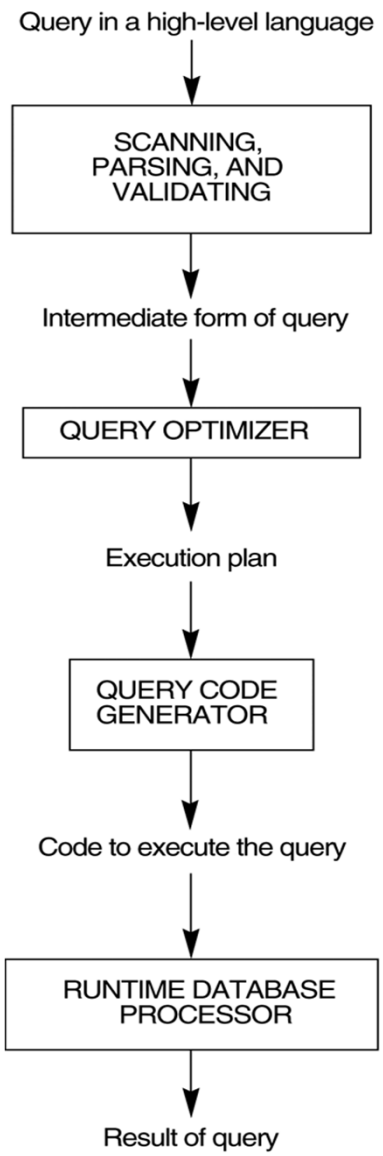
Algorithms for Query Processing And Optimization



Code can be:

- Executed directly (interpreted mode)
- Stored and executed later whenever needed (compiled mode)

Query optimization

- A query typically has many possible execution strategies, and the process of choosing a suitable one for processing a query is known as **query optimization**.

QUERY BLOCK

- A **query block** contains a **single**
  SELECT-FROM-WHERE
  expression (may contain GROUP BY and HAVING)

- Nested queries are not query blocks, but are identified as separate query blocks

- SQL queries are first decomposed into query blocks, then translated into equivalent extended relational algebra expressions

Translating SQL Queries Into Relational Algebra

For example, the following compound query

```
SELECT    FNAME, LNAME
FROM      EMPLOYEE
WHERE     SALARY > (SELECT    MAX(SALARY)
                    FROM      EMPLOYEE
                    WHERE     DNO=5);
```

Can be decomposed into two blocks:

```
SELECT    FNAME, LNAME
FROM      EMPLOYEE
WHERE     SALARY > c
```

And

```
SELECT    MAX(SALARY)
FROM      EMPLOYEE
WHERE     DNO=5
```

Where ‘c’ is the result returned from the inner query block.

- The inner query block (which need to be calculated first) could be translated into the expression

