Advanced Databases - LAB Week 5

Indexes and Query Optimization

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In this lab we will experiment with query optimization.

Create the following tables:

1. Persons
2. Jobs
3. Jobs-persons

A list of persons is connected many-to-many to a list of jobs (the table jobs-person is the relation table).

```
drop table persons; create
table persons( person_id
integer, person_name
varchar(20),
person_surname varchar(20),
person_age integer not null,
person_wealth integer,
person_weight float
);

drop table jobs_person;
create table
jobs_person( jobs_id
integer, person_id
integer, start_date
date, end_date date);

drop table jobs;
create table jobs(
jobs_id integer,
job_description varchar(200),
salary integer
);
```

Lab 4

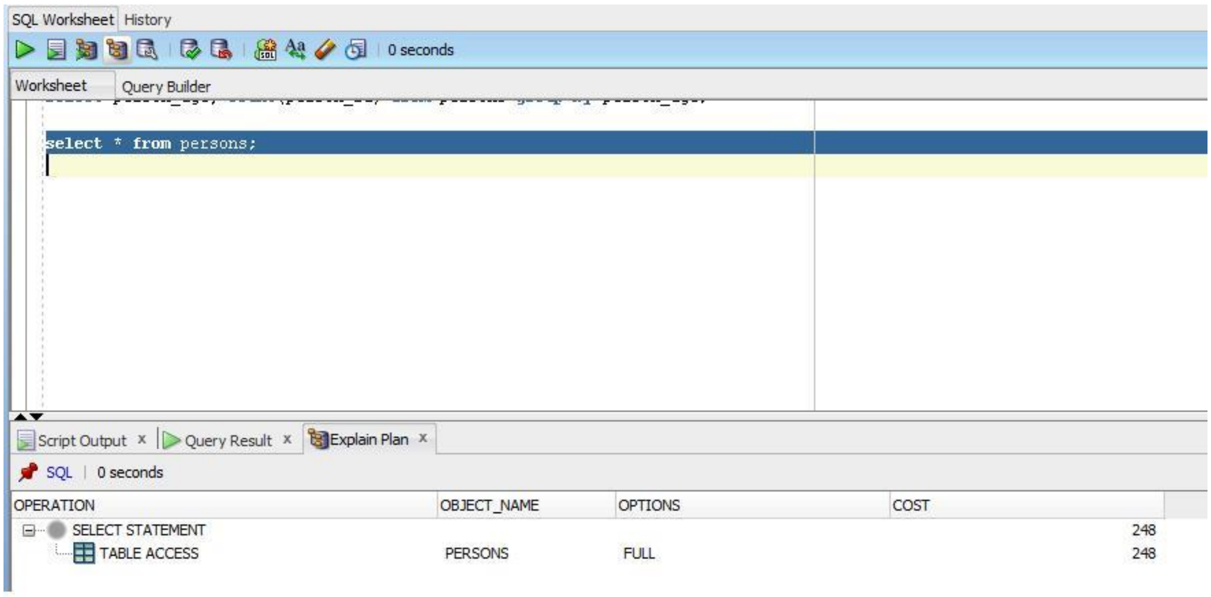
Execute the following sql 3 commands block **ONE BY ONE** to fill the tables with random data. The commands are also in the *populate.sql* (but execute them one by one!!)

```
/* 1. populate table persons */
declare v_p_id number; v_p_name
varchar2(20); v_p_surname
varchar2(20); v_p_age integer;

 p_wealth float;
p_weight  float;
BEGIN
  FOR i IN 1..10000 LOOP
   select DBMS_RANDOM.STRING('a', 20) into v_p_name from dual; select
   DBMS_RANDOM.STRING('a', 20) into v_p_surname from dual; SELECT
   TRUNC(DBMS_RANDOM.VALUE(18, 100)) into v_p_age FROM DUAL; SELECT
   TRUNC(DBMS_RANDOM.VALUE(0,10000000)) into p_wealth FROM
DUAL;
   SELECT trunc(DBMS_RANDOM.VALUE(40, 120),2) into p_weight FROM
DUAL;
   insert into persons
values(i,v_p_name,v_p_surname,v_p_age,p_wealth,p_weight);
  END LOOP;

end;

/* 2. populate table jobs */
declare j_id number;
j_description varchar2(100);
j_salary float;
BEGIN
  FOR i IN 1..10000 LOOP
   select DBMS_RANDOM.STRING('a', 100) into j_description from dual;
   SELECT TRUNC(DBMS_RANDOM.VALUE(0,100000)) into j_salary FROM
DUAL;
   insert into jobs values(i,j_description,j_salary);
  END LOOP;
end;
```

```
/* 3. populate table jobs-persons */
declare j_id number;
 p_id integer;
 start_date date;
 end_date date;
 st integer;
 en integer;
BEGIN
   FOR i IN 1..10000 LOOP
    FOR j in 1..15 LOOP
    SELECT TRUNC(DBMS_RANDOM.VALUE(0,1000000)) into p_id FROM DUAL;
    SELECT TRUNC(DBMS_RANDOM.VALUE(0, 1000)) into st FROM DUAL; SELECT
    TRUNC(DBMS_RANDOM.VALUE(0, 2000)) into en FROM DUAL; SELECT
    TO_DATE(TRUNC(DBMS_RANDOM.VALUE(2452641,2452641+st)),'J')
into start_date FROM DUAL;
    SELECT
TO_DATE(TRUNC(DBMS_RANDOM.VALUE(2452641+st,2452641+st+en)),'J') into
end_date FROM DUAL;
    insert into jobs_person values(i,p_id,start_date,end_date);
     END LOOP;
   END LOOP;

end;
```

