured  
Both the column precision & special register precision must change to achieve greater precision  
DB2 for i support includes implicit data type and precision conversion
TRUNCATE

- Similar to “fast delete”
- Additional functions to
  - IGNORE or RESTRICT when delete triggers are present
  - CONTINUE or RESTART identity values
  - DROP or REUSE storage
  - IMMEDIATE performs the operation without commit even if running under commit

TRUNCATE Order_Table IGNORE DELETE TRIGGERS
TRUNCATE Order_Table RESTRICT WHEN DELETE TRIGGERS IMMEDIATE
TRUNCATE Order_Table CONTINUE IDENTITY
TRUNCATE Order_Table RESTART IDENTITY IMMEDIATE
Built-in Global Variables

- Can be referenced anywhere a column name can be used
- DB2 for i maintains the value
- Can’t be the targets of a data change operation (not settable)
- Will be set to NULL when not applicable

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Schema</th>
<th>Data Type</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLIENT_IPADDR</td>
<td>SYSIBM</td>
<td>VARCHAR</td>
<td>128</td>
</tr>
<tr>
<td>CLIENT_HOST</td>
<td>SYSIBM</td>
<td>VARCHAR</td>
<td>255</td>
</tr>
<tr>
<td>CLIENT_PORT</td>
<td>SYSIBM</td>
<td>INTEGER</td>
<td>-</td>
</tr>
<tr>
<td>PACKAGE_NAME</td>
<td>SYSIBM</td>
<td>VARCHAR</td>
<td>128</td>
</tr>
<tr>
<td>PACKAGE_SCHEMA</td>
<td>SYSIBM</td>
<td>VARCHAR</td>
<td>128</td>
</tr>
<tr>
<td>PACKAGE_VERSION</td>
<td>SYSIBM</td>
<td>VARCHAR</td>
<td>64</td>
</tr>
<tr>
<td>ROUTINE_SCHEMA</td>
<td>SYSIBM</td>
<td>VARCHAR</td>
<td>128</td>
</tr>
<tr>
<td>ROUTINE_SPECIFIC_NAME</td>
<td>SYSIBM</td>
<td>VARCHAR</td>
<td>128</td>
</tr>
<tr>
<td>ROUTINE_TYPE</td>
<td>SYSIBM</td>
<td>CHAR</td>
<td>1</td>
</tr>
</tbody>
</table>
Built-in Global Variables – Client information

SELECT SYSIBM.client_host AS CLIENT_HOST,
       SYSIBM.client_ipaddr AS CLIENT_IP,
       SYSIBM.client_port AS CLIENT_PORT
FROM LP92UT27.SYSIBM.SYSDUMMY1

SELECT * FROM LP92UT27.QSYS2.TCPIP_INFO

• Two ways to extract the detail
• Global variables fit nicely into View definitions & RCAC masks/permissions
CURRENT_USER special register

The CURRENT USER special register specifies the primary authorization ID that is being used for statement authorization. In other words, in a program that adopts authority, it will return the adopted profile name.

Useful anywhere identity is helpful (masks, permissions, triggers, etc…)

When multiple authorization IDs have been adopted within a thread, the value of the most recently adopted authorization ID within the thread will be returned.

CREATE MASK SSN_MASK ON EMPLOYEE
FOR COLUMN SSN RETURN
CASE
   WHEN (VERIFY_GROUP_FOR_USER(CURRENT_USER,'PAYROLL') = 1)
       THEN SSN
   WHEN (VERIFY_GROUP_FOR_USER(CURRENT_USER,'MGR') = 1)
       THEN 'XXX-XX-' CONCAT SUBSTR(SSN,8,4)
   ELSE NULL
END
ENABLE;

Deploying Column Mask logic based upon Adopted authority
### Special registers – similar names, different purposes

**USER this, USER that… which one should I use?**

<table>
<thead>
<tr>
<th>Special Register</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>USER or SESSION_USER</td>
<td>The effective user of the thread is returned.</td>
</tr>
<tr>
<td>SYSTEM_USER</td>
<td>The authorization ID that initiated the connection is returned.</td>
</tr>
</tbody>
</table>
| CURRENT USER or CURRENT_USER | The most recently adopted authorization ID within the thread will be returned.  
                             | When no adopted authority has occurred, the effective user of the thread is returned.                                                       |
Expressions in PREPARE and EXECUTE IMMEDIATE

Before:
SET var_total_stmt = var_select_stmt CONCAT var_orderby;
PREPARE stmt1 FROM var_total_stmt;

After:
PREPARE stmt1 FROM var_select_stmt CONCAT var_orderby;

Achieve “Set at a Time” in a new way
One statement replaces many...
Obfuscation of SQL Triggers

- Obfuscation provides the capability of optionally obscuring proprietary SQL statements and logic within SQL procedures, functions & triggers.
- This support can be used to prevent others from seeing or changing SQL routines & triggers.

