COL362/632 Introduction to Database Management Systems

Query Processing - Processing Models

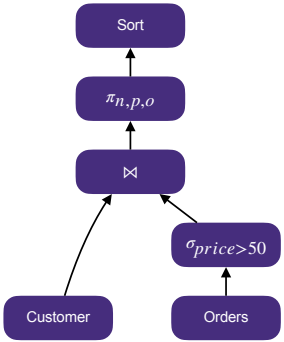
Kaustubh Beedkar

Department of Computer Science and Engineering
Indian Institute of Technology Delhi

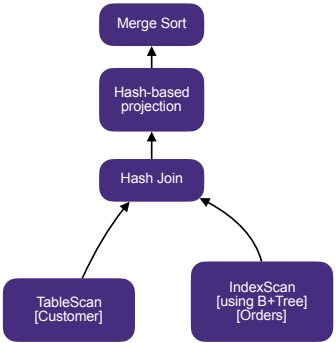
Query Processing (Overview)

- SQL : What?
- Physical plan: How?
- Query processing and optimization "compiles" a logical plan in to a physical plan

```
SELECT c.name, o.price, o.order_date
FROM customer c, orders o
WHERE c.customer_id = o.customer_id
AND o.price > 50
ORDER BY o.order_date DESC;
```



Logical Plan



Physical Plan

Outline

Processing Models

1. Materialization model
   - Evaluate one operation at a time, and materialize intermediate output
2. Vocano model

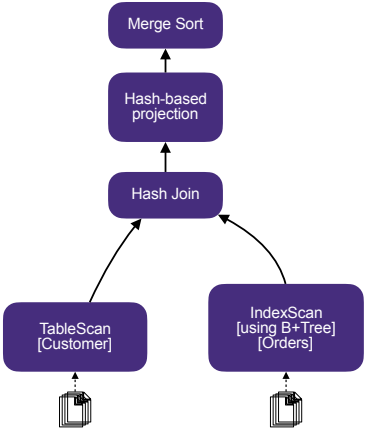
   – also known as pipelining model or iterator model
   - Evaluate multiple operations in parallel in a pipline

Outline

Materialization Model

- Tuples generated by an operator are written to disk in intermediate table
- Has no direct benefit!
- But, necessary
  - For certain operator implementations
  - When there is not enough memory

Materialization Model (Example)



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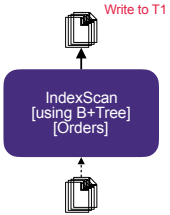

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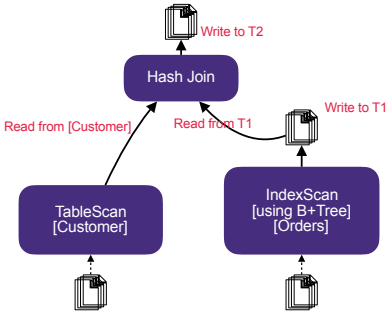

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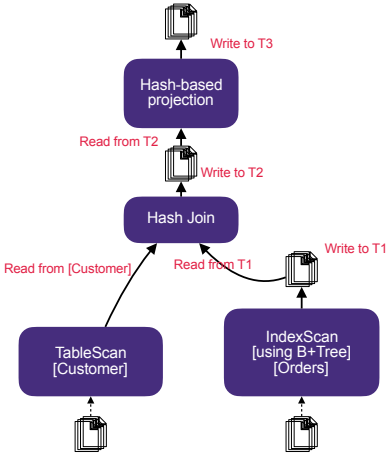

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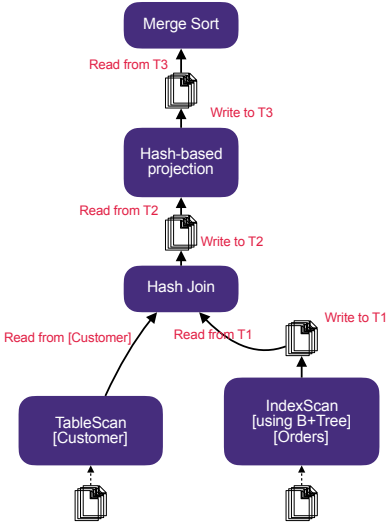

