COL 362 & COL 632

Processing SQL – Intro to QOpt, and Storage

15 Feb 2023

Blocking and pipelined execution
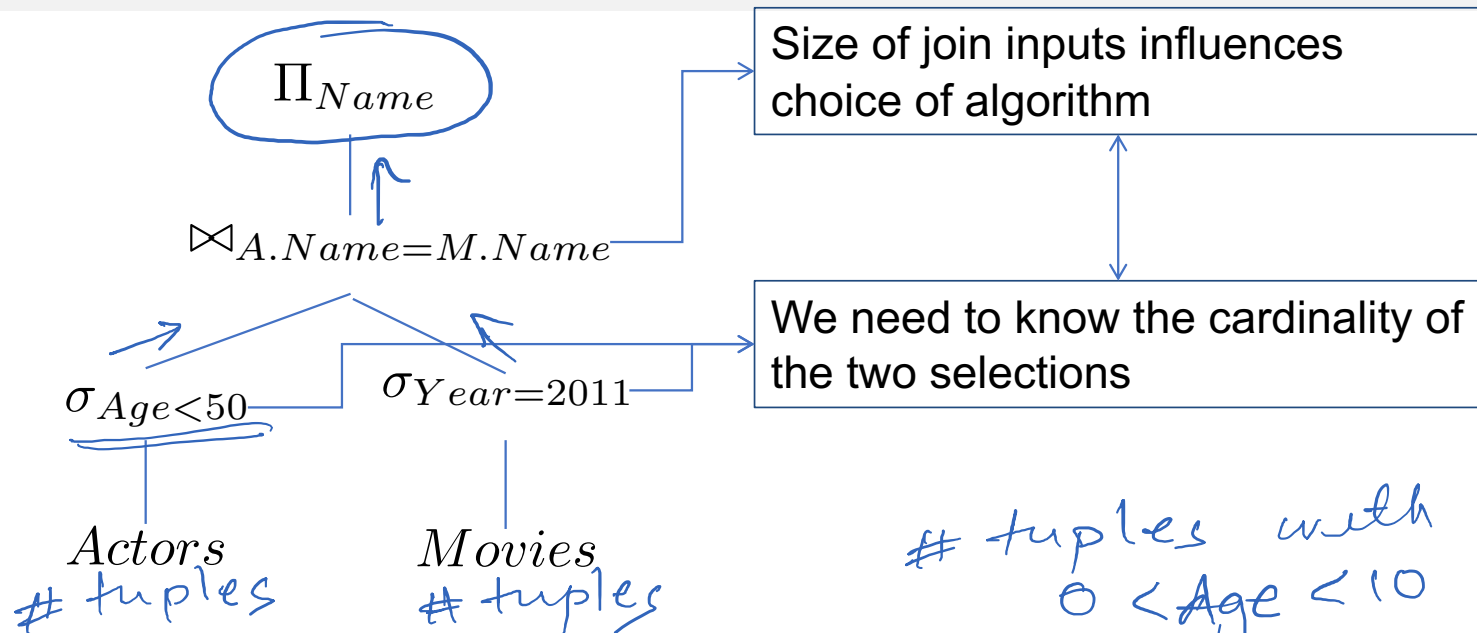
$$\Pi_{Name}$$

