Maximizing Materialized Views

John Jay King
King Training Resources
john@kingtraining.com

Download this paper and code examples from:
http://www.kingtraining.com

Session Objectives

- Learn how to create and use Materialized Views and Materialized View logs.
- Set Materialized Views to refresh in a variety of ways.
- Understand Materialized View Groups.
- Exploit Oracle's Query Rewrite capability.
- Increase application performance using Materialized Views.

What are Materialized Views?

- Materialized Views (MViews) allow a view query's results to be physically stored in the database
  - Originally introduced in Oracle8i, based upon SNAPSHOTs
  - Normally only a view's SELECT statement is stored in the database; the result set is "Materialized" (recreated) each time the view is accessed
  - Materialized Views are based upon a SELECT too; but the "materialized" result set is stored in the database as well as the defining SELECT
  - View materialization is refreshed periodically based upon time criteria, upon commit of changes, or upon demand
  - Materialized View (MView) data is "old" until the view is refreshed (good idea to use temporal names like ***daily***_sales_summary)
  - MViews provide substantial performance gains since the result set is only materialized once rather than for each repeated use
  - To further speed things, indexes may be defined for MViews

MView Feature Overview

- Used like any Table or View, “transparent” to user
- Physically store data, can be indexed
- Frequently used to make local copies of remote data
- Dramatically improve performance of queries that make repeated use of non-volatile result sets
  (ideal for Business Intelligence and Data Warehouses)
- Usually used for aggregate/summary (GROUP BY) output
- Need to be refreshed:
  - Based upon date/time
  - When view data changes are committed
  - Upon Demand
- Created using CREATE MATERIALIZED VIEW

Three Types of MView

- Materialized Views may be separated into three basic types:
  - Materialized Views containing aggregate data
  - Materialized Views containing data from joins (but without aggregates)
  - Materialized Views querying from Materialized Views (nested MViews)

CREATE MATERIALIZED VIEW

```
create materialized view daily_dept_summary
 build immediate
 refresh complete
 enable query rewrite
as
select dname,count(empno) nbremps,
       sum(coalesce(sal,0)
           +coalesce(comm,0)) totpay
    from emp e full join dept d
          on e.deptno = d.deptno
    group by dname
    order by nbremps desc, totpay desc
```

- Build query results immediately (may be deferred)
- Each refresh completely replaces data
- Query Rewrite is enabled

Refresh criteria

- When defining MViews; it is important to consider different factors impacting data refresh:
  - How should the data be refreshed?
    - ON COMMIT Refresh when underlying data changes (must be "fast refresh" capable)
    - ON DEMAND Refreshed using DBMS_MVIEW
    - START WITH Refresh using date/time calculation and/or NEXT
  - What type of refresh mechanism should be used?
    - COMPLETE Re-execute MView query
    - FAST Incremental changes using MView log
    - FORCE FORCE fast if possible; complete otherwise
    - NEVER MView does not get refreshed
  - May "trusted constraints" be used
    - QUERY_REWRITE_INTEGRITY = TRUSTED
    - QUERY_REWRITE_INTEGRITY = ENFORCED

Using DBMS_MVIEW

- DBMS_MVIEW includes several procedures including:
  - REFRESH — Refresh named mview
  - REFRESH_ALL_MVIEWS — Refresh all mviews
  - REFRESH_DEPENDENT — Refresh dependent mviews

```
begin
   dbms_mview.refresh('daily_dept_summary');
end;
/
```

  - Be Careful! This packaged procedure COMMITs changes in the active transaction as part of its execution

Primary Key / ROWID

- MViews may specify the use of keys:
  - WITH PRIMARY KEY (default)
    - Base table must include primary key
    - All primary key columns must be used in MView query (without modification)
  - WITH ROWID
    - MView must be based upon single table
    - MView query may not use:
      - Aggregate functions or GROUP BY
      - DISTINCT
      - Distinct or aggregate functions
      - CONNECT BY
      - Joins
      - Subqueries
      - Set operations

Using ROLLBACK Segment

- This clause is still supported for backward compatibility; requires ROLLBACK segments
- Most installations use Undo Tablespaces and automatic undo mode making this clause irrelevent

Fast Refresh Restrictions

- Each MView query table must have Materialized View Log
- Fast Refresh is possible only for queries that do not have:
  - RAW or LONG RAW data
  - Non-deterministic data like SYSDATE
  - SELECT list subqueries
  - Analytic functions (e.g. RANK, DENSE_RANK)
  - MODEL clause
  - HAVING with subquery
  - Subqueries using ANY, ALL, or NOT EXISTS
  - START WITH / CONNECT BY
  - Tables from multiple sites
- Other (more complex) restrictions exist; see the Oracle Data Warehousing Guide and SQL Reference

