Data Warehousing and Decision Support, part 3

CS634
Class 24, May 5, 2014

Slides based on "Database Management Systems" 3rd ed, Ramakrishnan and Gehrke, Chapter 25

Partition Pruning

- The QP needs to be smart about partitions/MDC cells
- From Oracle docs, the idea: "Do not scan partitions where there can be no matching values".
- Example: partitions of table t1 based on region_code:

```
PARTITION BY RANGE( region_code )
 ( PARTITION p0 VALUES LESS THAN (64),
PARTITION p1 VALUES LESS THAN (128),
PARTITION p2 VALUES LESS THAN (192),
PARTITION p3 VALUES LESS THAN MAXVALUE );
```

Query:

```
SELECT fname, lname, region_code, dob FROM t1
   WHERE region_code > 125 AND region_code < 130;
```

- QP should prune partitions p0 (region_code too low) and p3 (too high).
- But the capability is somewhat fragile in practice.

Partition Pruning is fragile

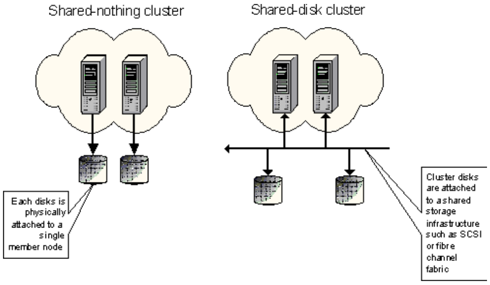
- From dba.stackexchange.com:
- The problem with this approach is that partition_year must be explicitly referenced in queries or partition pruning (highly desirable because the table is large) doesn't take effect. (Can't ask users to add predicates to queries with dates in them)
- Answer:
- … Your view has to apply some form of function to start and end dates to figure out if they're the same year or not, so I believe you're out of luck with this approach.
- Our solution to a similar problem was to create materialized views over the base table, specifying different partition keys on the materialized views.
- So need to master materialized views to be an expert in DW.

Parallelism is essential to huge DWs

Table 1: Parallelism approaches taken by different data warehouse DBMS vendors, from "How to Build a High-Performance Data Warehouse" by David J. DeWitt, Ph.D.; Samuel Madden, Ph.D.; and Michael Stonebraker, Ph.D.
(I've added bold for the biggest players, green for added entries)

Shared Memory (least scalable)	Shared Disk (medium scalable)	Shared Nothing (most scalable)
Microsoft SQL Server PostgreSQL MySQL	**Oracle RAC** Sybase IQ	**Teradata** **IBM DB2** Netezza EnterpriseDB (Postgres) Greenplum Vertica MySQL Cluster SAP HANA

Shared-nothing vs. Shared-disk



Views and Materialized Views

Views: review of pp. 86-91

View - rows are not explicitly stored, but computed as needed from view definition

Base table - explicitly stored

CREATE VIEW

Given tables for these relations:
Students (ID, name, major)
Enrolled (ID, CourseID, grade)

Can create view:
```
CREATEVIEW B_Students (name, ID, CourseID) AS
    SELECT   S.name, S.ID, E.CourseID
    FROM     Students S, Enrolled E
    WHERE    S.ID = E.ID AND E.grade = 'B';
```

- Now can use B_Students just as if it were a table, for queries
- Could be used to shield D_students from view
- Can grant select on view, but not on enrolled

Updatable Views

SQL-92: Must be defined on a single table using only selection and projection and not using DISTINCT.

SQL:1999: May involve multiple tables in SQL:1999 if each view field is from exactly one underlying base table and that table's PK is included in view; not restricted to selection and project, but cannot insert into views that use union, intersection, or set difference.

So B_Students is updatable by SQL99, and by Oracle 10.

Materialized Views

- What is a Materialized View?
  - Advantages and Disadvantages
- Creating Materialized Views
  - Syntax, Refresh Modes/Options, Build Methods
  - Examples
- Dimensions
  - What are they?
  - Examples

  - Slides of Willie Albino from http://www.nocoug.org/download/2003-05/materialized_v.ppt

What is a Materialized View?