Can execute projection, before completing join

$$\bowtie_{A.Name=M.Name}$$

Can start executing the join, before completing selection

$$\sigma_{Age<50}$$ $$\sigma_{Year=2011}$$

Actors   *Movies*
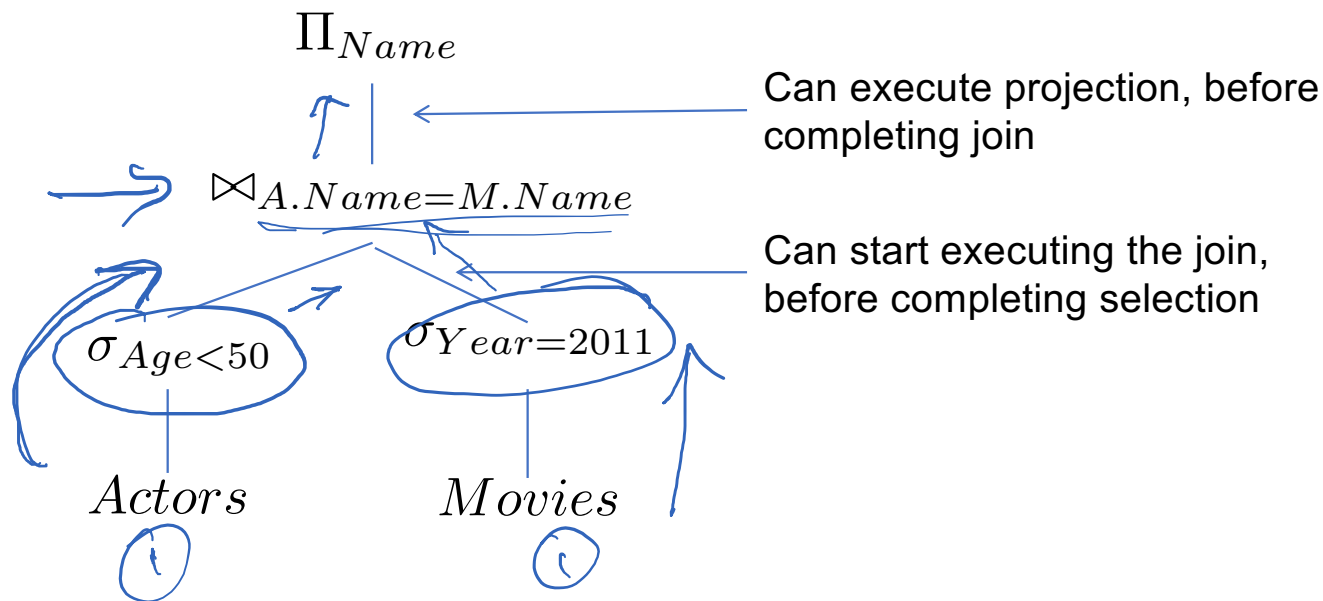
What operators are blocking?

Choosing the right operator

- Materialize or pipeline?
- Sort? Index-based? Hash-based?

- Depends on the size of (intermediate) relation
  - Determines amount of main memory required
- "What is the next operator?"
  - Use sort-based, if there is an `ORDER BY` ahead

Cardinality Estimation (1/2)

Π_{Name}

$\bowtie_{A.Name=M.Name}$

$\sigma_{Age<50}$

$\sigma_{Year=2011}$

Actors
tuples

Movies
tuples

Size of join inputs influences choice of algorithm

We need to know the cardinality of the two selections

tuples with
$0 < Age < 10 = 5$ +

tuples with
$10 \leq Age < 25 = 15$

Cardinality Estimation (2/2)

- Order of joins matters a lot

$$R \bowtie S \bowtie T$$

- Is it better to join R and S, then T? Or R and T, then S? Or…?
  - Depends on the cardinality
  - Also on other things…

Estimating Cardinalities

- Collect and store statistics about the data
  - What to collect?
  - Statistical summaries should be very small
- Estimate cardinalities for various operators
  - How to use the stats to estimate the cardinalities?
- Up-to-date statistics
  - Accurate statistics lead to accurate estimates

How can you force PostgreSQL to collect statistics?