Materialized View Logs

- Materialized view logs are required to perform FAST REFRESH or to use PCT (Partition Change Tracking) REFRESH
- Use CREATE MATERIALIZED VIEW LOG to define a log for each base table that might be changed (not on the MView)
- If FAST REFRESH is specified for nested Materialized Views; ROWID is normally required and and all columns referenced in the nested MView must be included

```
CREATE MATERIALIZED VIEW LOG ON sales
  WITH ROWID
       (prod_id, cust_id, time_id,
        channel_id, promo_id,
        quantity_sold, amount_sold)
   INCLUDING NEW VALUES;
```

ENABLE QUERY REWRITE

- Query Rewrite provides an added benefit to MViews; Oracle uses Materialized Views to “rewrite” queries
- When end user queries access tables and/or views used in a Materialized View; the query rewrite mechanism in the Oracle server can automatically rewrite the SQL query to use the MView instead
- Query Rewrite improves query result time transparently
- System-level or Session-level must specify: QUERY REWRITE ENABLED = TRUE
- If a data warehouse MView references data from a Dimension (“trusted” data) also required for rewrite; the System-level or Session-level must specify: QUERY REWRITE INTEGRITY = TRUSTED

Query Rewrite Restrictions

- To use Query Rewrite, an MView's SELECT statement's expressions must be repeatable and cannot include:
  - Non-deterministic user-defined functions
  - Oracle Sequence values
  - Current date/time variables (e.g. SYSDATE)
  - Other "current" values (e.g. USER)
  - SAMPLE
- DISABLE QUERY REWRITE is the default; each Materialized View should specify ENABLE QUERY REWRITE
- Query Rewrite is performed as part of statement optimization and requires that statistics exist for the Materialized View (use DBMS_STATS)

Query Rewrite & “Staleness”

- What if the Materialized View's data is no longer current? (i.e. underlying tables/views have changed without a refresh of the Materialized View; the MView is “stale”)

- Oracle’s ability to rewrite a “stale” MView depends upon the value of QUERY_REWRITE_INTEGRITY:
  - ENFORCED (default): materialized view used if data is not stale and does not involve any “trusted” relationships (like Dimensions)
  - STALE_TOLERATED: materialized view used even if detail data has changed
  - TRUSTED: materialized view used if data is not stale but query rewrite might use “trusted” relationships like Dimensions that have not been validated

Query Rewrite in Action, 1

- Given the following Materialized View definition:

```
create materialized view dept_summary_mview
 build immediate
 refresh complete
 enable query rewrite
as
select dname,count(empno) nbremps,
             sum(coalesce(sal,0)+
                 coalesce(comm,0)) totpay
     from emp e full join dept d
             on e.deptno = d.deptno
     group by dname
     order by nbremps desc, totpay desc
```

Query Rewrite in Action, 2

- This query is rewritten to use the Materialized View (DEPT_SUMMARY_MVIEW will be joined to DEPT rather then joining DEPT to the EMP table)

```
select dname,count(empno)
  from emp,dept
  where emp.deptno = dept.deptno
  group by dname
```

DBMS_MVIEW.EXPLAIN_REWRITE

- If you expect a rewrite to occur but the optimizer chooses a different path, the DBMS_MVIEW.EXPLAIN_REWRITE procedure may be used
(first, run <oraclehome>/rdbms/admin/utlxrw.sql to build a REWRITE_TABLE; see next page)

```
SQL> execute dbms_mview.explain_rewrite('select
  deptno,count(*) from emp group by deptno');
SQL> select message from rewrite_table:
 MESSAGE
 ----------------------------------------------------
 QSM-01009: materialized view, DEPT_SUMMARY_MVIEW2,
  matched query text
```

Query Rewrite Table

Name	Null?	Type
STATEMENT_ID		VARCHAR2(30)
MV_OWNER		VARCHAR2(30)
MV_NAME		VARCHAR2(30)
SEQUENCE		NUMBER(38)
QUERY		VARCHAR2(2000)
MESSAGE		VARCHAR2(512)
PASS		VARCHAR2(3)
MV_IN_MSG		VARCHAR2(30)
MEASURE_IN_MSG		VARCHAR2(30)
JOIN_BACK_TBL		VARCHAR2(30)
JOIN_BACK_COL		VARCHAR2(30)
ORIGINAL_COST		NUMBER(38)
REWRITTEN_COST		NUMBER(38)
FLAGS		NUMBER(38)
RESERVED1		NUMBER(38)
RESERVED2		VARCHAR2(10)

