CS525: Advanced Database Organization

Notes 6: Query Processing
Parsing and pre-processing

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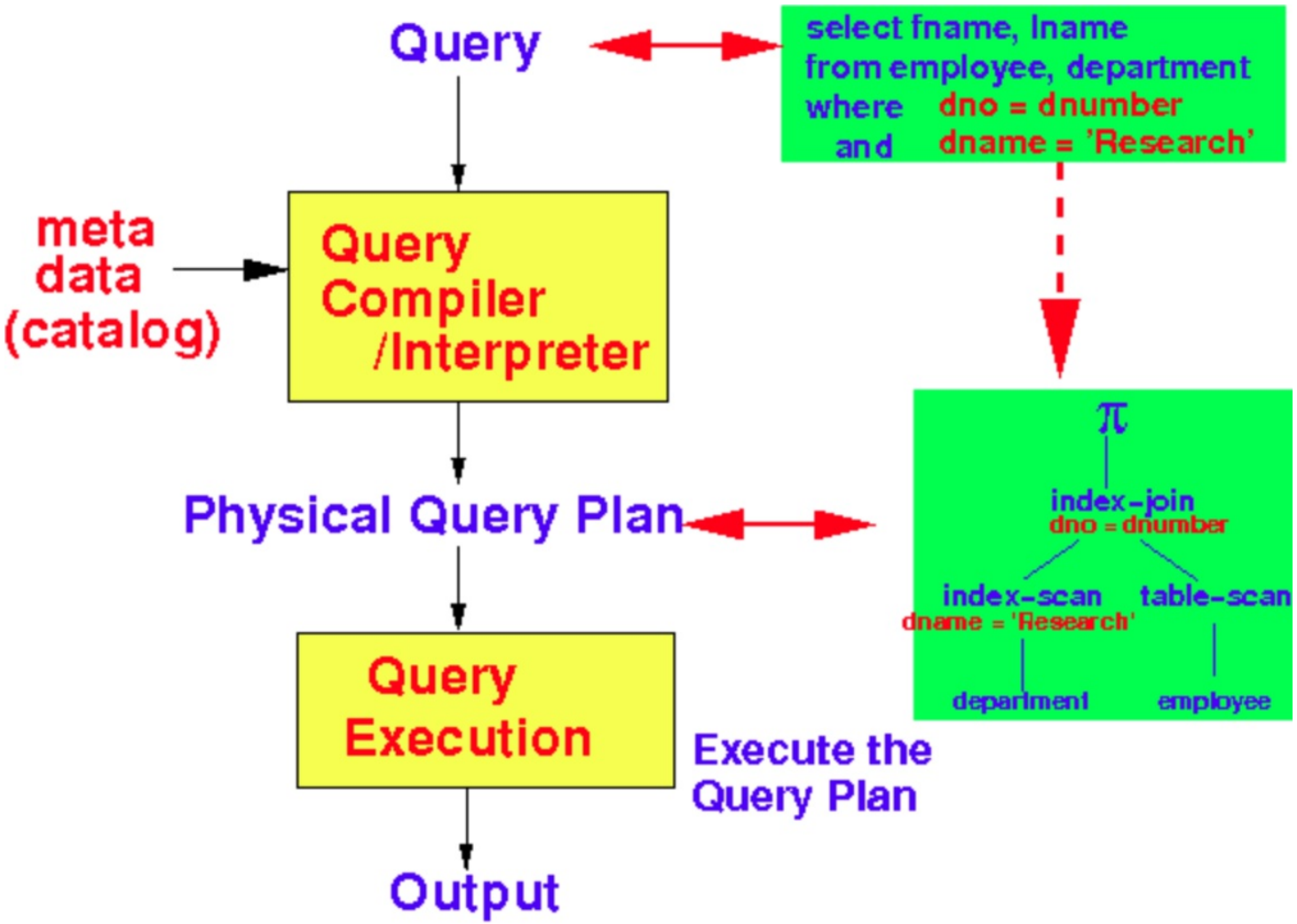
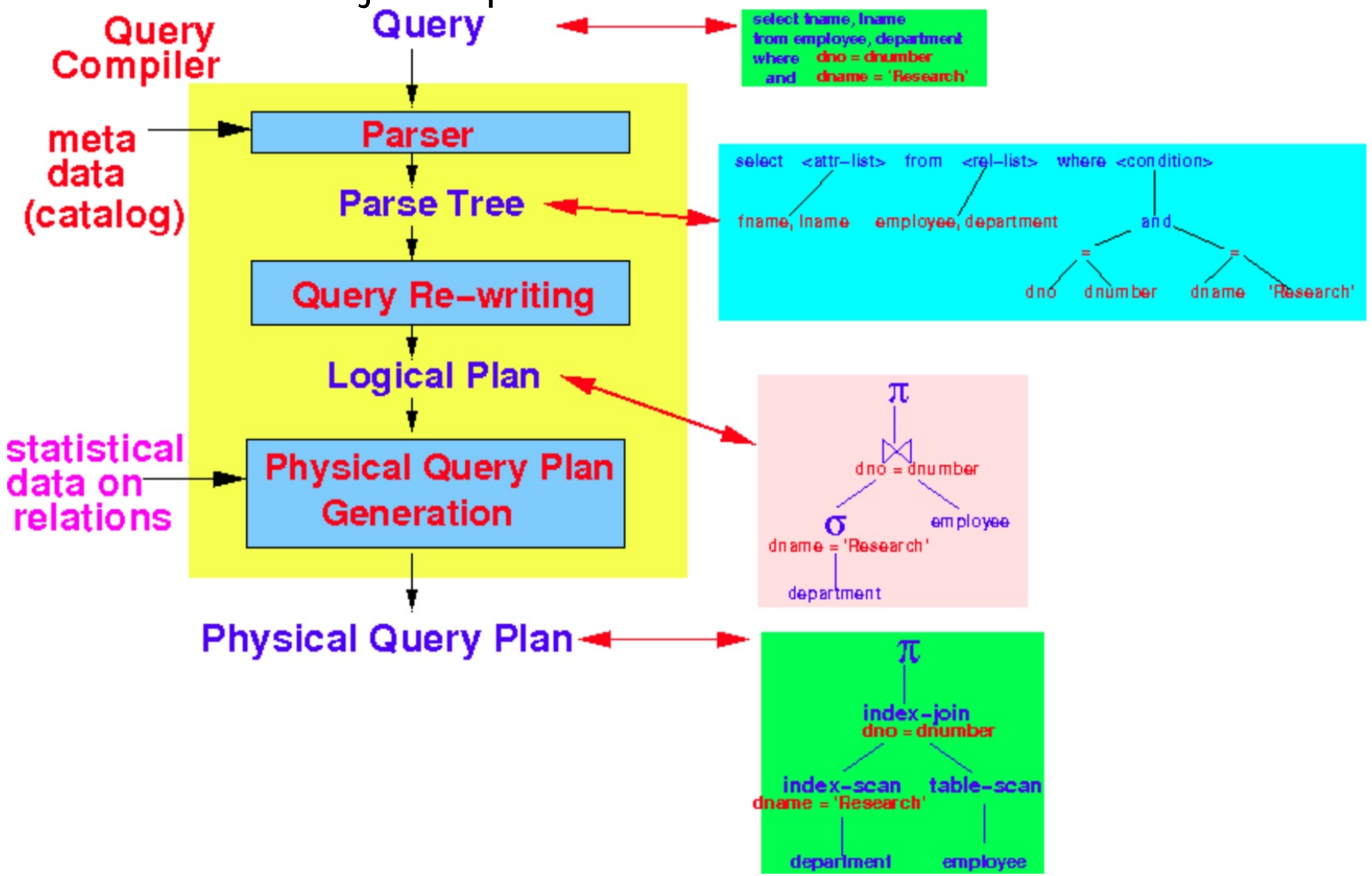
Steps needed to process a query (SQL command)



