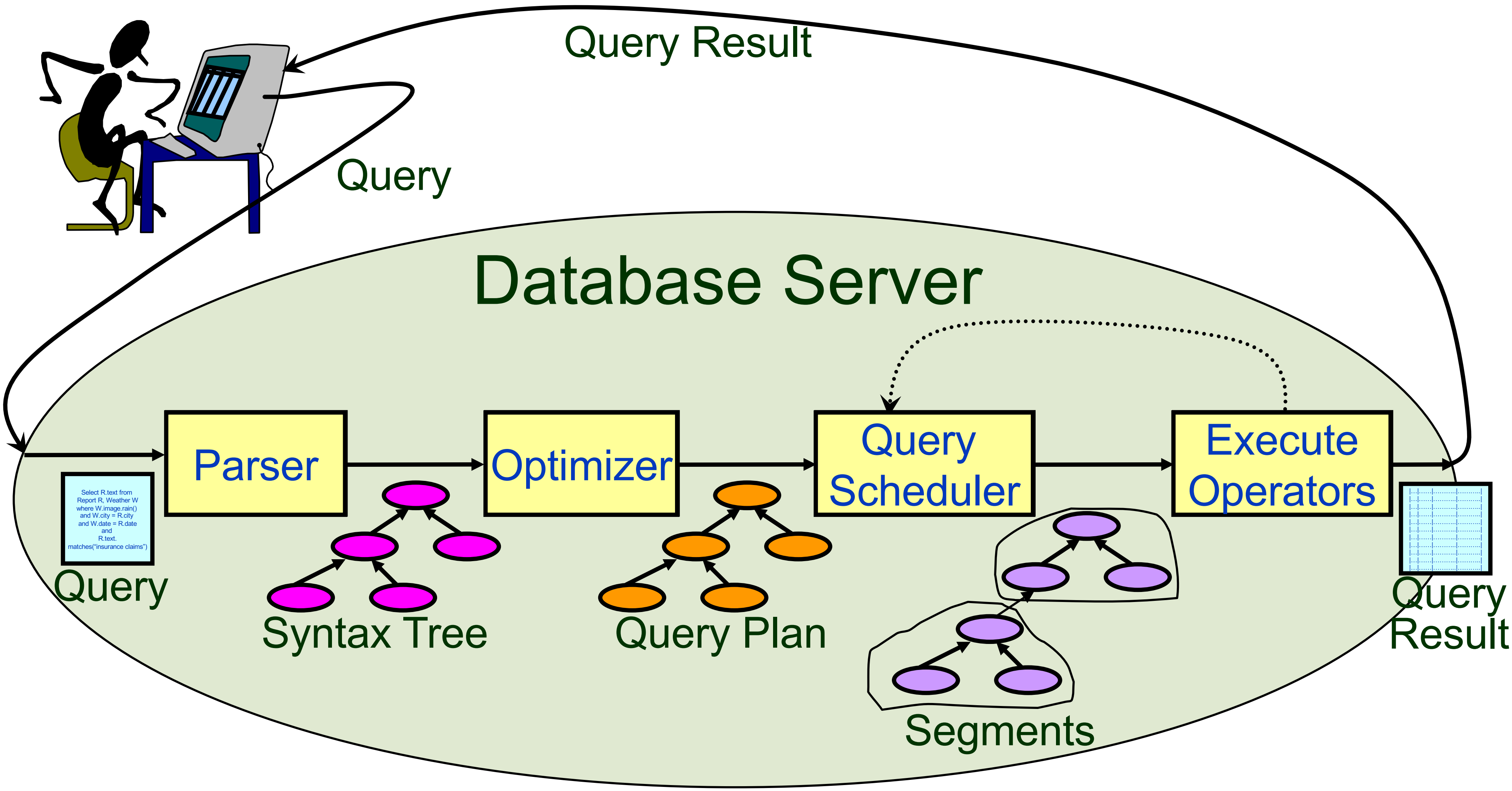
Spring 2017

QUERY PROCESSING

[BASED ON CH 12.1-12.3 AND 14 IN THE COW BOOK]

