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Performance Tuning

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❖ DB Application Performance

In order to make DB applications efficient, it is useful to know:

- what operations on the data does the application require

  (which queries, updates, inserts and how frequently is each one performed)

- how much each implementation will cost

  (in terms of the amount of data transferred between memory and disk ⇒ time)

and then, "encourage" the DBMS to use the most efficient methods

Achieve by using indexes and avoiding certain SQL query structures

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❖ DB Application Performance (cont)

Application programmer choices that affect query cost:

- how queries are expressed
  - generally join is faster than subquery
  - especially if subquery is correlated
  - filter first, then join (avoids large intermediate tables)
  - avoid applying functions in where/group-by clasues
- creating indexes on tables
  - index will speed-up filtering based on indexed attributes
  - indexes generally only effective for equality, gt/lt
  - mainly useful if filtering much more frequent than update

❖ DB Application Performance (cont)

Whatever you do as a DB application programmer

- the DBMS query optimiser will transform your query
- attempt to make it execute as efficiently as possible

You have no control over the optimisation process

- but choices you make can block certain options
- limiting the query optimiser's chance to improve

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❖ DB Application Performance (cont)

Example: query to find sales people earning more than $50K

```
select name from Employee
where  salary > 50000 and
       empid in (select empid from Worksin
                 where  dept = 'Sales')
```

A query evaluator might use the strategy

```
SalesEmps = (select empid from WorksIn where dept='Sales')
foreach e in Employee {
    if (e.empid in SalesEmps && e.salary > 50000)
        add e to result set
}
```

Needs to examine *all* employees, even if not in Sales

This is not a good expression of the query.

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❖ DB Application Performance (cont)

A different expression of the same query:

```
select name
from   Employee join WorksIn using (empid)
where  Employee.salary > 5000 and
       WorksIn.dept = 'Sales'
```

Query evaluator might use the strategy

```
SalesEmps = (select * from WorksIn where dept='Sales')
foreach e in (Employee join SalesEmps) {
    if (e.salary > 50000)
        add e to result set
}
```

Only examines Sales employees, and uses a simpler test

This is a good expression of the query.

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❖ DB Application Performance (cont)

A very poor expression of the query (correlated subquery):

```
select name from Employee e
where  salary > 50000 and
       'Sales' in (select dept from Worksin where empid=e.id)
```

A query evaluator would be forced to use the strategy:

```
foreach e in Employee {
    Depts = (select dept from WorksIn where empid=e.empid)
    if ('Sales' in Depts && e.salary > 50000)
        add e to result set
}
```

Needs to run a query for *every* employee ...

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❖ Indexes

Indexes provide efficient content-based access to tuples.

Can build indexes on any (combination of) attributes.

Definining indexes:

```
CREATE INDEX name ON table ( attr1, attr2, ... )
```

attr$_i$ can be an arbitrary expression (e.g. **`upper(name)`**).

`CREATE INDEX` also allows us to specify

- that the index is on **`UNIQUE`** values
- an access method (**`USING`** btree, hash, ...)

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❖ Indexes (cont)

Indexes can significantly improve query costs.

Considerations in applying indexes:

- is an attribute used in frequent/expensive queries?
  (note that some kinds of queries can be answered from index alone)
- should we create an index on a collection of attributes?
  (yes, if the collection is used in a frequent/expensive query)
- is the table containing attribute frequently updated?
- should we use B-tree or Hash index?

```
-- use hashing for (unique) attributes in equality tests, e.g.
select * from Employee where id = 12345
-- use B-tree for attributes in range tests, e.g.
select * from Employee where age > 60
```

❖ Query Tuning

Sometimes, a query can be re-phrased to affect performance:

- by helping the optimiser to make use of indexes
- by avoiding unnecessary/expensive operations

Examples which *may* prevent optimiser from using indexes:

```
select name from Employee where salary/365 > 100
       -- fix by re-phrasing condition to (salary > 36500)
select name from Employee where name like '%ith%'
select name from Employee where birthday is null
       -- above two are difficult to "fix"
select name from Employee
where  dept in (select id from Dept where ...)
       -- fix by using Employee join Dept on (e.dept=d.id)
```

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❖ Query Tuning (cont)

Other tricks in query tuning (effectiveness is DBMS-dependent)

- **`select distinct`** typically requires a sort ...
  is the **`distinct`** really necessary? (at this stage in the query?)
- if multiple join conditions are available ...
  choose join attributes that are indexed, avoid joins on strings

```
select ... Employee join Customer on (s.name = p.name)
vs
select ... Employee join Customer on (s.ssn = p.ssn)
```

- sometimes **`or`** prevents index from being used ...
  replace the **`or`** condition by a union of non-**`or`** clauses

```
select name from Employee where Dept=1 or Dept=2
vs
(select name from Employee where Dept=1)
union
(select name from Employee where Dept=2)
```

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❖ PostgreSQL Performance Analysis

PostgreSQL provides the **`explain`** statement to

- give a representation of the query execution plan
- with information that may help to tune query performance

Usage:

```
EXPLAIN [ANALYZE] Query
```

Without **`ANALYZE`**, **`EXPLAIN`** shows plan with estimated costs.

