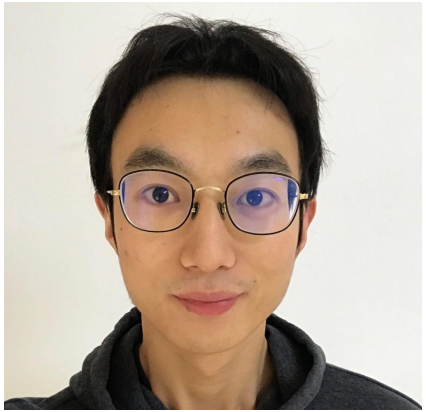
How to Protect the SQL Engine From Running Out of Memory

Presented by Huaiyu Xu/ Song Gao

PingCAP TiDB



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Committer of TiDB SIG planner

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Committer of TiKV SIG scheduling

Github: @Yisaer

Agenda

- Causes of SQL engine OOM
- Solutions
- Implementation in TiDB (TiDB is an open-source, distributed, NewSQL database)
- Q&A

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Part I - When will SQL engine run OOM

SQL engine runs out of memory

- statistics cache, table metadata cache, and etc. takes up too much memory space
- hash join builds a large hash table
- in-memory sort on a large dataset
- table scan/index scan reads data fast cause buffers too much data
- ...

Scenario summarization

- Memory resident object consumption
  - statistics cache, table metadata cache, ...
- Large memory consumption during calculating
  - pipeline breaker: hash join, sort, hash aggregation, …
  - pipelining operators: table scan, index scan, ...

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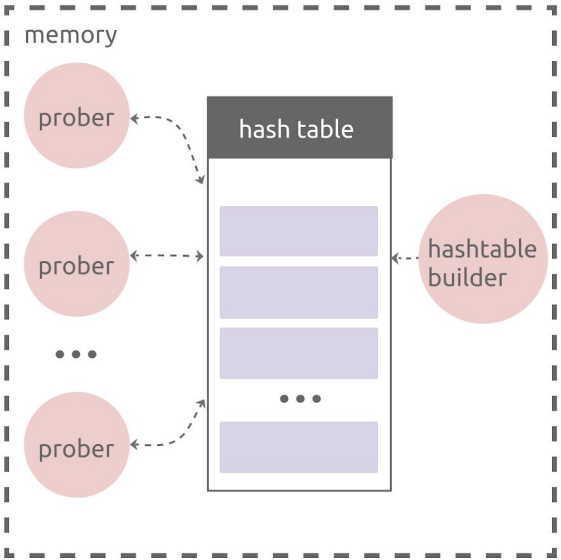
Part II - Solutions

Solution

- Memory resident object consumption
  - In-memory cache with limited size
- Large memory consumption during calculating
  - pipeline breaking operators: spill to disk
  - pipelining operators: adaptive control

