Dynamic Statement Cache

In A Nutshell

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What Will We Talk About?

— Some SQL Tuning Fundamentals
— Dynamic SQL in More Detail
— Introduction to DB2 Statement Caching
— DB2 10 Caching Enhancements
— Mining for Gold in the Global Statement Cache
SQL Tuning Fundamentals
DB2 Optimizer Determines SQL Performance

- SQL Statement Text
- Catalog Definitions
  - Tablespace DB04.TS1
  - Index App1.Index1
- Optimizer
- Access Path To the Data

Catalog Statistics
### Static SQL
- Access path determined at bind time – better performance at run time
- Authorization for execution at the plan/package level
- Qualifiers passed via host variables
- SQLJ provides for bound static SQL in Java applications

### Dynamic SQL
- Access Path Selection determined at execution
  - PREPARE operation
  - Exceptions to the Rule
    - KEEPDYNAMIC bind option
    - Global Dynamic Statement Cache
- Build and execute SQL on the fly
- User requires authorization to all accessed objects
- Parameter markers for passing variables
Trends in the Marketplace
Static vs. Dynamic SQL

—Dynamic SQL is > 50% of the workload at many shops
—What drives dynamic SQL usage?
  - Dynamic SQL offers flexibility that can simplify developing complex applications
  - New applications being developed on distributed platforms using connections that only support dynamic SQL
    • DB2 CONNECT, etc.
  - ERP applications implemented with dynamic SQL
    • SAP, PeopleSoft, Siebel
  - New applications being developed on distributed platforms
    • New developers are much more familiar with GUI and/or web-based programming environments and don’t even sign on to the mainframe
      - More Java and C++
SQL Fundamentals - Static SQL CURSOR Processing

— Data access requirements well defined and predictable
  
  — Define the Cursor

```sql
EXEC SQL
DECLARE INDCSR
    SELECT E.EMPNO, D.DEPTNO, D.DEPTNAME
FROM DSN8910.EMP E
    INNER JOIN DSN8910.DEPT D ON E.WORKDEPT = D.DEPTNO
WHERE D.DEPTNAME = :DEPTNAME-VAR
END-EXEC.
```

— Open the cursor

```sql
EXEC SQL
OPEN INDCSR
```

— Fetch the rows from the result set

```sql
EXEC SQL
    FETCH INDCSR INTO :DCLCR-EMP-DEPT-JOIN
```

— Close the cursor
SQL Fundamentals - Dynamic SQL

Data access requirements are ad hoc in nature and identified on the fly
- SELECT Operations

```
01 DYNAMCSR-A.
  49 DYNAMSQL-L PIC S9(4) USAGE COMP-4.
  49 DYNAMSQL-D1 PIC X(300).
01 DYNAMCSR-LIT.
  05 DYNSQL-TEXT.
    10 DYNSQL-TEXT-SECT-1 PIC X(57) VALUE 'SELECT E.EMPNO, D.DEPTNO, D.DEPTNAME FROM DSN8910.EMP E '.
    10 DYNSQL-TEXT-SECT-2 PIC X(50) VALUE 'INNER JOIN DSN8910.DEPT ON E.WORKDEPT = D.DEPTNO '.
    10 DYNSQL-TEXT-SECT-3 PIC X(20) VALUE 'WHERE D.DEPTNAME = ?'.
  01 DEPTNAME-VAR PIC X(10) VALUE 'ACCOUNTING'.
```

```
PREPARE STMT FROM :DYNAMCSR-A
EXEC SQL DECLARE EDCSR FOR STMT
OPEN EDCSR USING :DEPTNAME-VAR
```

Parameter marker provides placeholder for later substitution.

At Cursor OPEN the variable value will be substituted.
Introduction to Dynamic Statement Caching

Goal is to reduce or eliminate SQL Prepare operations required for dynamic SQL statements

Implementation

- Four kinds of caching
  - No caching
  - Local Dynamic Statement Caching
  - Global Dynamic Statement Caching
  - Full Caching
- Cache prepared SQL statement and statement text for dynamic SQL statements in DBM1address space
  - Local Statement Cache
  - Global Dynamic Statement Cache
- Controlled by various parameters
  - Bind options
  - DSNZPARMs
  - Application constructs
Dynamic Statement Caching
Global Statement Caching

— Allows reuse of prepared statements across UOWs
  ▪ Within and across program executions
  ▪ Prepared statement (SKDS) cached in global dynamic statement cache