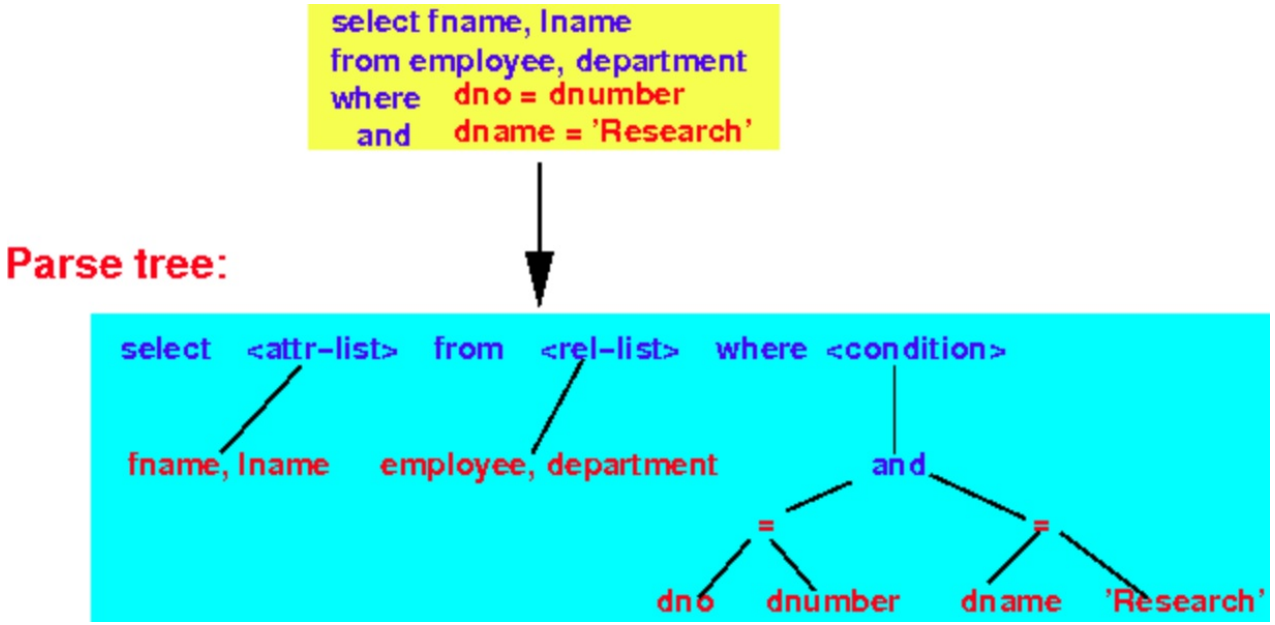
Query Compiler

- consists of 3 major steps:



