Cheap data analytics using cold storage devices

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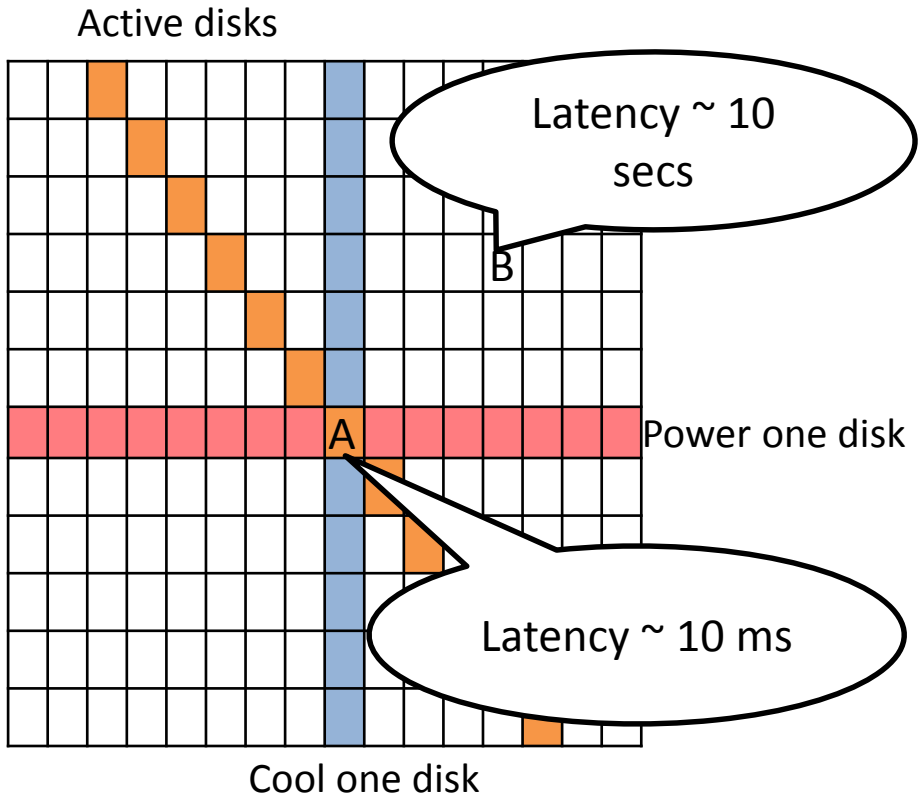
DATA-INTENSIVE APPLICATIONS AND SYSTEMS

Proliferation of cold data

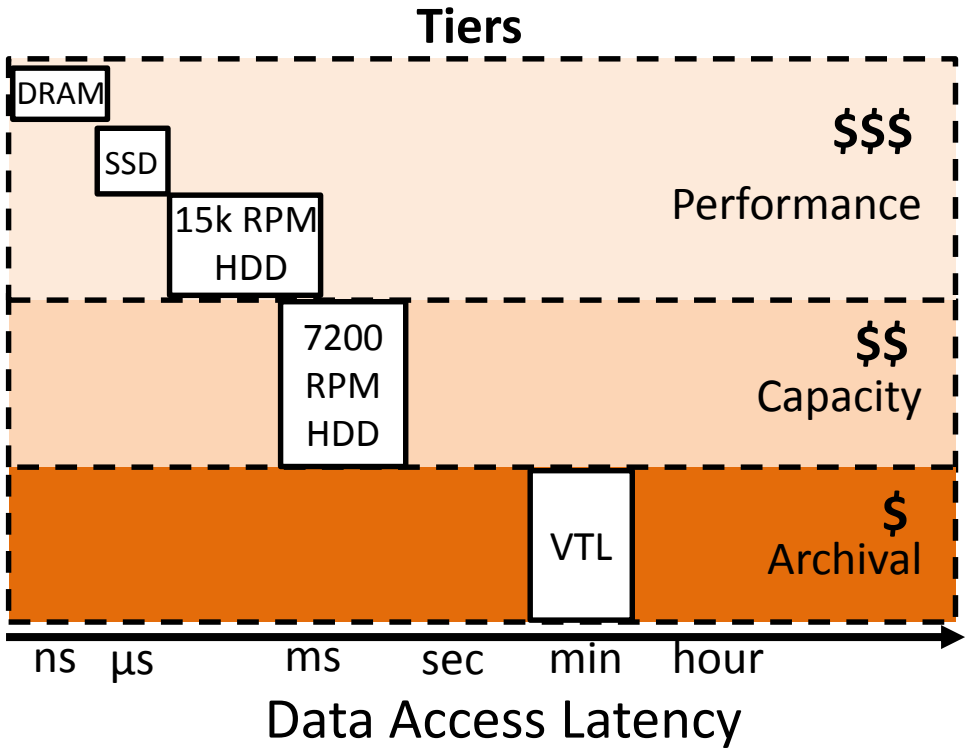
"80% enterprise data is cold with 60% CAGR" [Horison]
"cold data: an incredibly valuable piece of the analysis pipeline" [Intel]