There are no keys or indexes defined. The person_id and the jobs_id are unique.

Using the oracle function Explain Plain (in SQL developer is the fourth icon from the left in the sql script window or press F10), we3 will analyse how ORACLE executes queries and the cost of each query - a number expressing how much resources and time your query takes.



```
select * from persons;
```

```
OPERATION                  OBJECT_NAME   OPTIONS    COST
SELECT STATEMENT                                     248
  TABLE ACCESS             PERSONS       FULL        248
```

Lab 4

Execute the following steps to analyse Oracle Index behaviour

1. Check that data are in the three tables. Have a look at the data There are no indexes or keys defined at this stage.
2. Execute the following query

   Query1.

   *select * from persons*

   And select the explain plain function.

   How much is the cost? ***20***

   Was it a full or index scan of the table? ***Full Scan***

   Why? ***Because no indexes were specified and a full scan was carried out to display all the attributes inside the table***

3. Execute

   Query2 .

   *select * from persons where person_id>1000 and person_id<3000*

   Total cost? ***27***

   Full or index scan? Why? ***Full Scan because person_id is not a primary key but a unique key yet the table still needs to be fully scanned to compare and display the results***

   Any difference with the previous query? ***The use of the AND logical operator and the < > comparison operators***

4. Define a primary key over *person_id* (using an ALTER TABLE … ADD CONSTRAINTS statement) Remember that this creates an index on *person_id* as well. Perform **Query1**

   Cost? ***27***

   Full or Index? ***Full Scan***

   Comment the results.

   Since the query is looking to display all the attributes from the Persons table it needs to search through all of the table, even though the index has been specified but the query does not use the primary key persons_id. Hence the cost is very similar to executing the query when there was no primary key specified

   Perform **Query2**

   Cost? ***3 for utilising the SELECT statement, 3 for accessing the table using the row_id, 2 for carrying out the index scan due to the persons_id***

   Full or Index? ***Index Scan***

   Comment the results.