Obfuscation of Procedures & Functions was PTF’d back to IBM i 7.1
An autonomous procedure is one that is executed in a unit of work that is independent from the calling application.

Similar to running COMMIT(*NONE) except that you can do commit or rollback inside the autonomous procedure and the commit and rollback is independent of the calling application.

```
CREATE PROCEDURE writelog (loginfo VARCHAR(1000)
AUTONOMOUS
BEGIN
...
INSERT INTO SCOTT.TRACKING_TABLE VALUES(LOGINFO);
...
END
```

Autonomous procedures use the named activation group ‘QSQAUTOAG’.
DB Performance – 7.2 Enhancements
Performance Data Investigator (PDI) and Database

- Abundant amount of new perspectives... helping you to quickly answer important questions

Launch URL: https://<ibmi>:2005.ibm/console/logon.jsp
SQE - I/O Cost Model Enhancement

• Motivation
  – Query optimizer needs to know how much time it’s going to take to access an object (scan a table, probe an index)
  – Original I/O Cost model assumption: 25 msec access time per I/O for all H/W
  – Hardware has changed a lot since V5R2 (e.g. faster and smaller HDDs, external storage, SSDs)
  – I/O implementation and execution algorithms diverged from model over time
  – Big Data paradigm means more dependency on I/O cost model correctness

• Costing Change @ 7.2
  – New method to sample actual access times rather than hard-code a fixed time; Every system will have unique I/O performance metrics tracked over time
  – Sampling enables optimizer to distinguish unique performance characteristics of internal, external, and solid state storage devices

• Result
  – SQE has more accurate I/O detail when costing plans
SQE - I/O Cost Model Enhancement

- Typical access times for modern disks:
  - HDDs: 4-10 msec
  - External Disks/SAN: 1-6 msec
  - SSDs: < 1 msec
  - Original SQE Model: 25 msec

- Relative cost of I/O is now lower; SQE processes I/O more aggressively

- **Potential for moderate performance gains on OLAP queries which drive significant I/O**

- Negligible benefit for short running OLTP queries which drive little I/O
DB2 for i & In-Memory controls

➢ Set Object Access (SETOBJACC) command (tenured service)
  • Target physical & logical files and programs
  • Object is brought into memory when the command is issued and can help with any form of access
  • Separate memory pools can be used, effectively shielding the memory from competing applications
  • The file attributes do not change
  • A single thread brings the object into memory
  • No guarantee that objects will remain in memory

➢ CL Command level memory control (added in 7.1)
  • Target existing DDS and SQL tables and views
    CHGPF/CHGLF … KEEPINMEM(*YES|*NO)
    Database will bring the object into memory when accessed using SQL
  • Parallel I/O will be considered to bring the object into memory
  • Stored in the file attribute survives IPLs, Save/Restore, etc.
  • No guarantee that objects will remain in memory, but the odds are good because it happens whenever rows are fetched

➢ SQL KEEP IN MEMORY memory-attribute (new in 7.2)
  • Target new or existing SQL tables & indexes
    ALTER/CPLITATE TABLE … KEEP IN MEMORY NO or YES
    Database will bring the object into memory when accessed using SQL
  • Granular control for managing partition tables
  • SQL statements can participate in a transaction
  • Once set, behavior matches KEEPINMEM

Blog thread: In Memory…
http://db2fori.blogspot.com/2013/10/in-memory.html
Temporary storage – A mystery revealed

- Observe System-wide Temporary storage consumption via a new DB2 for i Service: QSYS2/SYSTMPSTG
- Read all about it in IBM Knowledge Center:
  www.ibm.com/support/knowledgecenter/ssw_ibm_i_72/rzajq/rzajqviewsystmpstg.htm

-- Which jobs are the top consumers of temporary storage?
SELECT bucket_current_size, bucket_peak_size, rtrim(job_number) concat '/' concat rtrim(job_user_name) concat '/' concat rtrim(job_name) as q_job_name FROM QSYS2.SYSTMPSTG WHERE job_status = '*ACTIVE' ORDER BY bucket_current_size desc
DB Navigator – 7.2 Enhancements
# Navigator – what database users need to know

<table>
<thead>
<tr>
<th>What are the choices?</th>
<th>IBM i Navigator (aka System i Navigator)</th>
<th>IBM Navigator for i</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where does it run?</td>
<td>Windows PC Install</td>
<td>Browser</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Served from IBM i 6.1, 7.1 &amp; 7.2</td>
</tr>
<tr>
<td>Recent service level?</td>
<td>IBM i Access Windows Service Pack 7.1 – SI53584 ➔ TR8</td>
<td>IBM HTTP SERVER FOR i PTF Group: 7.2 - SF99713 Level 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.1 - SF99368 Level 27 ➔ TR8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.1 - SF99115 Level 38</td>
</tr>
<tr>
<td>Database commonality</td>
<td>Most features are identical, including TRx enhancements</td>
<td>Most features are identical, including TRx enhancements</td>
</tr>
<tr>
<td>Database differences</td>
<td>Run SQL Scripts Visual explain</td>
<td>PDI Time-based performance metrics OmniFind administration</td>
</tr>
<tr>
<td>Next (planned) Update</td>
<td>December 31, 2014 ➔ IBM i 7.1 TR9 &amp; IBM i 7.2 TR1</td>
<td>December 31, 2014 ➔ IBM i 7.1 TR9 &amp; IBM i 7.2 TR1</td>
</tr>
</tbody>
</table>
IBM i Navigator 7.2 Enhancements