Cold Storage Devices (CSD) to the rescue



PB of storage at cost ~ tape and latency ~ disks

CSD in the storage tiering hierarchy



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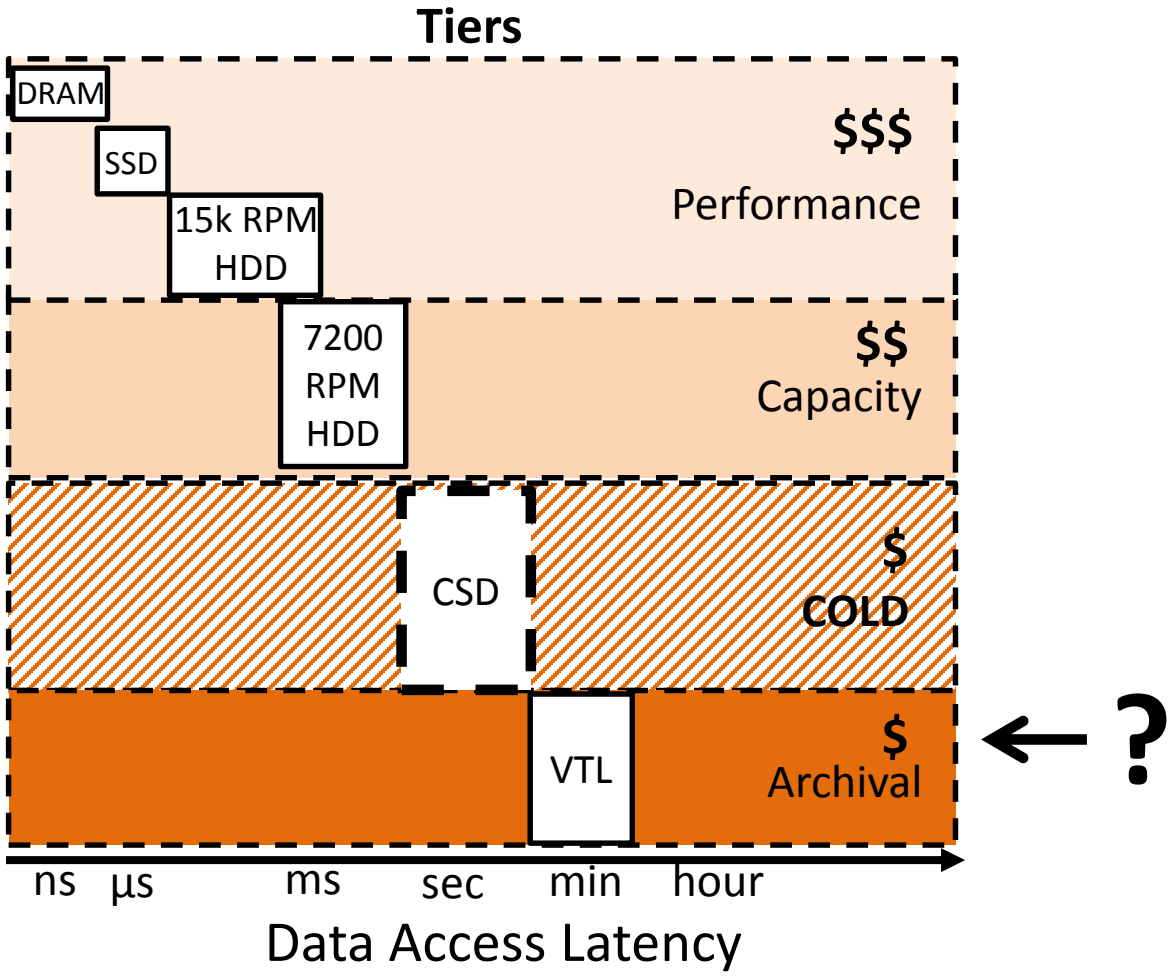
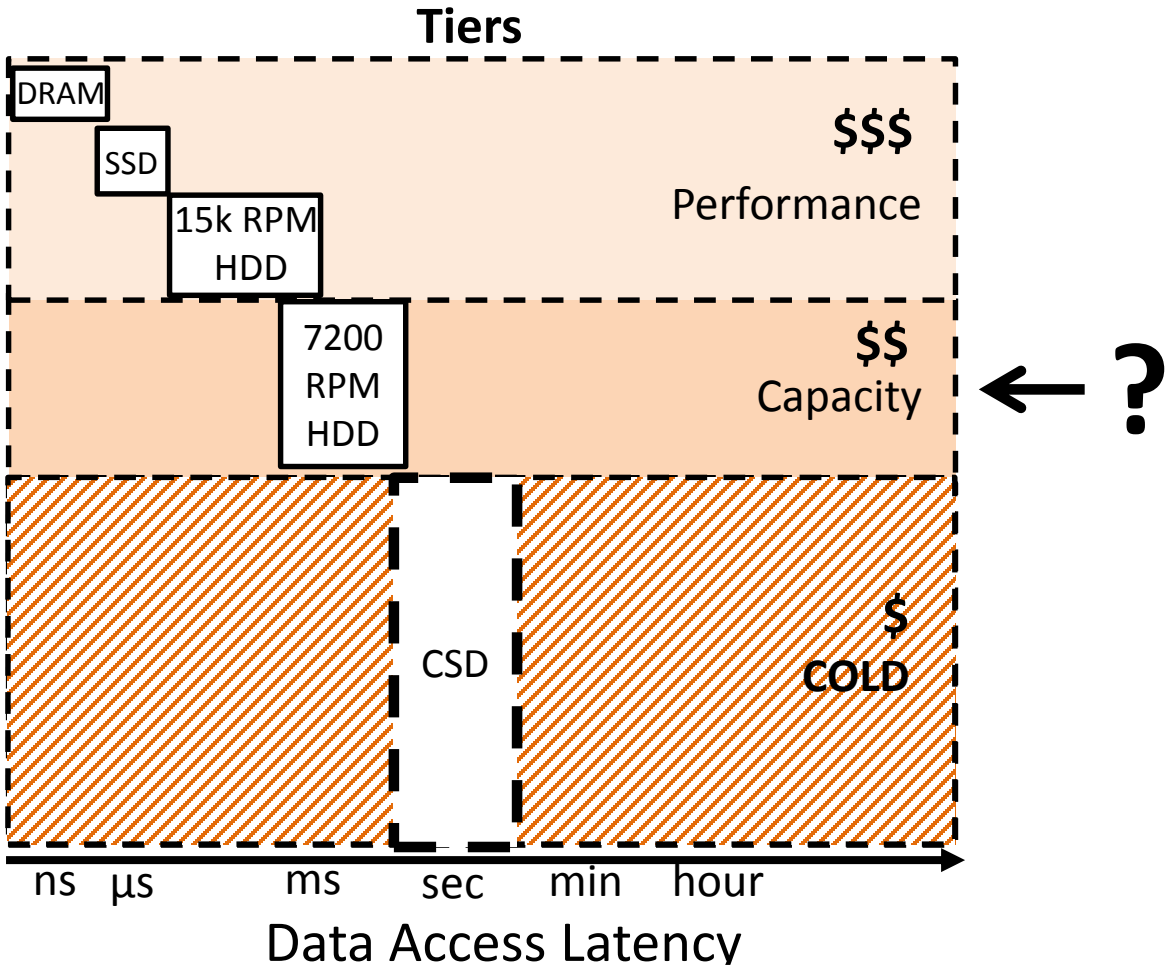


Can we shrink tiers to further save cost?