$$\delta_{\text{<MAX SALARY>}} (\sigma_{\text{<DNO=5>}} (\text{EMPLOYEE}))$$

And the outer block into the expression

$$\pi_{\text{<FNAME, LNAME>}} (\sigma_{\text{<SALARY > c>}} (\text{EMPLOYEE}))$$

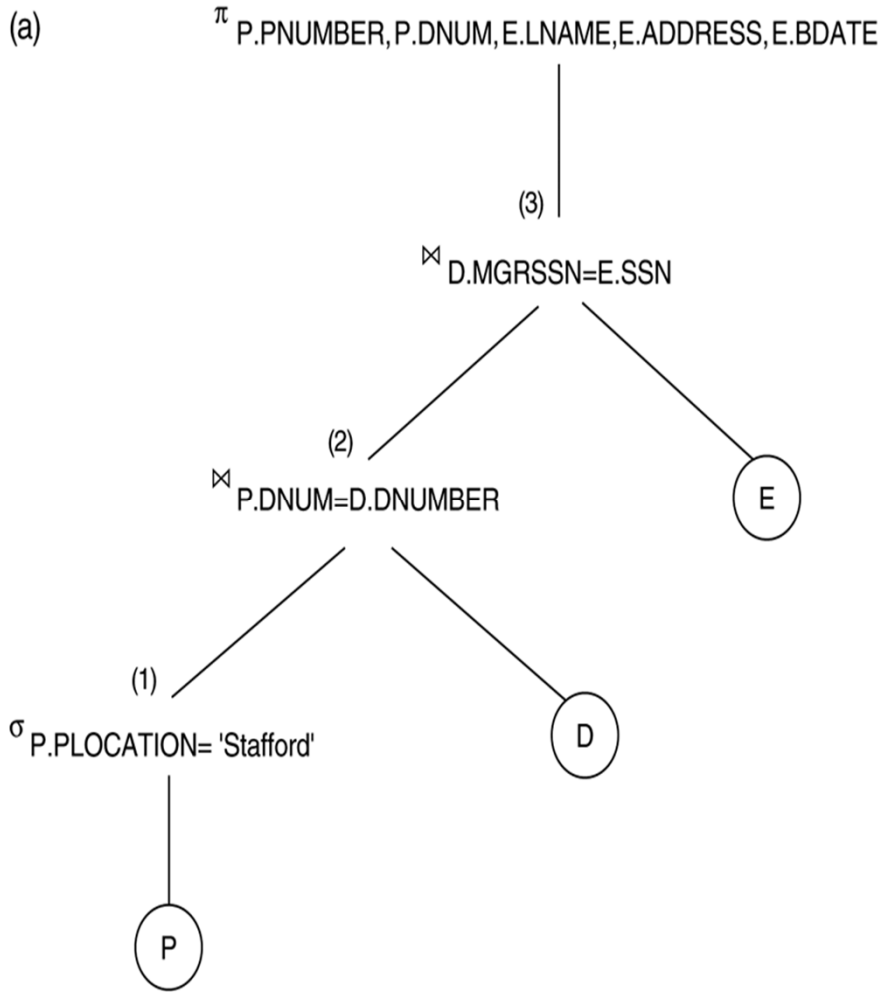
The query optimizer would then chooses an execution plan for each block.

Using Heuristics in Query Optimization

- The parser first generates an initial internal representation, the uses heuristic rules to optimize
- One of the main **heuristic rules** is to apply the unary operations ‘σ’ and ‘π’ before ⋈ or other binary operations
- A **query tree** is a tree data structure that represents the input relations of the query as **leaf nodes** and the relational algebra operations as **internal nodes**.

Query tree corresponding to the relational algebra expression for the SQL query

SELECT PNUMBER, DNUM, LNAME, ADDRESS, BDATE
FROM PROJECT, DEPARTMENT, EMPLOYEE
WHERE DNUM=DNUMBER AND MGRSSN=SSN AND PLOCATION='Stafford'



Using Heuristics in Query Optimization

- Execution of the query tree:

  1. Execute an internal node operation whenever its operands are available and then replace the internal node by the resulting operation.

  2. Repeat step 1 as long as there are leaves in the tree, that is, the execution terminates the root node is executed and produces the result relation for the query.

- A more natural representation of a query is the **query graph** notation.

