Parallel Join Algorithms

Two main parallel join algorithms:

- Hash Join
- Sort-Merge Join

许多OLTP DBMS是不会实现hash join的，因为没有必要build hashtable，有现成的index

index nested-loop join with small number of target tuples 可以大概等效于一个hash join

大概意思是说，hash join的hashtable是query查询临时构建的，查询完毕之后hashtable就会销毁。而index是本身就已经存在了的。

Join Algorithm Design Goals

- 减少同步开销

在执行过程中尽量避免用latches

- 最小化内存访问的开销

当data还在cpu cache的时候，尽最大可能重用

确保数据和工作线程的局部性

影响DBMS中cache misses的因素

- Cache + TLB容量(TLB就是快表，存储virtual address到physical address的mapping)
- 时空局部性

Non-Random Access:(sequential scan)

- Clustering data to a cache line.
- 那么可以对cache line的数据执行尽可能多的操作

Random Access: (lookups)

- partition data to fit in cache + TLB

什么是Hash Join?

可以划分为三个阶段

Phase #1: Partition (*optional*)

→ Divide the tuples of R and S into sets using a hash on the join key.

Phase #2: Build

→ Scan relation R and create a hash table on join key.

Phase #3: Probe

→ For each tuple in S, look up its join key in hash table for R. If a match is found, output combined tuple.

Partition Phase

PARTITION PHASE

Split the input relations into partitioned buffers by hashing the tuples' join key(s).

→ Ideally the cost of partitioning is less than the cost of cache misses during build phase.

→ Sometimes called ***hybrid hash join / radix hash join.***

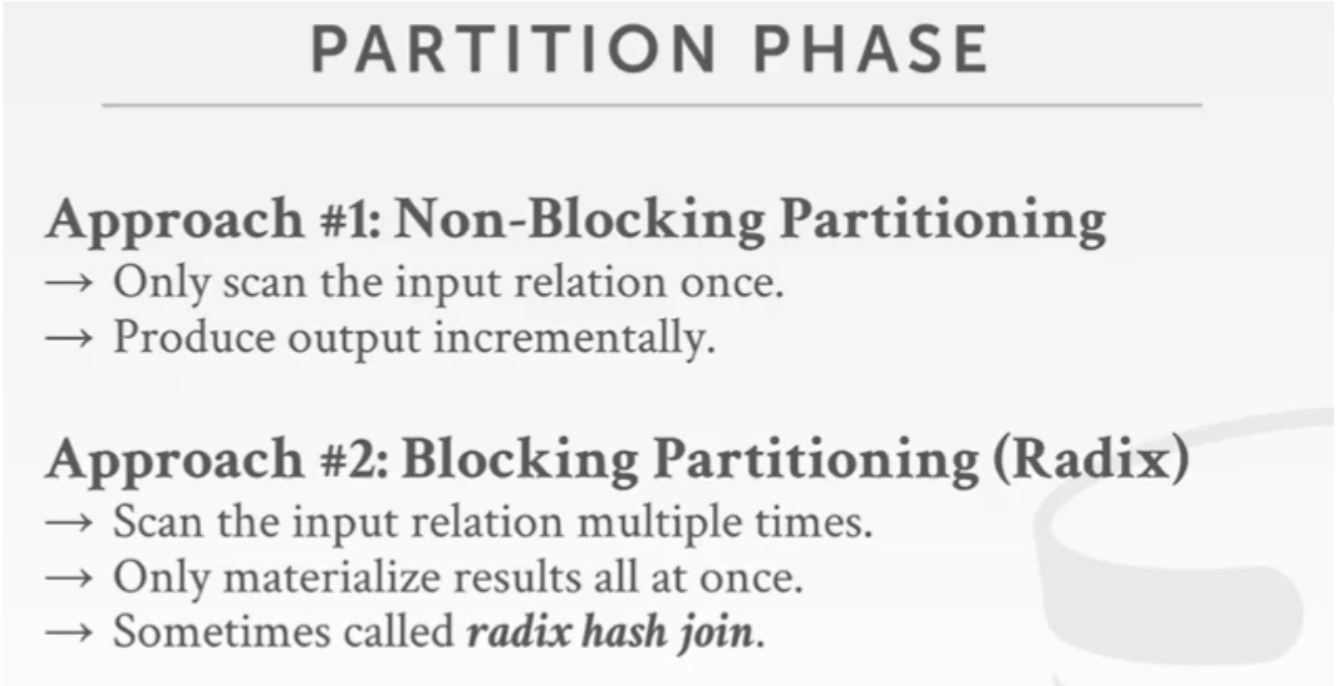
Contents of buffers depends on storage model:

→ **NSM**: Usually the entire tuple.