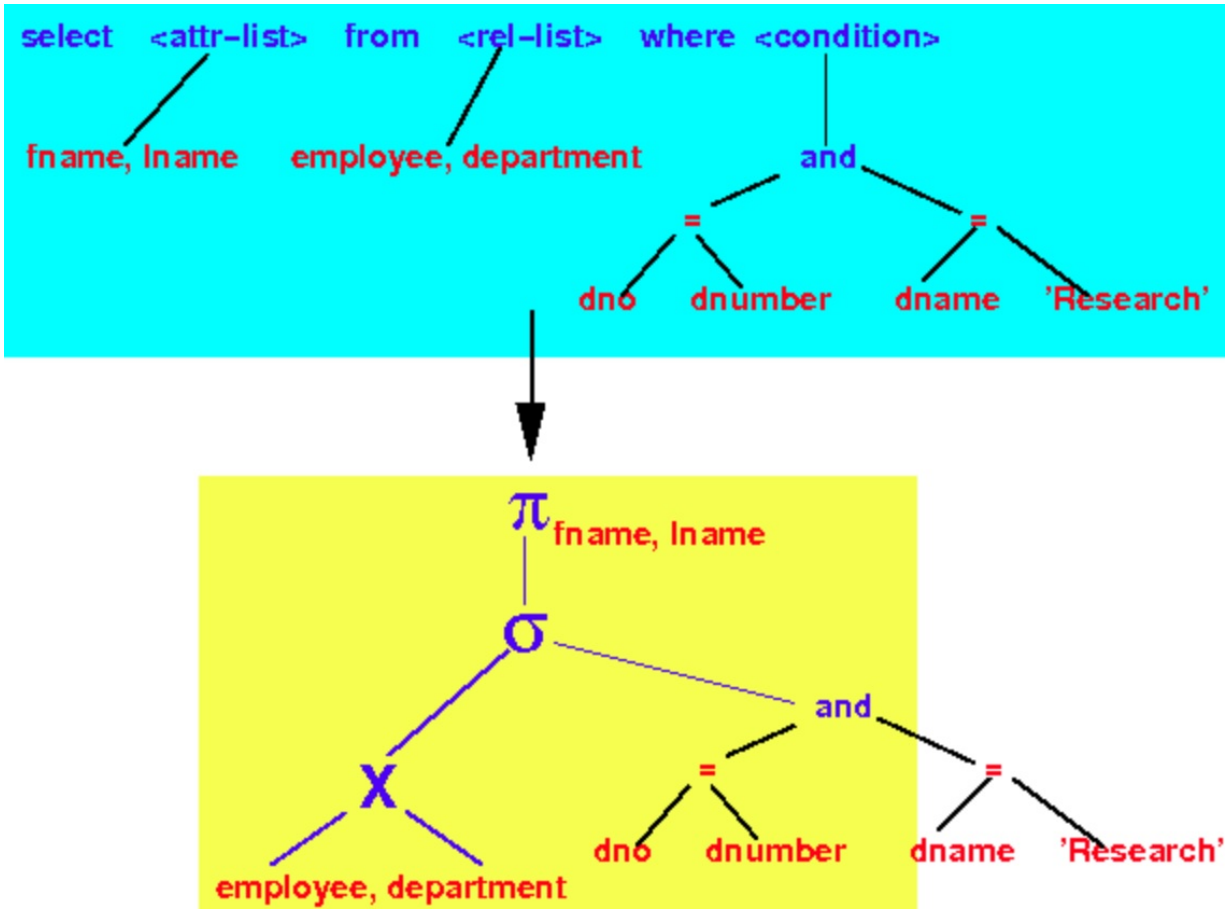
Parser

- Parses the `SQL command` and constructs a `parse tree` that represents the syntax elements in the `SQL command` (Queries need to be translated to an internal form)
  - Queries posed in a declarative DB language ("what should be returned", not "where is it found")
  - Queries can be evaluated in different ways



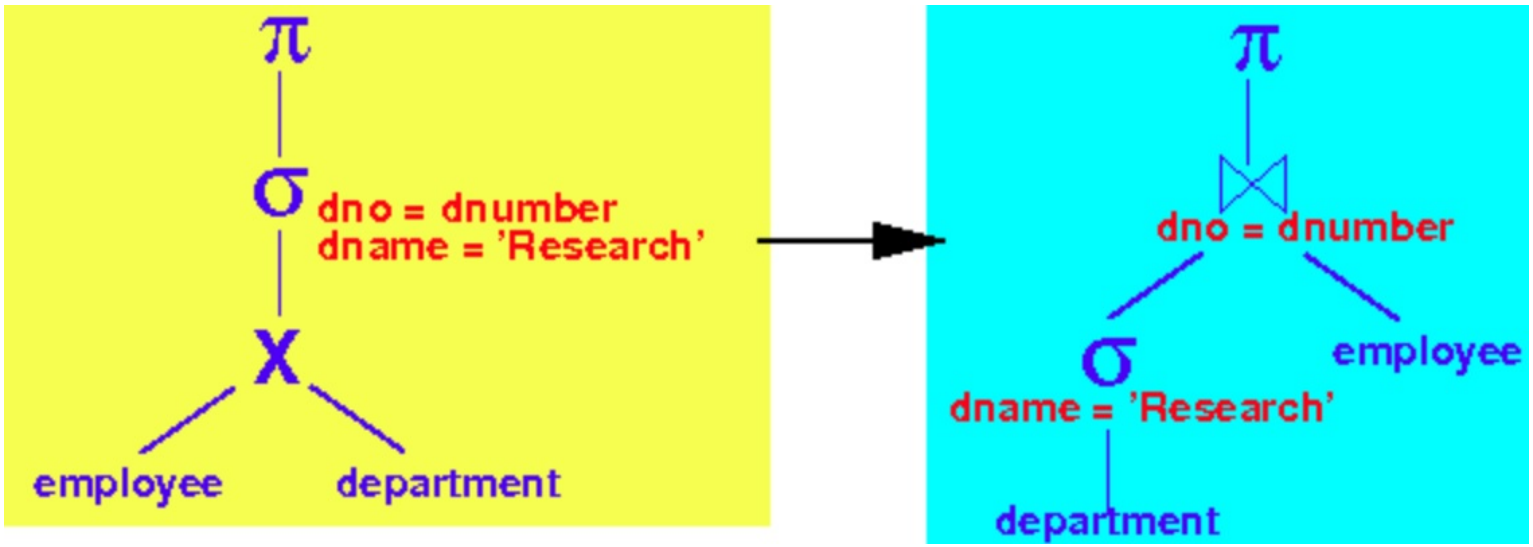
Query Re-writing

1. converts a parse tree into an un-optimized logical query plan
   - A logical query plan consists of Relational Algebra operators



Query Re-writing

2. converts the `un-optimized logical query plan` into an `optimized logical query plan`



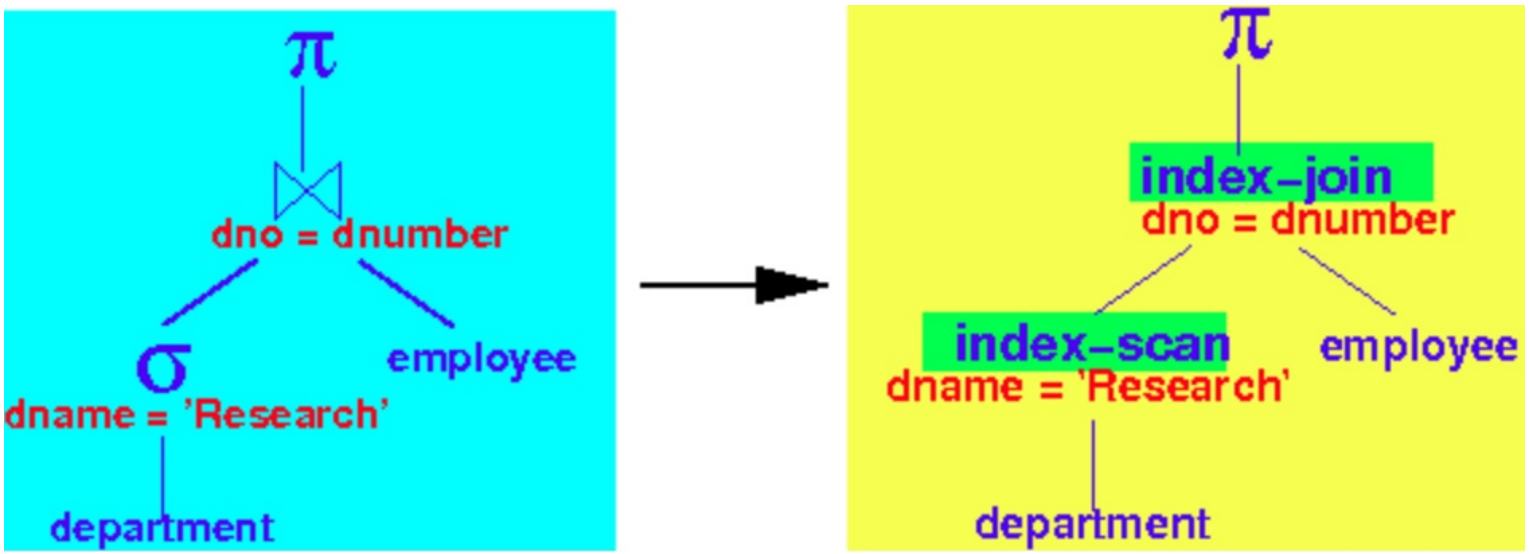
- The `optimized logical query plan` is a.k.a. the `logical query plan`

