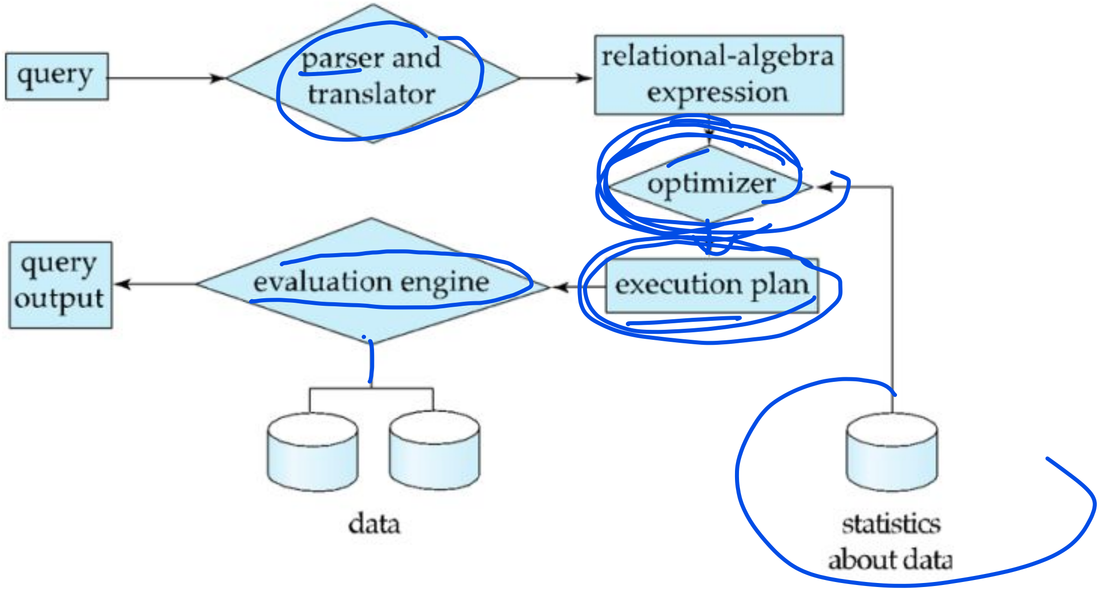
Basic Steps in Query Processing

a) Parsing and translation
b) Optimization
c) Evaluation



Basic Steps in Query Processing

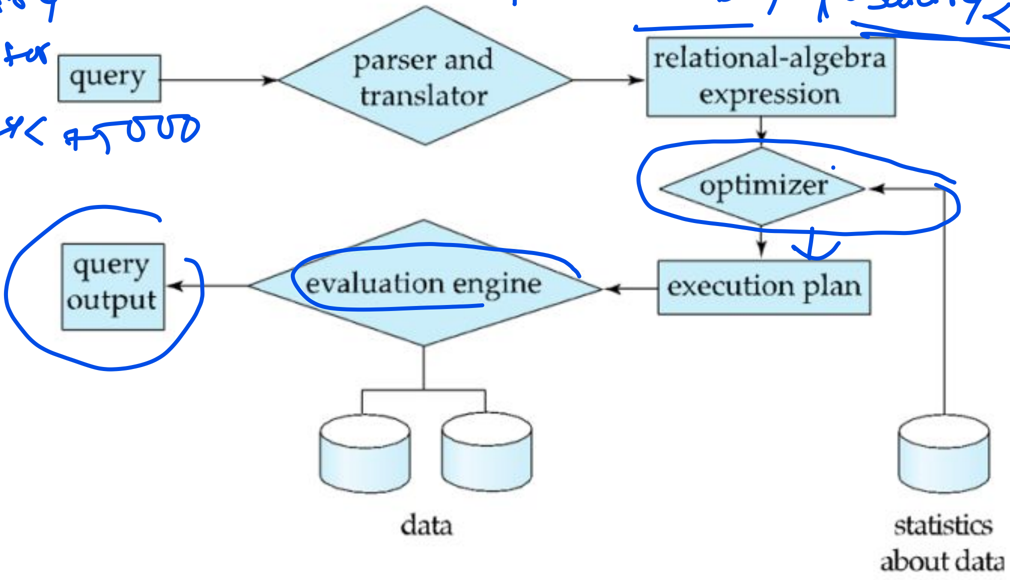
a) Parsing and translation
b) Optimization
c) Evaluation

