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Relational Operations

- DBMS Architecture (revisited)
- Relational Operations
- Cost Models
- Query Types

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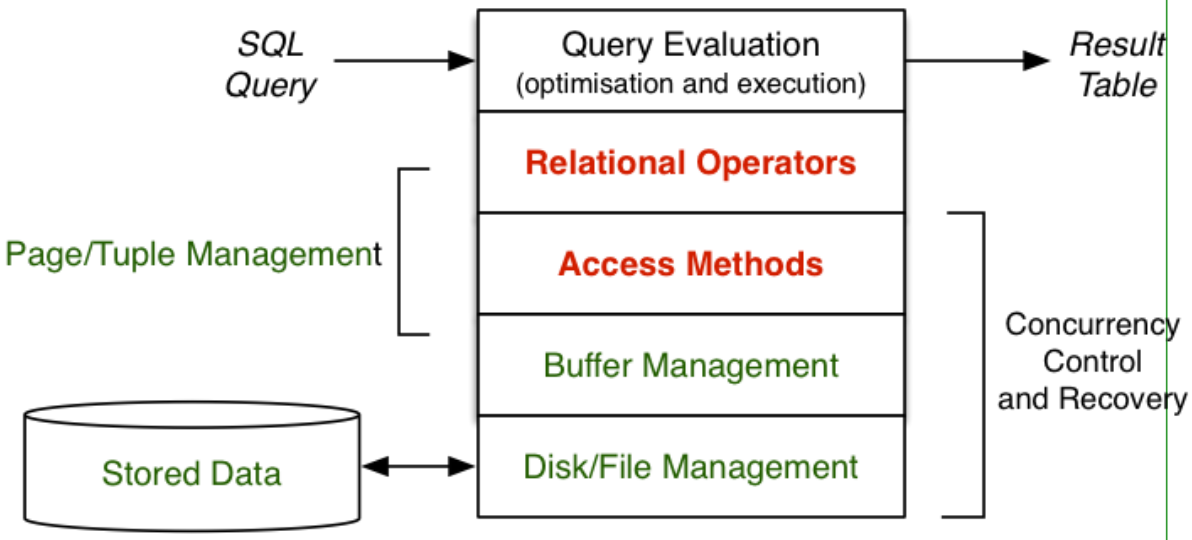
❖ DBMS Architecture (revisited)

Implementation of relational operations in DBMS:



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❖ Relational Operations

DBMS core = relational engine, with implementations of

- selection, projection, join, set operations
- scanning, sorting, grouping, aggregation, ...

In this part of the course:

- examine methods for implementing each operation
- develop cost models for each implementation
- characterise when each method is most effective

Terminology reminder:

- tuple = collection of data values under some schema ≅ record
- page = block = collection of tuples + management data = i/o unit
- relation = table ≅ file = collection of tuples

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❖ Relational Operations (cont)

In order to implement relational operations the low-levels of the system provides:

- **`Relation openRel(db,name)`**
  - get handle on relation **`name`** in database **`db`**
- **`Page request_page(rel,pid)`**
  - get page **`pid`** from relation **`rel`**, return buffer containing page
- **`Record get_record(buf,tid)`**
  - return record **`tid`** from page **`buf`**
- **`Tuple mkTuple(rel,rec)`**
  - convert record **`rec`** to a tuple, based on **`rel`** schema

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❖ Relational Operations (cont)

Example of using low-level functions

```
// scan a relation Emps
Page p;  // current page
Tuple t; // current tuple
Relation r = relOpen(db,"Emps");
for (int i = 0; i < nPages(r); i++) {
   p = request_page(rel,i);
   for (int j = 0; j < nRecs(p); j++)
      t = mkTuple(r, get_record(p,j));
      ... process tuple t ...
   }
}
```

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❖ Relational Operations (cont)

Two "dimensions of variation":

- which relational operation (e.g. Sel, Proj, Join, Sort, ...)
- which access-method (e.g. file struct: heap, indexed, hashed, ...)