CSD in the storage tiering hierarchy



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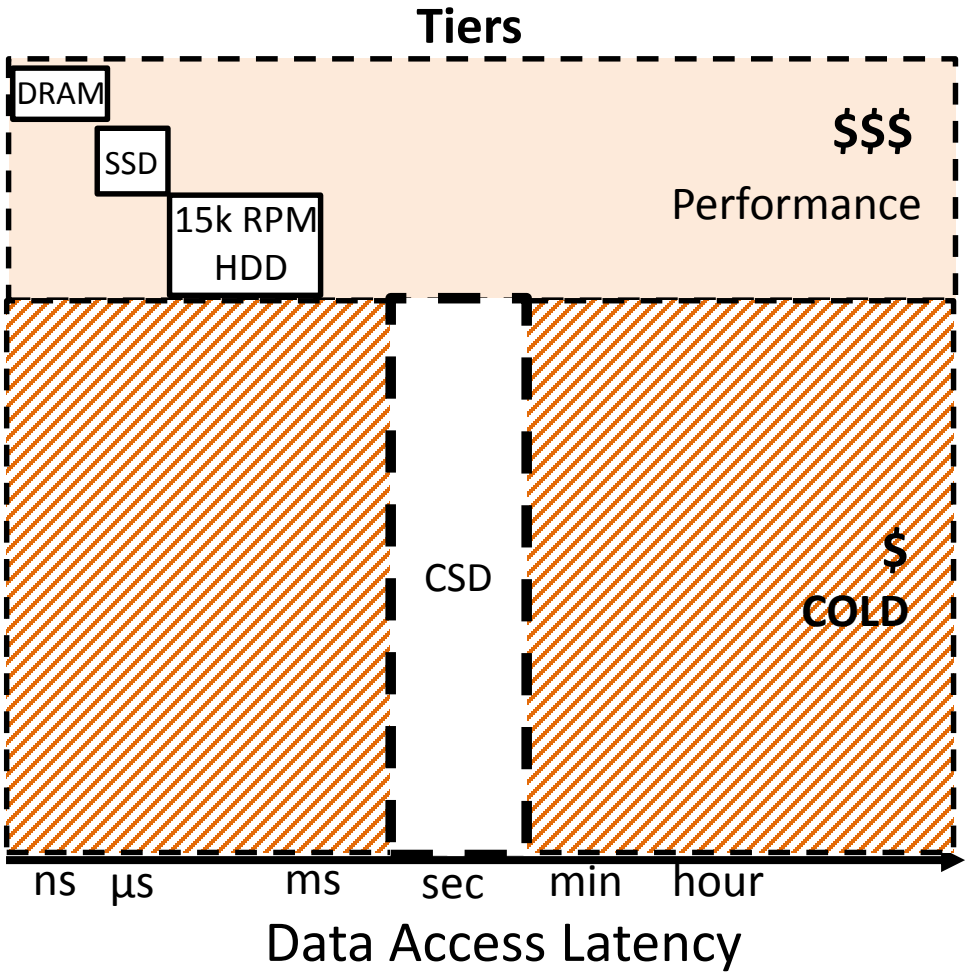
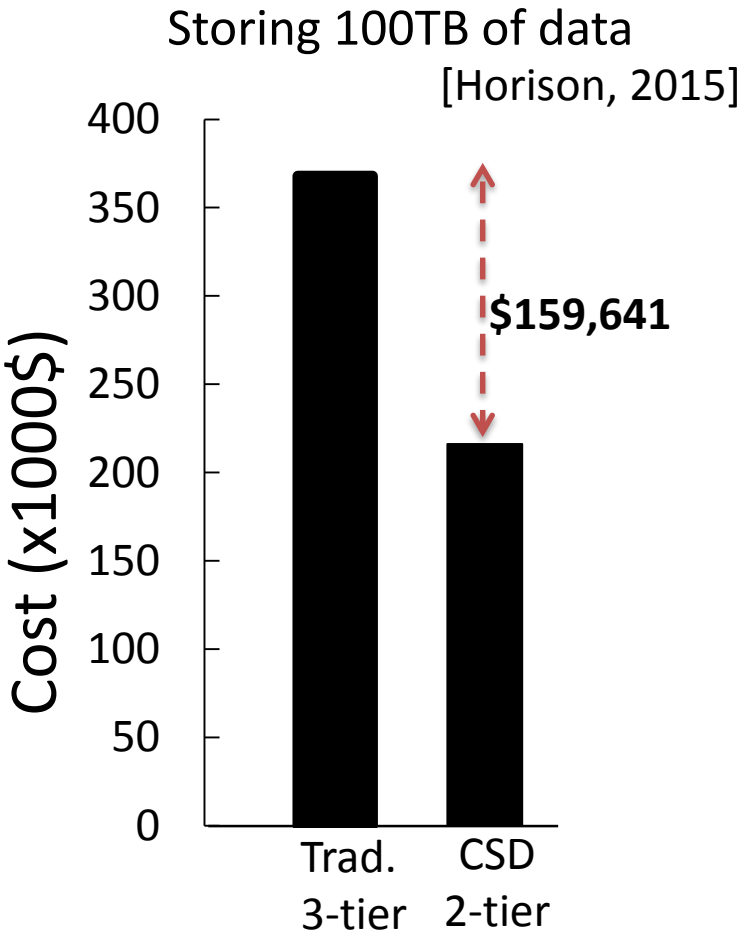
CSD in the storage tiering hierarchy