- A database object that stores the results of a query
- Features/Capabilities
  - Can be partitioned and indexed
  - Can be queried directly
  - Can have DML applied against it
  - Several refresh options are available (in Oracle)
  - Best in read-intensive environments

Advantages and Disadvantages

- Advantages
  - Useful for summarizing, pre-computing, replicating and distributing data
  - Faster access for expensive and complex joins
  - Transparent to end-users
    - MVs can be added/dropped without invalidating coded SQL
- Disadvantages
  - Performance costs of maintaining the views
  - Storage costs of maintaining the views

Similar to Indexes

- Designed to increase query Execution Performance.
- Transparent to SQL Applications allowing DBA's to create and drop Materialized Views without affecting the validity of Applications.
- Consume Storage Space.
- Can be Partitioned.
- Not covered by SQL standards
- But can be queried like tables

MV Support in DBs: from Wikipedia

- Materialized views were implemented first by the Oracle , and Oracle has the most features
- In IBM DB2, they are called "materialized query tables";
- Microsoft SQL Server has a similar feature called "indexed views".
- MySQL doesn't support materialized views natively, but workarounds can be implemented by using triggers or stored procedures or by using the open-source application Flexviews.

Views vs Materialized Views (Oracle), from http://www.sqlsnippets.com/en/topic-12874.html

Table	View	Materialized View
select * from T ; KEY VAL ---- ----- 1 a 2 b 3 c 4	create view v as select * from t ; select * from V ; KEY VAL ----- ----- 1 a 2 b 3 c 4	create materialized view mv as select * from t ; select * from MV ; KEY VAL ---- ----- 1 a 2 b 3 c 4

Update to T is not propagated immediately to simple MV

update t set val = upper(val);

Table	View	Materialized View
select * from T ; KEY VAL ---------- ----- 1 A 2 B 3 C 4	select * from V ; KEY VAL ---------- ----- 1 A 2 B 3 C 4	select * from MV ; KEY VAL ---------- ----- 1 a 2 b 3 c 4

MV “refresh“ command

execute dbms_mview.refresh('MV');

Table	View	Materialized View
select * from T ; KEY VAL ---------- ----- 1 A 2 B 3 C 4	select * from V ; KEY VAL ---------- ----- 1 A 2 B 3 C 4	select * from MV ; KEY VAL ---------- ----- 1 A 2 B 3 C 4

Materialized View Logs for fast refresh

- There is a way to refresh only the changed rows in a materialized view's base table, called fast refreshing.
- For this, need a materialized view log (MLOG$_T here) on the base table t:

```
create materialized view log on t ;
```

```
UPDATE t set val = upper( val ) where KEY = 1 ;
INSERT into t ( KEY, val ) values ( 5, 'e' );

select key, dmltype$$ from MLOG$_T ;
```

```
KEY DMLTYPE$$
---------- ----------
1 U
5 I
```

REFRESH FAST

create materialized view mv REFRESH FAST as select * from t ;

select key, val, rowid from mv ;

```
KEY VAL ROWID
 ---------- ----- ------------------
1  a  AAAWm+AAEAAAAaMAAA
2  b  AAAWm+AAEAAAAaMAAB
3  c  AAAWm+AAEAAAAaMAAC
4     AAAWm+AAEAAAAaMAAD
```

execute dbms_mview.refresh(list => 'MV', method => 'F'); --F for fast

select key, val, rowid from mv ;

--see same ROWIDs as above: nothing needed to be changed

Now let's update a row in the base table.

update t set val = 'XX' where key = 3 ;

commit;

execute dbms_mview.refresh(list => 'MV', method => 'F');

select key, val, rowid from mv;

```
KEY VAL ROWID
---------- ----- ------------------
1 a  AAAWm+AAEAAAAaMAAA
2 b  AAAWm+AAEAAAAaMAAB
3 XX AAAWm+AAEAAAAaMAAC –See update, same old ROWID
4    AAAWm+AAEAAAAaMAAD
```

So the MV row was updated based on the log entry

Adding Your Own Indexes

create materialized view mv
  refresh fast on commit as
  select t_key, COUNT(*) ROW_COUNT from t2 group by t_key ;

create index MY_INDEX on mv (T_KEY) ;

select index_name , i.uniqueness , ic.column_name
  from user_indexes i inner join user_ind_columns ic using (index_name)
  where i.table_name = 'MV' ;

```
INDEX_NAME  UNIQUENES COLUMN_NAME
--------------- --------- ---------------
I_SNAP$_MV  UNIQUE     SYS_NC00003$ --Sys-generated
MY_INDEX    NONUNIQUE  T_KEY
```