• salary of instructor whose salary is less than 75000

$\sigma_{salary<75000}(\Pi_{salary}(instructor))$

$\Pi_{salary}(\sigma_{salary<75000}(instructor))$

select salary
from instructor
where salary < 75000



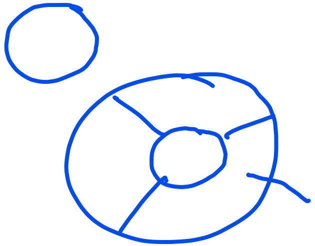
Measures of Query Cost

- Cost is generally measured as total elapsed time for answering query
  - Many factors contribute to time cost
    - *disk accesses*, *CPU*, or even network *communication*
- Typically disk access is the predominant cost, and is also relatively easy to estimate
- Measured by taking into account
  - Number of seeks * average-seek-cost
  - Number of blocks read * average-block-read-cost
  - Number of blocks written * average-block-write-cost
    - Cost to write a block is greater than cost to read a block
      - data is read back after being written to ensure that the write was successful

Measures of Query Cost (2)

we

- For simplicity we just use the **number of block transfers** *from disk and the* **number of seeks** as the cost measures
  - t_T: time to transfer one block
  - t_S: time for one seek
  - Cost for b block transfers plus S seeks



cost = $b * t_T + S * t_S$

number

=

- We ignore CPU costs for simplicity
  - Real systems do take CPU cost into account
- We do not include cost to writing output to disk in our cost formulae

one seek time + $b \times t_T$

Selection Operation: File / Index Scan

A#	Algorithm	Cost	Reason
A1	Linear Search	$t_S + b_r \times t_T$	One initial seek plus b_r block transfers
A1	Linear Search, Eq. on Key	Average case $t_S + (b_r/2) \times t_T$	Since at most one record satisfies condition, scan can be terminated as soon as the required record is found. b_r blocks transfers in worst case
A2	Prm. Index, Eq. on Key	$(h_i + 1) \times (t_T + t_S)$	Index lookup traverses the height of the tree plus one I/O to fetch the record; each of these I/O operations requires a seek and a block transfer
A3	Prm. Index, Eq. on Nonkey	$h_i \times (t_T + t_S) + b \times t_T$	One seek for each level of the tree, one seek for the first block. Here all of b are read. These blocks are leaf blocks assumed to be stored sequentially (for a primary index) and don't require additional seeks
A4	Snd. Index, Eq. on Key	$(h_i + 1) \times (t_T + t_S)$	This case is similar to primary index
A4	Snd. Index, Eq. on Nonkey	$(h_i + n) \times (t_T + t_S)$	Here, cost of index traversal is the same as for $A3$, but each record may be on a different block, requiring a seek per record. Cost is potentially very high if n is large
A5	Prm. Index, Comparison	$h_i \times (t_T + t_S) + b \times t_T$	Identical to the case of $A3$, equality on nonkey
A6	Snd. Index, Comparison	$(h_i + n) \times (t_T + t_S)$	Identical to the case of $A4$, equality on nonkey

t_T is time to transfer one block. t_S is time for one seek
b_r denotes the number of blocks in the file
b denotes the number of blocks containing records with the specified search key
h_i denotes the height of the index. n is the number of records fetched

Let us consider the following statistics for searching a condition within a given relation.

- Number of blocks containing record of the relation (b) = 200
- Time to transfer one block (tb) = 0.6 milliseconds
- Time for one seek (ts) = 8 milliseconds

What will be the cost of selection query using linear search file scan

Linear seer

cost = 8 + 0.6 × 200

= 8 + 120 mil

= 128 ms

Average case onk

$= 8 + \frac{0.6 \times 200}{2}$

$= 8 + 0.6 \times 100$

= 68 ms

Join Operation

- Several different algorithms to implement joins
  - **Nested-loop join**
  - **Block nested-loop join**
  - **Indexed nested-loop join**
  - Merge-join
  - Hash-join
- Choice based on cost estimate
- Examples use the following information
  - Number of records of *student*: $n_{students} = 5{,}000$
  - Number of records of *takes*: $n_{takes} = 10{,}000$
  - Number of blocks of *student*: $b_{students} = 100$
  - Number of blocks of *takes*: $b_{takes} = 400$

Nested-Loop Join

- To compute the theta join r $\bowtie_\theta$ s

  for each tuple t_r **in** r **do begin**

      for each tuple t_s **in** s **do begin**

          test pair (t_r, t_s) to see if they satisfy the join condition θ

          if they do, add $t_r \bullet t_s$ to the result.

      end

  end

- r is called the **outer relation** and s the **inner relation** of the join
- Requires no indices and can be used with any kind of join condition
- Expensive since it examines every pair of tuples in the two relations

Studens

take

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main memory Buff

S

Student outer relati

worst

Name	ID
Raj	101
Ram	102
Rakesh	103
Shyam	104
Arijit	105
Rudra	106
advik	107
Adi	108
Ravi	109

takes tab

ID	Course_id
101	C01
104	C03
106	C02
106	C04
109	C01
108	C11

ID n

Raj	101
Ram	102
Rak	1.

