Pixels: Using Cloud Functions as Accelerator for Elastic Data Analytics

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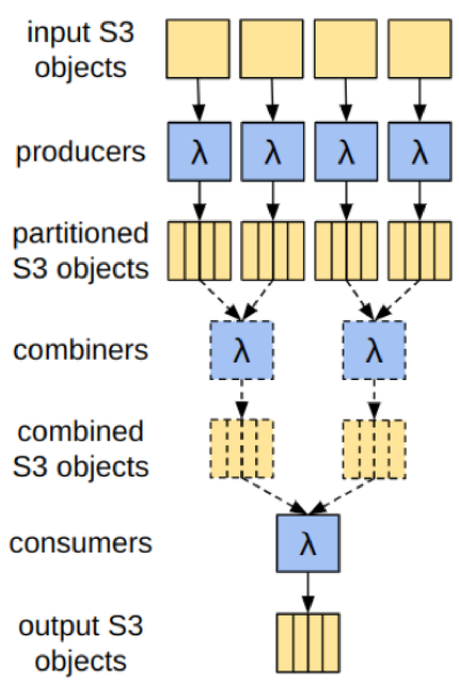
Cloud Resources for Query Processing: Cloud Function (CF) vs. Cloud Virtual Machine (VM)

CF is Popular for Query Processing in the Cloud

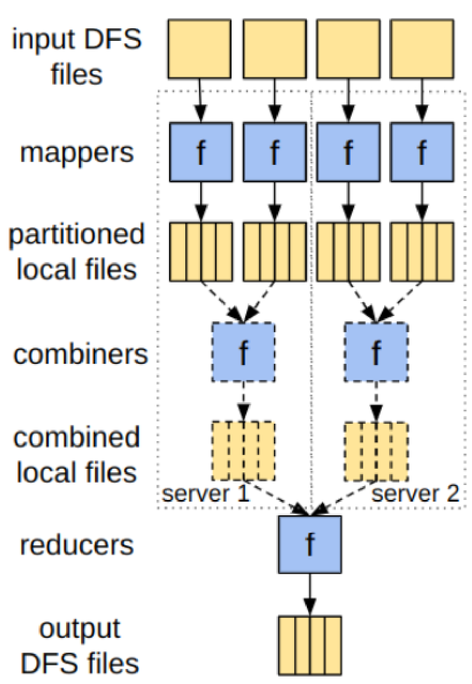
Features of CF:

+ Quick start-up: start-up hundreds of CFs in 1 second.
+ Easy to use: no hardware and software to manage (by users).
- Limited size: e.g., up to 10GB memory and 6 vCPUs.
- Limited lifetime: e.g., each instance lives up to 15 minutes.
- No interconnection between instances.
- No persistent local storage.

Query processing on CF is similar to that on MapReduce:



(a) Starling shuffle.



(b) MapReduce shuffle.

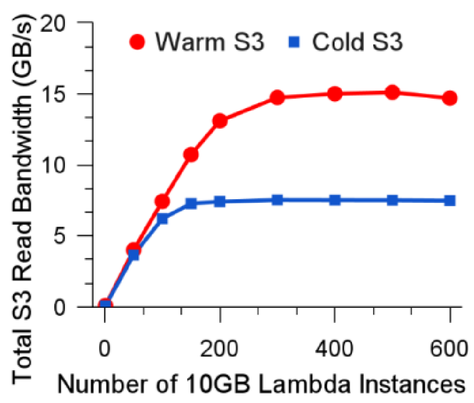
Insight 1: CF is More Expensive than VM

The unit prices of CF (e.g., Lambda) and VM (e.g., EC2 on-demand or spot) resources on AWS:

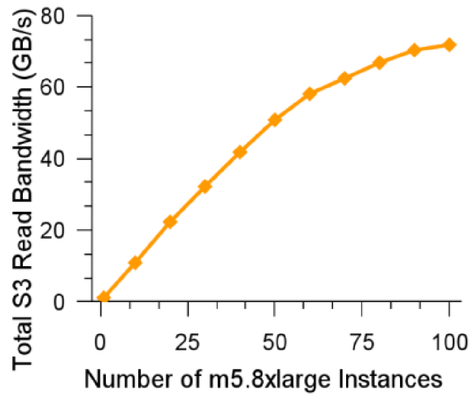
Resource type	Lambda	EC2 on-demand	EC2 spot
CPU (¢/core-h)	10	4.8	1.1
RAM (¢/GB-h)	6	1.2	0.27
Network (¢/Gbps-h)	85.71	15.36	3.53

Insight 2: CF is Less Scalable than VM

S3-based data shuffling and the lower scalability of S3 read bandwidth make CF-based query processing less scalable.