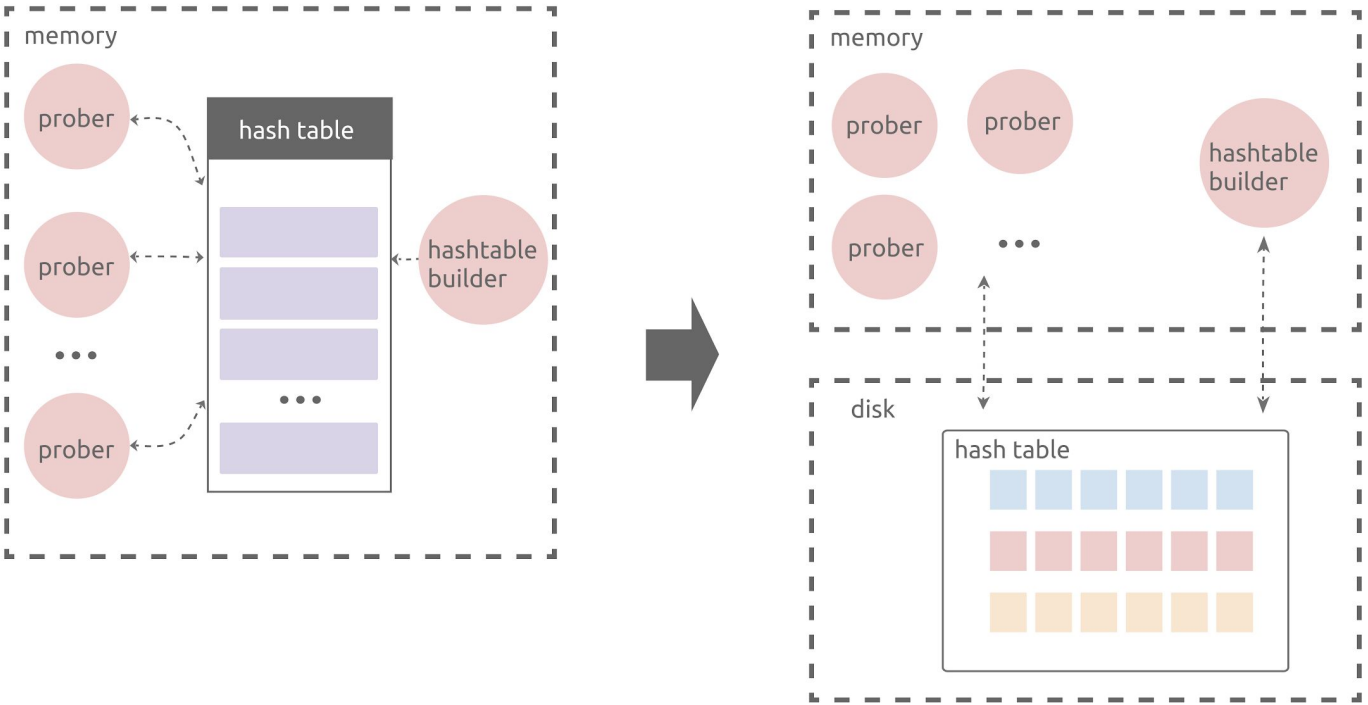
Pipeline breaker

- HashJoin



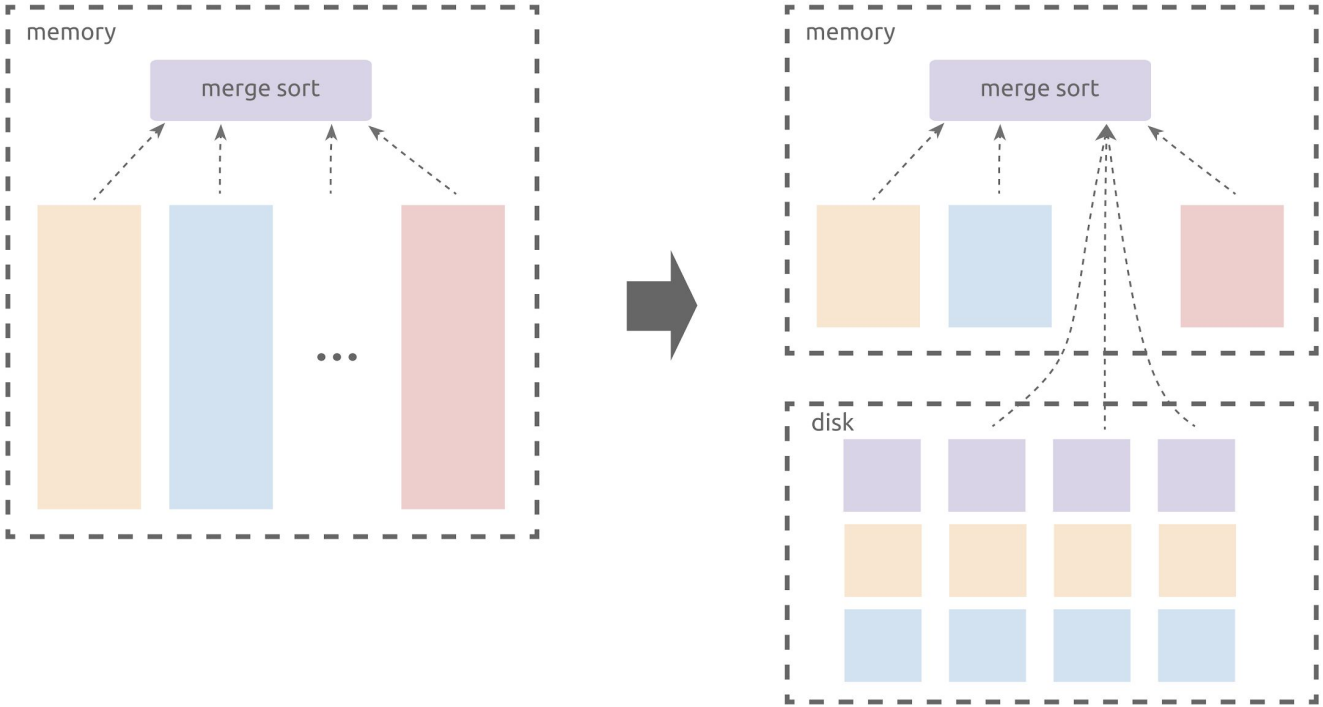
Pipeline breaker

- HashJoin



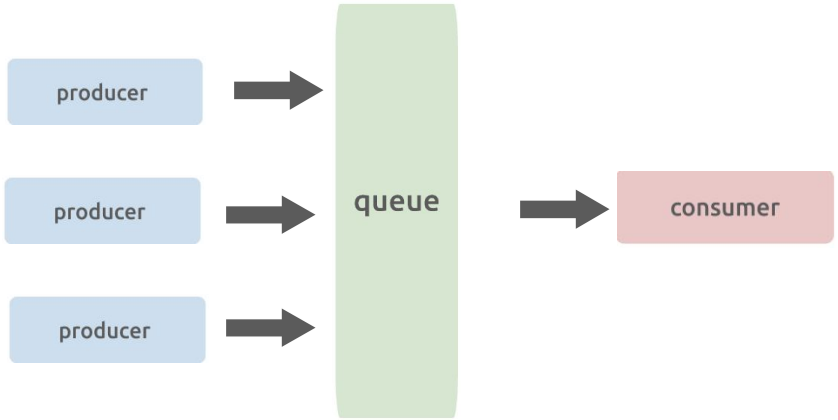
Pipeline breaker

- Sort



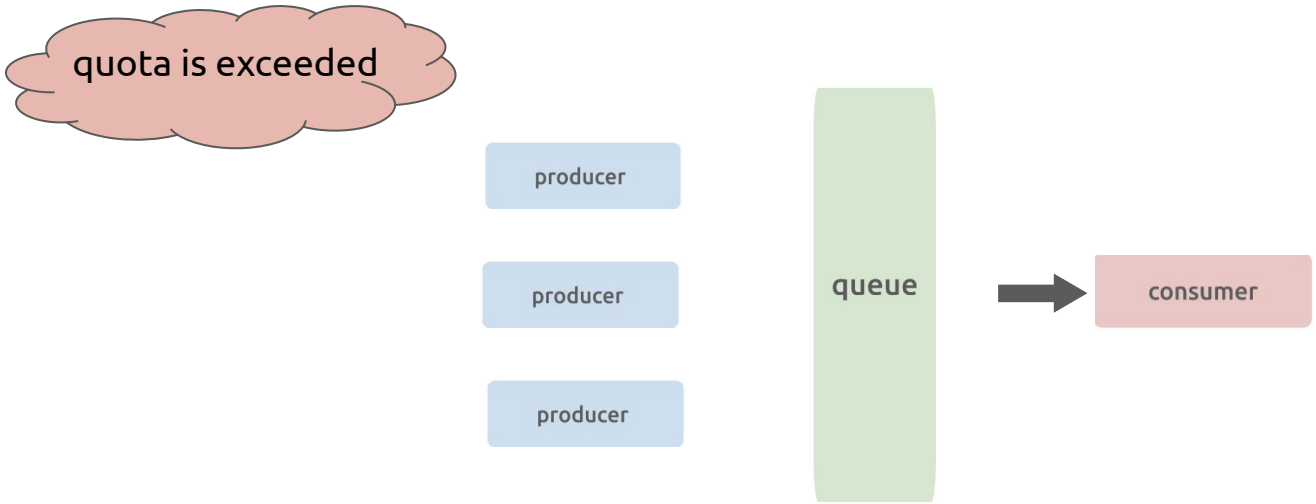
Pipelining operators

- producer-consumer model



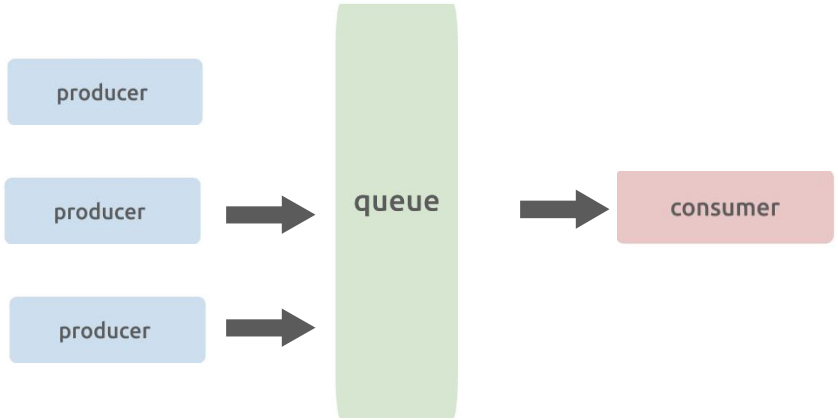
Pipelining operators

- suspend all the producers when the memory quota is exceeded



Pipelining operators

- producers keep creating data
- the rate will be controlled by removing one producer



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Part III - Implementation in TiDB

What is TiDB?