Physical Query Plan Generation

- Select the best algorithm to execute the `logical query plan`
  - Usually, there are multiple algorithms available to implement one `relation algebra operation`
  - We select the best algorithm depending on
    - Availability of indexes
    - How much main memory is available for query processing (Fast algorithms require more memory)

Physical Query Plan Generation

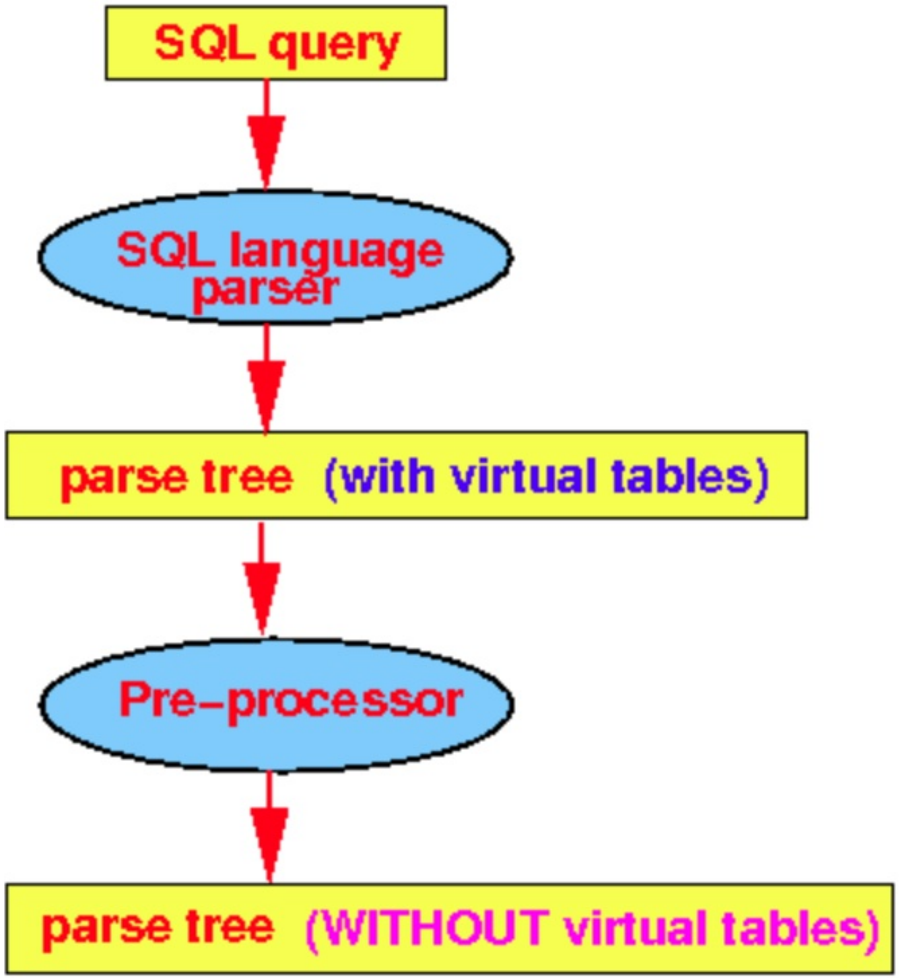
- Example: choosing an algorithm for relational algebra operators



SQL Query Parser

- The SQL query parser consists of 2 parts
  - The SQL language parser
    - Parses an SQL command into a parse tree
  - The SQL pre-processor
    - Checks for some semantic consistencies
    - Replaces virtual tables (views) by the corresponding SQL query used to obtain the virtual tables (views)