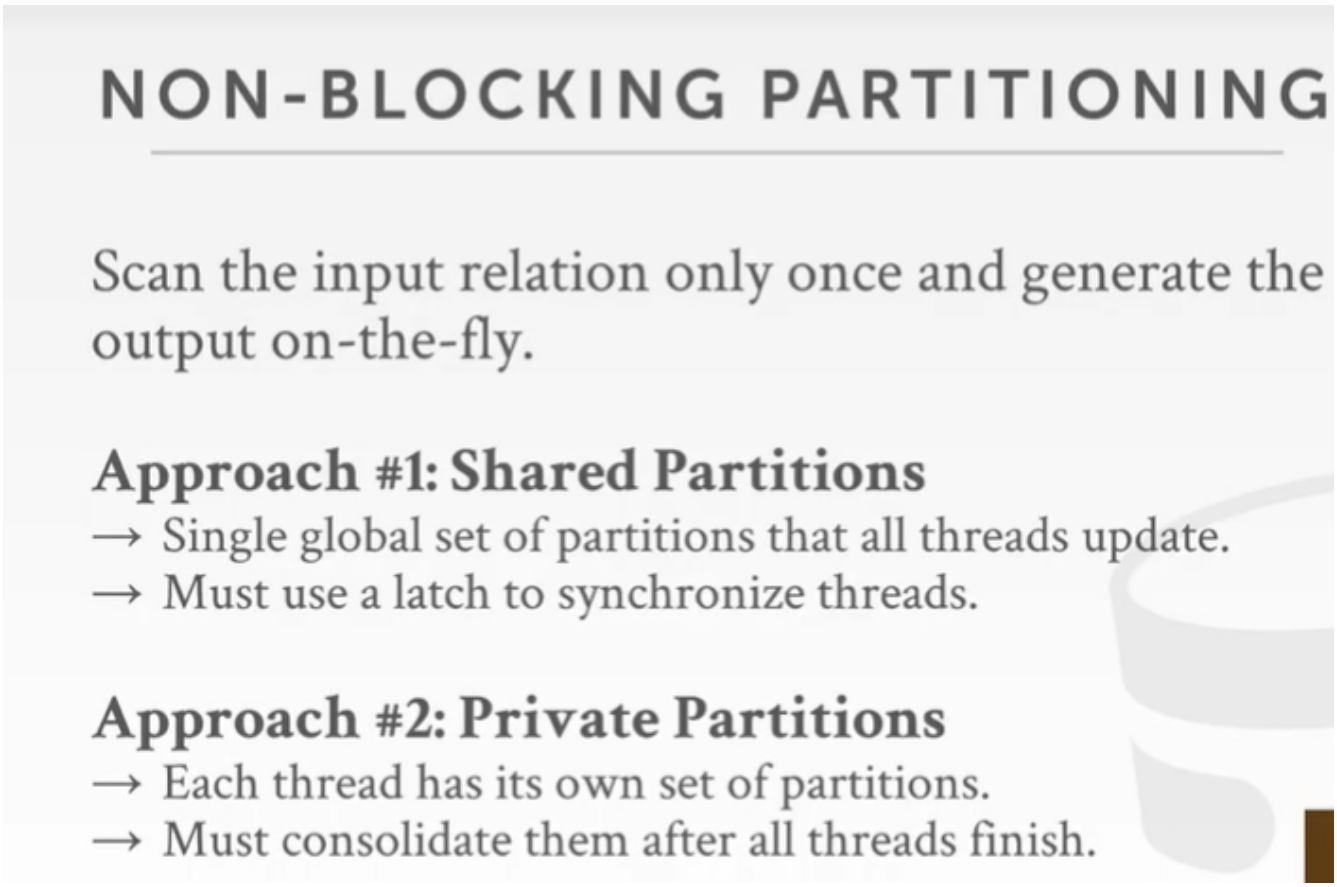
→ **DSM**: Only the columns needed for the join + offset.