— Enabling global statement caching
  ▪ CACHEDYN=YES DSNZPARM value
  ▪ Storage allocation discussed later

— PREPARE Flavors
  ▪ Full prepare – Statement is not found in the cache and must be prepared from scratch
  ▪ Short prepare – Statement is found in the cache and can be reused; no need to regenerate access path
  ▪ Prepare avoidance – Access path information is still in the thread’s local storage and requires no flavor of prepare
    • MAXKEEPD parameter specifies how many of these statement can exist
Dynamic Statement Caching
Where Cached Statements can be Reused

Statement text must be 100% the same
- Use parameter markers
- Literals won’t work (usually)

Additional items must be 100% the same or compatible
- Bind rules
- Special registers
- Authorizations
- Others

You may not get any benefit out of the dynamic statement cache at all
- Most likely to benefit if you using an ERP or some other application that uses dynamic SQL extensively
Dynamic Statement Caching
Prepare Costs

<table>
<thead>
<tr>
<th>Full Prepare</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Statement not in cache</td>
</tr>
<tr>
<td>- Global statement caching not active</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Short Prepare</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Dynamic statement (SKDS) in the global cache</td>
</tr>
<tr>
<td>- Global caching active</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Avoided Prepare</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Local and global caching active</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SQL_CALL</th>
<th>STMT#</th>
<th>SECT#</th>
<th>INDB2_CPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREPARE</td>
<td>00324</td>
<td>00001</td>
<td>00:00.0003628</td>
</tr>
<tr>
<td>FETCH</td>
<td>00391</td>
<td>00001</td>
<td>00:00.000680</td>
</tr>
<tr>
<td>OPEN</td>
<td>00398</td>
<td>00001</td>
<td>00:00.000045</td>
</tr>
<tr>
<td>CLOSE</td>
<td>00405</td>
<td>00001</td>
<td>00:00.000023</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SQL_CALL</th>
<th>STMT#</th>
<th>SECT#</th>
<th>INDB2_CPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>FETCH</td>
<td>00391</td>
<td>00001</td>
<td>00:00.000454</td>
</tr>
<tr>
<td>PREPARE</td>
<td>00324</td>
<td>00001</td>
<td>00:00.000231</td>
</tr>
<tr>
<td>OPEN</td>
<td>00398</td>
<td>00001</td>
<td>00:00.000020</td>
</tr>
<tr>
<td>CLOSE</td>
<td>00405</td>
<td>00001</td>
<td>00:00.000007</td>
</tr>
</tbody>
</table>
Dynamic SQL Statement Caching
DB2 Cache Statistics (from DB2 statistics)

**Statement Discarded**
- Shoot for 0
- Increase MAXKEEPD if > 0

**Prepare Avoided**
- Specific for Applications bound with KEEPDYNAMIC(YES)
- High is good

**Statement Not In Cache** (worst case)
- Full prepare
- Should be low depending on dynamic workload

**Requested statement was found in cache** (nearly best case)
- Short Prepare
- Higher the better

**Dynamic PREPARE**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stmt found in cache</td>
<td>24</td>
</tr>
<tr>
<td>Stmt not found in cache</td>
<td>131</td>
</tr>
<tr>
<td>Implicit prepare performed</td>
<td>0</td>
</tr>
<tr>
<td>Prepare avoided</td>
<td>0</td>
</tr>
<tr>
<td>Stmts discarded - MAXKEEPD</td>
<td>0</td>
</tr>
<tr>
<td>Stmts purged - dep. object</td>
<td>0</td>
</tr>
<tr>
<td>Prep restricted indx pend.</td>
<td>0</td>
</tr>
</tbody>
</table>
The Global Dynamic Statement Cache
More Details

— Dynamic Statements
  - Inserted in the cache if:
    • CACHEDYN=YES – Global Cache is active

— Bind Options Impact on the cache
  - REOPT ALWAYS – prepared statements aren’t placed in the cache
  - REOPT ONCE – Prepares the statement the first time the statement is executed with host variables available at that time
  - REOPT AUTO – DB2 9 feature where DB2 will examine the host variable values and will generate new access paths only when host variable values change and DB2 has not already generated an access path for those values
  - REOPT NONE – DB2 will not re-optimize the SQL at run time

— Cached statements reside in the cache until:
  • DROP or ALTER of any object
  • Authorization Revoked
  • LRU – Least Recently Used
  • RUNSTATS
— New STMT_ID (existed prior for dynamic cached statements)
  - For dynamic and static SQL
  - Included in IFCIDs for dynamic and static statements
  - Generated for dynamic statements that enter the cache
  - For static the STMT_ID column in SYSPACKSTMT

