



Google Cloud

Executing Spark on Dataproc

Agenda

The Hadoop ecosystem

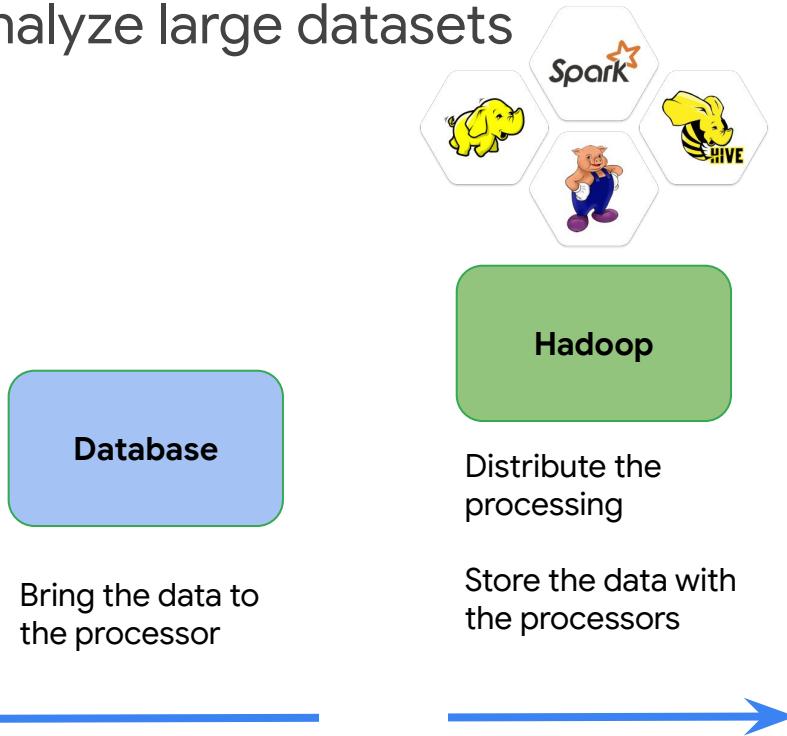
Running Hadoop on Cloud Dataproc

GCS instead of HDFS

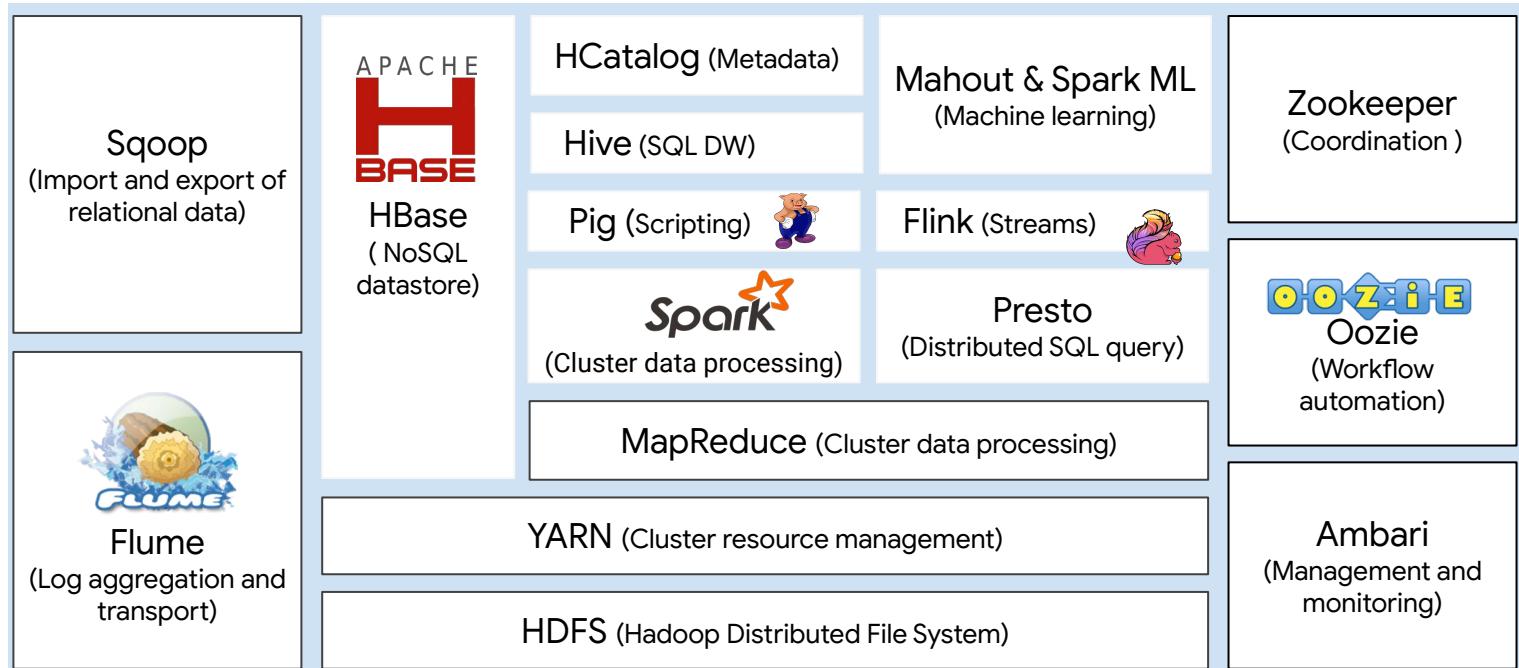
Optimizing Dataproc

Lab

The Hadoop ecosystem developed because of a need to analyze large datasets



The Hadoop ecosystem is very popular for Big Data workloads



On-premises Hadoop clusters have a number of limitations

-  Not elastic
-  Hard to scale fast
-  Have capacity limits
-  Have no separation between storage and compute resources

