QUERY OPTIMIZATION

CS 564- Fall 2015

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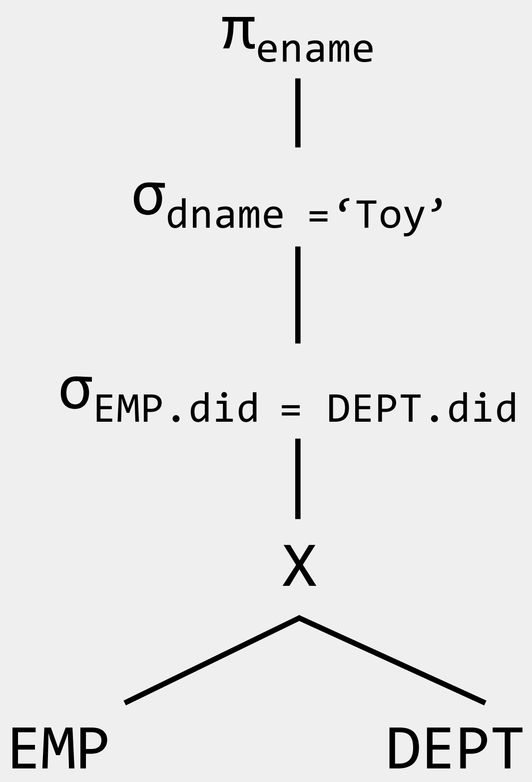
EXAMPLE QUERY

- EMP(ssn, ename, addr, sal, did)
  - 10000 tuples, 1000 pages
- DEPT(did, dname, floor, mgr)
  - 500 tuples, 50 pages

```
SELECT DISTINCT ename
FROM   Emp E, Dept D
WHERE  E.did = D.did
AND    D.dname = 'Toy' ;
```

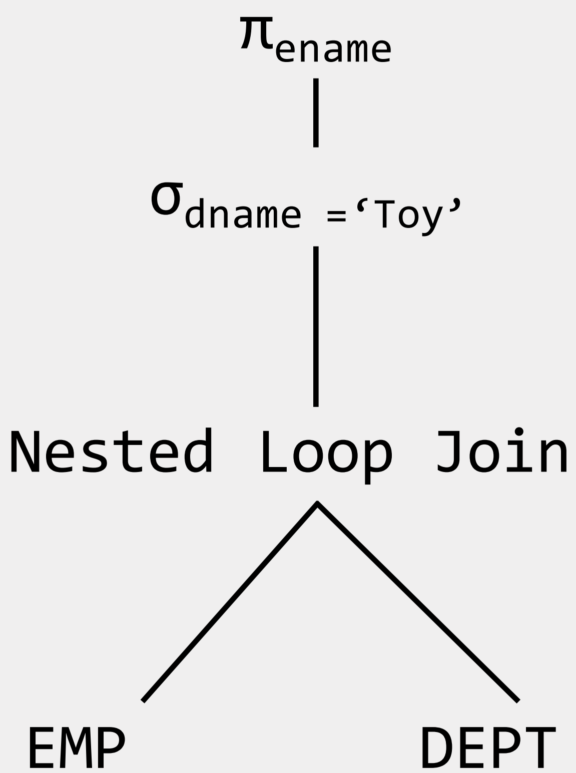
Evaluation Plan (1)

```
SELECT DISTINCT ename
FROM   Emp E, Dept D
WHERE  E.did = D.did
AND    D.dname = 'Toy';
```