Prove that MY_INDEX is in use using SQL*Plus's Autotrace feature

set autotrace on explain set linesize 95

select * from mv where t_key = 2 ;

```
T_KEY ROW_COUNT
 ---------- ----------
 2 2
Execution Plan
 ----------------------------------------------------------
Plan hash value: 2793437614
---------------------------------------------------------------------
|Id| Operation                  | Name | Rows | Bytes | Cost (%CPU)| Time |
---------------------------------------------------------------------
|0| SELECT STATEMENT             |       | 1 | 26 | 2 (0)| 00:00:01 |
|1| MAT_VIEW ACCESS BY INDEX ROWID| MV    | 1 | 26 | 2 (0)| 00:00:01 |
|*2| INDEX RANGE SCAN            | MY_INDEX | 1 | | 1 (0)| 00:00:01 |
 --------------------------------------------------------------------
```

MV on Join query

create materialized view log on t with rowid, sequence ;
  create materialized view log on t2 with rowid, sequence

create materialized view mv
  refresh fast on commit enable query rewrite
  as select t.key t_key , t.val t_val , t2.key t2_key ,
    t2.amt t2_amt , t.rowid t_row_id , t2.rowid t2_row_id
    from t, t2
    where t.key = t2.t_key ;

create index mv_i1 on mv (t_row_id) ;

create index mv_i2 on mv (t2_row_id) ;

MV with aggregation

create materialized view log on t2 with rowid, sequence (t_key, amt)
  including new values ;

create materialized view mv
  refresh fast on commit enable query rewrite
  as select t_key , sum(amt) as amt_sum , count(*) as row_count ,
      count(amt) as amt_count
  from t2 group by t_key ;

create index mv_i1 on mv (t_key) ;

MV with join and aggregation from Oracle DW docs

CREATE MATERIALIZED VIEW LOG ON products WITH SEQUENCE,
  ROWID (prod_id, prod_name,…) INCLUDING NEW VALUES;

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

CREATE MATERIALIZED VIEW product_sales_mv BUILD IMMEDIATE
  REFRESH FAST ENABLE QUERY REWRITE
  AS SELECT p.prod_name, SUM(s.amount_sold) AS dollar_sales, COUNT(*)
  AS cnt, COUNT(s.amount_sold) AS cnt_amt
  FROM sales s, products p WHERE s.prod_id = p.prod_id
  GROUP BY p.prod_name;

Dimensions

- A way of describing complex data relationships
  - Used to perform query rewrites, but not required
  - Defines hierarchical relationships between pairs of columns
    - Hierarchies can have multiple levels
    - Each child in the hierarchy has one and only one parent
    - Each level key can identify one or more attribute
- Dimensions should be validated using the `DBMS_OLAP.VALIDATE_DIMENSION` package
  - Bad row ROWIDs stored in table: `mview$_exceptions`

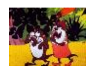
Example of Creating A Dimension

```
CREATE DIMENSION time_dim
    LEVEL CAL_DATE IS calendar.CAL_DATE
    LEVEL PRD_ID   IS calendar.PRD_ID
    LEVEL QTR_ID   IS calendar.QTR_ID
    LEVEL YEAR_ID  IS calendar.YEAR_ID
    LEVEL WEEK_IN_YEAR_ID IS calendar.WEEK_IN_YEAR_ID
  HIERARCHY calendar_rollup
    (CAL_DATE CHILD OF
     PRD_ID CHILD OF
     QTR_ID CHILD OF YEAR_ID)
  HIERARCHY week_rollup
    (CAL_DATE CHILD OF
     WEEK_IN_YEAR_ID CHILD OF YEAR_ID)
  ATTRIBUTE PRD_ID DETERMINES PRD_DESC
  ATTRIBUTE QTR_ID DETERMINES QTR_DESC;
```