With **`ANALYZE`**, **`EXPLAIN`** executes query and prints real costs.

Note that runtimes may show considerable variation due to buffering.

If simply knowing the runtime is ok, maybe **`\timing`** is good enough

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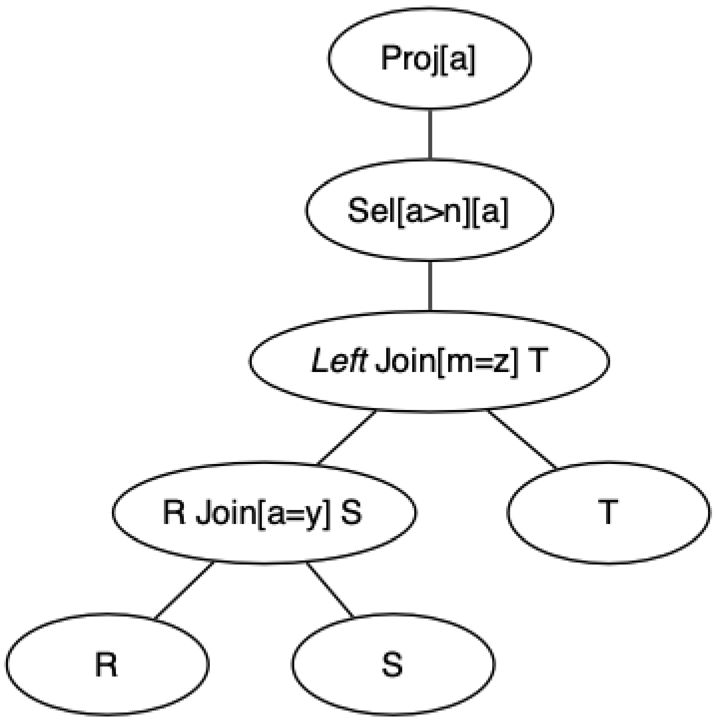
❖ EXPLAIN Examples

Note that PostgreSQL builds a query evaluation tree, rather than a linear plan, e.g.




```
select a
from   R
       join S on (R.a = S.y)
       join T on (T.m = S.z)
where  R.a > T.n
```

```
Tmp1 = R Join[a=y] S
Tmp2 = Tmp1 Join[m=z] T
Tmp3 = Sel[a>n](Tmp2)
Res  = Proj[a](Tmp3)
```

`EXPLAIN` effectively shows a pre-order traversal of the plan tree

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❖ EXPLAIN Examples (cont)

Example: Select on indexed attribute

```
db=# explain analyze select * from Students where id=100250;
                          QUERY PLAN
------------------------------------------------------------
 Index Scan using student_pkey on student
                  (cost=0.00..5.94 rows=1 width=17)
                  (actual time=3.209..3.212 rows=1 loops=1)
   Index Cond: (id = 100250)
 Total runtime: 3.252 ms
```

Example: Select on non-indexed attribute

```
db=# explain analyze select * from Students where stype='local';
                       QUERY PLAN
-------------------------------------------------------------
 Seq Scan on student  (cost=0.00..70.33 rows=18 width=17)
             (actual time=0.061..7.784 rows=2512 loops=1)
   Filter: ((stype)::text = 'local'::text)
 Total runtime: 7.554 ms
```

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❖ EXPLAIN Examples (cont)

Example: Join on a primary key (indexed) attribute

```
db=# explain
db-# select s.sid,p.name
db-# from Students s join People p on s.id=p.id;

                        QUERY PLAN
-------------------------------------------------------
 Hash Join  (cost=70.33..305.86 rows=3626 width=52)
   Hash Cond: ("outer".id = "inner".id)
   -> Seq Scan on people p
               (cost=0.00..153.01 rows=3701 width=52)
   -> Hash  (cost=61.26..61.26 rows=3626 width=8)
       -> Seq Scan on student s
                   (cost=0.00..61.26 rows=3626 width=8)
```

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