Using Heuristics in Query Optimization

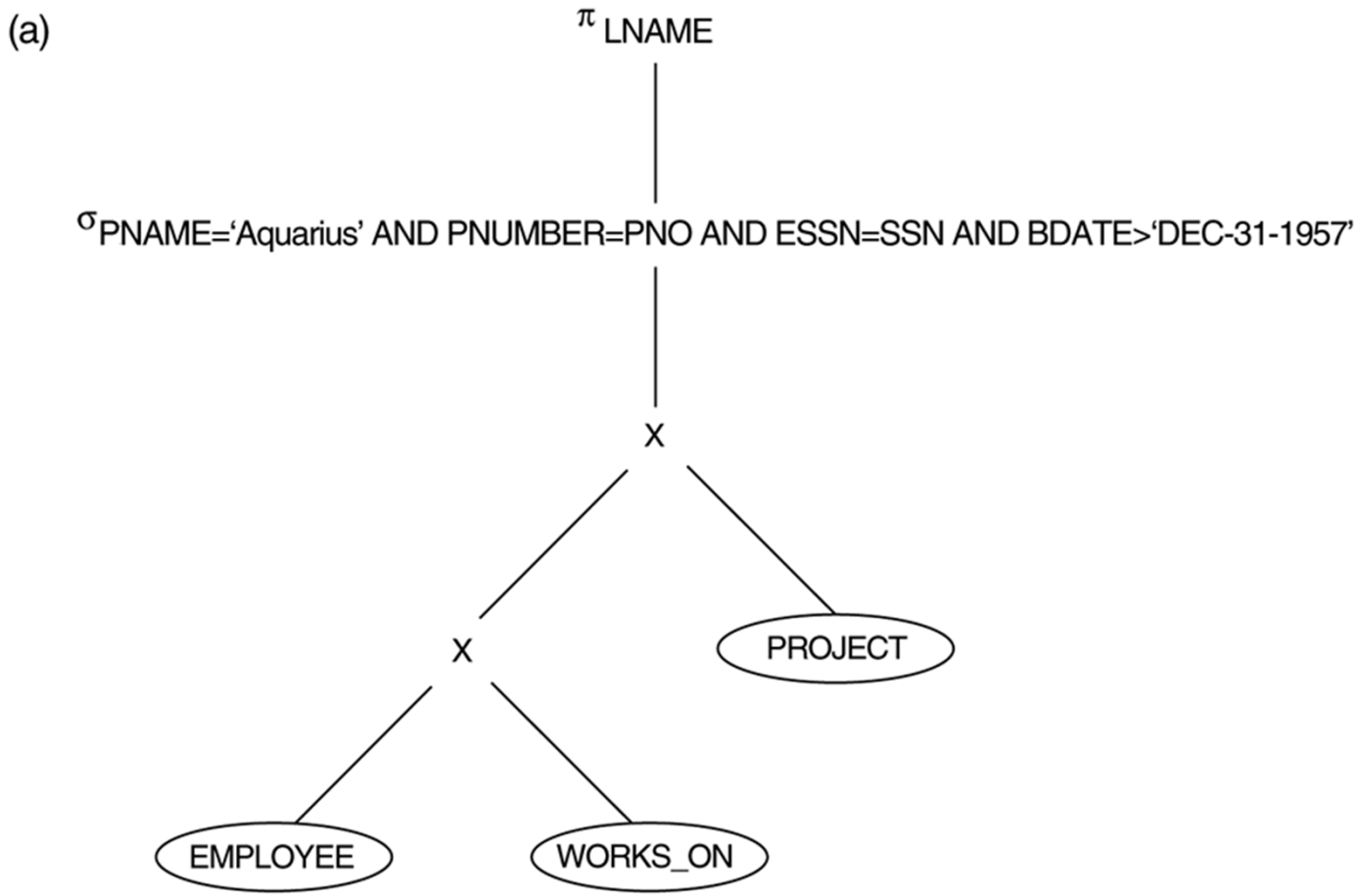
- Example of Transforming a Query:

  Consider the query Q that states “Find the last names of employees born after 1957 who work on a project named ‘Aquarius’.”

