

# DBMS Overview

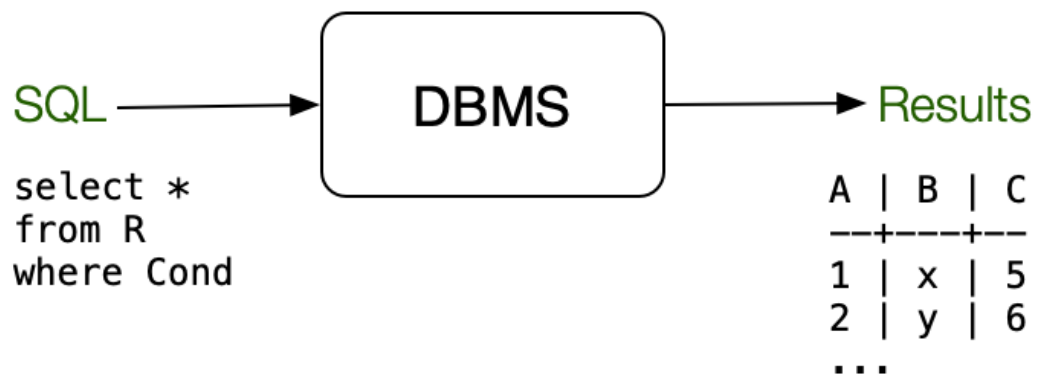
---

- DBMSs
- Query Evaluation
- Mapping SQL to RA
- Mapping Example
- Query Cost Estimation
- Implementations of RA Ops
- DBMS Architecture

## ❖ DBMSs

DBMS = DataBase Management System

Our view of the DBMS so far ...



A machine to process SQL queries.

## ❖ DBMSs (cont)

One view of DB engine: "relational algebra virtual machine"

Machine code for such a machine:

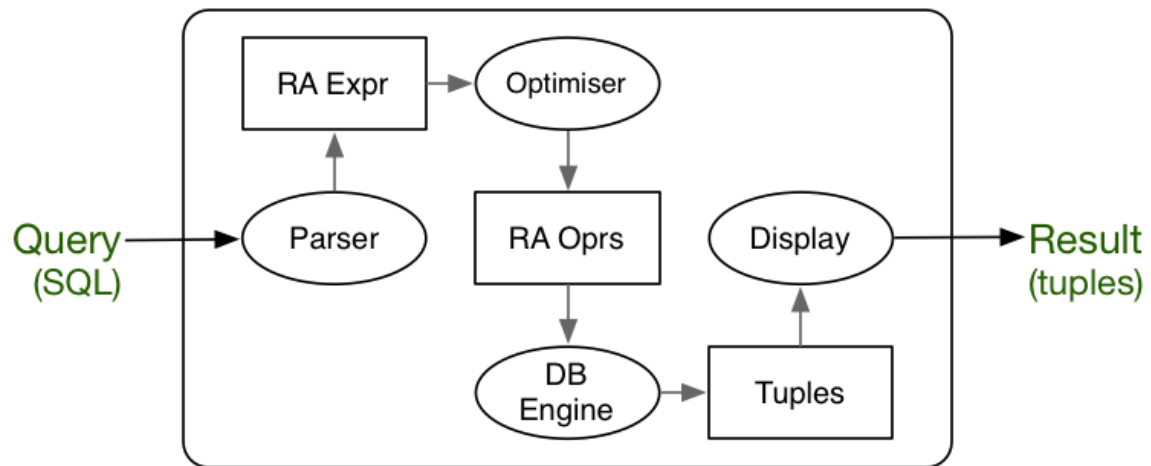
selection ( $\sigma$ )	projection ( $\pi$ )	join ( $\bowtie, \times$ )
union ( $\cup$ )	intersection ( $\cap$ )	difference ( $-$ )
sort	insert	delete

For each of these operations:

- various data structures and algorithms are available
- DBMSs may provide only one, or may provide a choice

## ❖ Query Evaluation

The path of a query through its evaluation:



## ❖ Mapping SQL to RA

Mapping SQL to relational algebra, e.g.

```
-- schema: R(a,b) S(c,d)
select a as x
from   R join S on (b=c)
where  d = 100
-- could be mapped to
Tmp1(a,b,c,d) = R Join[b=c] S
Tmp2(a,b,c,d) = Sel[d=100](Tmp1)
Tmp3(a)       = Proj[a](Tmp2)
Res(x)        = Rename[Res(x)](Tmp3)
```