Life Cycle of a Query



Problem Statement

```
CREATE TABLE User (
   uid          INTEGER,        -- unique id or the user
   login        VARCHAR(20)     -- unique login name
   lname        VARCHAR(80),    -- lastname
   fname        VARCHAR(80),    -- firstname
   dob          DATE,           -- date of birth
   PRIMARY KEY (uid),           -- primary key for the table
   UNIQUE (login)               -- twid is also unique
);


CREATE TABLE Messages (
   uniqueMsgID INTEGER,         -- unique message id
   tstamp       TIMESTAMP,      -- when was the message posted
   uid          INTEGER,        -- unique id of the user
   msg          VARCHAR (140), -- the actual message
   zip          INTEGER,        -- zipcode when the message was posted
   reposted     BOOLEAN         -- is this a reposted message?
   PRIMARY KEY (uniqueMsgID), -- primary key
   FOREIGN KEY (uid) REFERENCES USER – Foreign key to the User table
   );
```

Problem Statement

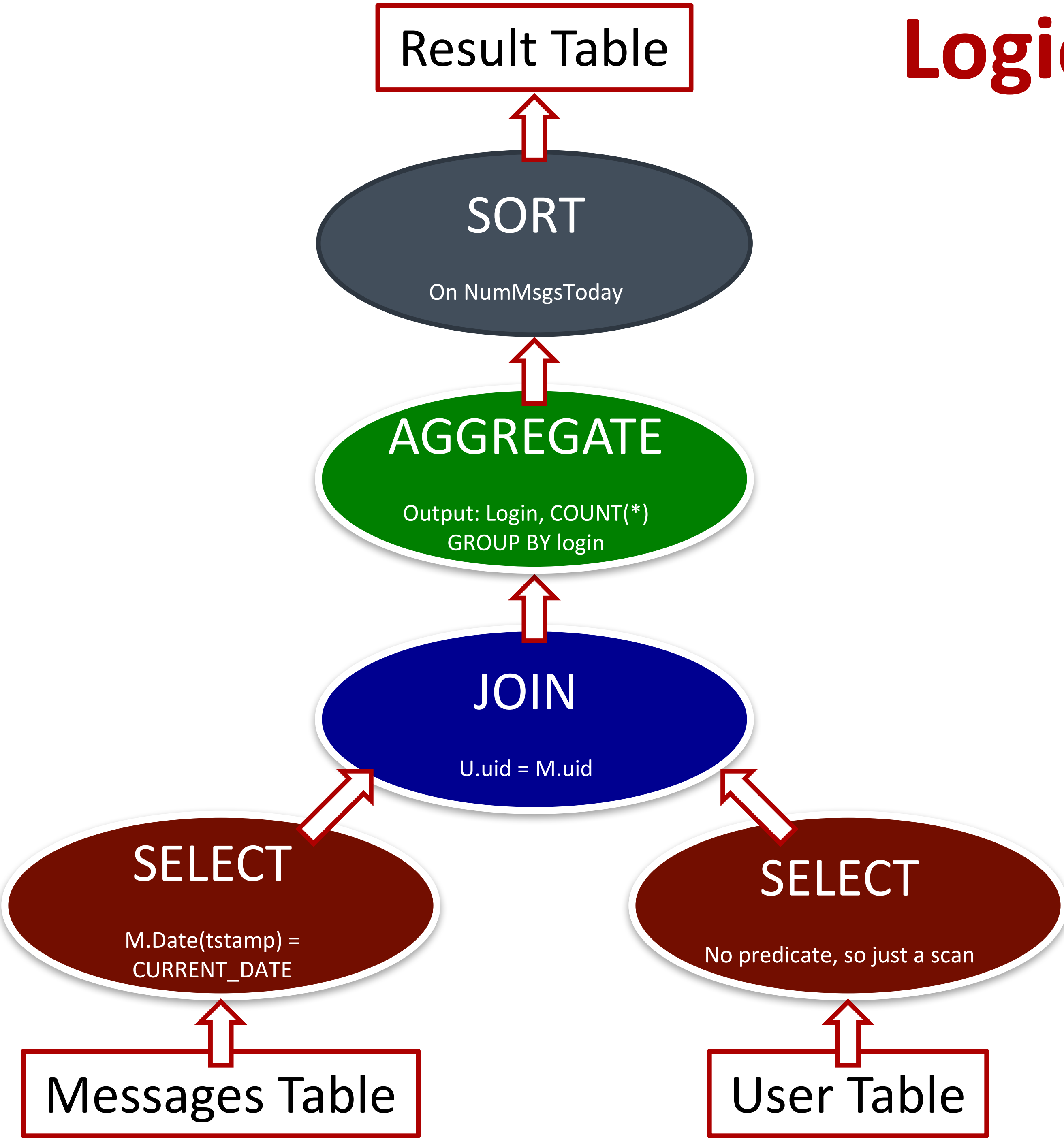
- Run the following query:

```
SELECT U.login AS login, COUNT(*) AS NumMsgsToday
FROM   User U, Messages M
WHERE  U.uid = M.uid
  AND  M.Date(tstamp) = CURRENT_DATE   -- select msgs posted today
GROUP BY U.login                       -- group by login
ORDER BY NumMsgsToday DESC             -- order by descending msg count
```