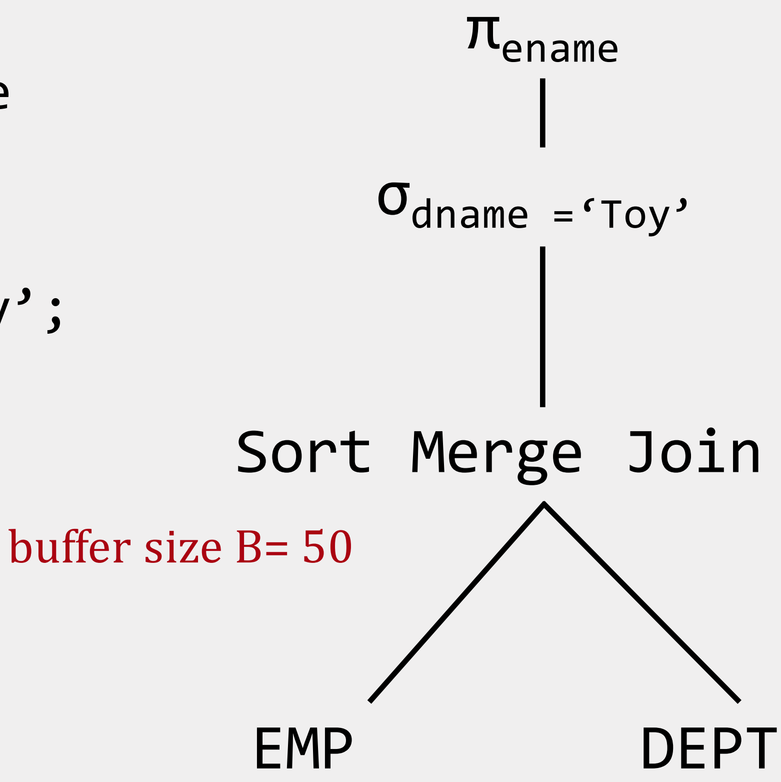
Evaluation Plan (2)

```
SELECT DISTINCT ename
FROM    Emp E, Dept D
WHERE   E.did = D.did
AND     D.dname = ‘Toy’;
```



Evaluation Plan (3)

```
SELECT DISTINCT ename
FROM   Emp E, Dept D
WHERE  E.did = D.did
AND    D.dname = 'Toy';
```