Open-source distributed NewSQL database for hybrid transactional and analytical processing (HTAP) which speaks MySQL protocol

Horizontal Scalability

Transparent scale-out or scale-in

High Availability

Auto-failover to ensure business continuity

Strongly Consistent

Full ACID transactions at distributed environments

MySQL Compatibility

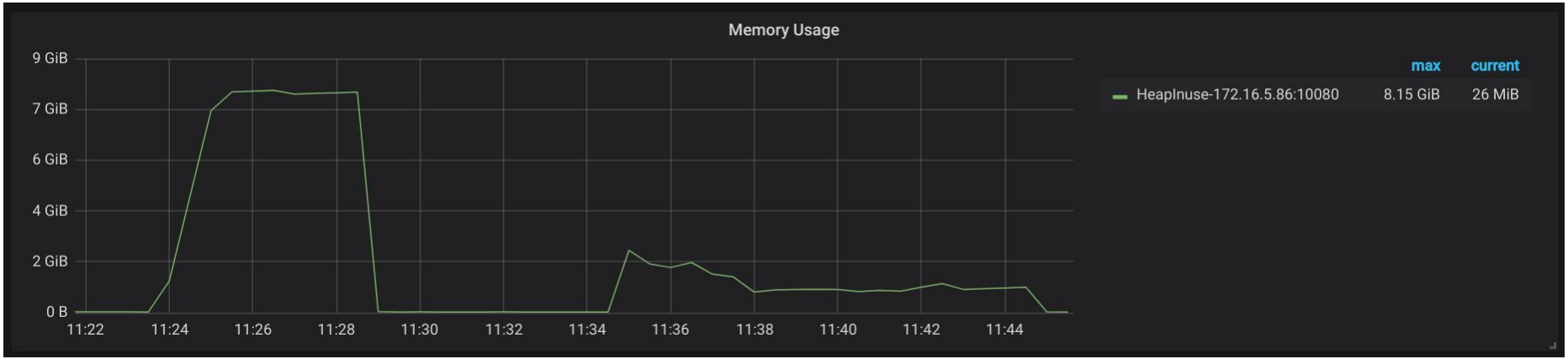
Without changing MySQL application code in most cases

Interfaces

- MemTracker
  - track the memory usage of each element
- OOMAction
  - abstract of different memory management strategies
  - DiskSpillAcion (spill to disk strategy)
  - RateLimitAction (adaptive control strategy)

DiskSpillAction

- select * from partsupp order by PS_AVAILQTY; (TPC-H SF:50)