— New Monitor Class 29
  - Turns on IFCID 318 (more later)
  - IFCID 316 new behavior – when statement is ejected from pool the 316 is written
  - IFCID 400 – similar to IFCID 318 except for static statements
  - IFCID 401 – similar to IFCID 316 when statement is ejected from EDM Pool the 401 IFCID is written
— Literals vs. parameter marker issue mitigated using new CONCENTRATE STATEMENTS WITH LITERALS clause
  - Can be added to the PREPARE Statement
  - Can be set in JCC driver on the client side
    • enableliteralReplacement='YES'
  - ODBC initialization file in z/OS can set LITERALREPLACEMENT
  - New column in statement cache ‘LITERAL_REPL’ indicates literal replacement

— Sequence of events
  - Incoming SQL with literals is looked up in the cache (DB2 9 behavior)
  - If not found, literals are replaced and the new SQL is searched for
  - If not found, new SQL is prepared and stored in the cache.

— Actual literals are stored in the cache as well.
Retrieving Data From the Global Cache

— As shown previously
  - Statement caching performance data in DB2 statistics records
  - Metrics show details about cache hit ratios and other useful data points that help you evaluate overall performance of your statement caches

— For more detail on Global Statement Cache usage the following instrumentation is provided
  - IFCID 316 – Provides details on statements in the cache
    • First 60 bytes of SQL text
    • Includes execution statistics (0 if not being collected)
  - IFCID 317 can then be used to retrieve the entire SQL statement from the cache once you have identified the statement of interest

— EXPLAIN STMTCACHE
  - V8 feature that exports Dynamic Statement Cache information to the DSN_STATEMENT_CACHE_TABLE
  - Nearly identical to the detail in IFCID 316 & 317
  - Multiple options including ALL, stmt-id, and stmt-token
### Reviewing Global Statement Cache Information

**IFCID 316 Results**

- First 60 Bytes of SQL Text
  - IFCID 317 gives full text
- Bind Options
- Statement Statistics (more later)

#### SQL Text

<table>
<thead>
<tr>
<th>User String (on 2nd line if present)</th>
<th>Current Users</th>
<th>Active Copies</th>
</tr>
</thead>
<tbody>
<tr>
<td>SELECT E.EMPNO, D.DEPTNO, D.DEPTNAME</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>UPDATE ANDRO16.BIGEMP1 SET PHONE = 57128521635 WHERE EMPKEY =</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>UPDATE ANDRO16.BIGEMP1 SET PHONE = 4328327866 WHERE EMPKEY =</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

#### Performance Data

<table>
<thead>
<tr>
<th>Users</th>
<th>Stmt num</th>
<th>Program name</th>
<th>Active copies</th>
<th>Executions</th>
<th>Transaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>324</td>
<td>DSNESM68</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bind SQLID</th>
<th>Table qual</th>
<th>Owner user ID</th>
<th>Stmt status</th>
<th>Current data</th>
<th>Dynamic rules</th>
<th>Current degree</th>
<th>Isolation</th>
<th>Current rules</th>
<th>Cur precision</th>
<th>Csr with hold</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARLW101</td>
<td>ARLW101</td>
<td>ARLW101</td>
<td>00</td>
<td>Y</td>
<td>R</td>
<td></td>
<td>CS</td>
<td>D</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

#### Elapsed Time

<table>
<thead>
<tr>
<th>Elapsed time</th>
<th>Getpages</th>
<th>CPU time</th>
<th>Rows examined</th>
<th>Sync I/O time</th>
<th>Rows processed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.004</td>
<td>N/A</td>
<td>0.001</td>
<td>150</td>
<td>0.000</td>
<td>6</td>
</tr>
<tr>
<td>CPU time</td>
<td></td>
<td>0.000</td>
<td></td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Sync I/O time</td>
<td></td>
<td>0.000</td>
<td></td>
<td>0.000</td>
<td></td>
</tr>
</tbody>
</table>
Reviewing Global Statement Cache Information
IFCID 317 Results

• IFCID 317 returns the full text of the SQL statement
• Notice that the two statements are functionally equivalent but have different formatting
  • 2 statements in the cache

