

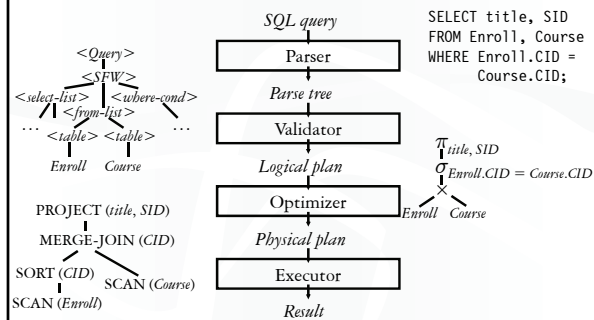
Query Processing: A Systems View

CPS 116
Introduction to Database Systems

Announcements (November 19)

- ❖ Audio lecture segments to be posted this weekend
- ❖ Homework #4 due December 1
- ❖ Sign up (via email) for a slot in the project demo period, December 1-8

A query's trip through the DBMS



Parsing and validation

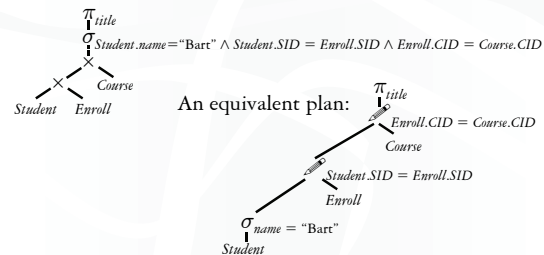
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- ❖ Parser: SQL \rightarrow parse tree
 - Good old lex & yacc will do
 - Detect and reject syntax errors
- ❖ Validator: parse tree \rightarrow logical plan
 - Detect and reject semantic errors
 - Nonexistent tables/views/columns?
 - Insufficient access 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

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

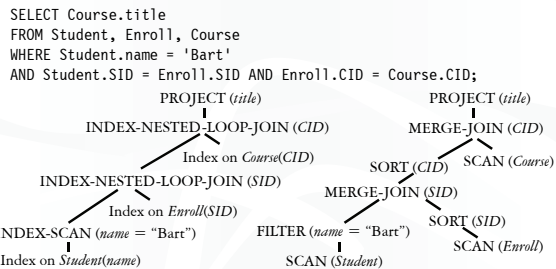


Physical (execution) plan

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- ❖ 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



- ❖ 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

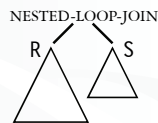
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- ❖ State: a block of memory for buffering input R ;
a pointer to a tuple within the block
- ❖ `open()`: allocate a block of memory
- ❖ `getNext()`
 - If no block of R has been read yet, read the first block from the disk and return the first tuple 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

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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

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- ❖ `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 13

- ❖ A blocking iterator must call `getNext()` exhaustively (or nearly exhaustively) on its children before returning its first output tuple
 - Examples:
- ❖ A non-blocking iterator expects to make only a few `getNext()` calls on its children before returning its first (or next) output tuple
 - Examples:

Execution of an iterator tree 14

- ❖ 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