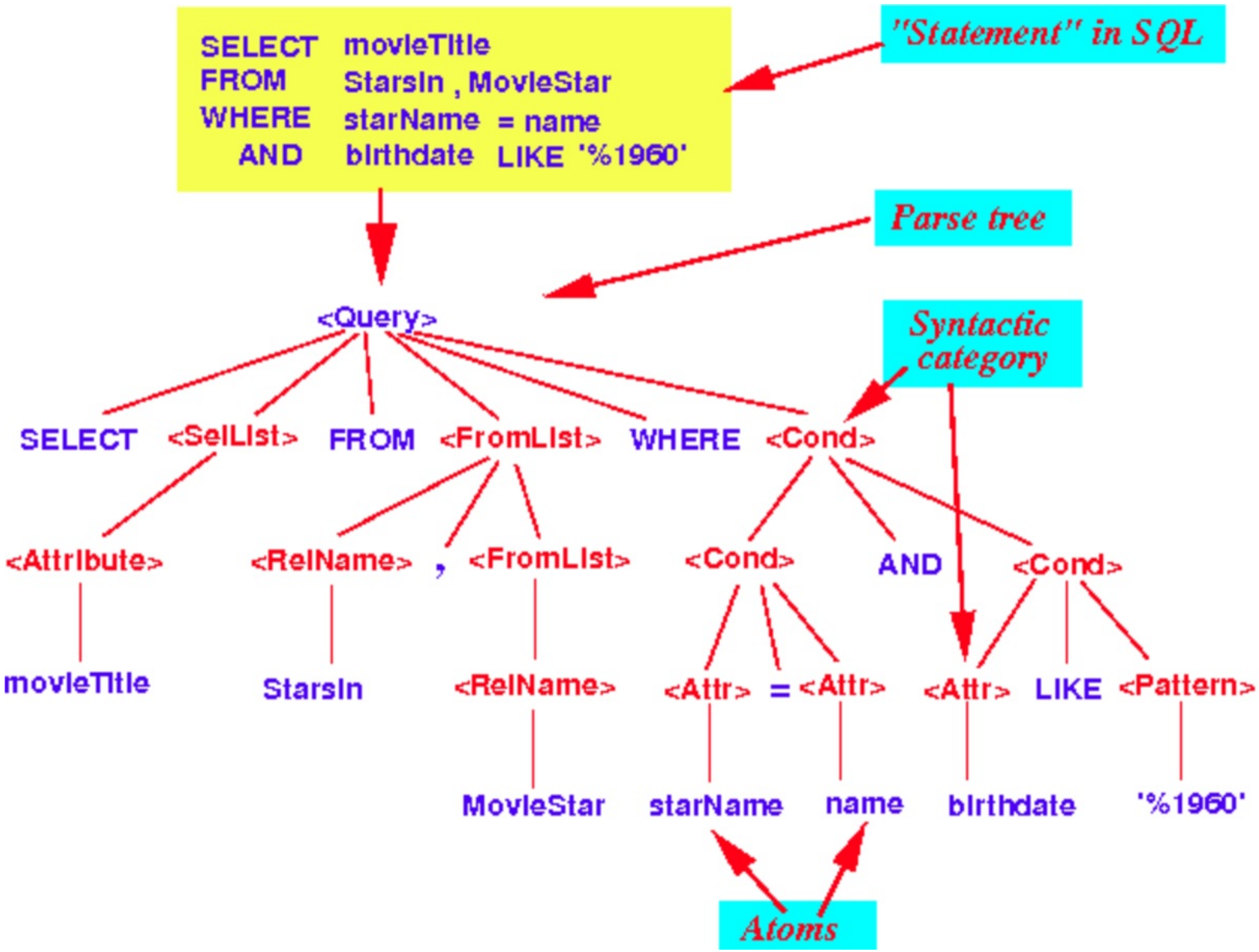
SQL query parser



Parser and parse tree

- **Parser**
  - a computer program that translate statements ("sentences") in a programming language (e.g., SQL) into a `parse tree`
- **Parse tree**: a tree whose nodes corresponds to
  - `atoms` of the programming language or
  - `syntactic categories` of the programming language

Example


SELECT movieTitle
FROM StarsIn , MovieStar
WHERE starName = name
AND birthdate LIKE '%1960'
"Statement" in SQL
Parse tree
Syntactic category
<Query>
SELECT
<SelList>
FROM
<FromList>
WHERE
<Cond>
<Attribute>
<RelName>
,
<FromList>
<Cond>
AND
<Cond>
movieTitle
StarsIn
<RelName>
<Attr>
=
<Attr>
<Attr>
LIKE
<Pattern>
MovieStar
starName
name
birthdate
'%1960'
Atoms

Atoms and Syntactic Categories

- **Atom**
  - a lexical element in a (programming) language that cannot be expressed in more elementary lexical elements
  - i.e.: `Atoms` can not be divided any further
- Examples
  - **keywords**: `SELECT, FROM, WHERE, etc`
  - **identifiers**: `employee, name, ...`
  - **Constants**: `3`, 3.14, `'April', ...`
  - **Operators**: `+, >= , LIKE, ...`
  - **Tokens**: `(, ; , , , ...`

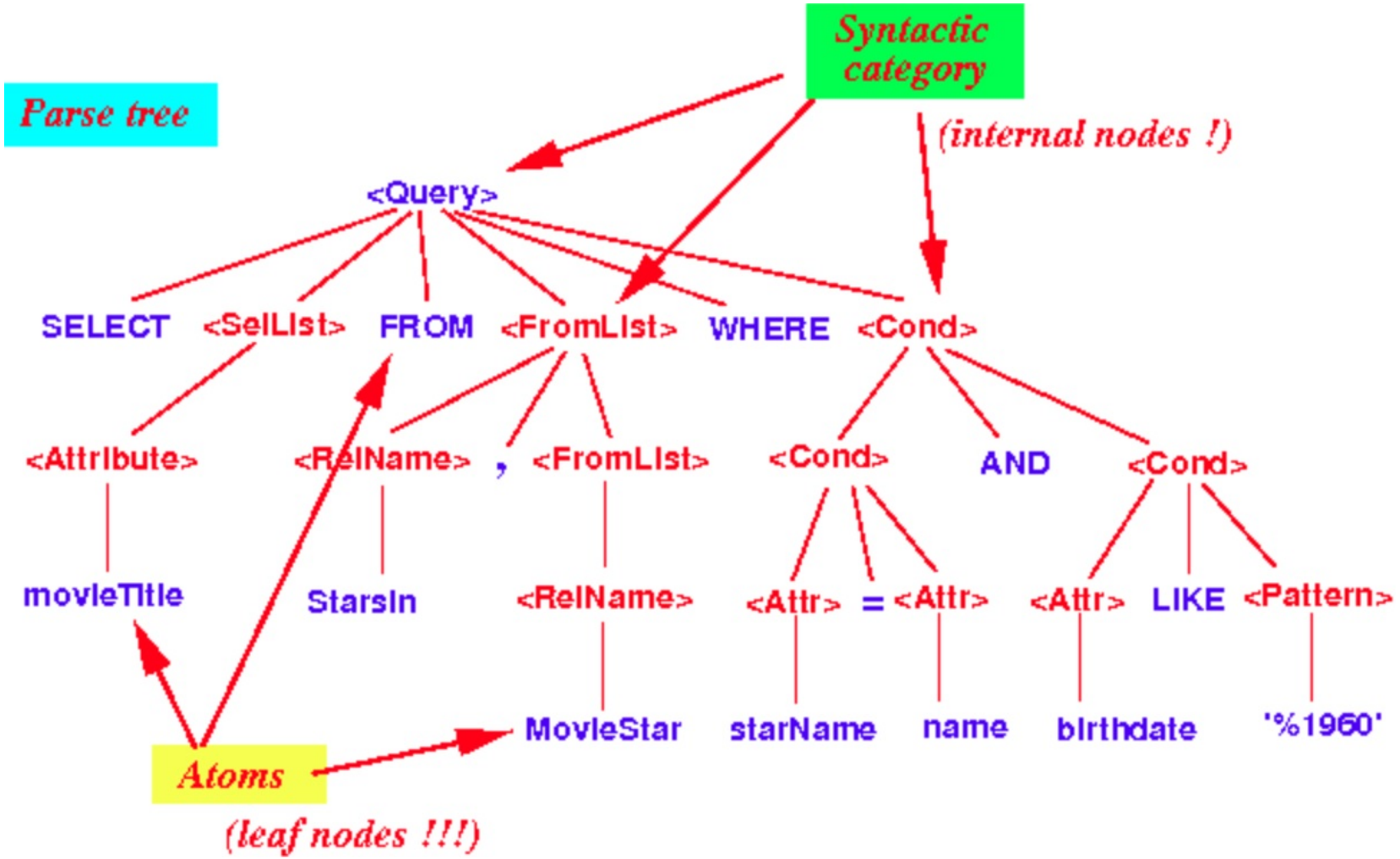
Syntactic category

- a lexical construct in a (programming) language that is built up with other lexical elements following some syntactic rules
  - Syntactic categories can be divided further
- A syntactic category is denoted as follows:
  - < Name-of-a-Syntactic-category >
- Examples of syntactic categories
  - < Query >
  - < Arithmetic expression >
  - < Condition> (or Boolean expression)