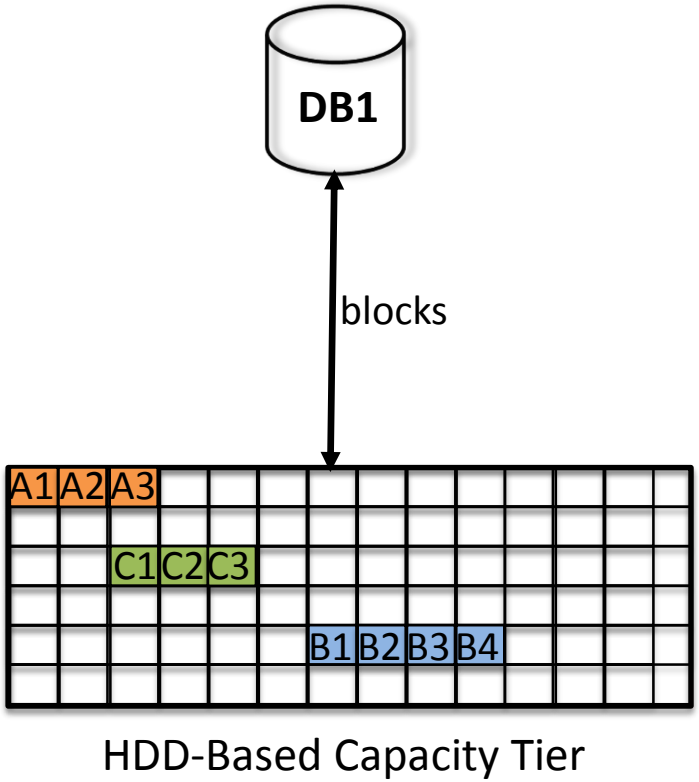


CSD offers significant cost savings (40%)

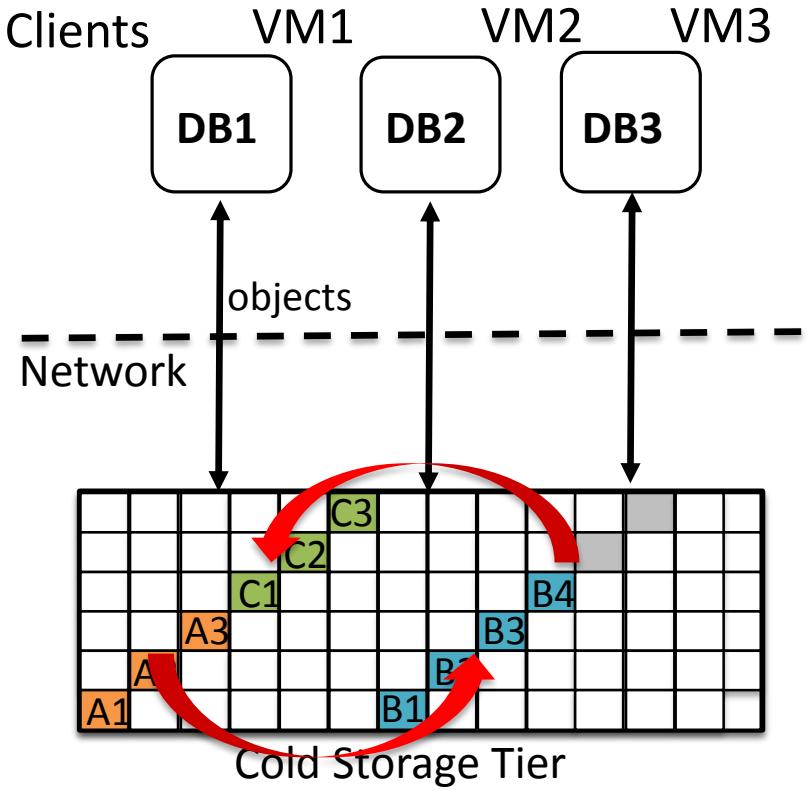
But… can we run queries over CSD?