In general:

- **SELECT** clause becomes *projection*
- **WHERE** condition becomes *selection* or *join*
- **FROM** clause becomes *join*

## ❖ Mapping Example

Consider the database schema:

```
Person(pid, name, address, ...)
Subject(sid, code, title, uoc, ...)
Terms(tid, code, start, end, ...)
Courses(cid, sid, tid, ...)
Enrolments(cid, pid, mark, ..)
```

and the query: *Courses with more than 100 students in them?*

which can be expressed in SQL as

```
select s.sid, s.code
from   Course c join Subject s on (c.sid=s.sid)
      join Enrolment e on (c.cid=e.cid)
group by s.sid, s.code
having count(*) > 100;
```

## ❖ Mapping Example (cont)

The SQL might be compiled to

```
Tmp1(cid,sid,pid)    = Course Join[c.cid = e.cid] Enrolment
Tmp2(cid,code,pid)   = Tmp1 Join[t1.sid = s.sid] Subject
Tmp3(cid,code,nstu)  = GroupCount[cid,code](Tmp2)
Res(cid,code)        = Sel[nstu > 100](Tmp3)
```

or, equivalently

```
Tmp1(cid,code)       = Course Join[c.sid = s.sid] Subject
Tmp2(cid,code,pid)   = Tmp1 Join[t1.cid = e.cid] Enrolment
Tmp3(cid,code,nstu)  = GroupCount[cid,code](Tmp2)
Res(cid,code)        = Sel[nstu > 100](Tmp3)
```

Which is better?

## ❖ Query Cost Estimation

---

The cost of evaluating a query is determined by

- the operations specified in the query execution plan
- size of relations (database relations and temporary relations)
- access mechanisms (indexing, hashing, sorting, join algorithms)
- size/number of main memory buffers (and replacement strategy)

Analysis of costs involves *estimating*:

- the size of intermediate results
- then, based on this, cost of secondary storage accesses

Accessing data from disk is the dominant cost in query evaluation



## ❖ Query Cost Estimation (cont)

Consider **execution plans** for:  $\sigma_c(R \bowtie_d S \bowtie_e T)$  where  $R(c,d)$ ,  $S(d,e)$ ,  $T(e)$

```
Tmp1(c,d,e)  := hash_join[d](R,S)
Tmp2(c,d,e)  := sort_merge_join[e](tmp1,T)
Res(c,d,e)   := binary_search[c](Tmp2)
```

or

```
Tmp1(d,e)    := sort_merge_join[e](S,T)
Tmp2(c,d,e)  := hash_join[d](R,Tmp1)
Res(c,d,e)   := linear_search[c](Tmp2)
```

or

```
Tmp1(c,d)    := btree_search[c](R)
Tmp2(c,d,e)  := hash_join[d](Tmp1,S)
Res(c,d,e)   := sort_merge_join[e](Tmp2,T)
```

All produce same result, but have different costs.

## ❖ Implementations of RA Ops

---

**Sorting** (quicksort, etc. are not applicable)

- external merge sort (cost  $O(N \log_B N)$  with  $B$  memory buffers)

**Selection** (different techniques developed for different query types)

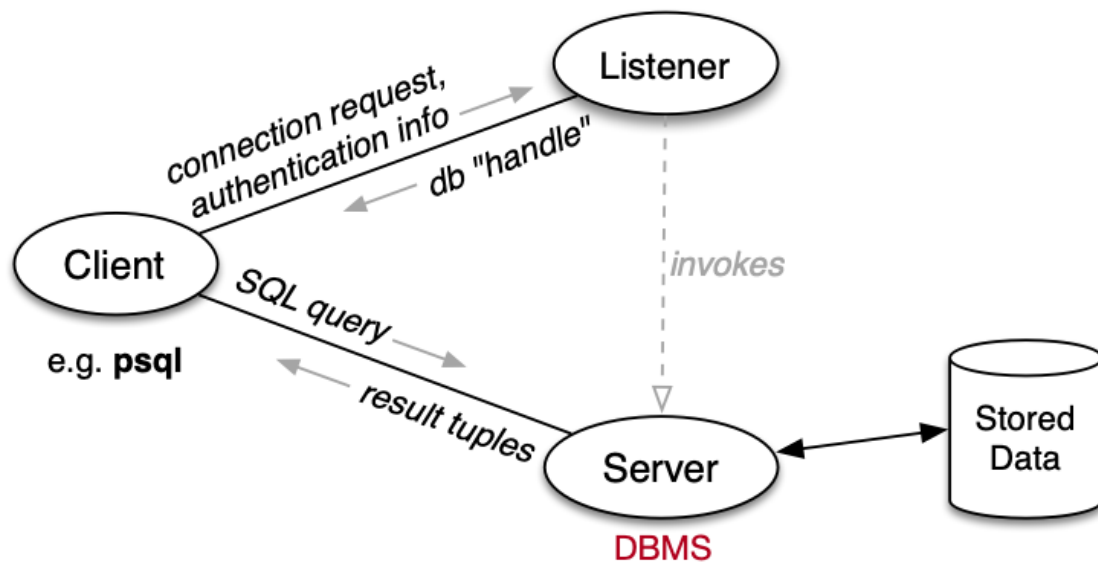
- sequential scan (worst case, cost  $O(N)$ )
- index-based (e.g. B-trees, cost  $O(\log N)$ , tree nodes are pages)
- hash-based ( $O(1)$  best case, only works for equality tests)

