(Volcano) Iterator Model

- everything implements ONC interface
  - open
  - next
  - close
- query exectution from root node
- hierarchical and scalable
- everything one by one
- blocking operations may prevent this
  - sorting/grouping/aggregation/hash joins
  - require knowledge of all tuples not just one
- e.g.

Example $\sigma_{A=7}(R)$

```
void open() { R.open(); }

void close() { R.close(); }

Record next() {
  while( (r = R.next()) != EOF )
    if( p(r) ) //A==7
      return r;
  return EOF;
}
```

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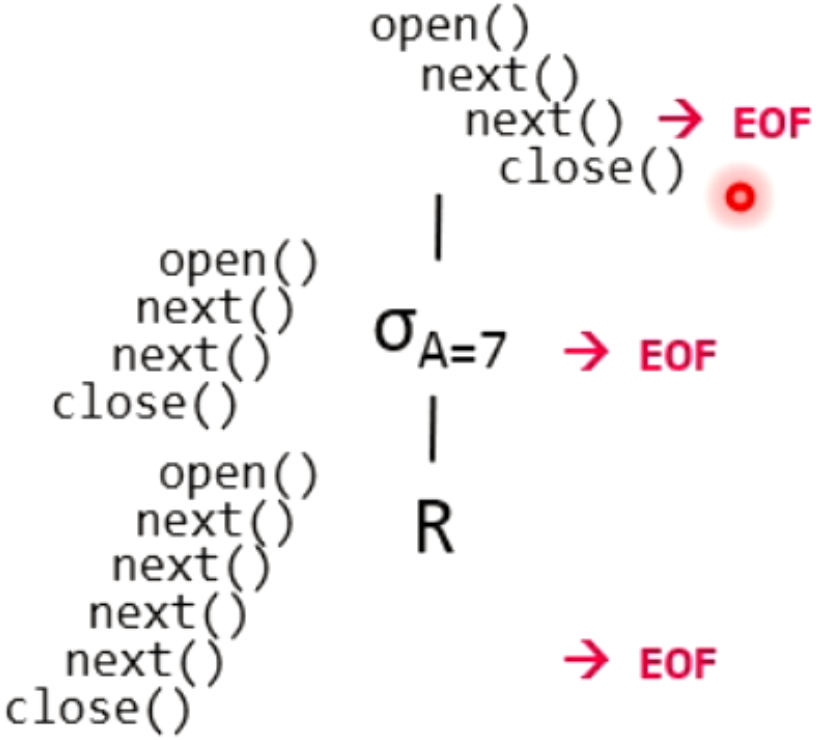

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Physical Table Access Operator

- seq scan
  - sequential read of table
  - reading tuples one by one
- index scan
  - first reads all indexes
  - throwing all away which do not satisfy certain criteria
  - reads remaining attributes afterwards
- index only scan
  - only reads indexes

Physical Join Operators

- nested loop join
  - like two nested for loops
  - for every tuple in table A iterate over every tuple in table B
  - slow
- hash/hash join
  - only for equi joins
  - smaller table A is read first

  - create hashmap out of A
  - if value in B equal to A ==> hash equal
  - access via hashmap
  - fast
- sort/merge join
  - no clue… VO#04 1:28
  - efficient if one table is already sorted

Physical Grouping Operators

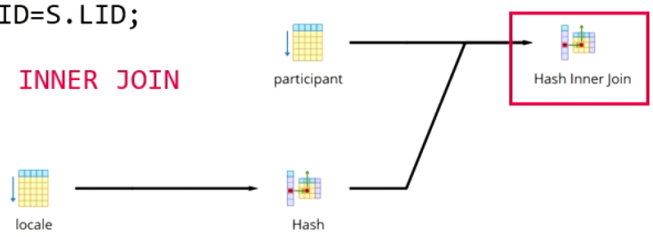
- hash aggregate
  - groups into hash tables
  - useful for additive/incremental aggregations
- group aggregate
  - sorting
  - group by easy if sorted

Analyzing/Explaining Queries

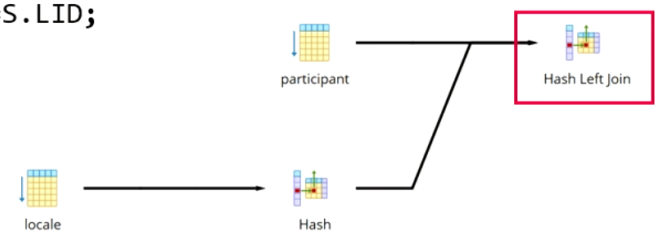
- EXPLAIN command before SQL-query
- returns query tree
  - physical operators instead of SQL operators
- EXPLAIN does not update regularly
  - ANALYZE beforehand necessary
    - **Step 1:**
```
EXPLAIN SELECT * FROM Participant AS R, Locale AS S
        WHERE R.LID=S.LID;
```
```
Hash Join (.. rows=70 width=1592)
  Hash Cond:(s.lid = r.lid)
  ->  Seq Scan on locale s (.. rows=140 width=520)
  ->  Hash (.. rows=70 width=1072)                          } build
        ->  Seq Scan on participant r (.. rows=70 width=1072) } side
```
    - **Step 2:**
```
ANALYZE Participant, Locale;
```
    - **Step 3:**
```
EXPLAIN SELECT * FROM Participant AS R, Locale AS S
        WHERE R.LID=S.LID;
```
```
Hash Join (.. rows=17 width=47)
  Hash Cond:(r.lid = s.lid)
  ->  Seq Scan on participant r (.. rows=17 width=30)
  ->  Hash (.. rows=11 width=17)
        ->  Seq Scan on locale s (.. rows=11 width=17)
```
    WHY?
- Visual EXPLAIN

- **SELECT** * **FROM** Participant **AS** R, Locale **AS** S
  WHERE R.LID=S.LID;

  $\sigma_F(R \times S)$ → INNER JOIN



- **SELECT** * **FROM** Participant **AS** R **LEFT JOIN** Locale **AS** S
  ON R.LID=S.LID;



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[[Relational Algebra]]