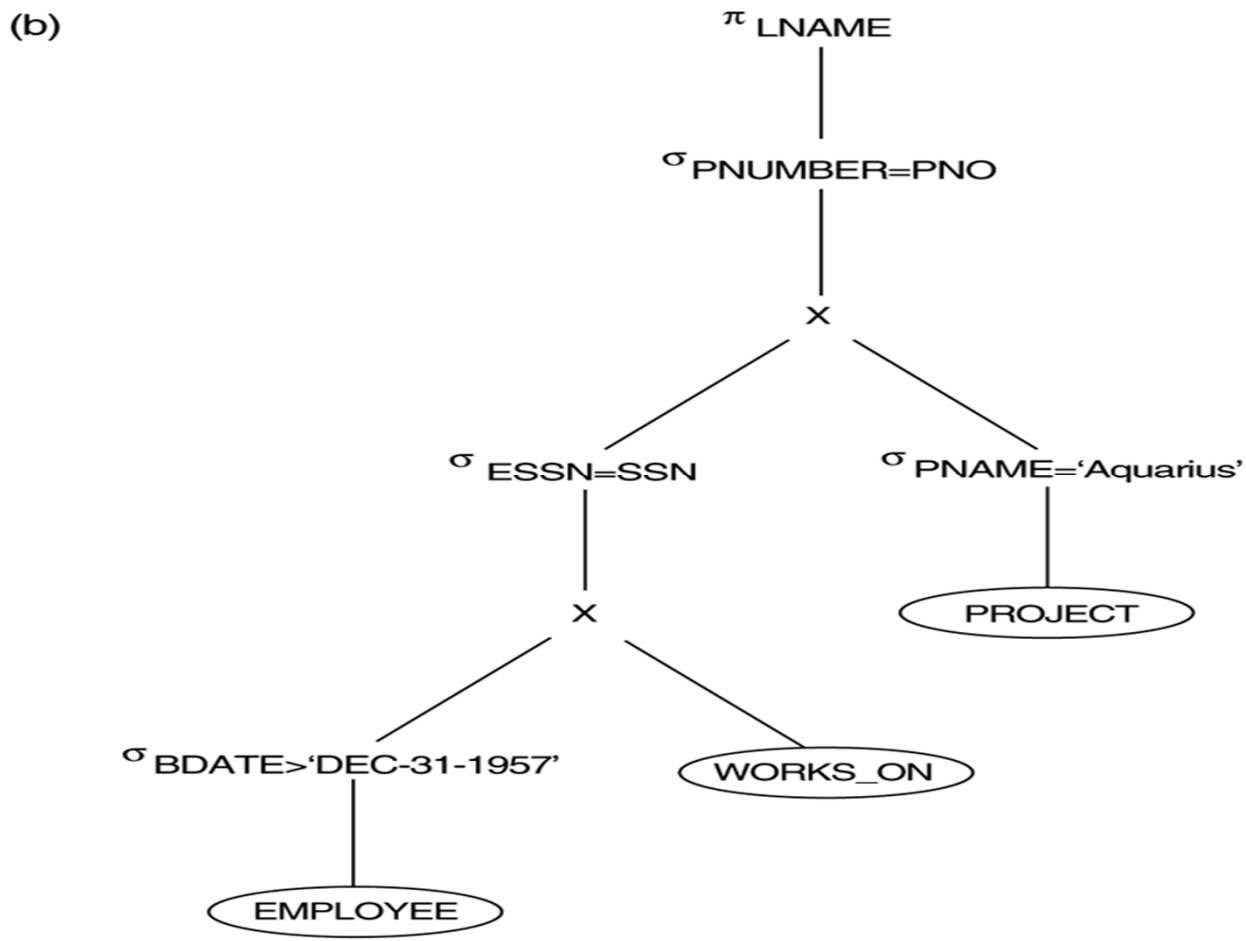
In SQL, this query can be specified as:

```
SELECT    LNAME
FROM      EMPLOYEE, WORKS_ON, PROJECT
WHERE     PNAME='Aquarius' AND ESSN=SSN
                    AND PNUMBER=PNO
                    AND BDATE > '1957-12-31';
```

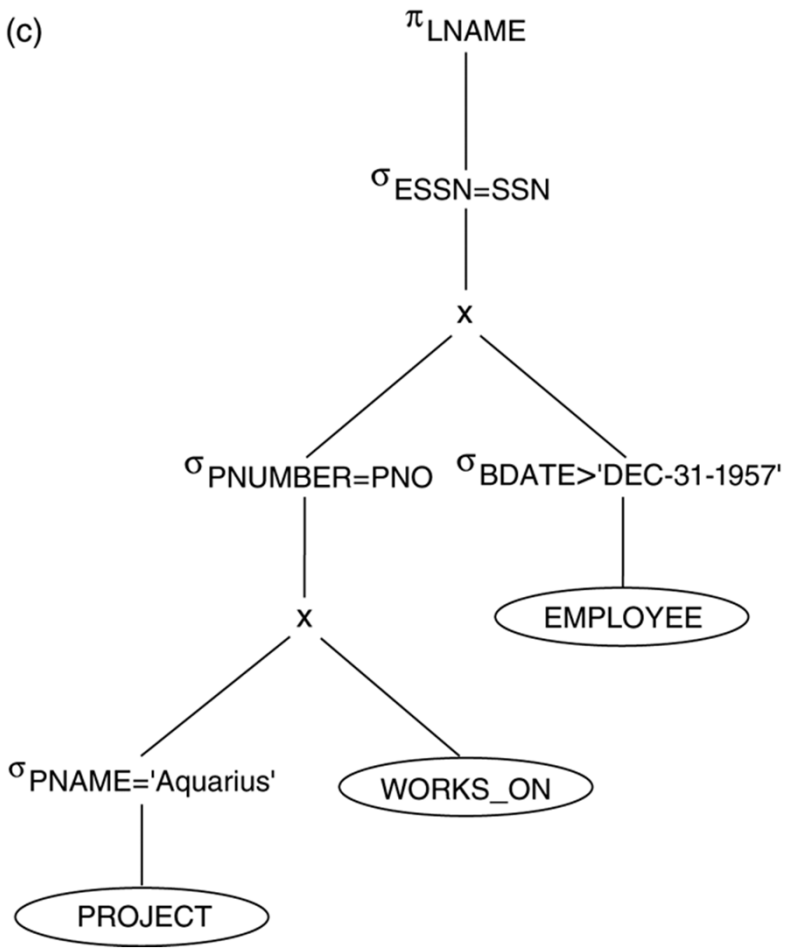
Steps in converting a query tree during heuristic optimization.
Initial (canonical) query tree for SQL query