如果是行存：整个tuple

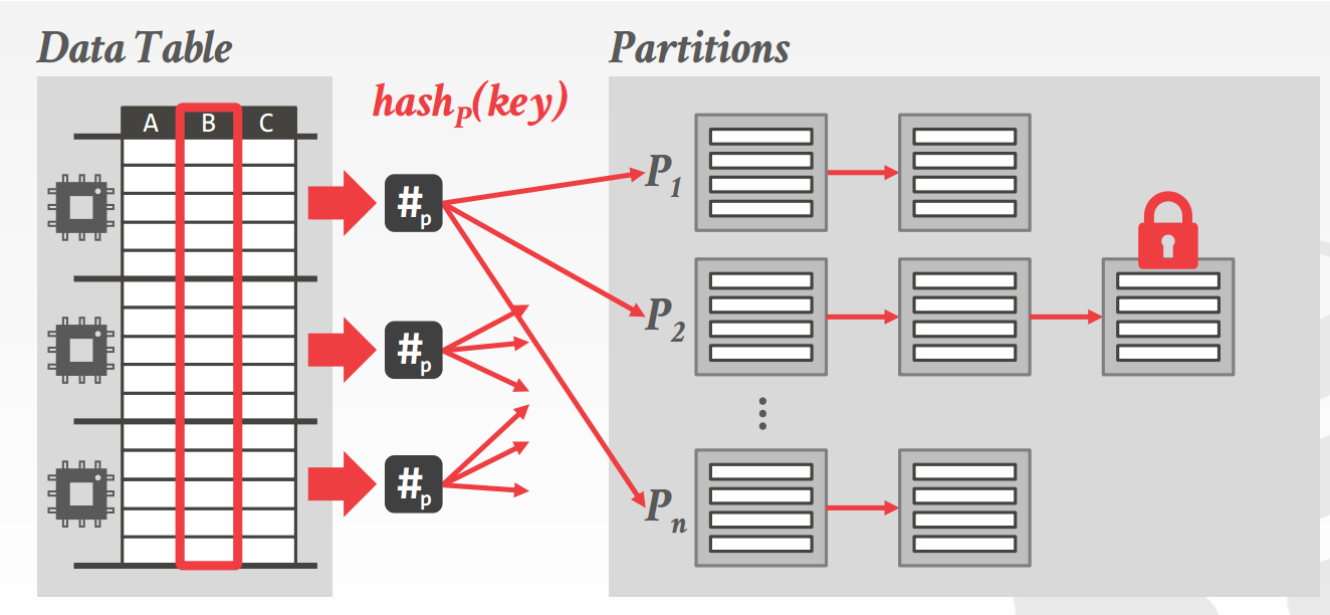
如果是列存：只需要存储部分列的数据



- Non-Blocking Partitioning

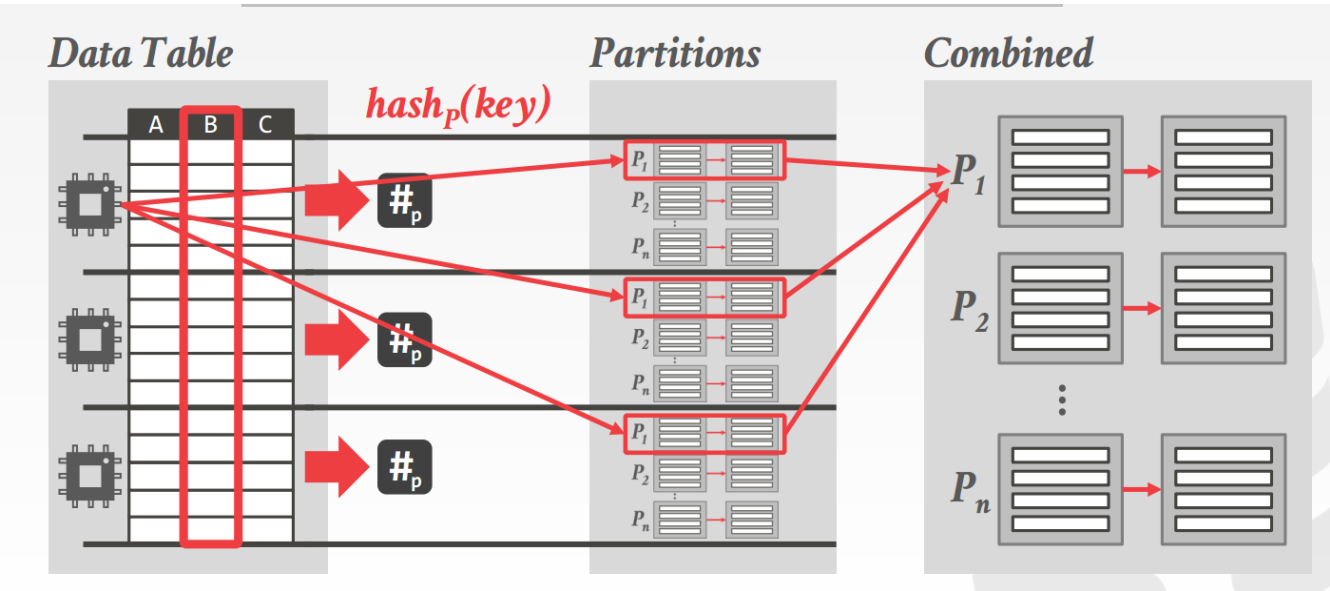


- Shared Partitions



性能开销在于latch同步比较影响性能

- Private Partitions



性能开销主要是copy data了两次，如果是行存而且一行tuple很大的话，copy开销其实不小。

- Blocking Partitioning（Radix Partitioning）

RADIX PARTITIONING

Scan the input relation multiple times to generate the partitions.