Statistics in the system
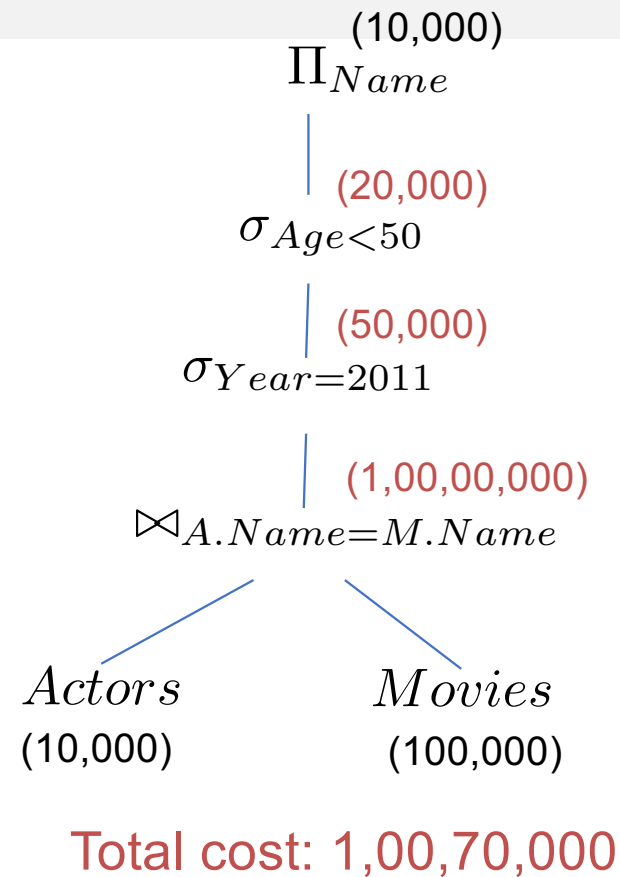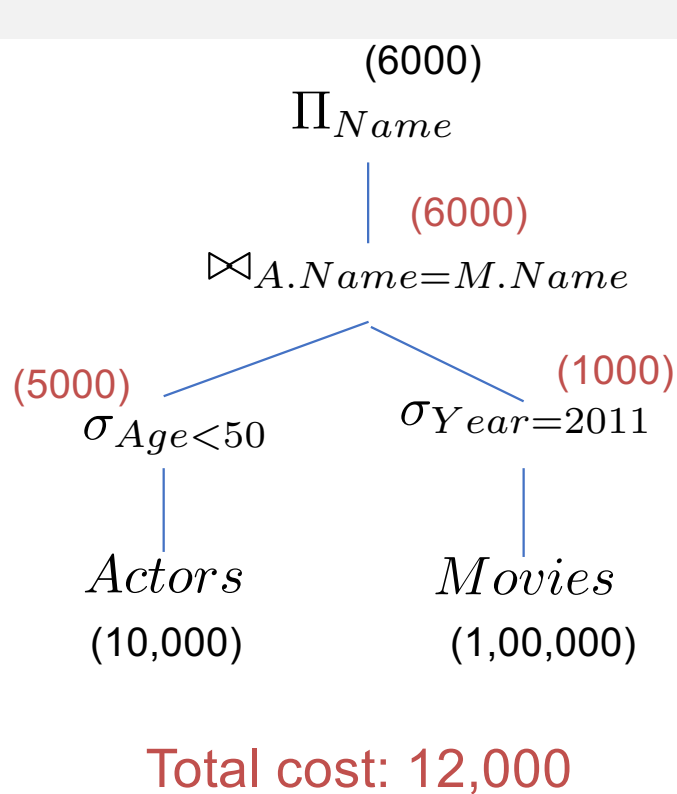
- For table T
  - total number of tuples ✓
  - no. of disk blocks
- For a given attribute
  - Min/max values, no. of distinct values
  - Histogram of values

width of a tuple (# of bytes)

Pg-statistic

Vaccuum

What statistics does PostgreSQL collect?