Example of Using Dimensions

```
-- Step 1 of 4
-- Create materialized view (join-aggregate type)
CREATE MATERIALIZED VIEW items_mv
BUILD IMMEDIATE
REFRESH ON DEMAND
ENABLE QUERY REWRITE
AS
SELECT l.slr_id ,
       c.cal_date,
       sum(l.gms) gms
  FROM items l,
       calendar c
 WHERE
       l.end_date=c.cal_date
 GROUP BY
       l.slr_id, c.cal_date;
```


Example of Using Dimensions (cont'd)



```
-- Step 2 of 4: (not really required, for demonstration only)
-- Execute query based on "quarter", not "date", without a time
dimension
-- Note that the detail tables are accessed

SQL> select c.qtr_id, sum(l.gms) gms
  2  from items l, calendar c
  3  where l.end_date=c.cal_date
  4  group by l.slr_id, c.qtr_id;

Execution Plan
----------------------------------------------------------
SELECT STATEMENT Optimizer=CHOOSE (Cost=16174 Card=36258…)
 SORT (GROUP BY) (Cost=16174 Card=36258 Bytes=1160256)
  HASH JOIN      (Cost=81 Card=5611339 Bytes=179562848)
   TABLE ACCESS (FULL) OF 'CALENDAR' (Cost=2 Card=8017 …)
   TABLE ACCESS (FULL) OF 'ITEMS' (Cost=76 Card=69993 …)
```


Example of Using Dimensions (cont'd)

```
-- Step 3 of 4: Create time dimension (see slide .-4 for SQL)
@cr_time_dim.sql
Dimension Created
-- Step 4 of 4: Rerun query based on "quarter" with time
dimension

SQL> select c.qtr_id, sum(l.gms) gms
  2  from items l, calendar c
  3  where l.end_date=c.cal_date
  4  group by l.slr_id, c.qtr_id;

Execution Plan
----------------------------------------------------------
SELECT STATEMENT Optimizer=CHOOSE (Cost=3703 Card=878824…)
 SORT (GROUP BY) (Cost=3703 Card=878824 Bytes=44820024)
  HASH JOIN (Cost=31 Card=878824 Bytes=44820024)
   VIEW (Cost=25 Card=8017 Bytes=128272)
    SORT (UNIQUE) (Cost=25 Card=8017 Bytes=128272)
     TABLE ACCESS (FULL) OF 'CALENDAR' (Cost=2 Card=8017…)
   TABLE ACCESS (FULL) OF 'ITEMS_MV' (Cost=3 Card=10962…)
```


DW Partitioning, Oracle case

- Clearly a win to partition fact table, big MVs by time intervals for roll-out, clustering effect
- Can sub-partition fact table by a dimension attribute, but need to modify queries to get QP to optimize
- Ex: partition by date intervals, product category
- Query: select p.subcategory, … from F where … (no mention of p.category)
- Modified query: select p.subcategory … where … AND category='Soft Drinks' --now QP uses partition pruning
- MVs are usually rolled-up, much smaller, don't need effective partitioning so much

Summary

- Query Rewrite using dimension hierarchies apparently helps only Oracle MVs, not partition pruning.
- So put raw data in one fact table, partitioned for roll-out
- Create MVs with various roll-ups, for queries, also partitioned by time
- Add indexes to MVs
- Note MVs are much smaller than raw fact tables
- Every day (say) add data to raw fact table, refresh MVs

Oracle OLAP Cube

- Another way to hold data, optimized for cube queries
- Related to master tables: fact tables, dimensions
- Excel can get data with MDX
- Not itself a MV, but can be used like one
- i.e. SQL queries can be automatically rewritten to use the OLAP cube, run faster
- Other OLAP servers exist too

Working cheaply: what about mysql?

- If your data can be fit into memory, you don't need fancy software… so buy a terabyte of memory…no longer a crazy idea.
- Example: Dell's PowerEdge FX2 FC830 (review June '15) can take up to 1.5TB memory, 4 CPU sockets for Xeon processors with 4-18 cores/CPU. Basic system (8GB memory) $8,300. Maybe $15K for 1TB compatible RAM (not sure).
- Have warehouse data in mysql on disk, comes into memory as accessed.
- Mysql has no MV's, but can compute a joined table periodically as needed for Excel
- Use Excel for UI