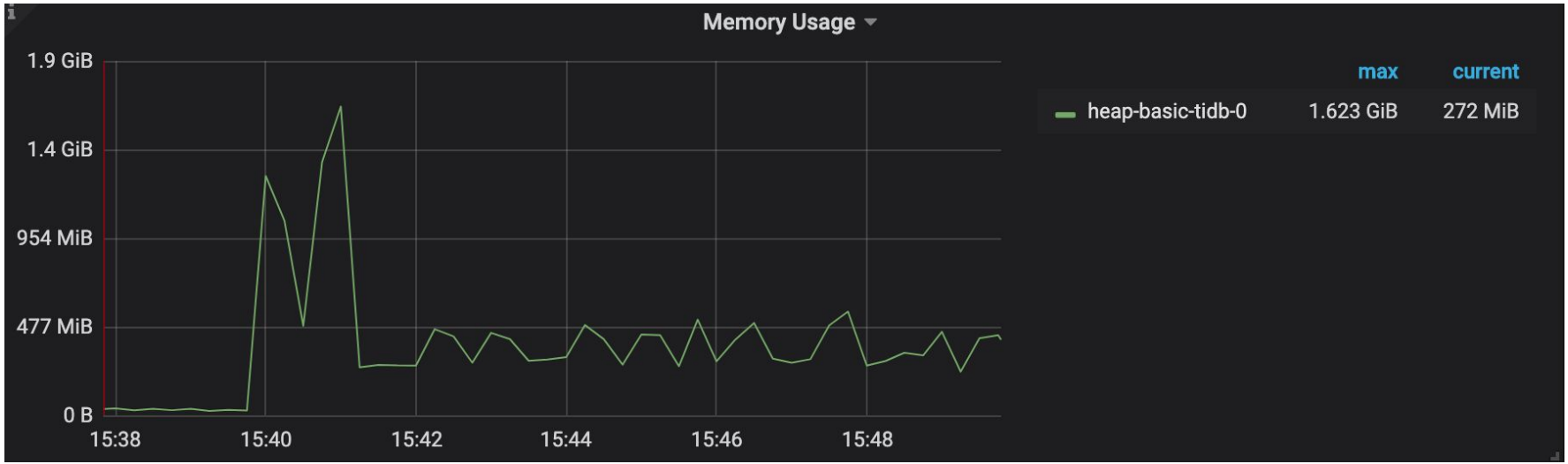


mem_quota is unlimited

mem_quota is set to 1GB
DiskSpillAction is triggered

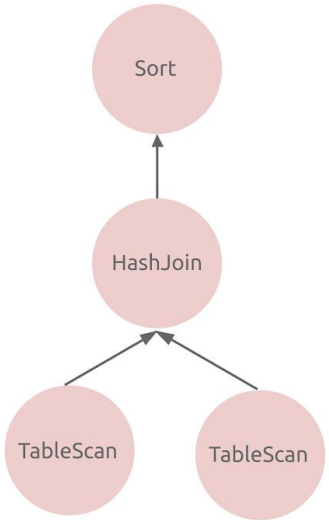
RateLimitAction

- dump 200GB data
    - OOM will happen when mem_quota is unlimited



Implementation in TiDB

- select s.b from t join s on t.a = s.a order by s.b



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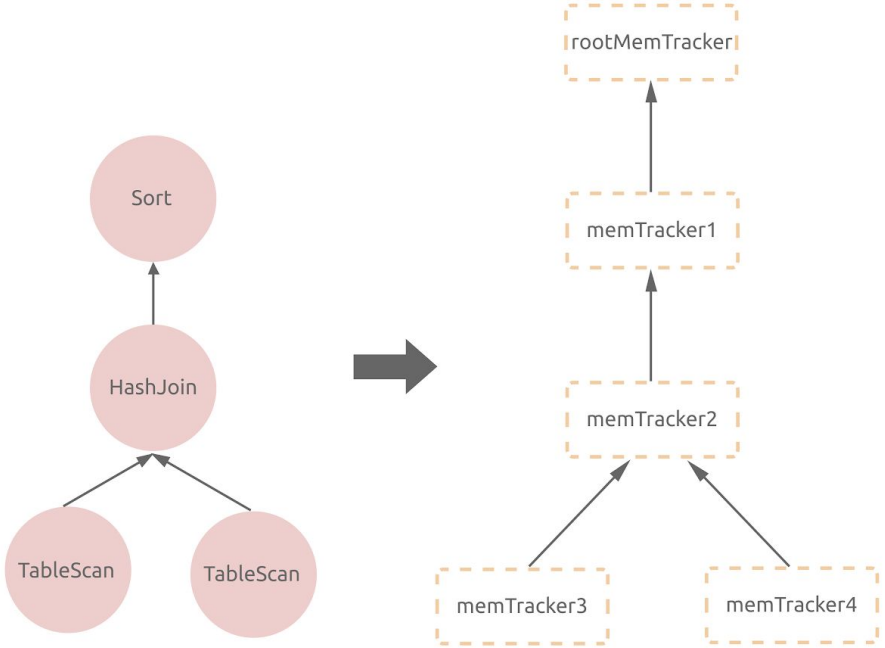

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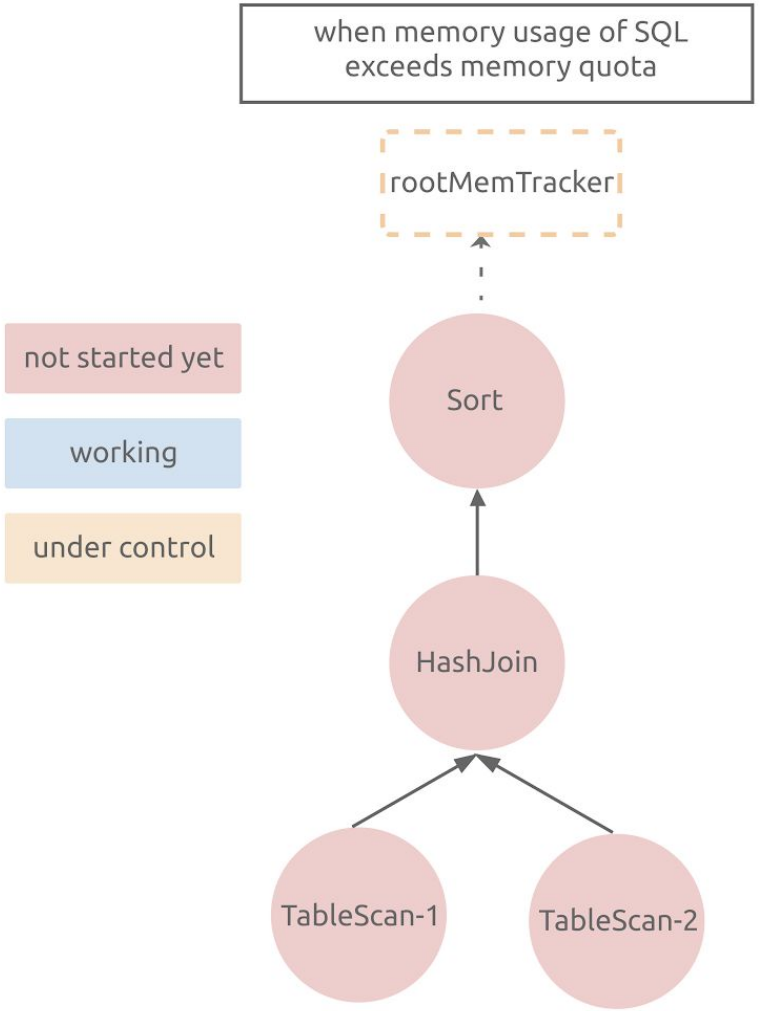

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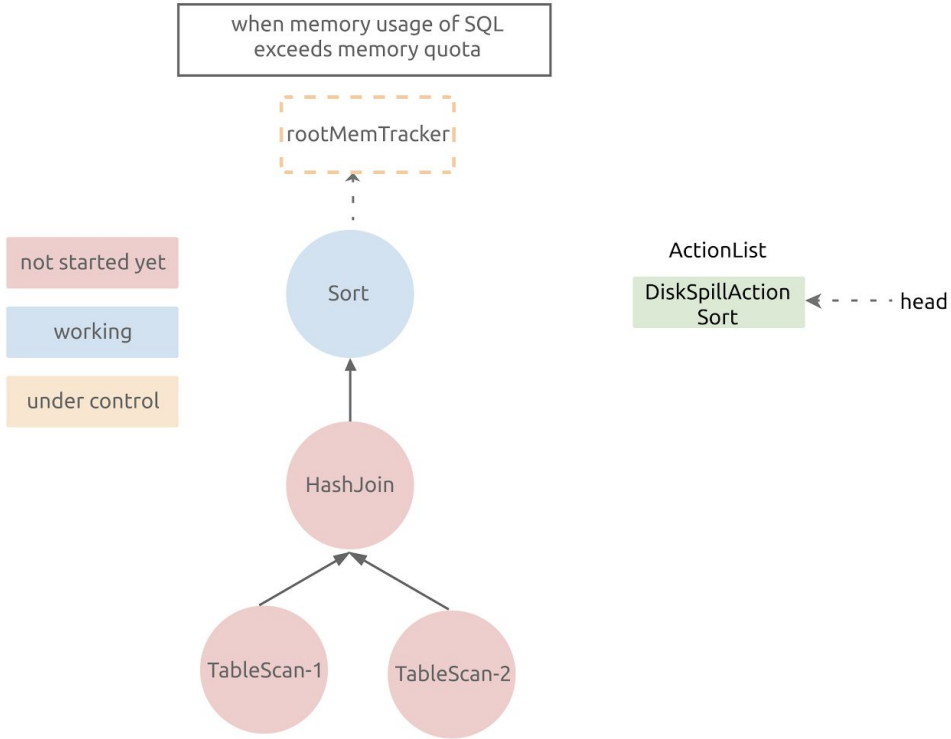