(a) AWS Lambda.



(b) AWS EC2.

Insight 3: CF is More Elastic for Bursty Workload

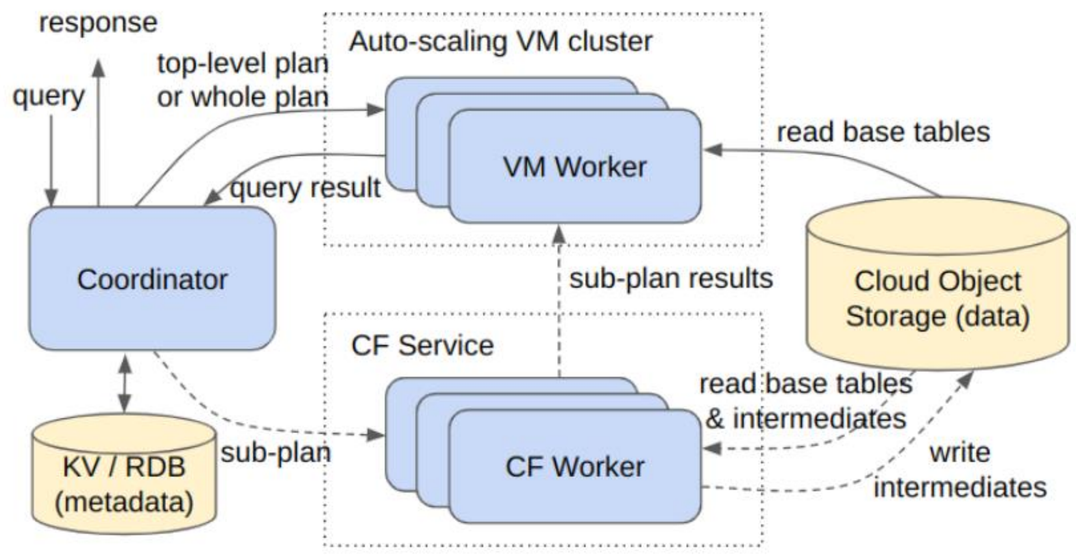
CF provides shorter start-up time than VM (1 sec vs. 1-2 min).

CF is suitable for processing unpredictable workload spikes.

Problem: How to improve cost-efficiency without compromising the elasticity.

Our Solution: Adaptive Query Processing on CF and VM

Our solution prioritizes processing queries in an auto-scaling VM cluster, and leverages CFs as accelerator (by sub-plan pushdown) to process the workload spikes if the VM cluster is unable to scale-out promptly.



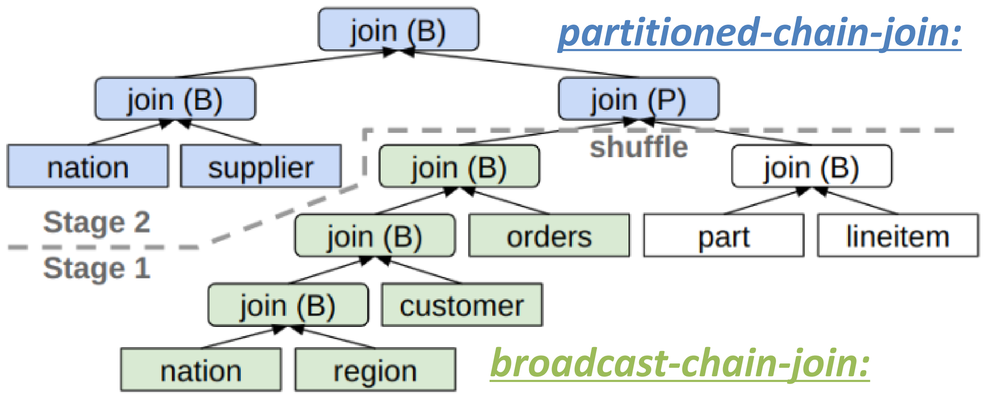
Auto-scaling VM Cluster

We propose a framework that keeps the query concurrency stable by automatically adding or removing VMs to/from the VM cluster. It also handles the reclaim events of spot VMs.