Multi-step pass over the relation:

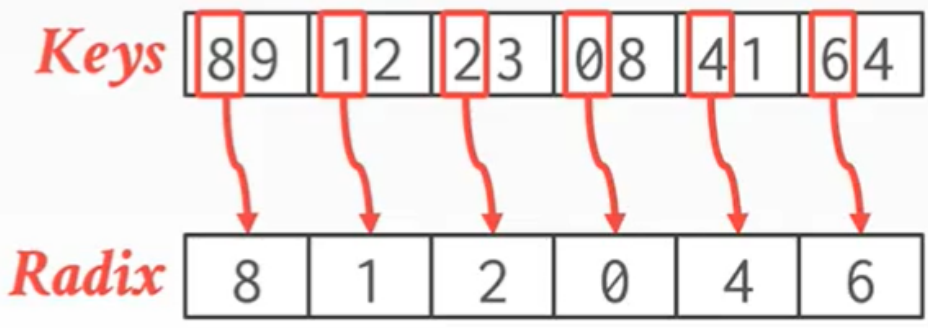
→ **Step #1:** Scan **R** and compute a histogram of the # of tuples per hash key for the radix at some offset.

→ **Step #2:** Use this histogram to determine output offsets by computing the **prefix sum**.

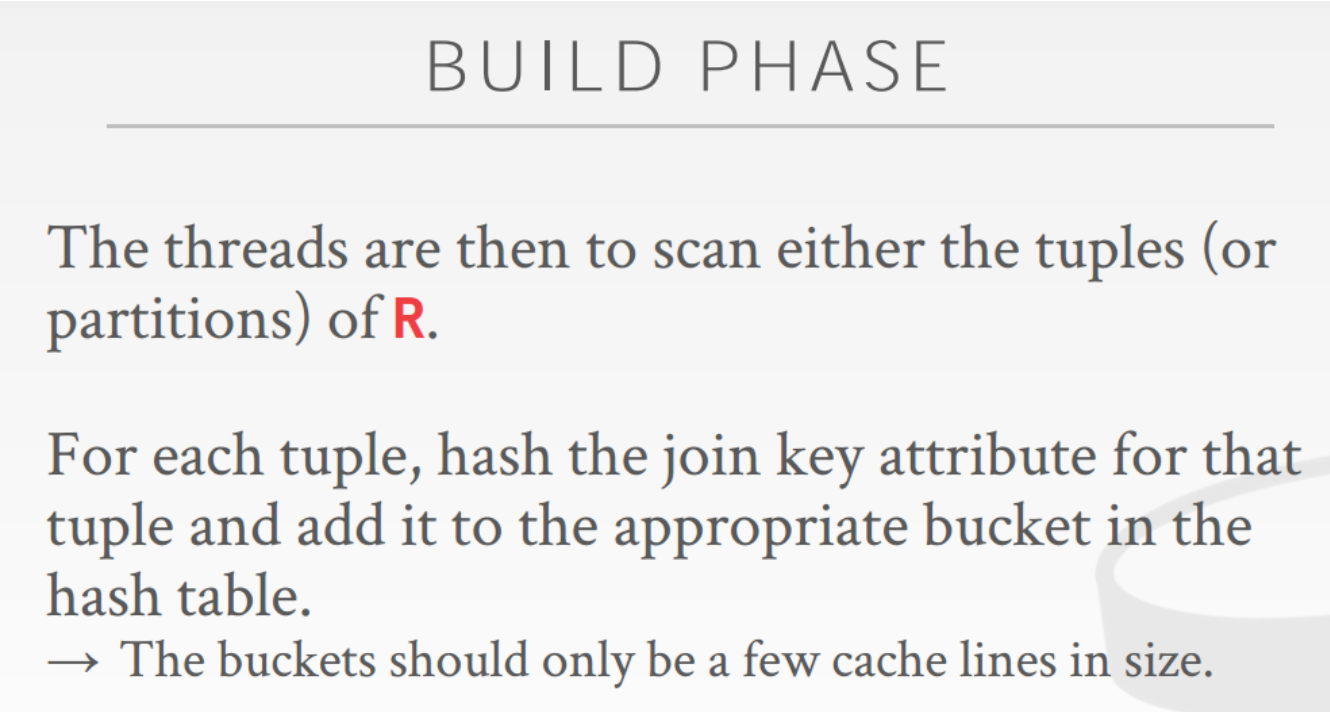
→ **Step #3:** Scan **R** again and partition them according to the hash key.