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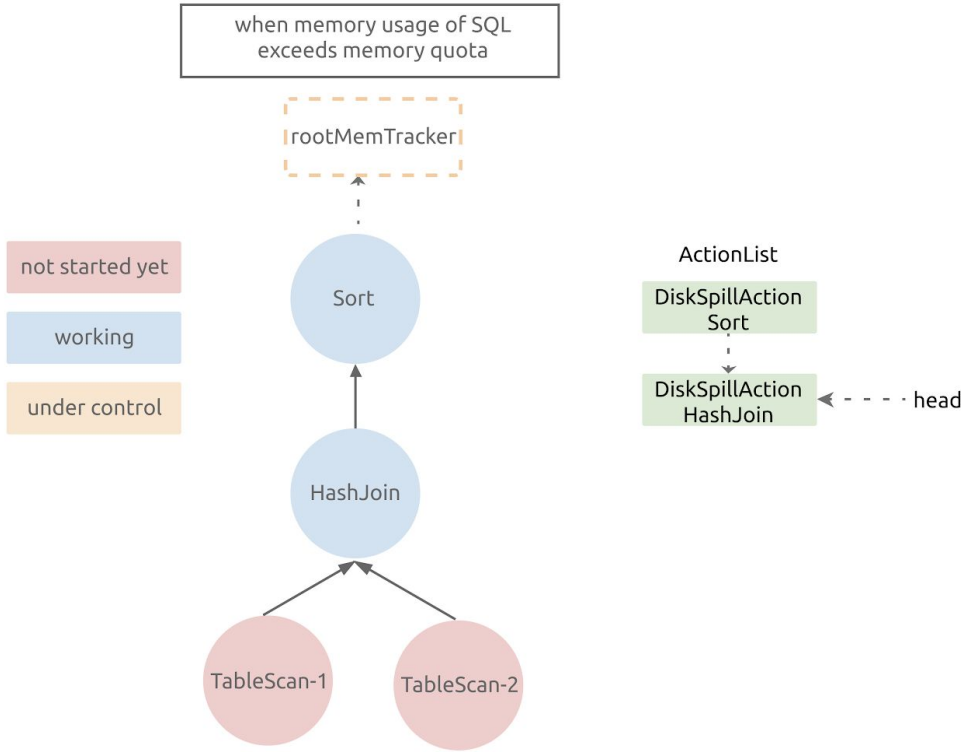

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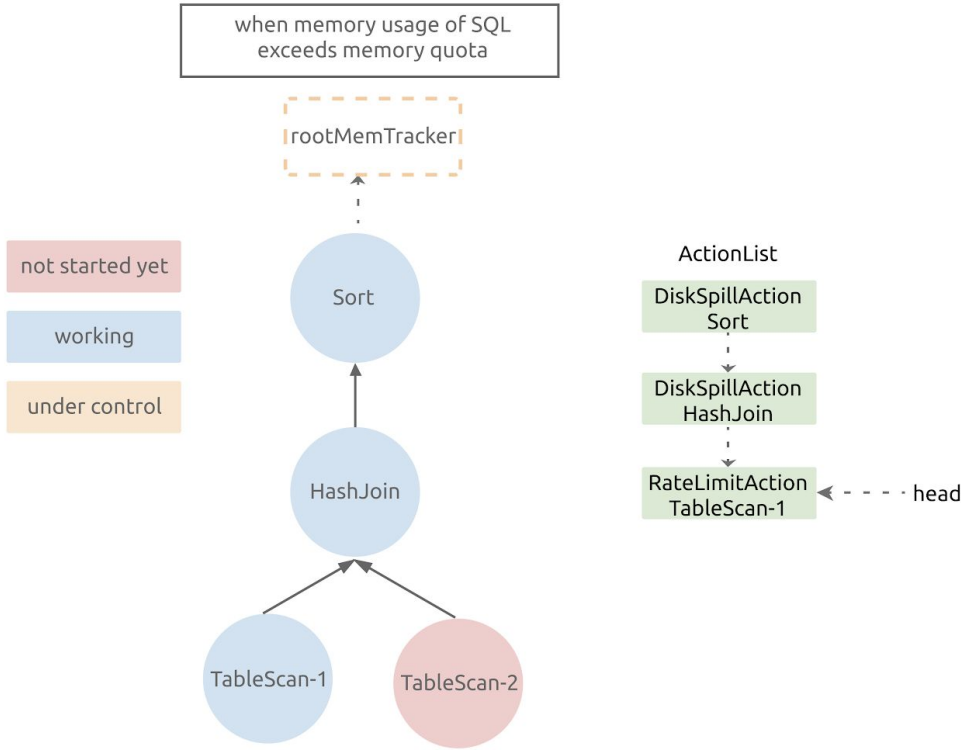
4. TableScan-1 starts to work.



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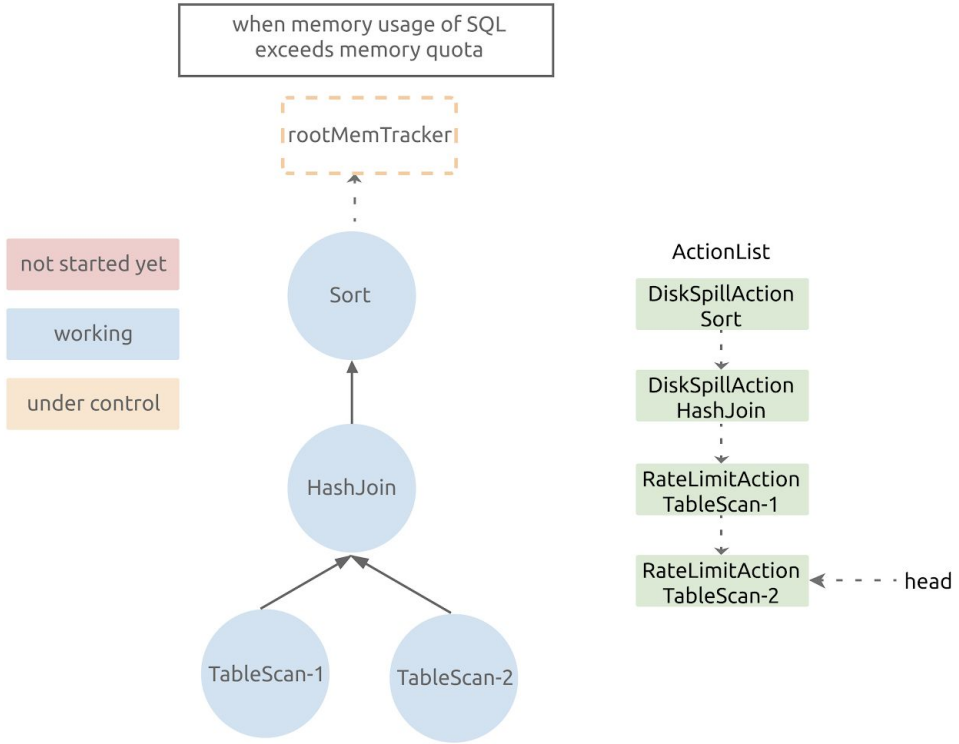