Comparing query plans

Left plan:

(6000)
Π_{Name}

(6000)
$\bowtie_{A.Name=M.Name}$

(5000)
$\sigma_{Age<50}$

(1000)
$\sigma_{Year=2011}$

$Actors$
$(10,000)$

$Movies$
$(1,00,000)$

Total cost: 12,000

Right plan:

$(10,000)$
Π_{Name}

$(20,000)$
$\sigma_{Age<50}$

$(50,000)$
$\sigma_{Year=2011}$

$(1,00,00,000)$
$\bowtie_{A.Name=M.Name}$

$Actors$
$(10,000)$

$Movies$
$(100,000)$

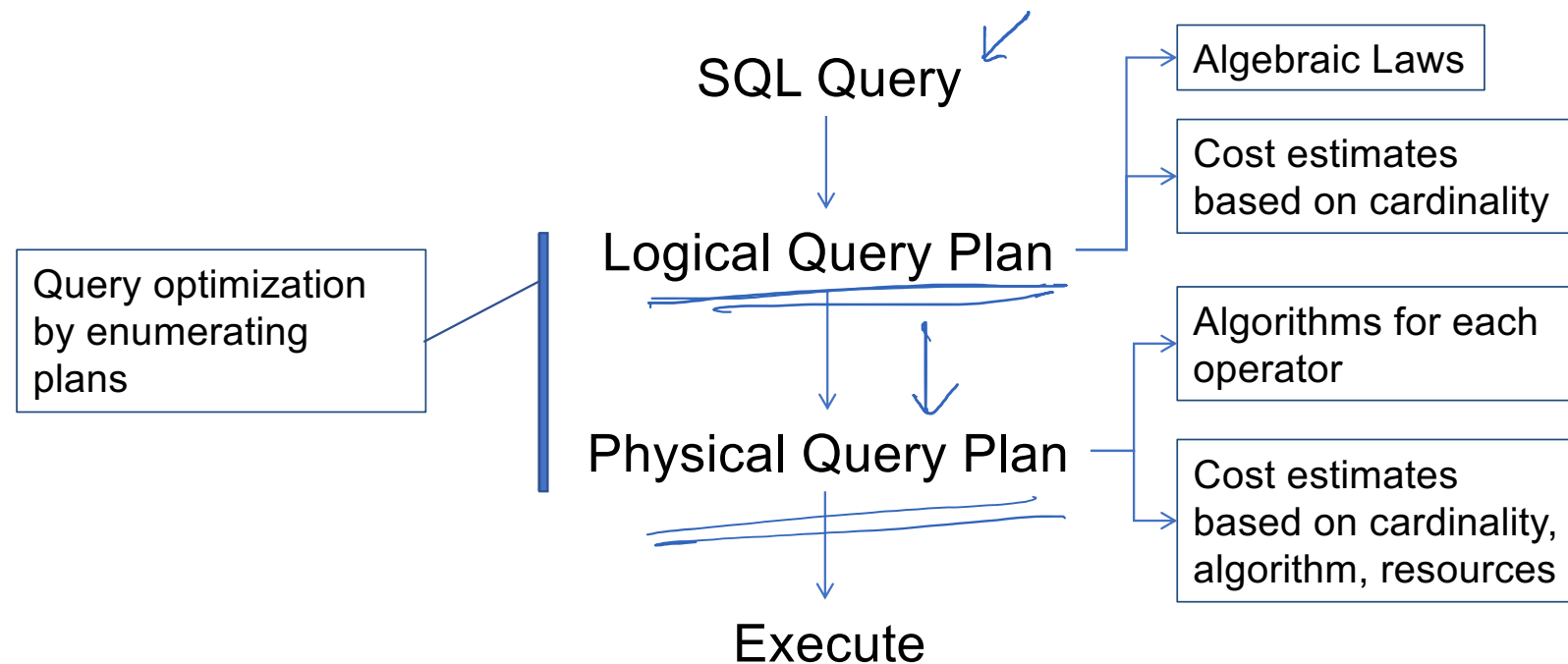Total cost: 1,00,70,000

Query plan enumeration

- Top-down
  - Start from the root
  - For each implementation of the root operator, consider all implementations of its children

- Bottom-up
  - For each sub-expression, compute costs of evaluating in all possible ways
  - Dynamic programming