Query execution over CSD

Traditional setting



Virtualized enterprise data center



Uniform access ✓ **Control layout** ✓

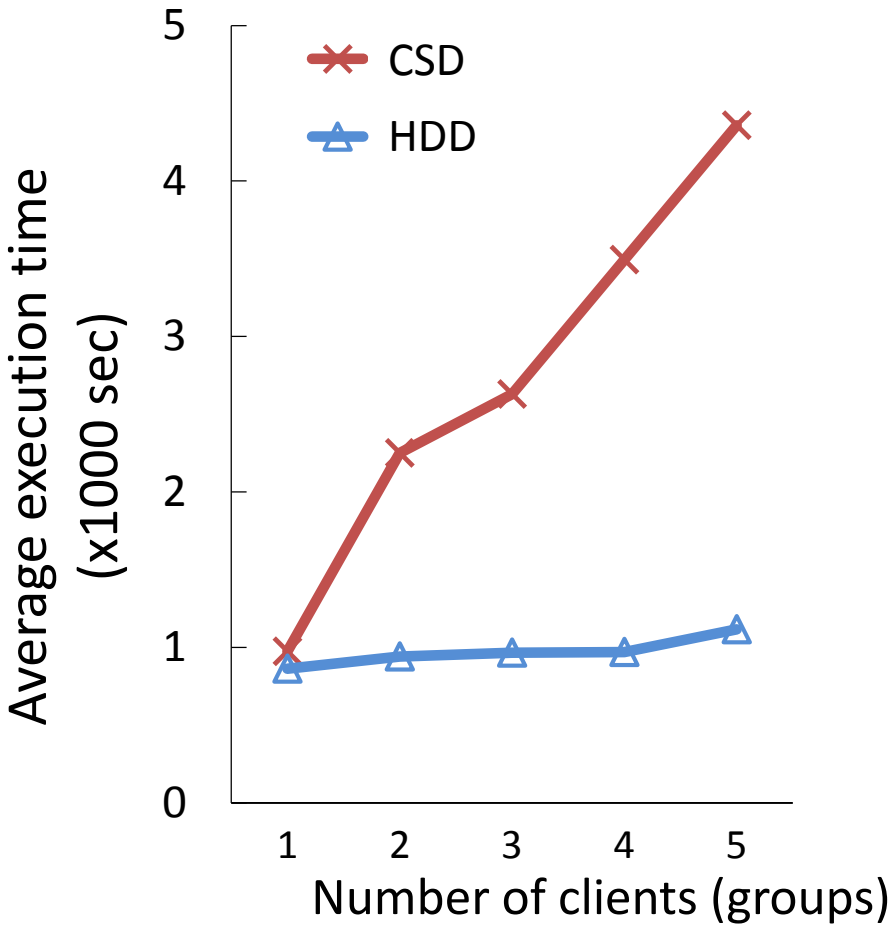
Static (pull-based) execution ✓

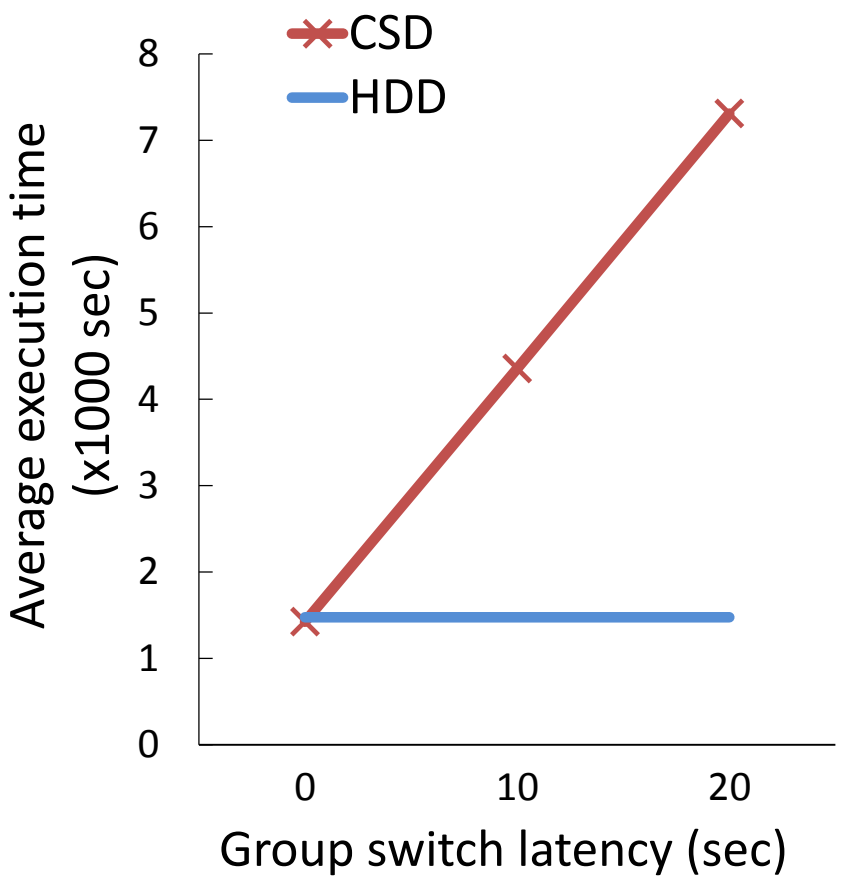
Uniform access ✗ **Control layout** ✗

Pull-based execution will trigger unwarranted group switches

What this means for an enterprise datacenter…

Setting: multitenant enterprise datacenter, clients: PostgreSQL , TPCH 50, Q12, CSD: shared, layout: one client per group