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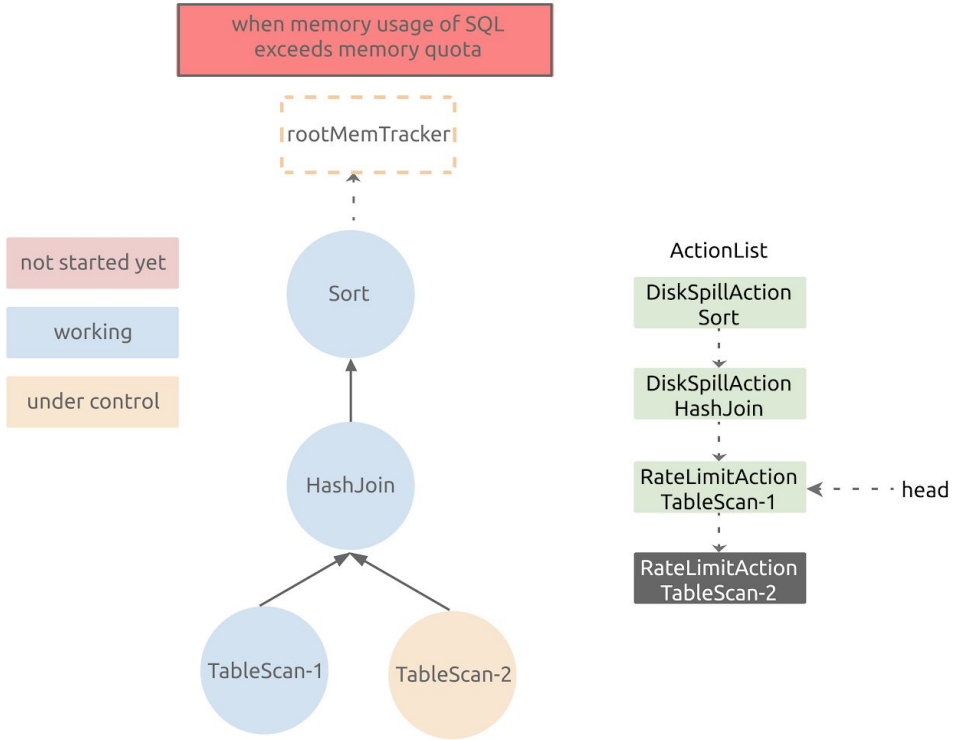

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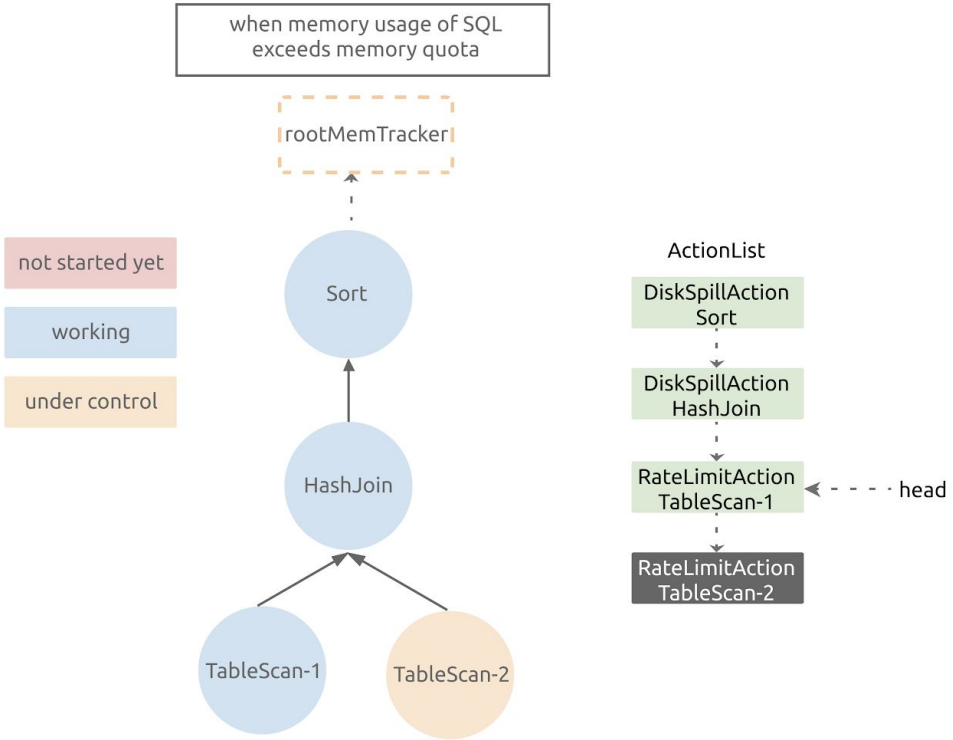