System R

↕

Volcano

Summary

SQL Query

Algebraic Laws

Cost estimates based on cardinality

Query optimization by enumerating plans

Logical Query Plan

Algorithms for each operator

Physical Query Plan

Cost estimates based on cardinality, algorithm, resources

Execute

Storage

Classification of Physical Storage Media

- Speed with which data can be accessed
- Cost per unit of data
- Reliability
  - data loss on power failure or system crash
  - physical failure of the storage device
- Can differentiate storage into:
  - volatile storage: loses contents when power is switched off
  - non-volatile storage:
    - Contents persist even when power is switched off.
    - Includes secondary and tertiary storage, as well as battery-backed up main-memory.

Storage Hierarchy
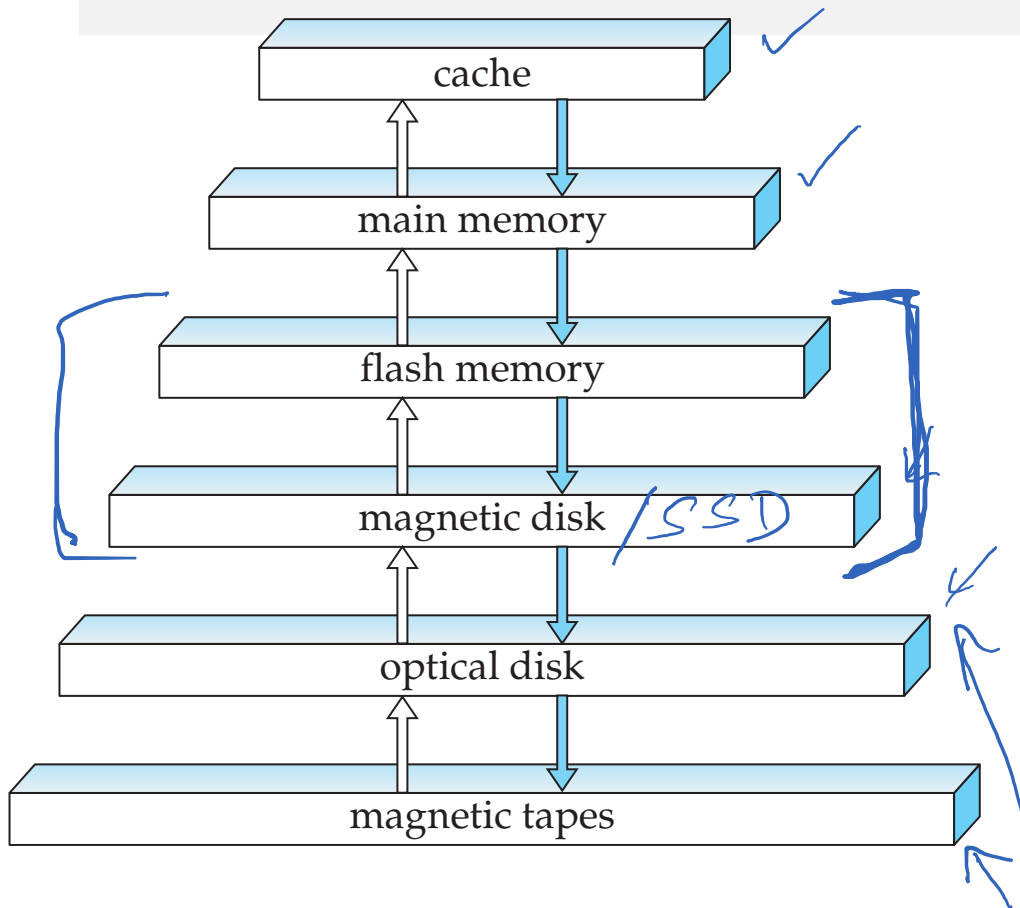
- Cache
  - Fastest, costliest
- Main Memory
- Flash
  - NAND and NOR flash
  - Used in phones, USB sticks, as SSDs
- Magnetic Disk
- Optical Storage
  - CDs, DVDs
- Tape storage