Enabling Query Rewrite

- If query rewrite is not set at the System level, it may be set at the Session level
  (if your userid is allowed to ALTER SESSION)

```
ALTER SESSION SET query_rewrite_integrity=TRUSTED;
ALTER SESSION SET query_rewrite_enabled=FORCE;
show parameters query
```

Disabling Query Rewrite

- Occasionally it might be useful disable the query rewrite capability for a Materialized View

```
ALTER MATERIALIZED VIEW dept_summary_mview
  disable query rewrite;
```

Using Prebuilt Tables, Table

- Basing a materialized view upon an existing table (ON PREBUILT TABLE) allows the use of existing tables and indexes
- Here is some syntax to create a table upon which a view may be based, this creates a normal table with no special features

```
create table dept_summary_tab
  as
    select dept.deptno
           ,dname
           ,count(*) nbr_emps
           ,sum(nvl(sal,0)) tot_sal
         from scott.emp emp
              ,scott.dept dept
         where emp.deptno(+) = dept.deptno
         group by dept.deptno,dname;
```

Using Prebuilt Tables: MView

```
create materialized view dept_summary_tab
  on prebuilt table
  with reduced precision
  refresh start with sysdate next sysdate + 1
  as
    select dept.deptno
           ,dname
           ,count(*) nbr_emps
           ,sum(nvl(sal,0)) tot_sal
         from scott.emp emp
              ,scott.dept dept
         where emp.deptno(+) = dept.deptno
         group by dept.deptno,dname;
```

- In this case, the MView uses the same query as the one used to create the original table, this is not required
- Table and Materialized View must use the same name and schema
- WITH REDUCED PRECISION allows a refresh to work properly even if some columns generate different precision than originally defined

Indexing

- Materialized Views are usually used for queries
- Query execution may be improved if a single-column bitmap index is defined for each "key" column in the MView
- If an MView containing aggregates is set for FAST refresh; an index is created automaticlly unless USING NO INDEX is specified in CREATE MATERIALIZED VIEW
- Note: When a partitioned MView is refreshed, indexes must be rebuilt before FAST Refresh will work

Update

- Specify FOR UPDATE to allow update of a Materialized View:
  - Primary key
  - Rowid
  - Subquery
  - Object
- When using Advanced Replication the allowed changes are propagated to the master

Materialized View Query

- MView SELECT defines a query that creates the result set to be “materialized” and stored
- The SELECT statement may reference:
  - Any number of tables joined together
  - Views, Inline views (subqueries in the FROM clause of a SELECT statement), Subqueries, and Materialized Views can all be joined or referenced in the SELECT clause
- The SELECT statement may not:
  - Use a subquery in the SELECT list of the defining query (subqueries may be used elsewhere; for example in the WHERE clause)

MView Refresh Groups

- Oracle's Advanced Replication features allow definition of Materialized View Refresh Groups
- Oracle can refresh collections of MViews in "Refresh Groups" to maintain Referential Integrity and Read Consistency
- When two (or more) MViews should be "in-synch" a "Refresh Group" should be used
- After refreshing a "Refresh Group" all MViews in the group corrspond to a consistent point in time

Create Refresh Group

```
BEGIN
   DBMS_REFRESH.MAKE (
      name => 'myschema.mymviewrefgroup',
      list => '',
      next_date => SYSDATE,
      interval => 'SYSDATE + 1',
      implicit_destroy => FALSE,
      rollback_seg => '',
      push_deferred_rpc => TRUE,
      refresh_after_errors => FALSE);
END;
/
```

Add to Refresh Group

```
BEGIN
   DBMS_REFRESH.ADD (
      name => 'myschema.mymviewrefgroup',
      list => 'sh.sales_mview',
      lax => TRUE);
END;
/
BEGIN
   DBMS_REFRESH.ADD (
      name => 'myschema.mymviewrefgroup',
      list => 'sh.countries_mview',
      lax => TRUE);
END;
/
```

Refresh Using Group

```
EXECUTE DBMS_REFRESH.REFRESH
   ('myschema.mymviewrefgroup');
```

MViews in the Catalog

- The catalog provides support for MViews
  - ALL_BASE_TABLE_MVIEWS
  - ALL_MVIEWS
  - ALL_MVIEW_AGGREGATES
  - ALL_MVIEW_ANALYSIS
  - ALL_MVIEW_COMMENTS
  - ALL_MVIEW_DETAIL_PARTITION
  - ALL_MVIEW_DETAIL_RELATIONS
  - ALL_MVIEW_DETAIL_SUBPARTITION
  - ALL_MVIEW_JOINS
  - ALL_MVIEW_KEYS
  - ALL_MVIEW_LOGS
  - ALL_MVIEW_REFRESH_TIMES
  - ALL_REGISTERED_MVIEWS