R/DYNSQLTX Selected Dynamic SQL Statement in Cache Row 20-33/33

Sync writes 0 0.0

Enter E to EXPLAIN the following SQL ===> _

SELECT E.EMPNO , D.DEPTNO , D.DEPTNAME
  FROM DSN8910.EMP E INNER JOIN DSN8910.DEPT D ON E.WORKDEPT = D.DEPTNO
  WHERE LASTNAME IN ('PULASKI','HAAS')

SELECT E.EMPNO , D.DEPTNO , D.DEPTNAME
  FROM DSN8910.EMP E INNER JOIN DSN8910.DEPT D ON E.WORKDEPT = D.DEPTNO
  WHERE LASTNAME
  IN ('PULASKI','HAAS')
Reviewing Global Statement Cache Information Literals vs. Parameter Markers

- In this example we have multiple statements in the cache that are exactly the same except for the literals used in the statement.
- What’s the downside
  - No re-use of the prepared statement so more CPU
  - Other statements in the cache may be tossed out if many of these statements run in a given period of time.
Mining the Dynamic Statement Cache
EXPLAINing the SQL

— **EXPLAIN STMTCACHE ALL**
  - Inserts one row for each entry in the global DSC
    • Populates DSN_STATEMENT_CACHE_TABLE only
    • STMT_ID column matches the Unique ID in the global statement cache
    • Nearly exact match to the DSC with a few additional columns
    • COLLID set to DSNDYNAMICSQLCACHE

— **EXPLAIN STMTCACHE STMT_ID**
  - Extracts a single statement from the global DSC
    • Populates PLAN, DSN_DYNAMIC_STATEMENT, DSN_STATEMENT, and DSN_FUNCTION tables if they exist
    • Access path is current access path for statement in the cache
    • Numeric literal or host variable from program

— **EXPLAIN STMTCACHE STMTTOKEN**
  - Extracts a group of statements from the global DSC
    • Populates PLAN, DSN_DYNAMIC_STATEMENT, DSN_STATEMENT, and DSN_FUNCTION tables if they exist
    • Access path is current access path for statement in the cache
    • Based on STMT_TOKEN value in the cache
    • Alphanumeric literal or host variable in program
Reviewing Global Statement Cache Information
IFCID 318

› Execution statistics for dynamic SQL statements
› Turn on collection with Monitor trace IFCID 318
  – Begins collecting statistics and accumulates them for the length of time the monitor trace is on
  – Stop Monitor trace resets all statistics
  – 2-4% overhead per dynamic SQL statement stored in the cache
› Recommended approach
  – Run the trace only when actively monitoring the cache
› Use EXPLAIN STMTCACHE to externalize data for evaluation

```
-START_TRACE (MON) IFCID(318)
```

```
DSNW130I !S91A MON TRACE STARTED, ASSIGNED TRACE NUMBER 06
DSN9022I !S91A DSNWCM1 ' -START TRACE' NORMAL COMPLETION
```

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Average % Elp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elapsed time</td>
<td>0.000</td>
<td>0.000 N/A</td>
</tr>
<tr>
<td>CPU time</td>
<td>0.000</td>
<td>0.000 76.7</td>
</tr>
<tr>
<td>Sync I/O time</td>
<td>0.000</td>
<td>0.000 0.0</td>
</tr>
<tr>
<td>Other read</td>
<td>0.000</td>
<td>0.000 0.0</td>
</tr>
<tr>
<td>Other write</td>
<td>0.000</td>
<td>0.000 0.0</td>
</tr>
<tr>
<td>Lock suspend</td>
<td>0.000</td>
<td>0.000 0.0</td>
</tr>
<tr>
<td>Global lock</td>
<td>0.000</td>
<td>0.000 0.0</td>
</tr>
<tr>
<td>Exec unit sw</td>
<td>0.000</td>
<td>0.000 0.0</td>
</tr>
</tbody>
</table>

```

```
Getpages    16  16.0
Rows examined  50  50.0
Rows processed  2  2.0
Sorts        0  0.0
Index scans  3  3.0
Tblspace scans 0  0.0
Parallel grps 0  0.0
Sync reads   0  0.0
Sync writes  0  0.0
```

9/13/2011
Summary

— Dynamic SQL is a major part of many workloads
  - ERP Vendors
  - Distributed applications

— DB2 offers multiple options for reducing the overhead traditionally associated with dynamic SQL

— These options include multiple types of statement caching
  - Local statement caching
  - Global statement caching
  - Full statement caching

— DB2 9 and 10 both introduced new functionality to enhance dynamic statement cache usage