Outline

Iterator Interface

- Analogous to constructors and destructors
- Each operator implements the three functions
- Iterator maintains the state of its execution

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open()

- Initialize the operator state
- sets parameters (such as selection condition)

next()

- Performs processing and produces an output tuple
  - each invocation, operator returns either a single tuple of EOF
- Operator invokes the next function recursively on its inputs

close()

- Clean up

Selection Operator (Java Example)

```java
interface Operator<T>{
    void open();
    T next();
    void close();
}
```

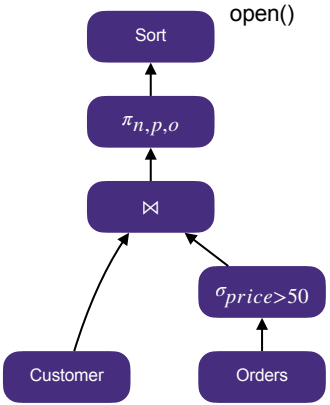
```java
class Selection implements Operator<Row>{
    private Operator<Row> input;
    private Predicate<Row> predicate;
    public Selection(Operator<Row> input, Predicate<Row> predicate)
        {
        this.input = input;
        this.predicate = predicate;
    }

    public void open() {
        input.open();
    }

    public Row next() {
        for(Row row = input.next; row!=null; row=row.next()) {
            if(predicate.check(row)) {
                return row;
            }
        }
        return null;
    }

    public void close() {
        input.close();
    }
}
```

Pipeline Execution (Illustration)



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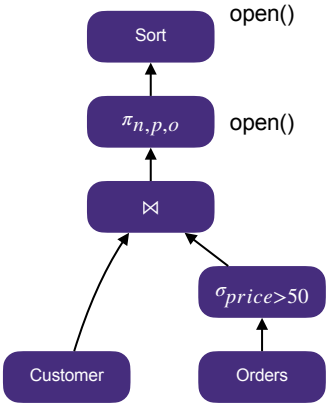

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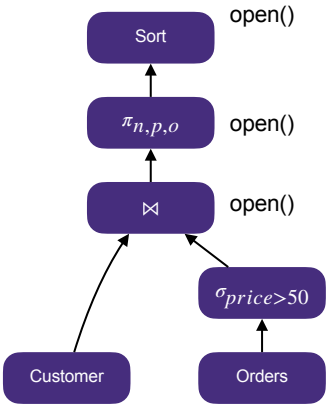

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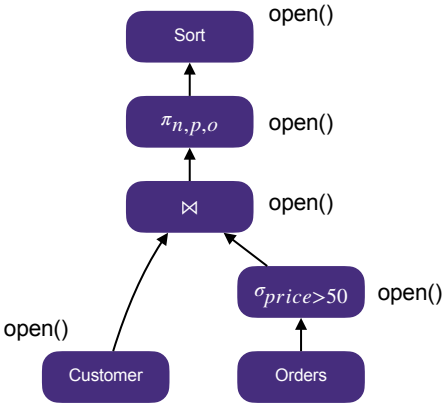

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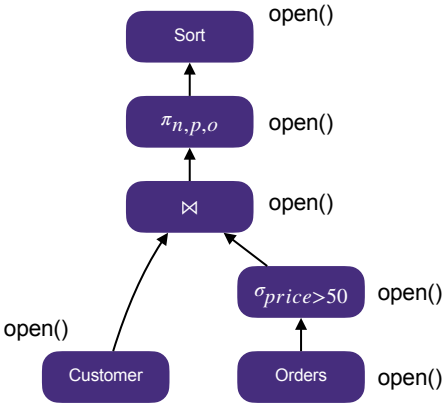

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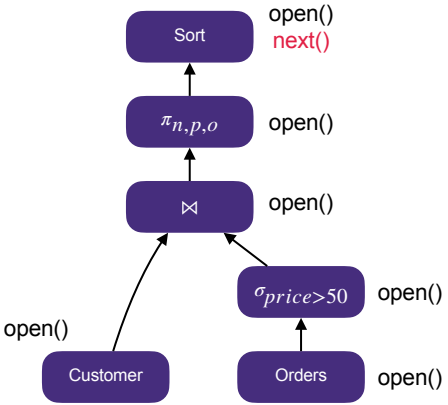