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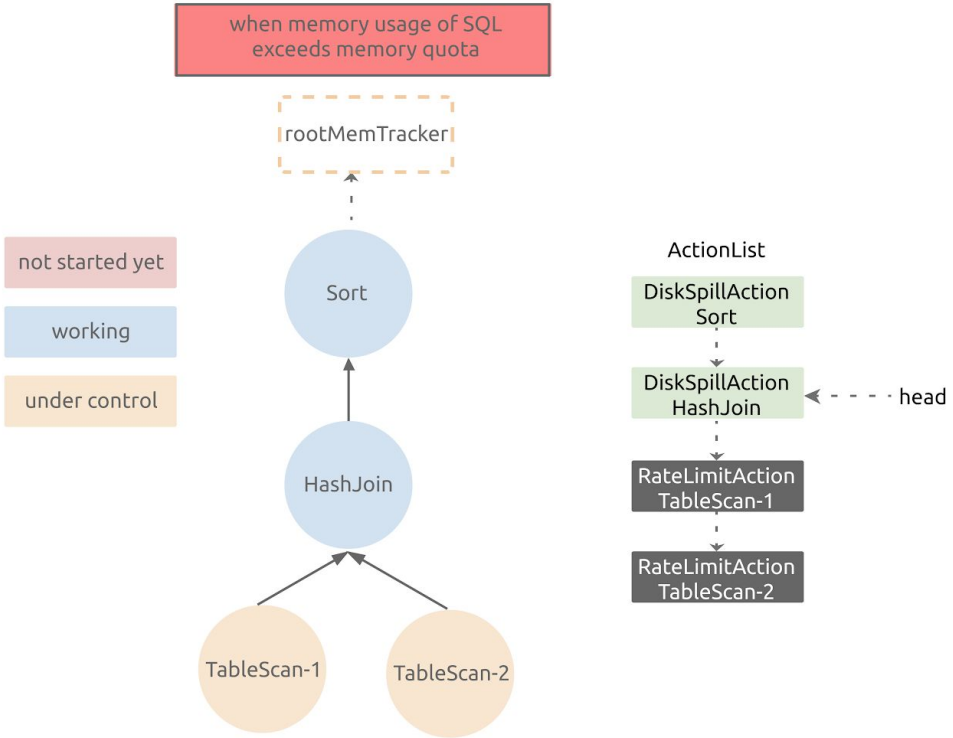

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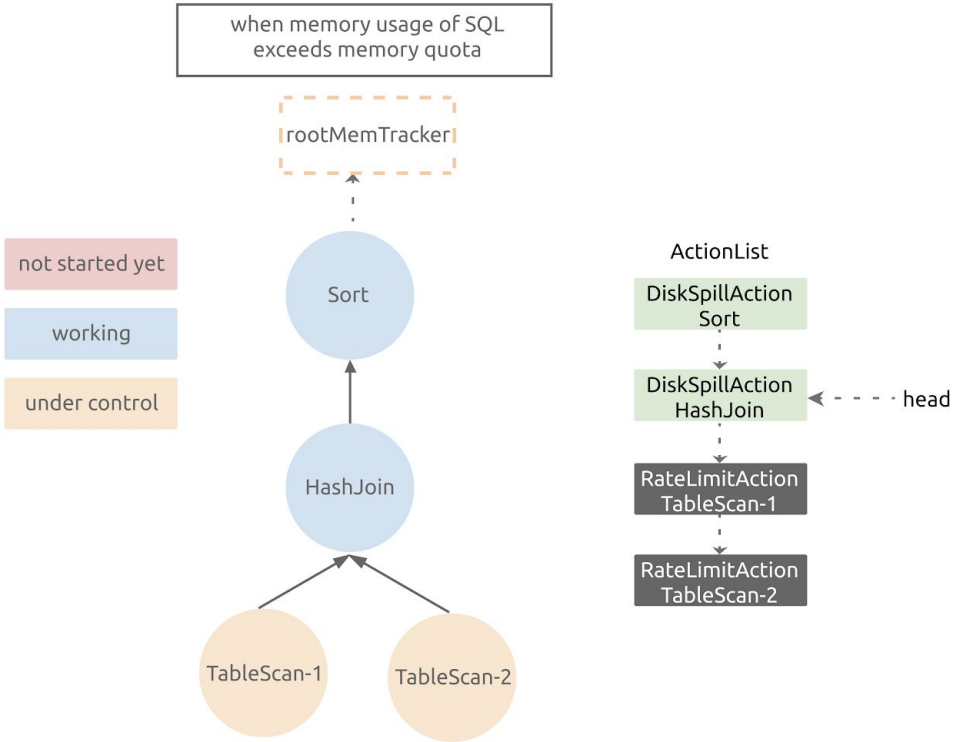

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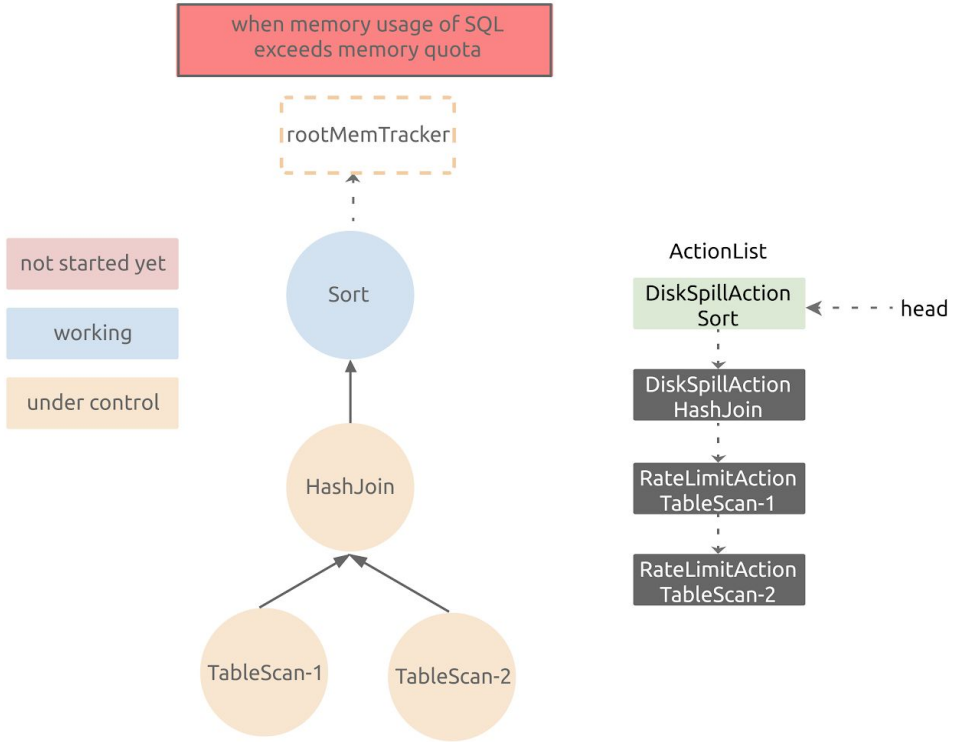