Sample output table

login	NumMsgsToday
angelak	211
jackdr	101
petescafe	10
…	…

Logical Query Plan

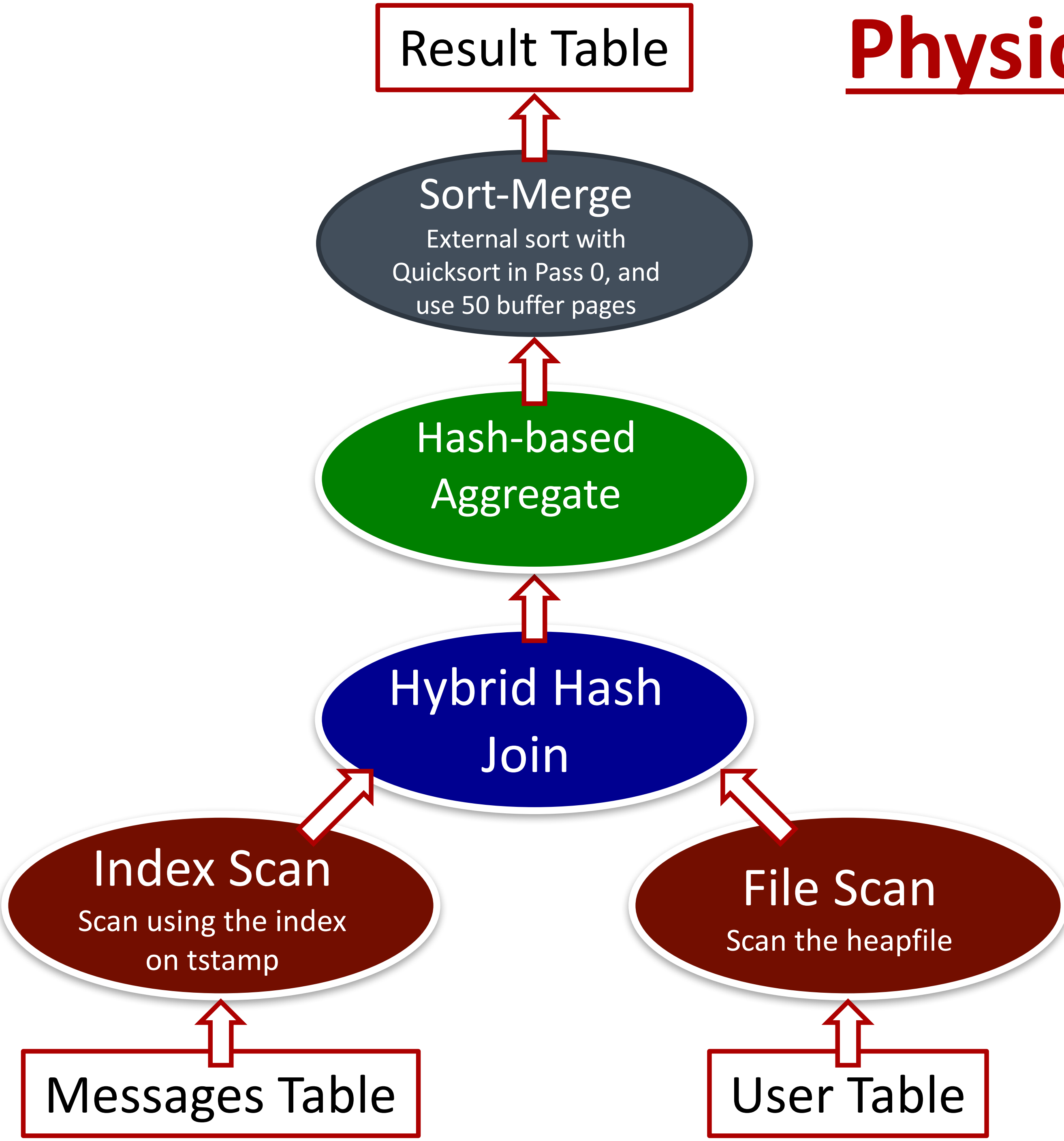


Here the ovals are logical operators. There are many different algorithms for each of these operators.

We study these algorithms next.

You already know the sort algorithm. So we can skip that one!

Physical Query Plan



Here the ovals are **physical operators**.

Each physical operator specifies the exact algorithm/code that should be run, and parameters (if any) for that algorithm.

Select Operation

- Algorithms: File Scan or Index Scan
- **File Scan:** Disk I/O cost:
- **Index Scan:** (on some predicate). Disk I/O cost:
  - Hash: O( ) can only use with equality predicates
  - B+-tree: O( ) + X
    - X = number of selected tuples/number of tuples per page
    - X = 1 per selected tuple with an unclustered index. To reduce the value of X, we could sort the rids and then fetch the tuples.
  - Bitmap Index:

When to use a B+tree index

- Consider
  - A relation with 1M tuples
  - 100 tuples on a page
  - 500 (key, rid) pairs on a page

data pages
= 1M/100 = 10K pages
leaf idx pgs
= 1M / (500 * 0.67)
~ 3K pages