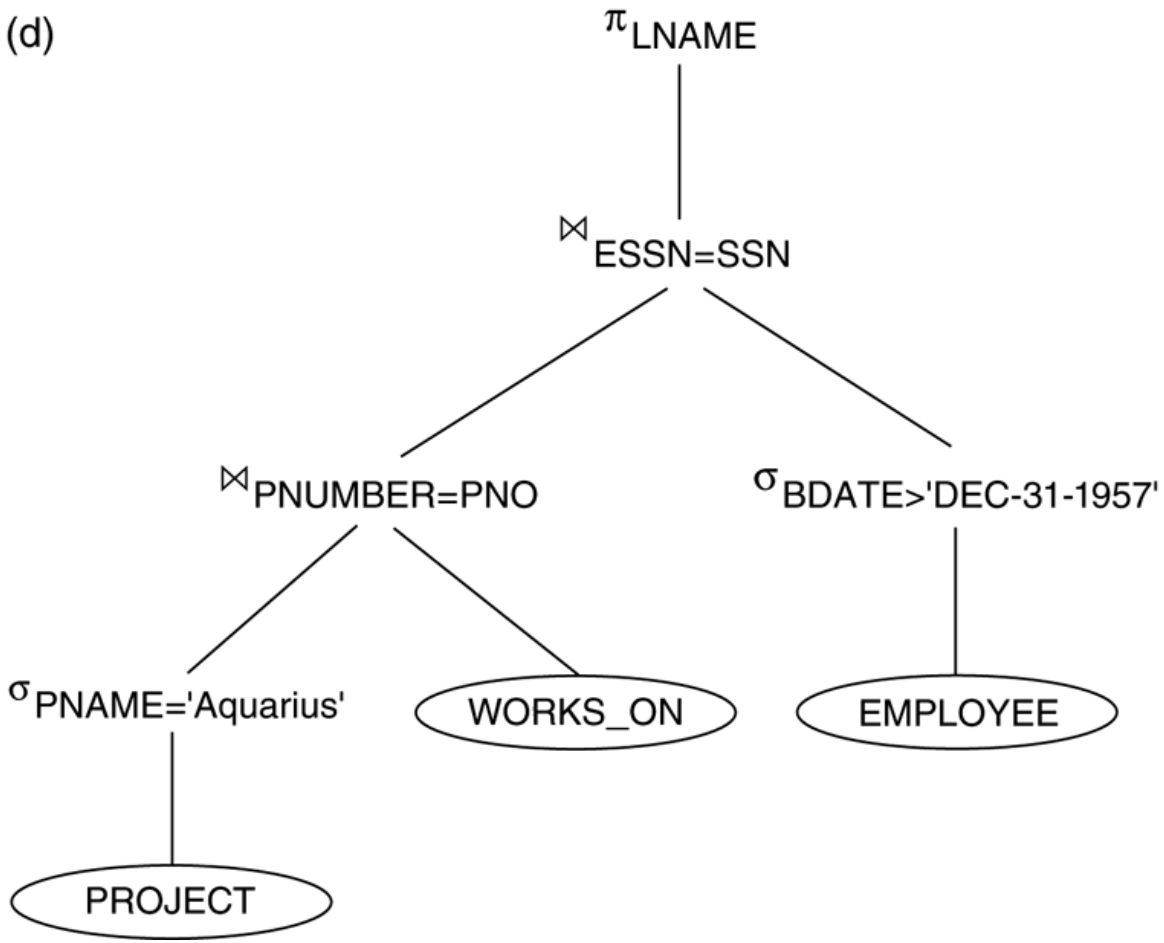
Moving SELECT operations down the query tree.