Health Center
- System Limits

Database Management
- Support of all new SQL features
  - Permissions
  - Masks
  - Named arguments and parameter defaults
  - Obfuscation of Triggers
  - Arrays in user-defined functions
  - Create based ON
- Performance Data Investigator (PDI) Graphing and Charting
  - Display Journal GUI (PTFed back to 7.1)
  - and more…

On Demand Performance Center
- Observance of OPNQRYF & Query/400 queries
- Advanced Compare
- Enhanced Plan Cache Filtering (For Index Advice)
- Filter Database monitor on SQLCODE and CQE
- Enhanced Show Statements (PTF back to 6.1)
SQL Plan Cache & 7.2

- Use ‘Query/400’ to find STRQRY, WRKQRY, RUNQRY activity
SQL Plan Cache & 7.2

- Probe an SQL Plan Cache Snapshot via the ‘Operation Summary’
Thank You
SQL catalogs → Landscape view

Landscape
DB2 for i enhancements in IBM i 7.2

Security
- Protect business critical data using data-centric design with RCAC
- Secure remote journaling with SSL

Application development
- Improved ability to build, maintain and extend complex database application architectures

Database Engineering (DBE)
- Timestamp precision control (0 thru 12)
- Partitioned tables automatically reposition a row when updated

Performance
- SQL Query Engine (SQE) supports OPNQRYF & Query/400
- Other SQE enhancements
- Use SQL to see temporary storage consumption
IBM® DB2® for i Catalogs

Catalogs
- SYSCATALOGS
- INFORMATION_SCHEMA_CATALOG_NAME

Schemas
- SYSSCHEMAS
- SQLSCHEMAS
- SCHEMATAS

SyMCALCeO SYSCOLAUTH
- SYSFUNCTIONS
- SYSJARCONTENTS
- SYSJAROBJECTS
- SYSIPARM
- SYSPRCS
- SYSROUTINEDEP
- SYSROUTINES

Constraints
- AUTHORIZATIONS
- ROUTINE_PRIVILEGES
- UDT_PRIVILEGES
- USAGE_PRIVILEGES
- VARIABLE_PRIVILEGES

Triggers
- SYSTRIGCOL
- SYSTRIGDEP
- SYSTRIGGERS
- SYSTRIGUPD

XML Schemas
- XSRANNOTATIONINFO
- XSROBJECTCOMPONENTS
- XSROBJECTHIERARCHIES
- XSROBJECTS

Statistics
- SYSCOLUMNSTAT
- SYSPACKAGESTAT
- SYSPACKAGESTMTSTAT
- SYSPARTITIONINDEX
- SYSPARTITIONINDEXEDINDEX
- SYSPARTITIONINDEXENS

Miscellaneous Objects
- SYSPACKAGE
- SYSSEQUENCES
- SYSSTYPES
- SYSVARIABLES

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http://www.ibm.com/systems/i/software/db2/
SQL Plan Cache & 7.2

- Use ‘OPNQRYF’ or ‘Query/400’ as a Statement Text filter
- Explore Visual Explain, Show longest runs, Index Advice, and more…
Documentation

• With IBM i 7.2, these and other services will be documented within the “Database Performance and Optimization” book

• The Technology Updates wiki includes fact pages for these services

www.ibm.com/developerworks/ibmi/techupdates/db2
Are you experiencing performance problems?
Are you using SQL?
Are you getting the most out of DB2 for i?

*IBM DB2 for i Center of Excellence*

- Database modernization
- DB2 Web Query
- Database architecture and design
- DB2 SQL performance analysis and tuning
- Data warehousing and Business Intelligence
- DB2 for i education and training

Contact: Mike Cain  
mcain@us.ibm.com  
IBM Systems and Technology Group  
Rochester, MN USA
Next steps for you…

- **Education (practice, study, repeat) are the underpinnings to success**

- **Article: “SQL for the Systems Administrator”**

- **Blog thread: Advancing Your SQL Knowledge and Skills**
  [http://db2fori.blogspot.com/2013/06/advancing-your-sql-knowledge-and-skills.html](http://db2fori.blogspot.com/2013/06/advancing-your-sql-knowledge-and-skills.html)

- **And engage** Mike’s CoE team if you want education or assistance
  ([mcain@us.ibm.com](mailto:mcain@us.ibm.com))
Education resources:

- IBM i 7.2 enhancements – landing page:  
  http://www.ibm.com/developerworks/ibmi/techupdates/i72

- Technical articles coming soon 😊
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