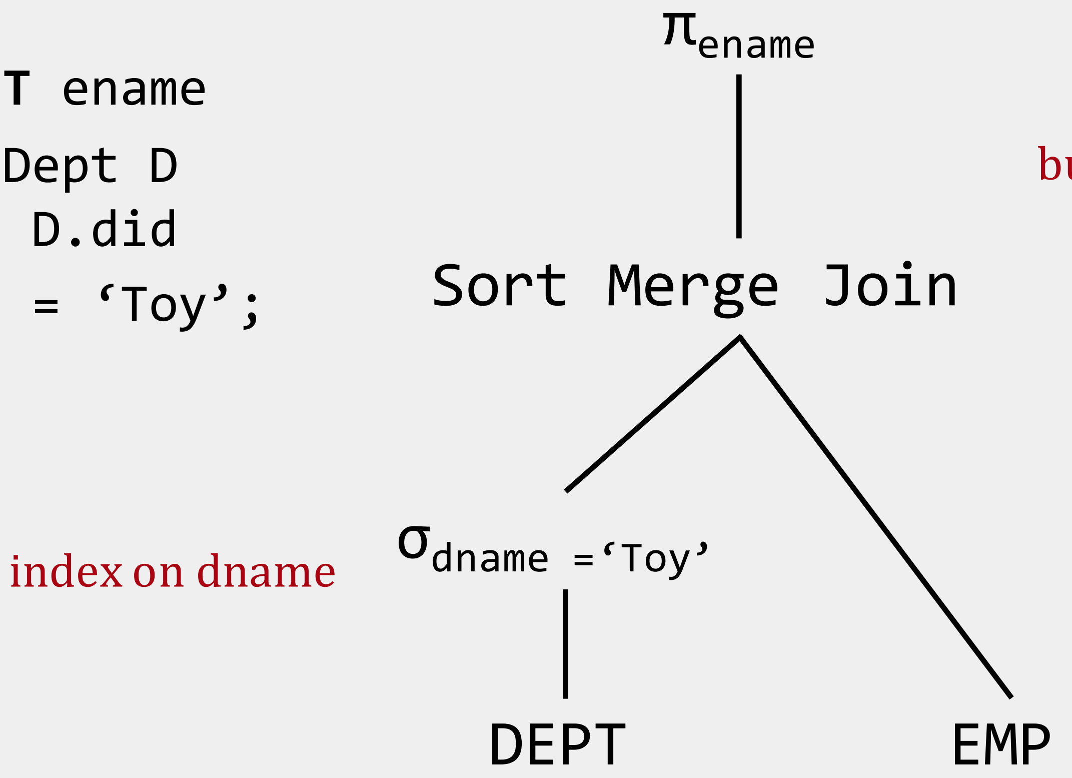
Pipelined Evaluation

Instead of materializing the temporary relation to disk, we can instead pipeline to the next operator

- How much cost does it save?
- When can pipelining be used?

Evaluation Plan (4)

```
SELECT DISTINCT ename
FROM   Emp E, Dept D
WHERE  E.did = D.did
AND    D.dname = 'Toy';
```