Important ALL_MVIEW Columns

- MVIEW_NAME
- QUERY
- REWRITE_ENABLED
- REFRESH_MODE
- REFRESH_METHOD
- BUILD_MODE
- FAST_REFRESHABLE
- LAST_REFRESH_DATE
- STALENESS
- STALE_SINCE

Performance Considerations, 1

- The main performance gain of Materialized Views is obtained by NOT re-materializing result sets repetitively
- If a regular View and Materialized View use the same query:

```
SELECT   substr(country_name,1,20) country
,substr(prod_name,1,15) product ,sales.prod_id     prodid
,calendar_year           year    ,SUM(amount_sold)  tot_amt
,SUM(quantity_sold)    tot_qty ,COUNT(amount_sold) tot_sales
   FROM sh.sales  sales join sh.times times
                on sales.time_id = times.time_id
                     join sh.products products
                on sales.prod_id = products.prod_id
                     join sh.customers customers
                on sales.cust_id = customers.cust_id
                     join sh.countries countries
                on customers.country_id = countries.country_id
     GROUP BY country_name,prod_name
             ,sales.prod_id,calendar_year
      ORDER BY country,product,year;
```

Performance Considerations, 2

- The two queries below process greatly different numbers of rows:

```
select country,year,product,tot_sales
   from sales_view
   where year = '2003'
   order by tot_sales,country;
   drop view sales_view;
```

  - Reads thousands of rows to generate the results

```
select country,year,product,tot_sales
   from sales_mview
   where year = '2003'
   order by tot_sales,country;
   drop view sales_view;
```

  - Reads 50 rows to generate the results

Recent Development

- Oracle 11g Materialized View changes
  - Query Rewrite will support queries containing inline views (SELECT in FROM subquery)
  - Query Rewrite can now rewrite queries referencing remote tables
  - Refresh now supports:
    - Automatic index creation for UNION ALL materialized views
    - Query rewrite during a materialized view refresh (single)
    - Materialized view refresh with set operators
    - Partition Change Tracking (PCT) can track refresh of MViews with UNION ALL
    - Catalog views have been expanded to include partition staleness
- Oracle 10 Materialized View changes
  - Materialized view fast refresh may involve multiple tables (partitioned or not)
  - Materialized View Fast Refresh involving multiple tables no longer always requires Materialized View Log (use DBMS_MVIEW.EXPLAIN_REWRITE
  - Query rewrite performance improved because Oracle 10g query rewrite may use multiple materialized views to rewrite a query

Wrapping it all Up

- Materialized Views reduce the impact of frequently executed queries by storing results and refreshing them on a selected basis
- Materialized Views may be indexed
- Materialized Views may be synchronized
- Materialized Views are best suited for a predominately read-only environment like Business Intelligence

Training Days 2008

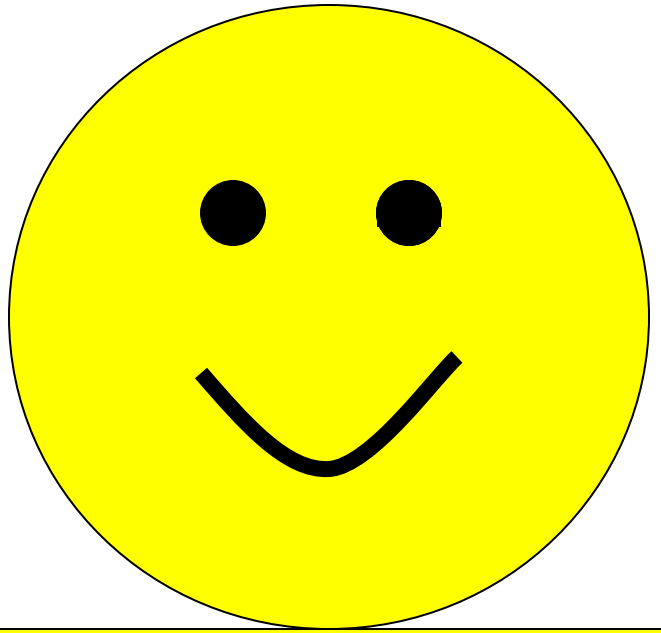
Mark your calendar for:

February 13-14 2008!

Please fill out session Evaluations

Maximizing Materialized Views

To contact the author:
John King
King Training Resources
6341 South Williams Street
Littleton, CO 80121-2627 USA
1.800.252.0652 - 1.303.798.5727
Email: john@kingtraining.com



Thanks for your attention!

Today's slides and examples are on the web:

http://www.kingtraining.com