Properties of a parse tree

- A node in the parse tree is either: An `atom` or `syntactic category`
- If a node is an `atom`, then
  - that node does not have any children (i.e.: `atoms` are always `leaf nodes`)
- If a node is a `syntactic category`, then
  - the `subtree` of the node is the instantiation of one of the `syntax rules` of the `grammar`

Properties of a parse tree: Example



Grammar of programming languages

- A **grammar** is defined by a set of `re-writing rules`
- A **re-writing rule** has the following form:

  `<A> ::= Re-write_Rule`
- Meaning: `<A>` can be expressed (replaced by) the right-hand-side (`re-write rule`)
- Example: `re-writing rules`

```
<expr>   ::= <term>     | <expr> + <term>    | <expr> - <term>
<term>   ::= <factor>   | <term> * <factor>  | <term> / <factor>
<factor> ::= <constant> | ( <expr> )
```

A simplified SQL grammar

- To illustrate the translation process from SQL query to logical query plan, we use a simplified SQL grammar

```
<Query>      ::=  SELECT <SelList>
                  FROM   <FromList>
                  WHERE  <Condition>

<SelList>    ::=  <Attribute> |
                  <Attribute> , <SelList>

<FromList>   ::=  <Relation>  |
                  <Relation>  , <FromList>

<Condition>  ::=  <Condition> AND <Condition>   |
                  <Attribute> IN ( <Query> )    |
                  <Attribute> = <Attribute>     |
                  <Attribute> LIKE <Pattern>
```

- Note: This is the grammar used by the text book. It is brief, but incomplete.

"Base" syntactic categories

- There are a number of special syntactic categories in any programming language.
- In SQL, these are
  - <Relation>
  - <Attribute>
  - <Pattern>
  - <Identifier>
  - <Constant>
- Properties
  - These syntactic categories are not defined using grammar rules
  - Instead, they are defined by rules about the atoms
  - Example
    - <Identifier> must start with a letter or _ and followed by letters, digits or _
    - <Relation> must start with a letter or _ and followed by letters, digits or _ And it must identify a relation in the database

Example of parse trees

- Relations used in the example
  - Which movie stars is in which movie in what year:
    StarsIn(movieTitle. movieYear, startName)
  - Moviestars:
    MovieStar(name, address, gender, birthdate)
- SQL Query

```
SELECT   movieTitle
FROM     StarsIn , MovieStar
WHERE    starName = name
          AND    birthdate LIKE '%1960'
```

Example of parse trees

- The `parse tree`
  - We re-write a `Query` using this rule:

```
<Query>::=   SELECT <SelList>
             FROM   <FromList>
             WHERE  <Condition>
```

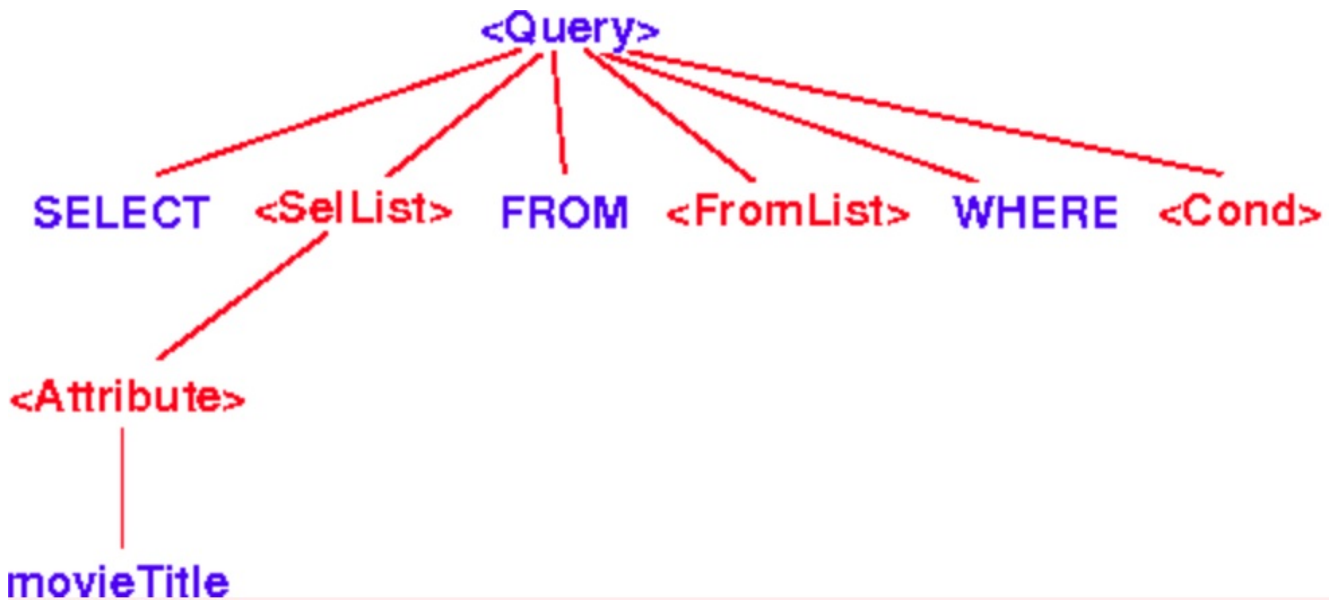
  - The `parse tree` is now

Example of parse trees

- Then we re-write `SelList` using

  $$\langle \mathtt{SelList} \rangle ::= \langle \mathtt{Attribute} \rangle$$
  $$::= \mathtt{movieTitle}$$