101	C0
104	C2

Name	ID

Raj	101
Ram	102
Rakesh	103

Shyam	104
Arijit	105
Rudra	106

advik	107
Adi	108
Ravi	109

ID	Course_id

101	C01
104	C03

106	C02
106	C04

109	C01
108	C11

n_r : number of record in outer relatio

b_r = number of block in outer relati

n_s : number record in inner relati

b_s : " block " " "

$\boxed{\text{nubler of block transfer} = n_r \times b_s + b_r}$

Number of seek require = $n_r + b_r$

Consider the information given on relation **project** and relation **allotment** in Table 1, and answer the questions 11 and 12.

Relation	Number of records	Number of blocks
project	2,000	200
allotment	9,000	600

Table 1: Information on **project** and **allotment**

number of block inner rel

$= n_r \times b_s + b_r$

number of record in outer relation

block in outer rel

11. Consider worst-case memory availability. Assuming **allotment** as outer relation, identify the correct cost estimate for the **nested-loop join** of **allotment** and **project**.

1,200,200 block transfers and 2,200 seeks

1,800,600 block transfers and 9,600 seeks

120,200 block transfers and 400 seeks

120,600 block transfers and 1200 seeks

$= n_r + b_r$

$= 9000 \times 200 + 600$

$= 1800600$ bh

seek $= 9000 + 600$

$= 960$

Consider the information given on relation **job** and relation **assignment** in Table 1, and answer the questions 5 and 6.

Relation	Number of records	Number of blocks
job	3,000	100
assignment	5,000	300

Table 1: Information about **job** and **assignment**

block

$= n_r * b_s + b_r$

$= 5000 \times 100 + 300$

$= 500300$ block

5. Consider worst-case memory availability. Assuming **assignment** as outer relation, identify the correct cost estimate for **nested-loop join** of **assignment** and **job**.

$n_r + b_r$

Seek $= 5000 + 300$

9,00,100 block transfers and 3,300 seeks

5,00,300 block transfers and 5,300 seeks

30,100 block transfers and 200 seeks

30,300 block transfers and 600 seeks

Block nested loop Join

Raj	101
Ram	102
Rakesh	103

C01	C02
104	C03

main memory

Student

Name	ID
Raj	101
Ram	102
Rakesh	103
Shyam	104
Arijit	105
Rudra	106
advik	107
Adi	108
Ravi	109

teacher

ID	Course_id
101	C01
104	C03
106	C02
106	C04
109	C01
108	C11

1:1

Name	ID
Raj	101
Ram	102
Rakesh	103
Shyam	104
Arijit	105
Rudra	106
advik	107
Adi	108
Ravi	109

ID	Course_id
101	C01
104	C03
106	C02
106	C04
109	C01
108	C11

nuber ~~of~~ block trans = br x bs + br

~~seek~~ s require = 2 br

Consider the information given on relation **project** and relation **allotment** in Table 1, and answer the questions 11 and 12.

Relation	Number of records	Number of blocks
project	2,000	200
allotment	9,000	600

Table 1: Information on **project** and **allotment**

$b_o \times b_s + b_r$

12. Consider worst-case memory availability. Assuming **allotment** as outer relation, identify the correct cost estimate for **block nested-loop join** of **allotment** and **project**.

- 1,200,200 block transfers and 2,200 seeks
- 1,800,600 block transfers and 9,600 seeks
- 120,200 block transfers and 400 seeks
- 120,600 block transfers and 1200 seeks

$= 600 \times 200 \; 600$

$= 120600$ bl

$2 \times b_o = 2 \cdot 600 = 1200$

Consider the information given on relation **job** and relation **assignment** in Table 1, and answer the questions 5 and 6.

Relation	Number of records	Number of blocks
job	3,000	100
assignment	5,000	300

Table 1: Information about **job** and **assignment**

6. Consider worst-case memory availability. Assuming **assignment** as outer relation, identify the correct cost estimate for **block nested-loop join** of **assignment** and **job**.

- 9,00,100 block transfers and 3,300 seeks
- 5,00,300 block transfers and 5,300 seeks
- 30,100 block transfers and 200 seeks
- 30,300 block transfers and 600 seeks

$= b_r \times b_s + b$

$= 300 \times 100 \times 300$

$= 30300$

$= 2 \times b_r$

$= 2 \times 300$

$= 600$