   Index scan was used because the persons_id specified the index on which the query needed to be executed. It filtered out the row and accessed the values it needed

   Query1 requires a full scan since it gives back the full unfiltered table

Query2 requires uses the index scan on the primary index *person_id* to filter the data. Note that range scan refers to accessing an interval of value (range) using an index (therefore oracle finds the starting point using the index and then the scan is sequential over an ordered list. It is therefore faster than full scan)

5. Perform the following

   Query3

   *select * from persons where person_id+5>1000 and person_id<3000*

   Check cost and type of scan

   Cost: ______________***3 for the SELECT statement, 3 for accessing the table by the row_id, 2 for carrying out the index scan***____

   Type of Scan ____________***Index Scan***____

   Query4

   *select * from persons where person_id+5>1000 and person_id*2<3000*

   Check cost and type of scan

   Cost: ____________________***27***____

   Type of Scan _______***Full Scan***____

   Comment the behaviour of Query3 and Query4

   _____***Query3 is faster because it uses the primary key person_id, an index, to do the searching instead of filtering the whole table. Whereas in Query4, the index person_id has been specified yet it is within the brackets which means it cannot be accessed like the regular queries and hence a Full Scan needs to be performed in order to filter out the tables and attributes that are required.***____

   In **Query3** the index person_id is contained in the expression (person_id+5) so it cannot be used. However, the index can be used in the other where clause (person_id<20000), so Oracle performs an index access of the table to get the persons with person_id<20000 and at the same time it filters the condition (person_id+5>20000)

   In **Query4**, none of the index can be used so a full scan is performed

   Remember: if an index is used in an expression that affects the ordering of the data , it won't be used!

6. Execute

   Query5.

   select person_age, count(person_id) from persons group by person_age;

   Cost? _____________________***27***____

   Full or Index? ____________***Full Scan***____

   Comment the results.

   ______***Since the "group" is used, it means the table needs to be fully scanned because you are trying to order the resulting values hence it scans the whole table in order to make this happen, even if the person_id is used, it will not do an Index Scan.***____

The index on *person_id* does not help since we are grouping by person_age, so a full scan is required. Note the extra cost of grouping, executed by Oracle in a quick way by hashing the persons by age during the full scan

7. Define an index on person_age by executing:

   create index p_age on persons(person_age);

   Execute again **Query5**

   Cost? ***8 for SELECT, 8 for GROUP BY, 7 for Index Scan***

   Full or Index? ***Index Scan***

   Even if an index is defined on person_age, the index is not used, why?
   The reason is the following (IMPORTANT!): if a column contains NULL values or it has been defined (with CREATE TABLE) without NOT NULL the index will be ineffective!

   1. Drop the table persons.

   2. Modify the create table statement adding "*not null*" to the field *person_age (*and add primary key to the *person_id* field so you do not need to alter the table afterwards).

   3. Populate the table with the sql command used before (page 2, block 1)
   4. Execute query5

   Cost? ***27***

   Full or Index? ***Full Scan***

   You should see an index-like access (hash, i.e. the type of index create on person_age – default) and the cost is now reduced

8. Joining two tables
   Perform the following query:

   select jobs.jobs_id,jobs.job_description, jobs.salary, jobs_person.person_id from jobs inner join jobs_person
   on jobs.jobs_id = jobs_person.jobs_id
   where jobs_person.jobs_id=34;

   Cost? ***217 for SELECT, 217 for Hash Join, 46 for accessing the table fully on JOBS, 171 for accessing the table fully on JOBS_PERSON***

   Full or Index? ***Full Scan***

   Comment the results.

   2 Full Scans were carried out to execute this query, Hash join was used to merge the tables and then a Full Scan was carried out to display the results. No primary keys had been used and no indexes hence no Index Scan was carried out

Note how the query is divided into steps: first the full scans and the hash table used to speed-up the join.

Add indexes on jobs_id.jobs_id and jobs_person.jobs_id (note that one could be aprimary key and the other a foreign key).
Check again the results.
Did they improve or not? Why? ***Results have improved because indexes were being used hence a full search did not need to be carried out to display the results, only the rows with indexes were touched upon and filtered and compared.***
(you should see a reduction in cost due to the usage of indexes).

9. Reduce the cost of this query as much as you can:

/* select person name, max salary and job description between 2003 and 2004
*/ *select p.person_name, j.salary, j.job_description*
from persons p inner join jobs_person jp on p.person_id =
jp.person_id inner join jobs j on jp.jobs_id=j.jobs_id
where jp.start_date> '01-JAN-2003' and jp.end_date < '31-DEC-03';

Use indexes, temporary tables, change the SQL code, split the join – but be sure the result is still equivalent!