- The `parse tree` is now

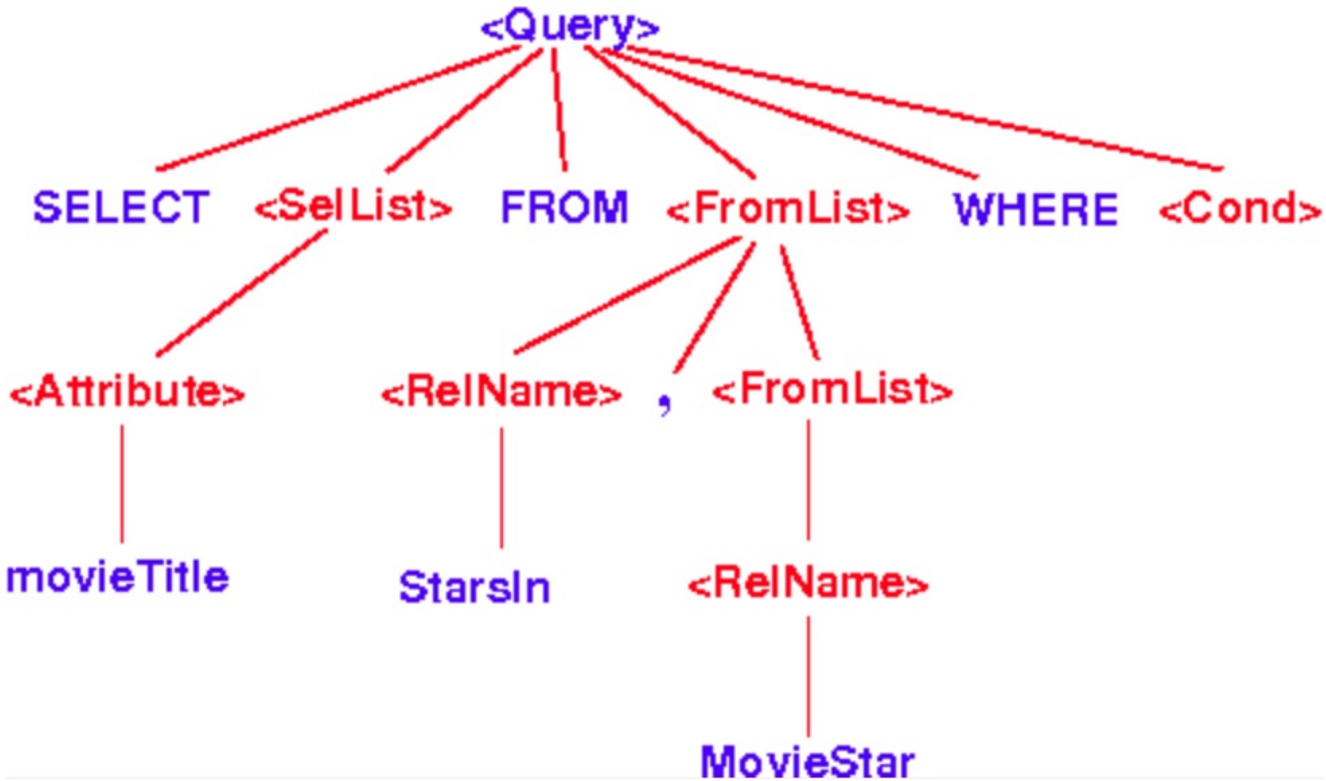


Example of parse trees

- Then we re-write `FromList` using

```
<FromList>  ::=  <Relation>  , <FromList>  (<FromList> ::= <Relation>)
            ::=  <Relation>  , <Relation>
            ::=  StarsIn     , <Relation>
            ::=  StarsIn     , MovieStar
```

- The `parse tree` is now



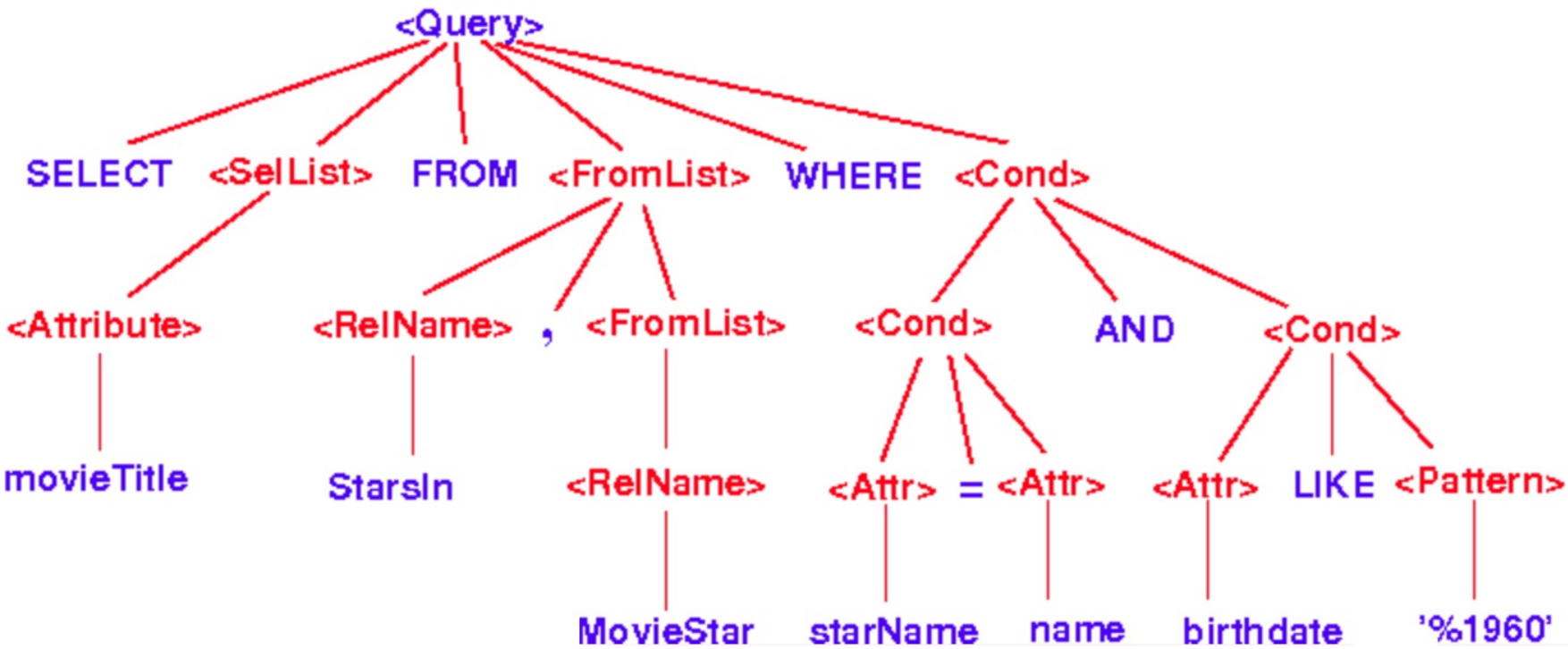
Example of parse trees

- Then we re-write `Condition` using

```
<Condition> ::= <Condition> AND <Condition>
            ::= <Attribute> = <Attribute>
                AND   <Condition>
            ::= <Attribute> = <Attribute>
                AND   <Attribute> LIKE <Pattern>
            ::= starName = name
                AND   birthdate LIKE '%1960'
```