RADIX

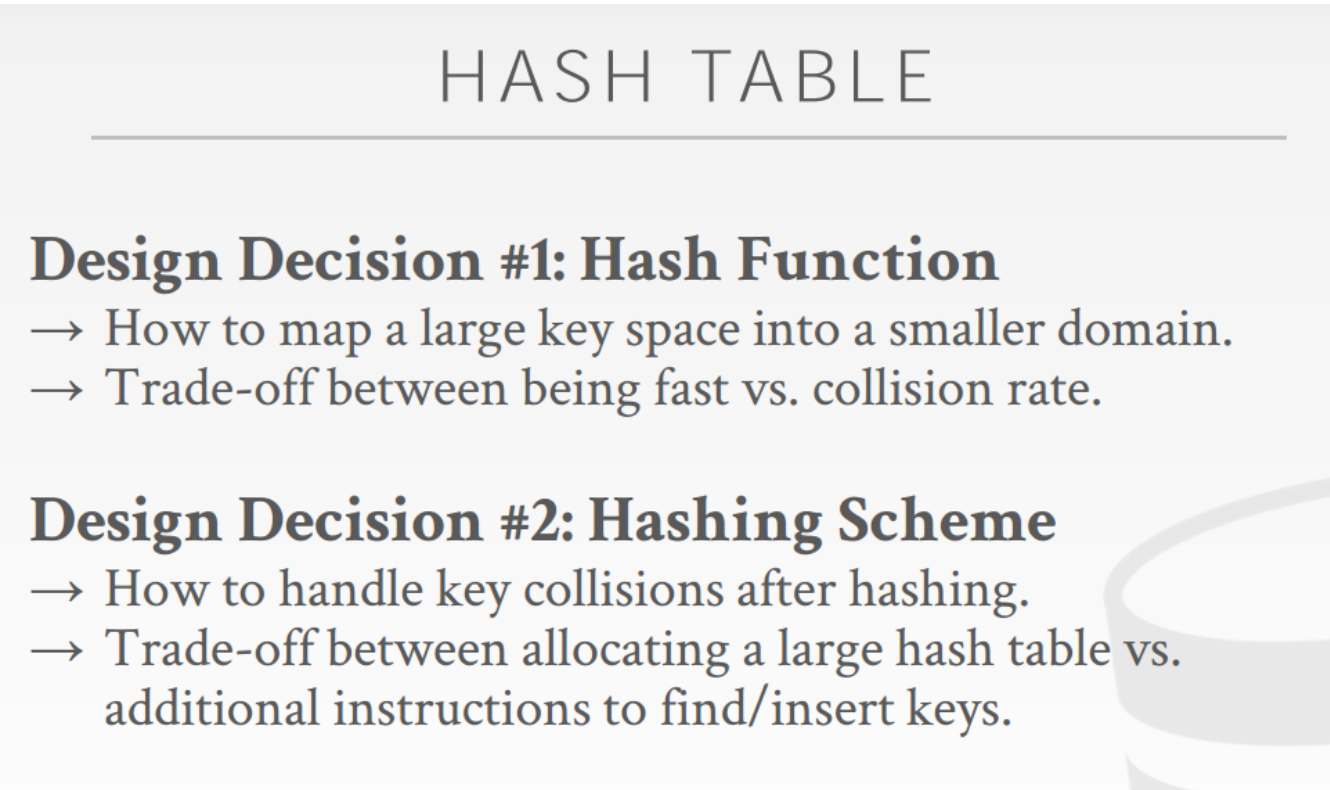
The radix of a key is the value of an integer at a position (using its base).