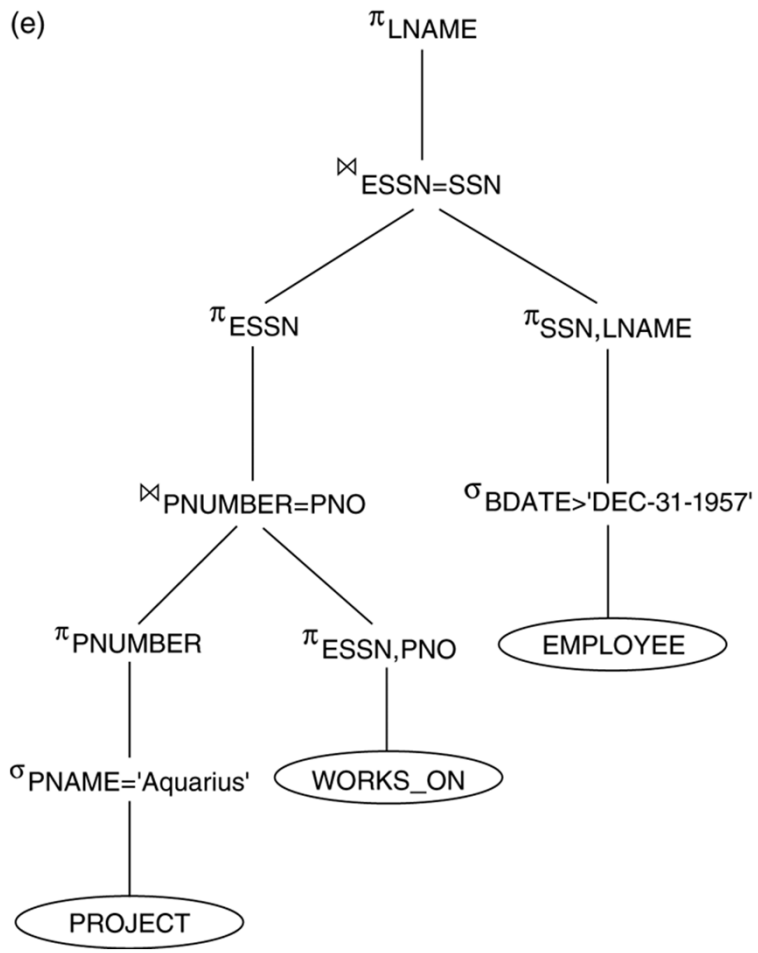
Applying the more restrictive SELECT operation first.



Replacing CARTESIAN PRODUCT and SELECT with JOIN operations.



Moving PROJECT operations down the query tree.



- Break up conjunctive selection condition, that is,

$\sigma_{<c1\ AND\ c2\ AND\ \ldots\ AND\ cn>}(R) \equiv \sigma_{<c1>}(\sigma_{<c2>}(\ldots(\sigma_{<cn>}(R))\ldots))$

- Move each 'σ' operation as far down the query tree as is permitted by the attribute involved in the 'σ' condition
- Rearrange the leaf nodes of the tree using;
  - Position the leaf node relation with the most restrictive σ operations so they are executed first,
  - Make sure that the ordering of leaf nodes does not cause CARTESIAN PRODUCT operations
- Combine a X with a subsequent σ in the tree into a $\bowtie$
- Break down and move lists of projection attributes down the tree as far as possible
- Identify subtrees that represent groups of operations that can be executed by a single algorithm.