Example of parse trees

- The `parse tree` is



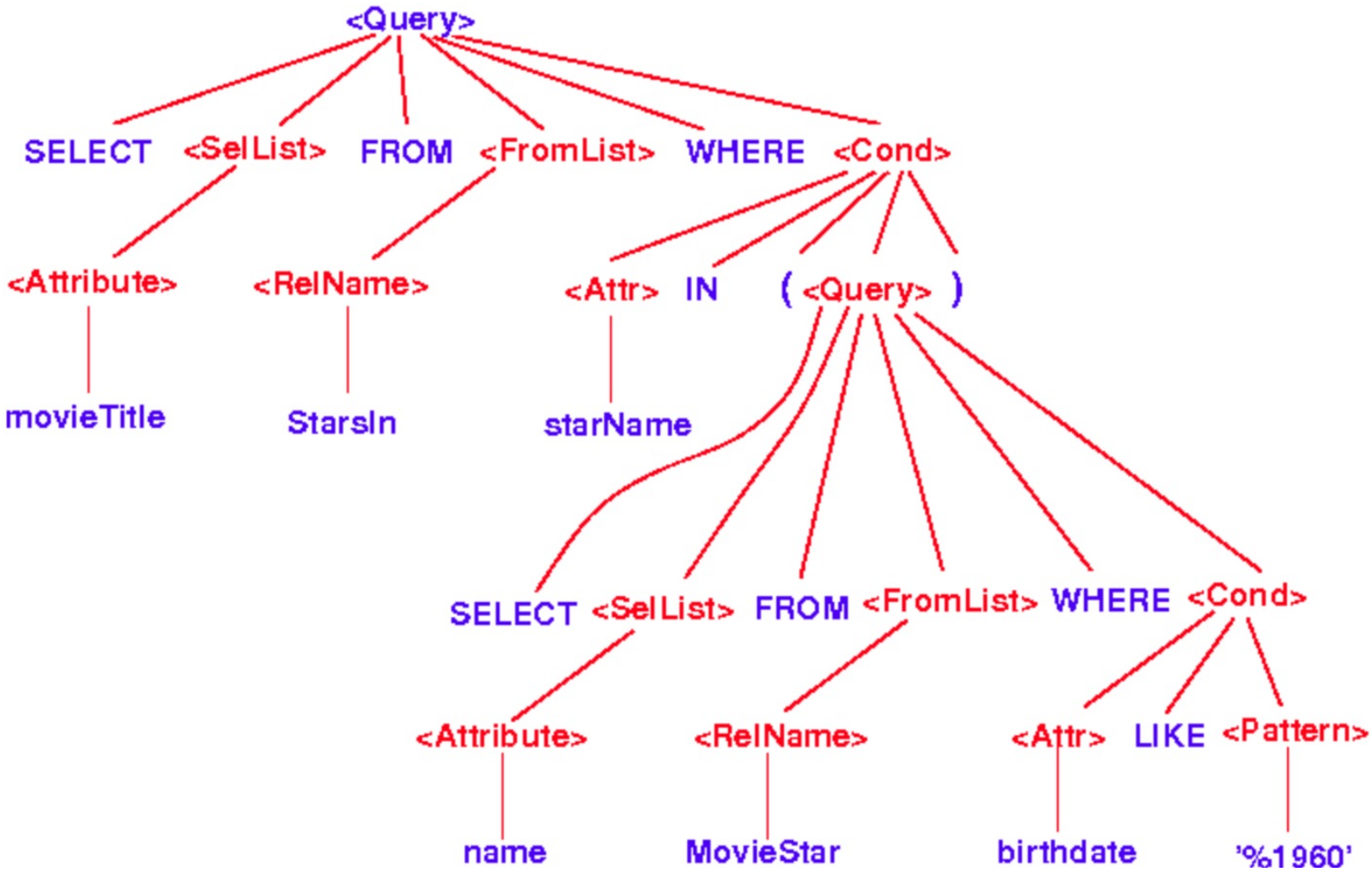
Example 2

- SQL query

```
SELECT movieTitle
FROM   StarsIn
WHERE  starName IN (SELECT name
                    FROM   MovieStar
                    WHERE  birthdate LIKE '%1960')
```

Example 2

- The `parse tree` is



Pre-processing an SQL query

- Sample of a `query`

```
SELECT    fname , dno
FROM      employee , department
WHERE     dnumber = dno
```

- Looks correct.
- Can have problems:
  - Does the relation `employee` exist?
  - Does the attribute `dno` exist?
  - If it does, which relation does `dno` belong to?
  - And so on

Pre-processing an SQL query

- Check whether the `relations` used in the FROM clause exist
- Check and resolve each `attributes` used in the `query`
  - Which `relation` is the `attribute` from? (Scope checks)
- Check the `data types` and correct usage of the `attributes`
  - Can the operation be applied to the `attribute`?
- Replace the `virtual relations (views)` by their corresponding `SQL query`

Semantic checks: Example

```
SELECT *
FROM R
WHERE R.a + 3 > 5
```

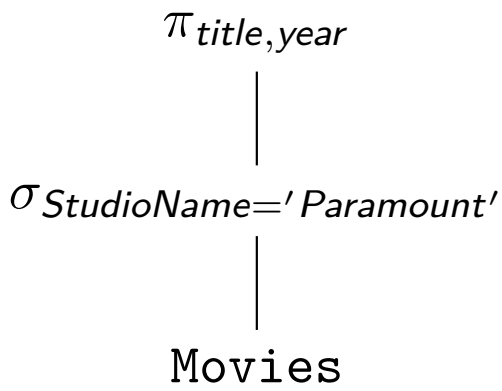
- `Relation R` exists?
- Expand `*`: which attributes in `R`?
- `R.a` is a column?
- Type of constants `3`, `5`?
- `Operator +` for types of `R.a` and `3` exists?
- `Operator >` for types of result of `+` and `5` exists?

Example: virtual relation pre-processing

- Virtual table definition

```
CREATE VIEW   Paramount_Movies AS
      (SELECT   title , year
       FROM     Movies
       WHERE    StudioName = 'Paramount')
```

  - The SELECT query is equivalent to the following `logical query plan`

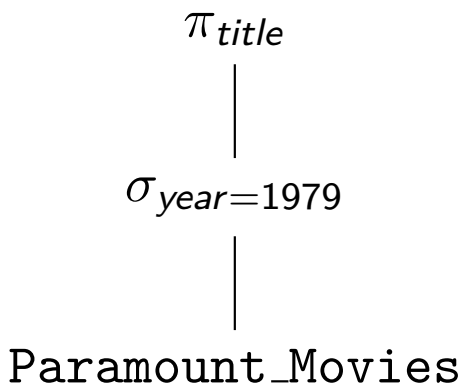


Example: virtual relation pre-processing

- Consider the following query on the virtual table `Paramount_Movies`:

```
SELECT    title
FROM      Paramount_Movies
WHERE     year = 1979
```

  - The `Query Processor` will first `parse the query` and create the following `logical query plan`



Example: virtual relation pre-processing

- Then, the `virtual table` is replaced by the corresponding `logical query plan`