	1% Selection	10% Selection
Clustered	30 + 100	300 + 1000
Non-Clustered	30 + 10,000	300 + 100,000
NC + Sort Rids	30 + (~ 10,000)	300 + (~ 10,000)

⇨ Choice of Index access plan, consider:
1. Index Selectivity **2. Clustering**
⇨ Similar consideration for hash based indices

When can we use an index

- Notion of "index matches a predicate"
- Basically mean when can an index be used to evaluate predicates in the query

General Selection Conditions

- Index on (R.a, R.b)
  - Hash or tree-based
- Predicate:
  - R.a > 10
  - R.b < 30
  - R.a = 10 and R.b = 30
  - R.a = 10 or R.b = 30
- Predicate: (p1 and p2) or p3
- Convert to Conjunctive Normal Form(CNF)
  (p1 or p3) and (p2 or p3)
- An index ***matches*** a predicate
  - Index can be used to evaluate the predicate

Index Matching

- B+-tree index on <a, b, c>
  - a=5 and b= 3?
  - a > 5 and b < 3
  - b=3
  - a=7 and b=5 and c=4 and **d>4**
  - a=7 and c=5

(primary conjunct)

Hash Idx

- Index matches (part of) a predicate
  1. Conjunction of terms involving only attributes (no disjuctions)
  2. Hash: only equality operation, predicate has all index attributes.
  3. Tree: Attributes are a prefix of the search key, any ops.