**Join** (fast joins are critical to success of relational DBMSs)

- nested-loop join (cost  $O(N.M)$ , buffering can reduce to  $O(N+M)$ )
- sort-merge join (cost  $O(N \log N + M \log M)$ )
- hash-join (best case cost  $O(N+M.N/B)$ , with  $B$  memory buffers)

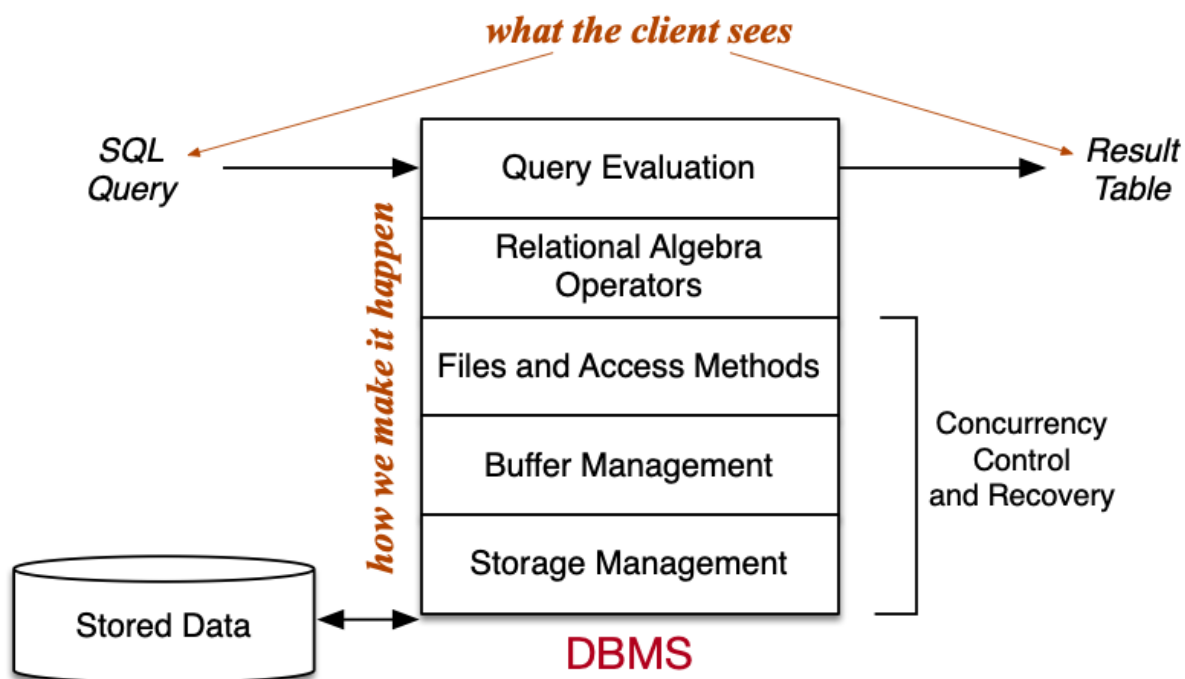
## ❖ DBMS Architecture

Most RDBMSs are client-server systems:



## ❖ DBMS Architecture (cont)

Layers within the DBMS server:



COMP9315 21T1 ◇ DBMS Overview ◇ [11/11]

Produced: 15 Feb 2021