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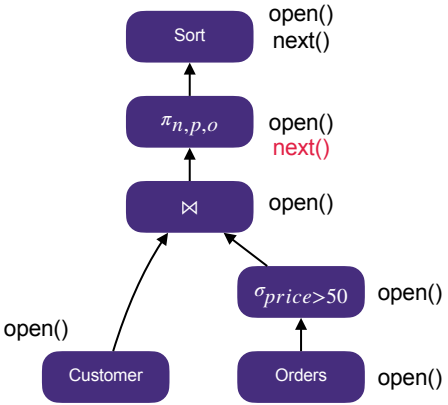

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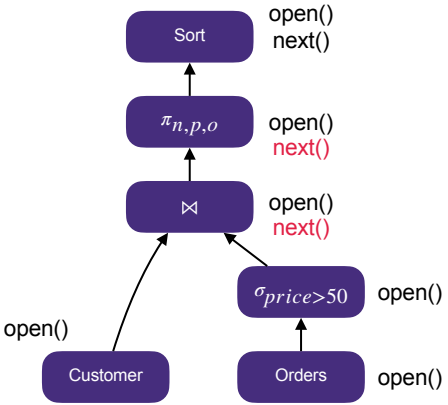

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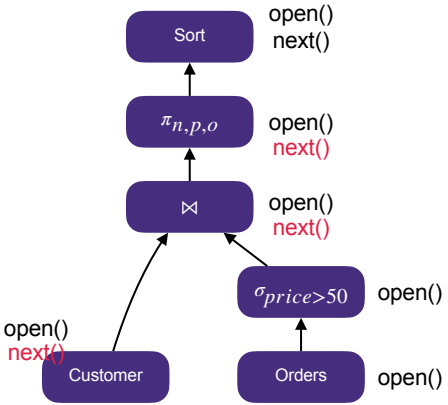

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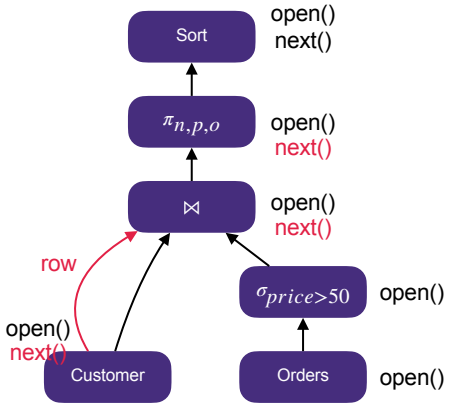

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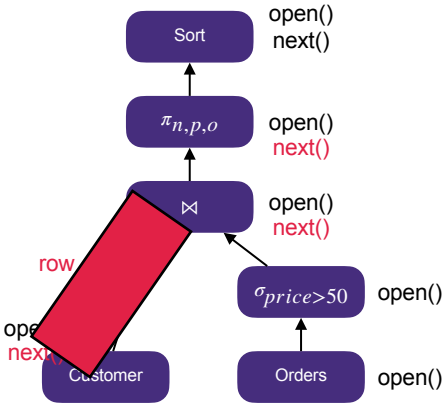

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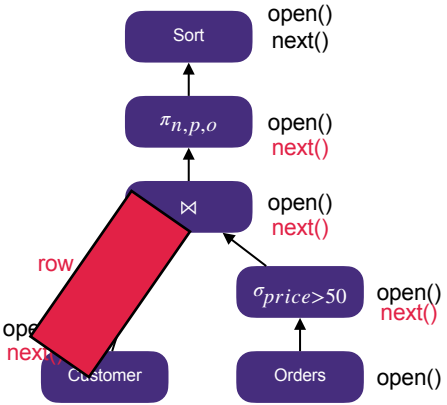