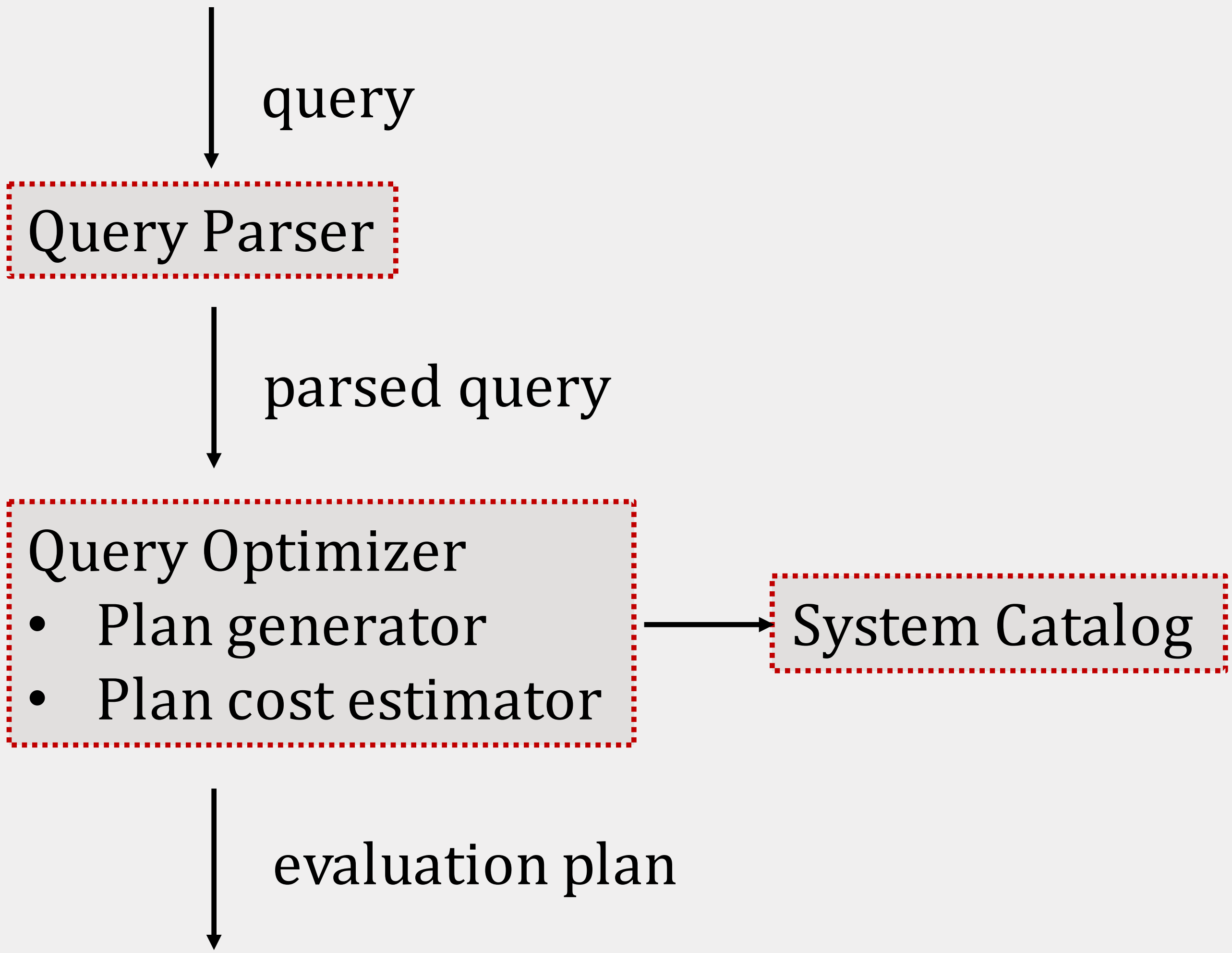
buffer size B= 50

Query Optimization

- identify candidate equivalent trees
- for each candidate find best annotated version (using available indexes)
- choose the best overall by estimating the cost of each plan

In practice we choose from a subset of possible plans

ARCHITECTURE OF AN OPTIMIZER



QUERY OPTIMIZATION

- Plan: Annotated RA Tree
  - operator interface: open/getNext/close
  - pipelined or materialized
- Two main issues:
  - What plans are considered?
  - How is the cost of a plan estimated?
- Ideally: best plan!
- Practically: avoid worst plans! Look at a subset of all plans

Cost Estimation

- Estimate the cost of each operation in the plan
  - depends on input cardinalities
  - algorithm cost (we know this!)
- Estimate the size of result
  - statistics about input relations
  - for selections and joins, we assume independence of predicates

Cost Estimation

- Statistics stored in the catalogs
  - cardinality
  - size in pages
  - # distinct keys (for index)
  - range (for numeric values)
- Catalogs update periodically
- Commercial systems use histograms, which give more accurate estimates

Evaluation Plans

- There is a huge space of plans to navigate through
- Relational algebra equivalences help to construct many alternative plans

EQUIVALENCE (1)

- Commutativity of σ

  $\sigma_{P_1}(\sigma_{P_2}(R)) \equiv \sigma_{P_2}(\sigma_{P_1}(R))$

- Cascading of σ

  $\sigma_{P_1 \wedge P_2 \wedge \cdots \wedge P_n}(R) \equiv \sigma_{P_1}(\sigma_{P_2}(\ldots \sigma_{P_n}(R)))$

- Cascading of π

  $\pi_{\alpha_1}(R) \equiv \pi_{\alpha_1}(\pi_{\alpha_2}(\ldots\pi_{\alpha_n}(R) \ldots))$ when $a_i \subseteq a_{i+1}$

This means that we can evaluate selections in any order!

EQUIVALENCE (2)

- Commutativity of join

$$R \bowtie S \equiv S \bowtie R$$

- Associativity of join

$$(R \bowtie S) \bowtie T \equiv R \bowtie (S \bowtie T)$$

This means that we can reorder the computation of joins in any way!

EQUIVALENCE (3)

- Selections + Projections

$\sigma_{\mathrm{P}}\ (\pi_a(R)) \ \equiv \pi_a(\sigma_P(R))$ (if the selection involves attributes that remain after projection)

- Selections + Joins

$\sigma_{\mathrm{P}}(R \bowtie S) \equiv \sigma_{\mathrm{P}}(R) \bowtie S$ (if the selection involves attributes only in S)

This means that we can push selections down the plan tree!

Evaluation Plans

Single relation plan (no joins)

- file scan
- index scan(s): clustered or non-clustered
  - More than one index may “match” predicates
- Choose the one with the least estimated cost
- Merge/pipeline selection and projection (and aggregate)
  - Index aggregate evaluation

Evaluation Plans

Multiple relation plan

- selections can be combined into joins
- joins can be reordered
- selections and projections can be pushed down the plan tree

JOIN REORDERING

Consider the following join: $R \bowtie S \bowtie T \bowtie U$

- Left-deep join plans
- Allow for fully pipelined evaluation