Index Matching

- A predicate could match more than 1 index
- Hash index on <a, b> and B+tree index on <a, c>
  - a=7 and b=5 and c=4 Which index?
  - Option1: Use either (or a file scan!)
    - Check selectivity of the primary conjuct
  - Option2: Use both! Algorithm: Intersect rid sets.
    - Sort rids, retrieve rids in both sets.
    - Side-effect: tuples retrieved in the order on disk!

Selection

- Hash index on <a> and Hash index on <b>
  - a=7 **or** b>5 Which index?
  - Neither! File scan required for b>5
- Hash index on <a> and B+-tree on <b>
  - a=7 **or** b>5 Which index?
  - Option 1: Neither
  - Option 2: Use both! Fetch rids and union
    - Look at selectivities closely. Optimizer!
- Hash index on <a> and B+-tree on <b>
  - (a=7 **or** c>5) and b > 5 Which index?
  - Could use B+-tree (check selectivity)

Projection Algorithm

- Used to project the selected attributes.

Simple case: Example SELECT R.a, R.d.

  - Algorithm: for each tuple, only output R.a, R.d

Harder case: DISTINCT clause

- Example: SELECT DISTINCT R.a, R.d
  - Remove attributes <u>and</u> eliminate duplicates
- Algorithms
  - Sorting: Sort on <u>all</u> the projection attributes
    - Pass 0: eliminate unwanted fields. Tuples in the sorted-runs may be smaller
    - Eliminate duplicates in the merge pass & in-memory sort
  - Hashing: Two phases
    - Partitioning
    - Duplicate elimination

Hashing

Can h1 = h2?

What if the hash table for a partition overflows, i.e. can't fit in memory?