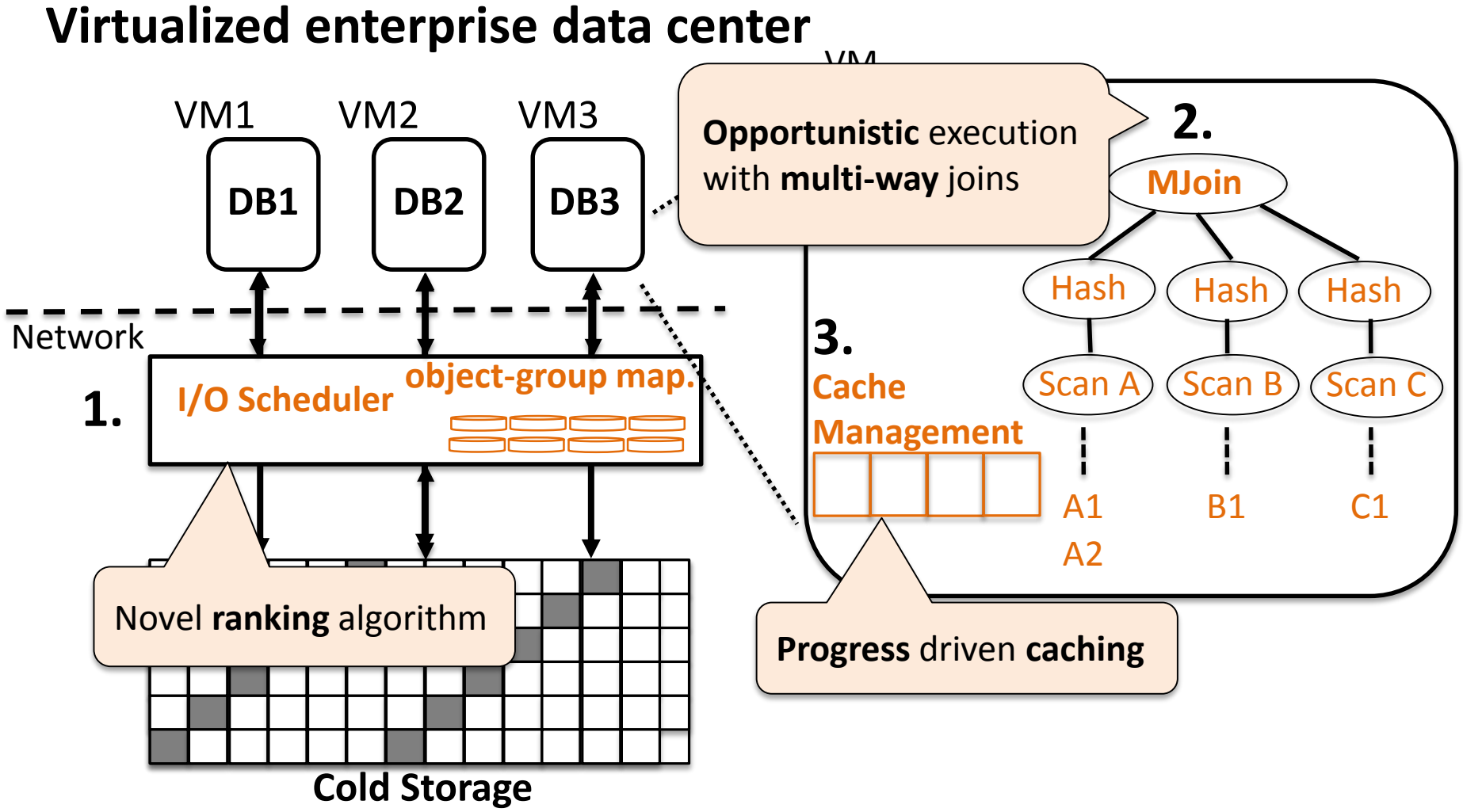


Lost opportunity: CSD relegated to archival storage

Need hardware-software codesign

1. Data access has to be **hardware-driven** to minimize group switches
2. Query execution engine has to process data pushed from storage in **out-of-order** (unpredictable) manner
3. Reduce data round-trips to cold storage by **smart** data **caching**

Skipper to the rescue



Multi-way joins in PostgreSQL

Setting: Query AxBxC, A:A1, A2; B: B1,B2; C:C1, C2;

VM: PostgreSQL

State Manager

Subplans:

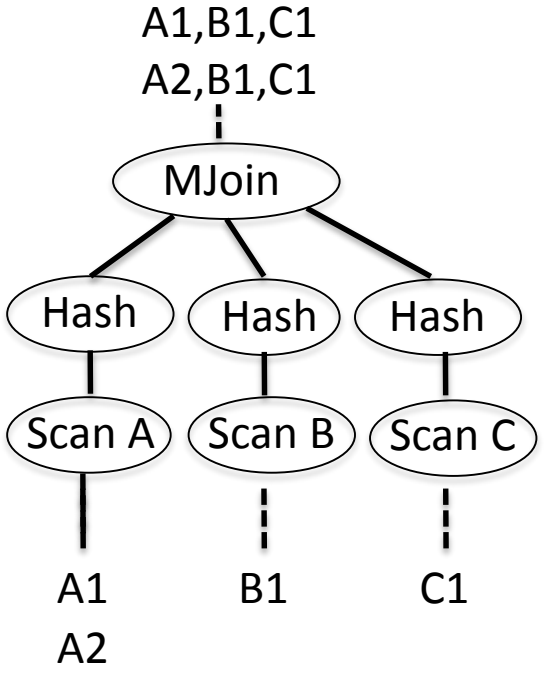
Pending
~~A1,B1,C1~~
~~A1,B1,C2~~
~~A1,B2,C1~~
~~A1,B2,C2~~
~~A2,B1,C1~~
~~A2,B1,C2~~
~~A2,B2,C1~~
~~A2,B2,C2~~