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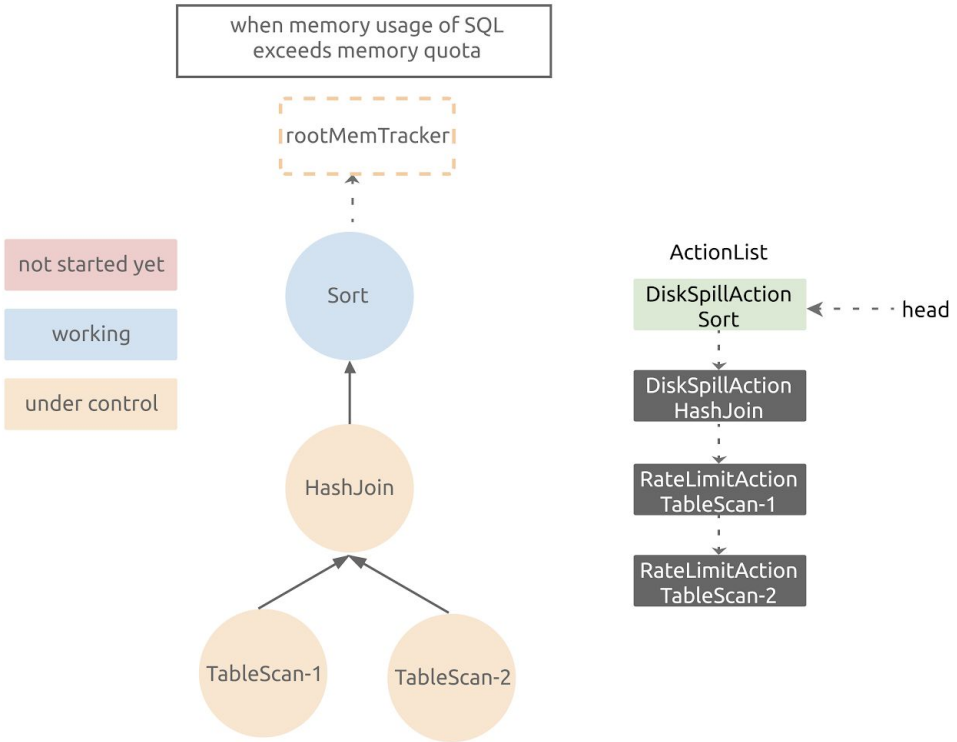

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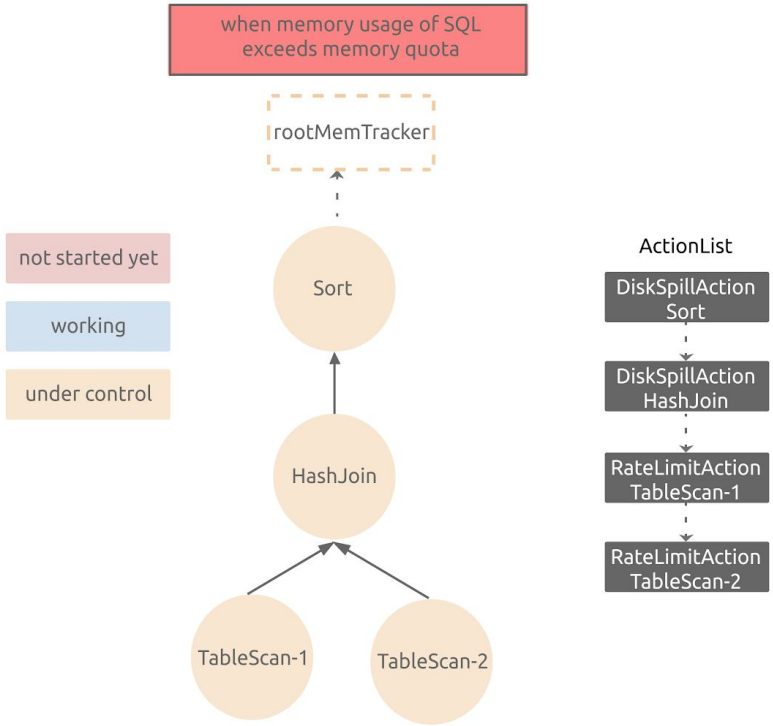
12. Limit is exceeded. Sort is spilled to disk.



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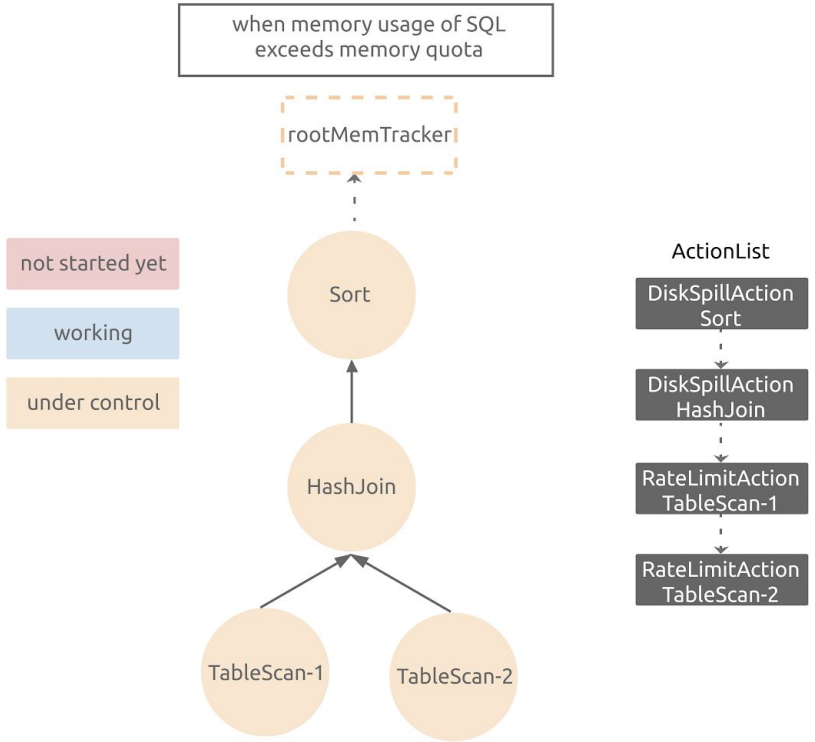

Future work

- Support priority for different actions
- Support more adaptive memory control strategy
- Support a server-level memory control strategy

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- Slack: #everyone in Slack

Q&A

Thank You !