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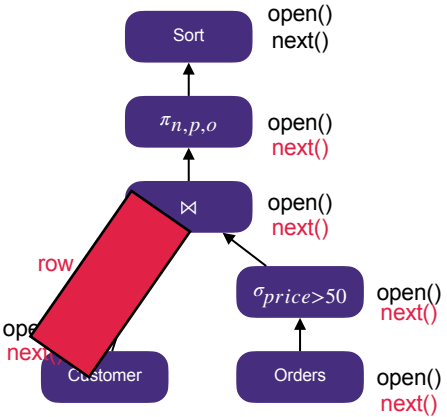

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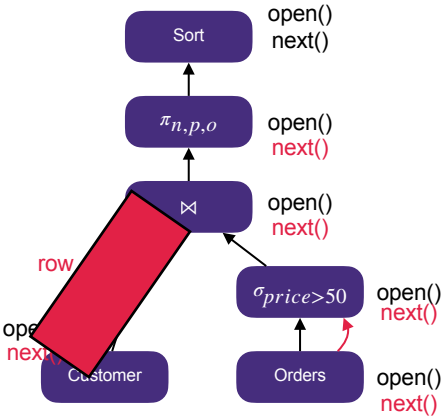

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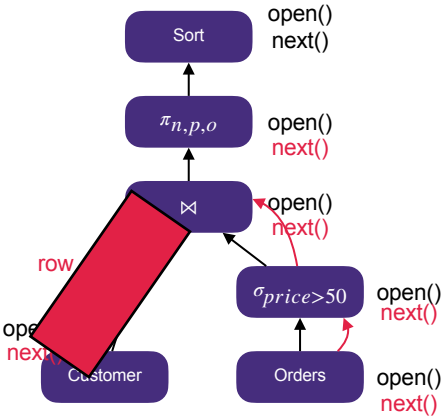

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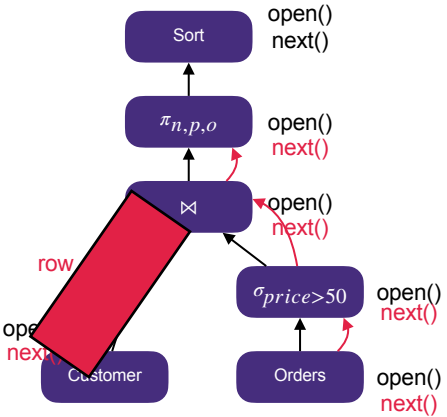

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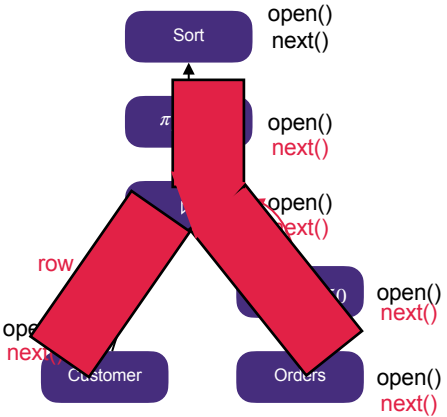

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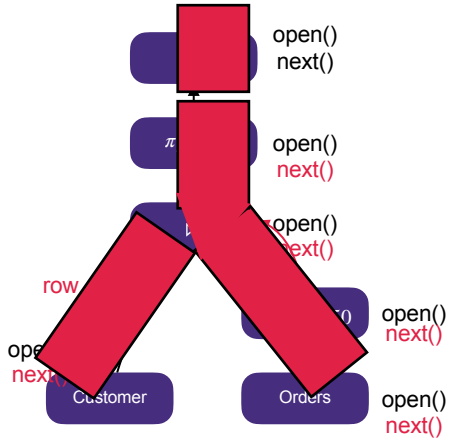

Pipelined Execution

- Tuples generated by an operator are immediately sent to the parent
- Benefits
  - No operator synchronization issues
  - Saves cost of writing intermediate data to disk
  - Saves cost of reading intermediate data from disk
- This approach is used whenever possible

Memory Management

Each operator

- Pre-allocates heap space for tuples
  - Pointers to base data in buffer pool
    or new tuples in the heap
- Allocates memory for its internal states
  - Either on heap or buffer pool (depends on system)
- DBMS may limit how much memory each operator, or each query can use