Executed
A1,B1,C1
A2,B1,C1

Cache Manager

A1	A2	C1	B1

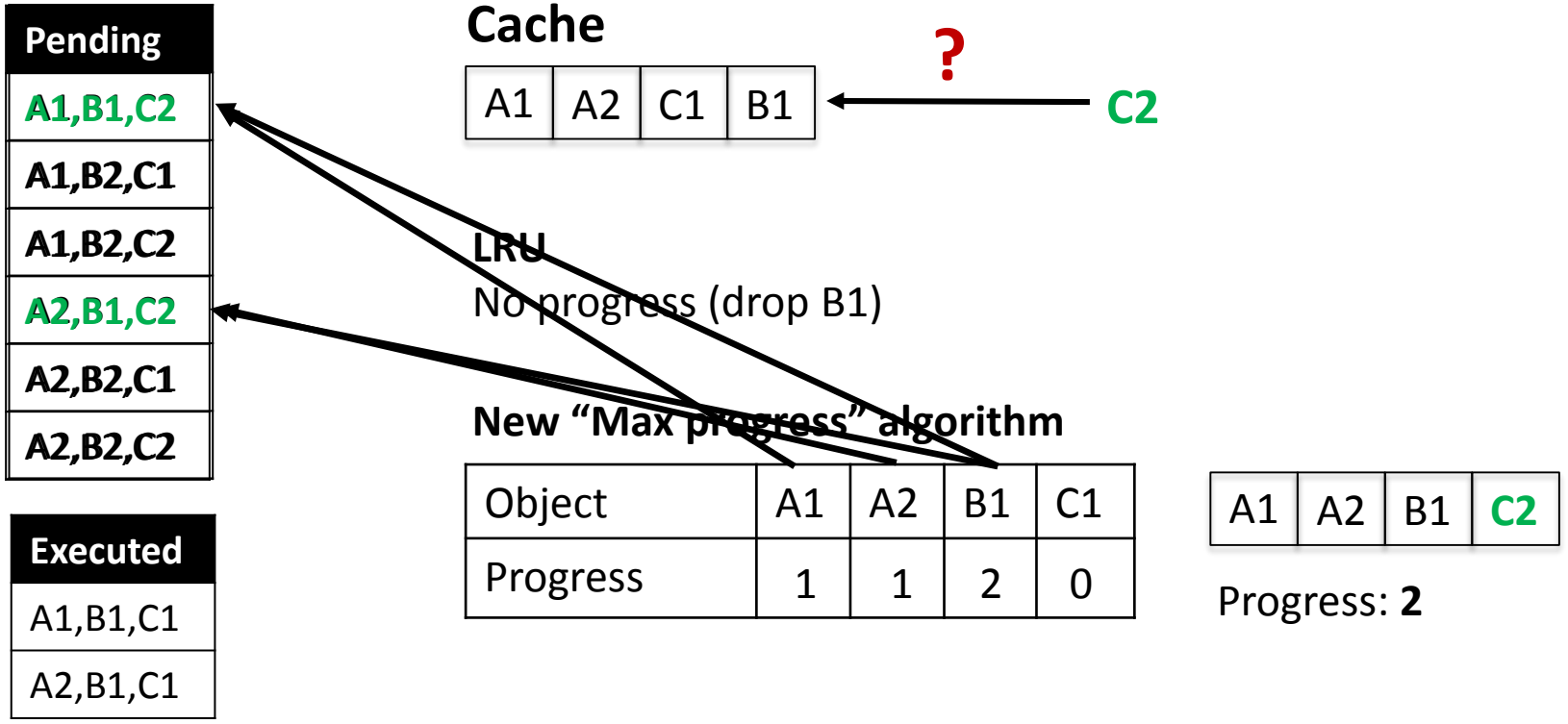
Join Execution



Enable out-of-order opportunistic execution

Progress driven caching

Setting: Query AxBxC, Cache size: 4, Cache full, Evict a candidate



Minimizes data roundtrips, maximizes query progress

Rank-based scheduling

Which group to switch to ?

Group	Table objects
G1	O1 (DB1), O3 (DB3)
G2	O2 (DB2), O4 (DB4)
G3	O5 (DB5)