Each query method involves an operator and a file structure:

- e.g. primary-key selection on hashed file
- e.g. primary-key selection on indexed file
- e.g. join on ordered heap files (sort-merge join)
- e.g. join on hashed files (hash join)
- e.g. two-dimensional range query on R-tree indexed file

We are interested in *cost* of query methods (and insert/delete operations)

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❖ Relational Operations (cont)

SQL vs DBMS engine

- **`select ... from R where C`**
  - find relevant tuples (satisfying C) in file(s) of R
- **`insert into R values(...)`**
  - place new tuple in some page of a file of R
- **`delete from R where C`**
  - find relevant tuples and "remove" from file(s) of R
- **`update R set ... where C`**
  - find relevant tuples in file(s) of R and "change" them

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❖ Cost Models

An important aspect of this course is

- analysis of cost of various query methods

Cost can be measured in terms of

- *Time Cost*: total time taken to execute method, or
- *Page Cost*: number of pages read and/or written

Primary assumptions in our cost models:

- memory (RAM) is "small", fast, byte-at-a-time
- disk storage is very large, slow, page-at-a-time

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❖ Cost Models (cont)

Since *time cost* is affected by many factors

- speed of i/o devices (fast/slow disk, SSD)
- load on machine

we do not consider time cost in our analyses.

For comparing methods, *page cost* is better

- identifies workload imposed by method
- BUT is clearly affected by buffering

Estimating costs with multiple concurrent ops *and* buffering is difficult!!

Addtional assumption: every page request leads to some i/o

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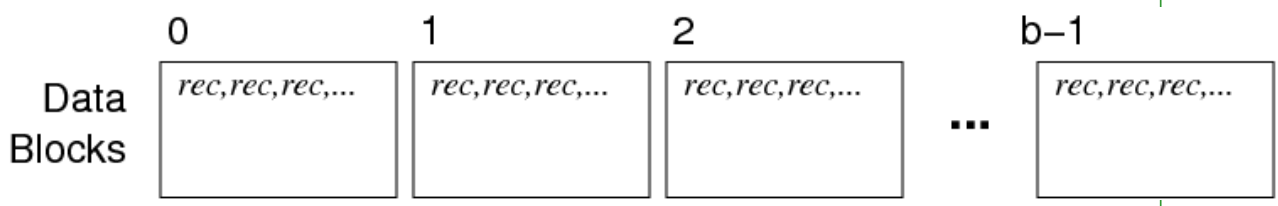
❖ Cost Models (cont)

In developing cost models, we also assume:

- a relation is a set of r tuples, with average tuple size R bytes
- the tuples are stored in b data pages on disk
- each page has size B bytes and contains up to c tuples
- the tuples which answer query q are contained in b_q pages
- data is transferred disk↔memory in whole pages
- cost of disk↔memory transfer $T_{r/w}$ is very high



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❖ Cost Models (cont)

Our cost models are "rough" (based on assumptions)

But do give an *O(x)* feel for how expensive operations are.

Example "rough" estimation: how many piano tuners in Sydney?

- Sydney has ≅ 4 000 000 people
- Average household size ≅ 3 ∴ 1 300 000 households
- Let's say that 1 in 10 households owns a piano
- Therefore there are ≅ 130 000 pianos
- Say people get their piano tuned every 2 years (on average)
- Say a tuner can do 2/day, 250 working-days/year
- Therefore 1 tuner can do 500 pianos per year
- Therefore Sydney would need ≅ 130000/2/500 = 130 tuners

Actual number of tuners in Yellow Pages = 120

Example borrowed from Alan Fekete at Sydney University.

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❖ Query Types

Type	SQL	RelAlg	a.k.a.
Scan	**select * from R**	*R*	-
Proj	**select** *x,y* **from R**	*Proj[x,y]R*	-
Sort	**select * from R order by** *x*	*Sort[x]R*	*ord*
Sel_1	**select * from R where id =** *k*	*Sel[id=k]R*	*one*
Sel_n	**select * from R where a =** *k*	*Sel[a=k]R*	-
$Join_1$	**select * from R,S where R.id = S.r**	*R Join[id=r] S*	-

Different query classes exhibit different query processing behaviours.

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