$R' = \pi_P(R)$

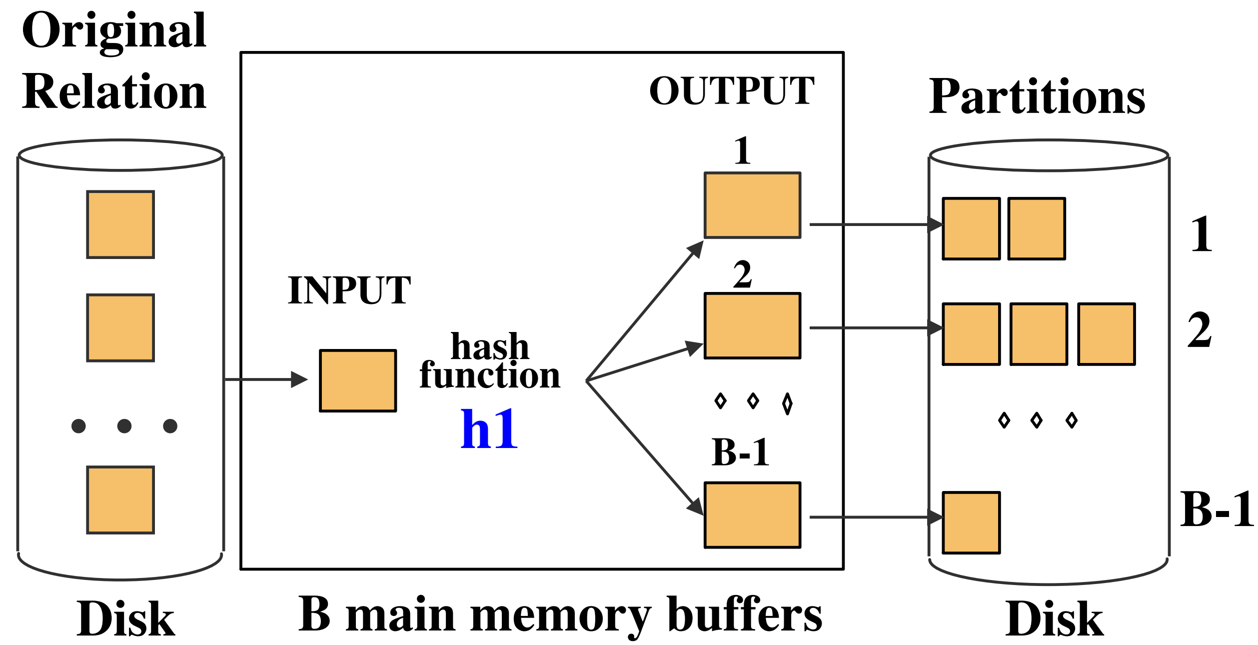
No overflows if

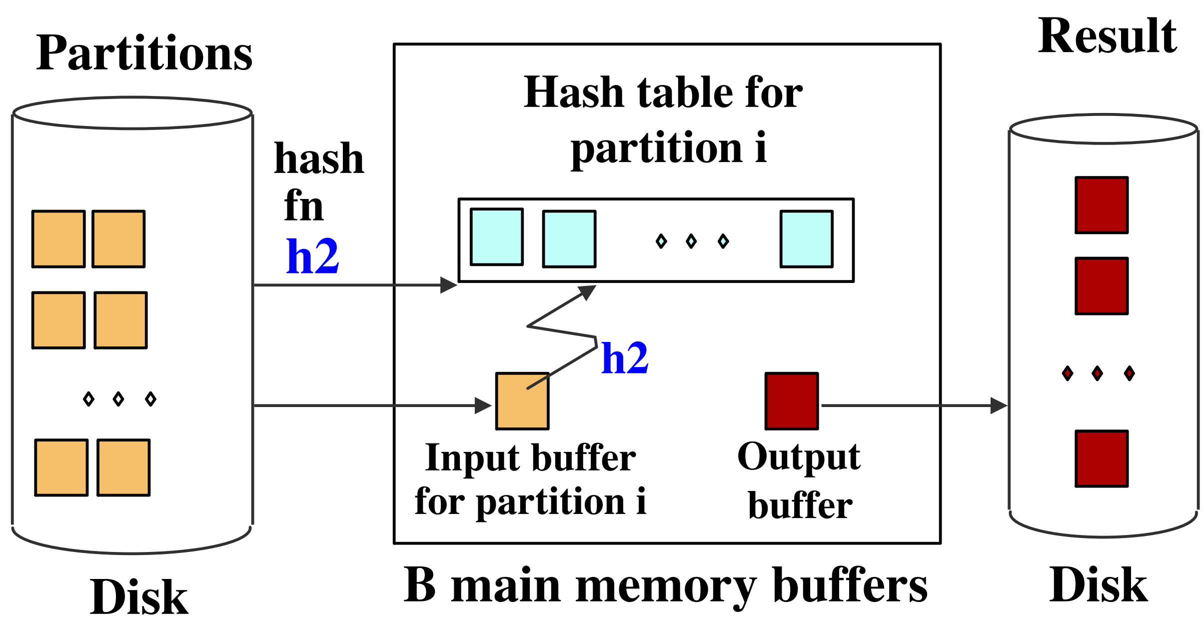
$|R'| < B^2/F$

F = fudge factor (to account for the hash table)

Part. Sz, $P = |R'|/B-1$

Hash Tab Sz = $F*P < B$





Projection …

- Sort-based approach
  - better handling of skew
  - result is sorted
  - I/O costs are comparable if $B^2 > |R'|$
- Index-only scan
  - Projection attributes subset of index attributes
  - Apply projection techniques to data entries (much smaller!)
- If an ordered (i.e., tree) index contains all projection attributes as *prefix* of search key:
  1. Retrieve index data entries in order
  2. Discard unwanted fields
  3. Compare adjacent entries to eliminate duplicates (if required)