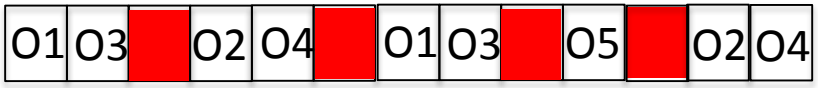
O1, O2, O3, O4, O5

TIME

New Ranking Algorithm

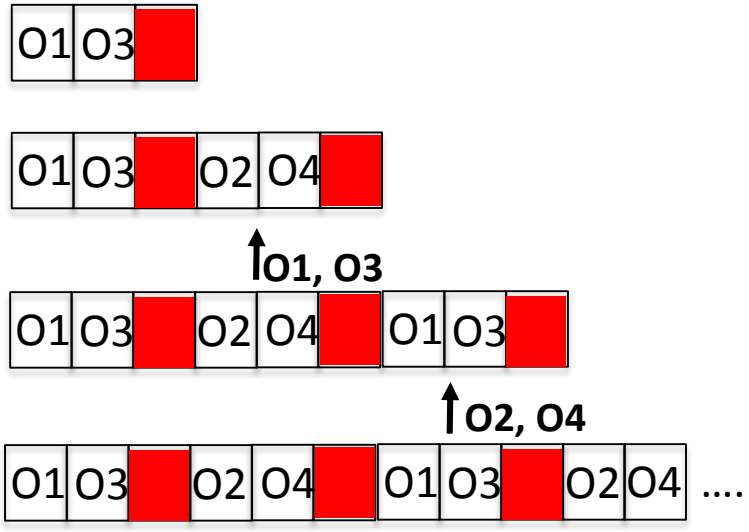
Rank(G) = #Requests + ∑Wait

Provides efficiency **Provides fairness**



FCFS – Fair but inefficient

Max-requests: Efficient, not fair

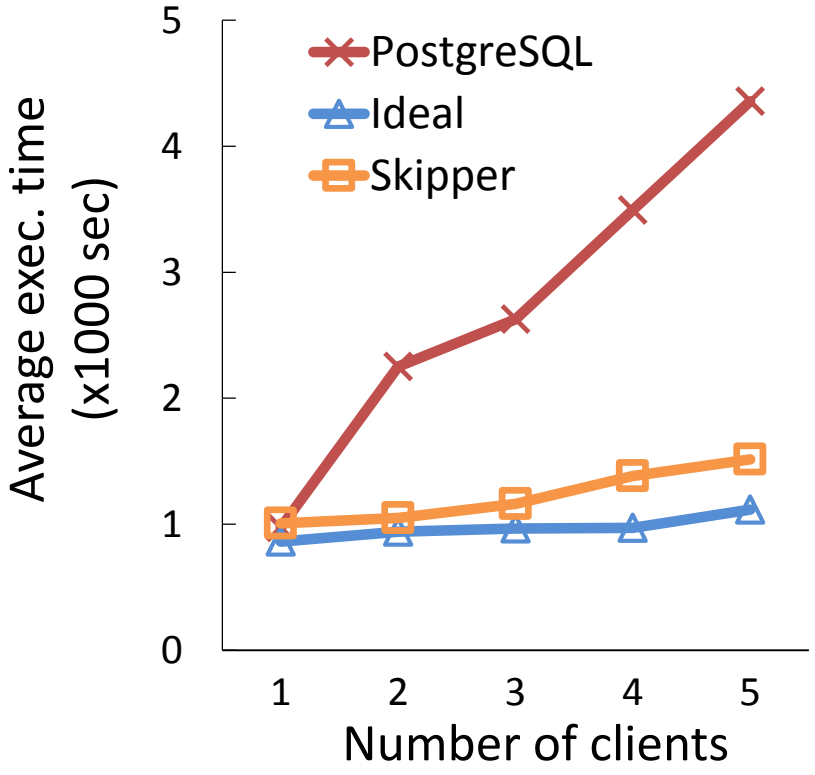


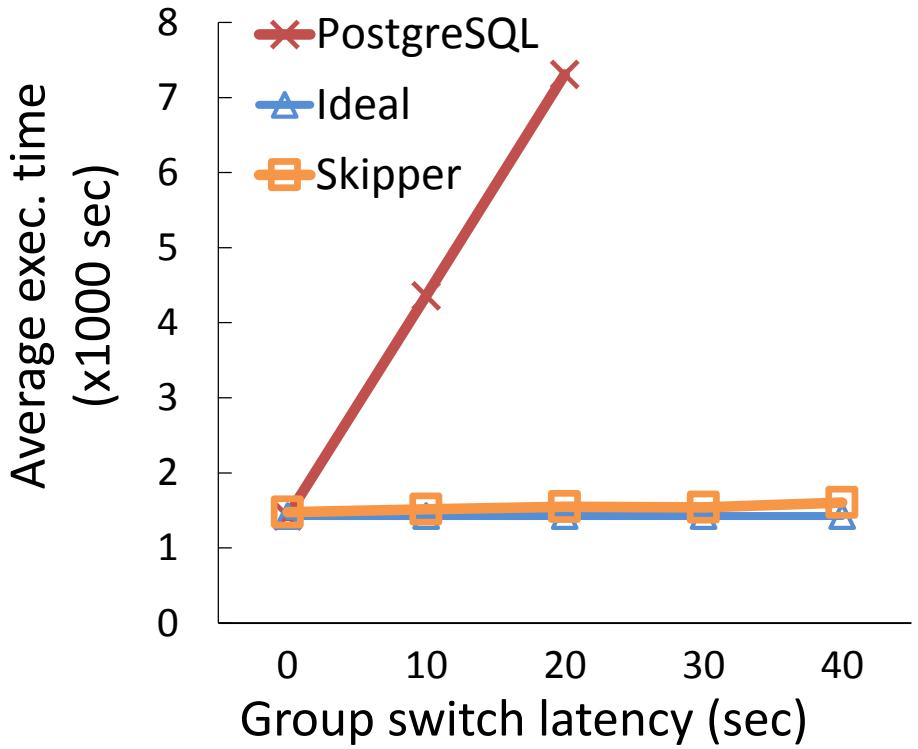
O5 STARVES

Balances efficiency and fairness

Skipper in action

Setting: multitenant enterprise datacenter, clients: TPCH 50, Q12, CSD: shared, layout: one client per group



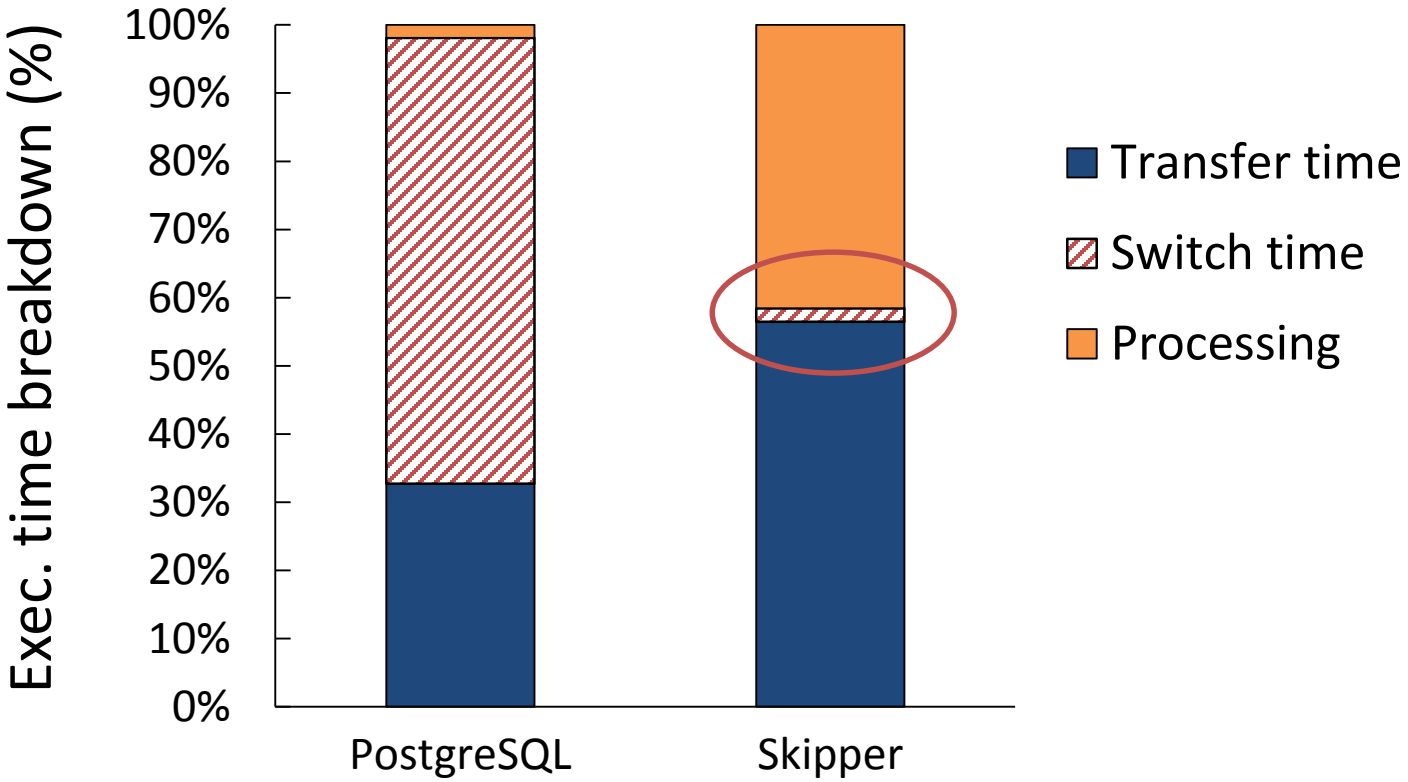


Skipper performs within 20% of HDD-based capacity tier

Skipper is resilient to group switch latency

Minimizing group switches

Setting: multitenant enterprise datacenter, 5 clients: TPCH 50, Q12, CSD: shared, layout: one client per group



Skipper substantially reduces overhead of group switches

Conclusions

- Cold storage can substantially reduce TCO
  - But DBMS performance suffers due to pull-based execution
- Skipper enables efficient query execution over CSD with
  - Out-of-order execution based on multi-way joins
  - Novel progress based caching policy
  - Rank based I/O scheduling
- Skipper makes data analytics over CSD as a service possible
  - Providers reduce cost by offloading data to CSD
  - Customers reduce cost by running inexpensive data analytics over CSD

Thank you!

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