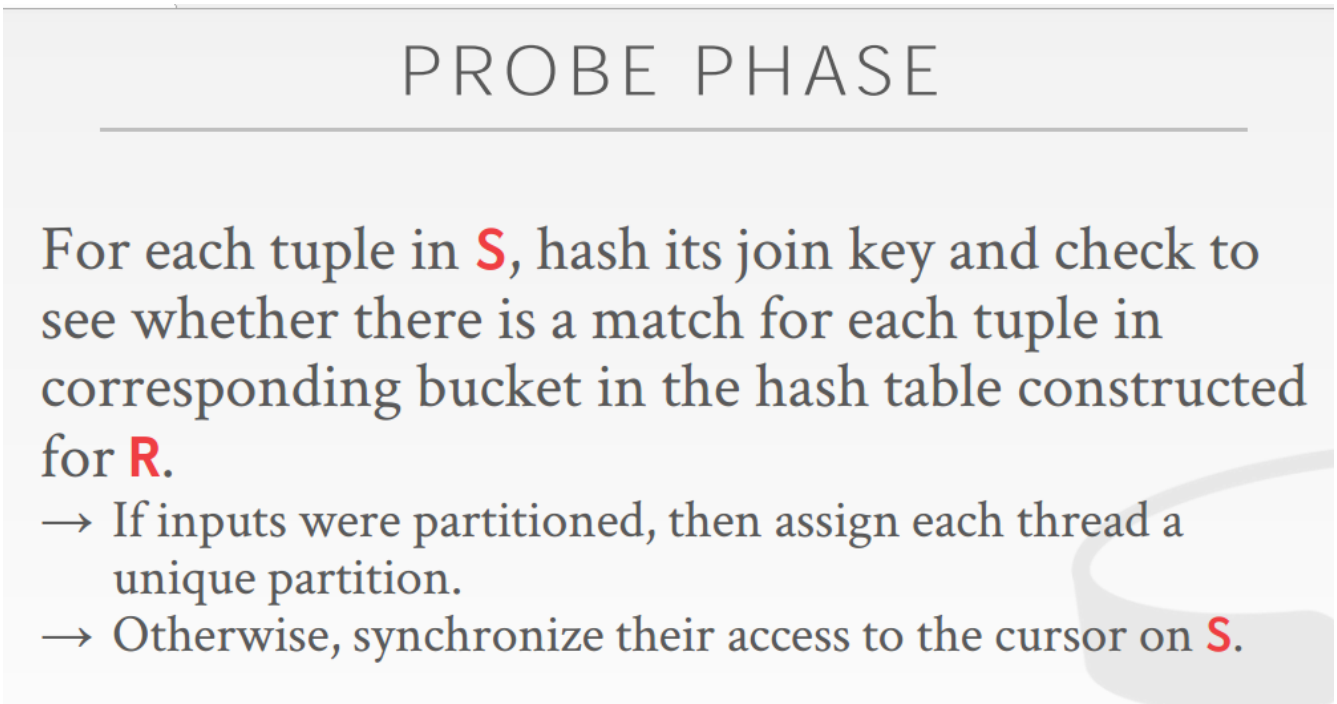
Build Phase



- hash table



Probe Phase



- Bloom Filter

PROBE PHASE – BLOOM FILTER

Create a Bloom Filter during the build phase when the key is likely to not exist in the hash table.

→ Threads check the filter before probing the hash table. This will be faster since the filter will fit in CPU caches.

→ Sometimes called ***sideways information passing.***