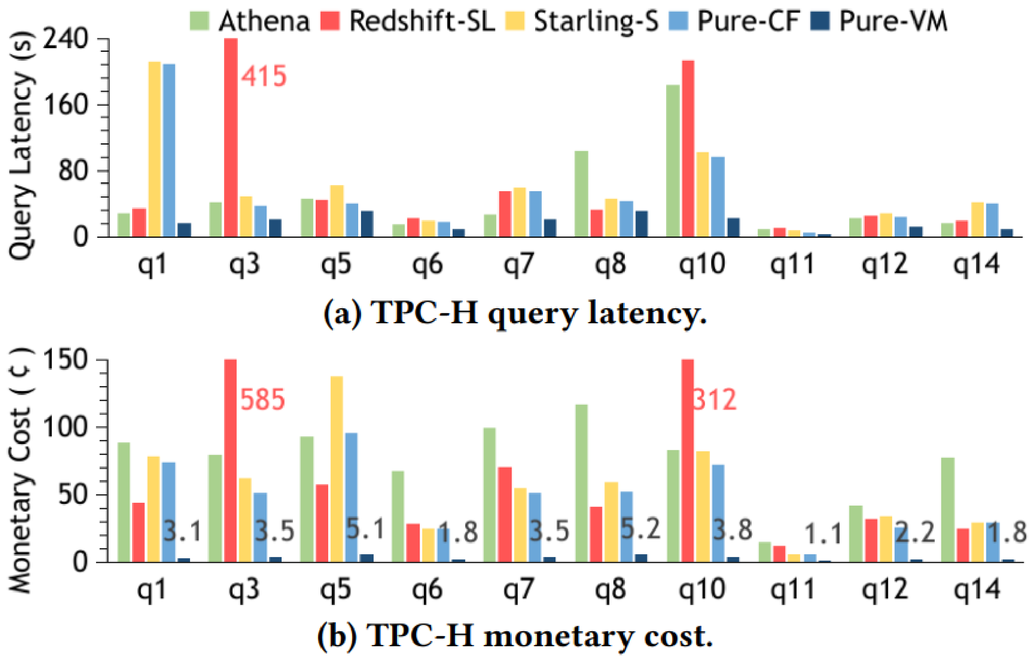
Sub-plan Optimization and Execution

We propose a cost-based optimizer for the sub-plan in CF.

We propose sub-plan execution optimizations such as *chain-joins*:



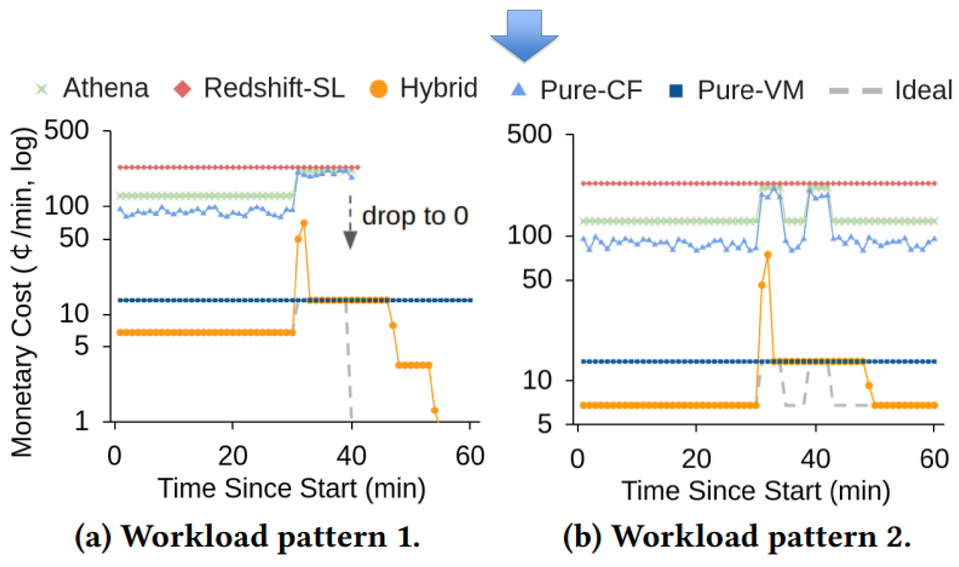
Experimental Evaluation



(a) TPC-H query latency.

(b) TPC-H monetary cost.

Our solution (Hybrid) is more cost-efficient than the baselines without compromising elasticity (TPCH 1TB q12 + a real-world log analysis query).



(a) Workload pattern 1.

(b) Workload pattern 2.

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Pure VM-based query processing provides 1-2 orders of magnitudes higher cost-efficiency on sustained workload (TPC-H 1TB, 2TB RAM for each system except Athena).