Query Processing: A Systems View

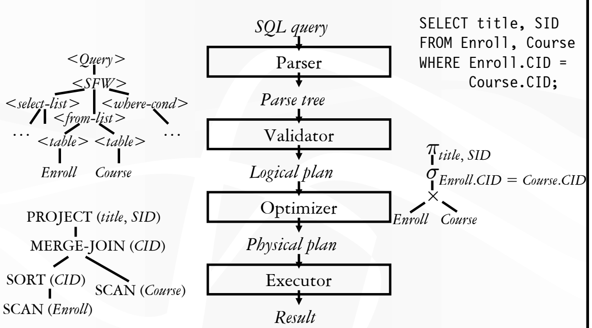
CPS 116

Introduction to Database Systems

Announcements (November 15)

- ❖ Homework #3 has been graded
- ❖ Project milestone #2 feedbacks by this weekend
- ❖ No class or office hours this Thursday (Nov. 17); I am out of town
  - Will schedule a make-up lecture towards the end of the semester (as a review session)

A query's trip through the DBMS

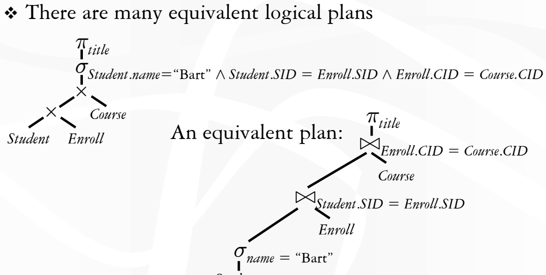


Parsing and validation

- ❖ Parser: SQL → parse tree
  - Good old lex & yacc
  - Detect and reject syntax errors
- ❖ Validator: parse tree → logical plan
  - Detect and reject semantic errors
    - Nonexistent tables/views/columns?
    - Insufficient access privileges?
    - Type mismatches?
      - Examples: `AVG(name)`, `name + GPA`, `Student UNION Enroll`
  - Also
    - Expand *
    - Expand view definitions
  - Information required for semantic checking is found in system catalog (contains all schema information)

Logical plan

- ❖ Nodes are logical operators (often relational algebra operators)
- ❖ There are many equivalent logical plans

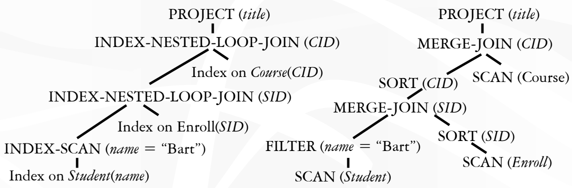


Physical (execution) plan

- ❖ A complex query may involve multiple tables and various query processing algorithms
  - E.g., table scan, index nested-loop join, sort-merge join, hash-based duplicate elimination…
- ❖ A physical plan for a query tells the DBMS query processor how to execute the query
  - A tree of physical plan operators
  - Each operator implements a query processing algorithm
  - Each operator accepts a number of input tables/streams and produces a single output table/stream

Examples of physical plans

```
SELECT Course.title
FROM Student, Enroll, Course
WHERE Student.name = 'Bart'
AND Student.SID = Enroll.SID AND Enroll.CID = Course.CID;
```



- Many physical plans for a single query
  - Equivalent results, but different costs and assumptions!
  - ☞DBMS query optimizer picks the "best" possible physical plan

Physical plan execution

- How are intermediate results passed from child operators to parent operators?
  - Temporary files
    - Compute the tree bottom-up
    - Children write intermediate results to temporary files
    - Parents read temporary files
  - Iterators
    - Do not materialize intermediate results
    - Children pipeline their results to parents

Iterator interface

- Every physical operator maintains its own execution state and implements the following methods:
  - `open()`: Initialize state and get ready for processing
  - `getNext()`: Return the next tuple in the result (or a null pointer if there are no more tuples); adjust state to allow subsequent tuples to be obtained
  - `close()`: Clean up

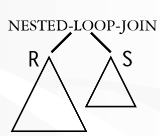
An iterator for table scan

- State: a block of memory for buffering input *R*; a pointer to a tuple within the block
- `open()`: allocate a block of memory
- `getNext()`
  - If no block of *R* has been read yet, read the first block from the disk and return the first tuple in the block
    - Or the null pointer if *R* is empty
  - If there is no more tuple left in the current block, read the next block of *R* from the disk and return the first tuple in the block
    - Or the null pointer if there are no more blocks in *R*
  - Otherwise, return the next tuple in the memory block
- `close()`: deallocate the block of memory

An iterator for nested-loop join

R: An iterator for the left subtree

S: An iterator for the right subtree



- `open()`

```
R.open(); S.open(); r = R.getNext();
```

- `getNext()`

```
do {
  s = S.getNext();
  if (s == null) {
    S.close(); S.open(); s = S.getNext(); if (s == null) return null;
    r = R.getNext(); if (r == null) return null;
  }
} until (r joins with s);
return rs;
```

Is this tuple-based or block-based nested-loop join?

- `close()`

```
R.close(); S.close();
```


An iterator for 2-pass merge sort

- `open()`
  - Allocate a number of memory blocks for sorting
  - Call `open()` on child iterator
- `getNext()`
  - If called for the first time
    - Call `getNext()` on child to fill all blocks, sort the tuples, and output a run
    - Repeat until `getNext()` on child returns null
    - Read one block from each run into memory, and initialize pointers to point to the beginning tuple of each block
  - Return the smallest tuple and advance the corresponding pointer; if a block is exhausted bring in the next block in the same run
- `close()`
  - Call `close()` on child
  - Deallocate sorting memory and delete temporary runs

Blocking vs. non-blocking iterators

- A blocking iterator must call `getNext()` exhaustively (or nearly exhaustively) on its children before returning its first output tuple
  - Examples: sort, aggregation
- A non-blocking iterator expects to make only a few `getNext()` calls on its children before returning its first (or next) output tuple
  - Examples: filter, merge join with sorted inputs

Execution of an iterator tree

- Call `root.open()`
- Call `root.getNext()` repeatedly until it returns null
- Call `root.close()`

- Requests go down the tree
- Intermediate result tuples go up the tree
- No intermediate files are needed
  - But maybe useful if an iterator is opened many times
    - Example: complex inner iterator tree in a nested-loop join; "cache" its result in an intermediate file