Cloud Dataproc simplifies Hadoop workloads on GCP



Built-in support for Hadoop



Managed hardware and configuration



Simplified version management



Flexible job configuration

Apache Spark is a popular, flexible, powerful way to process large datasets



etc.



spark.apache.org

Agenda

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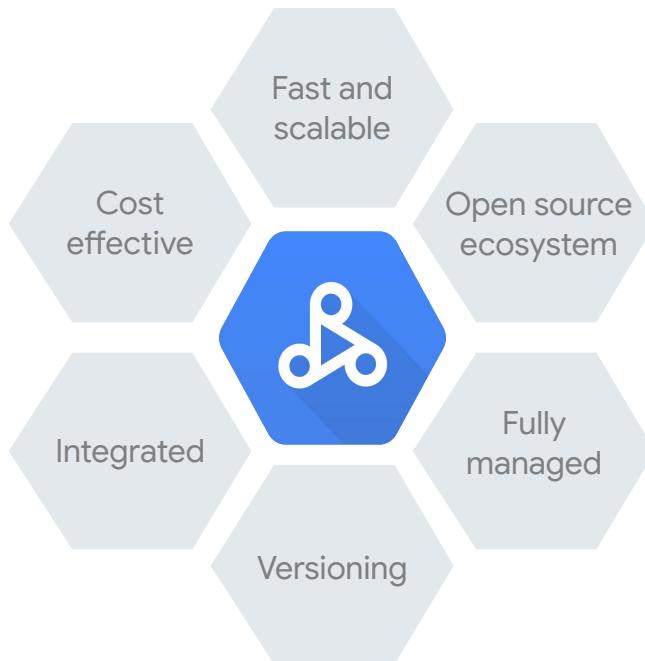
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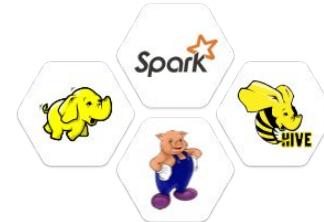
Optimizing Dataproc

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Cloud Dataproc is a managed service for running Hadoop and Spark data processing workloads



Google Cloud Platform

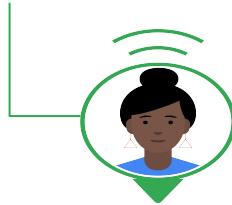


There are other OSS options available in Cloud Dataproc

Spark (default)	Hive (default)	HDFS (default)
Pig (default)	Zeppelin	Zookeeper
Kafka	Hue	Tez
Presto	Anaconda	Cloud SQL Proxy
Jupyter	Apache Flink	Cloud Datalab
IPython	Oozie	Sqoop
Much more...		

Use initialization actions to add other software to cluster at startup

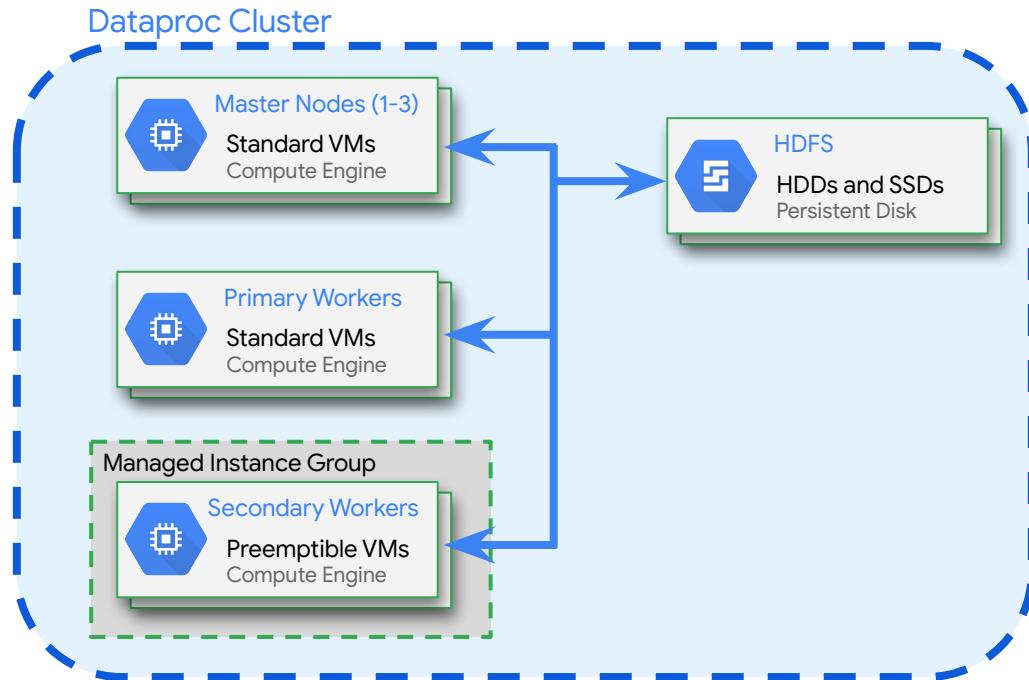
Use **initialization actions** to install additional components on the cluster.



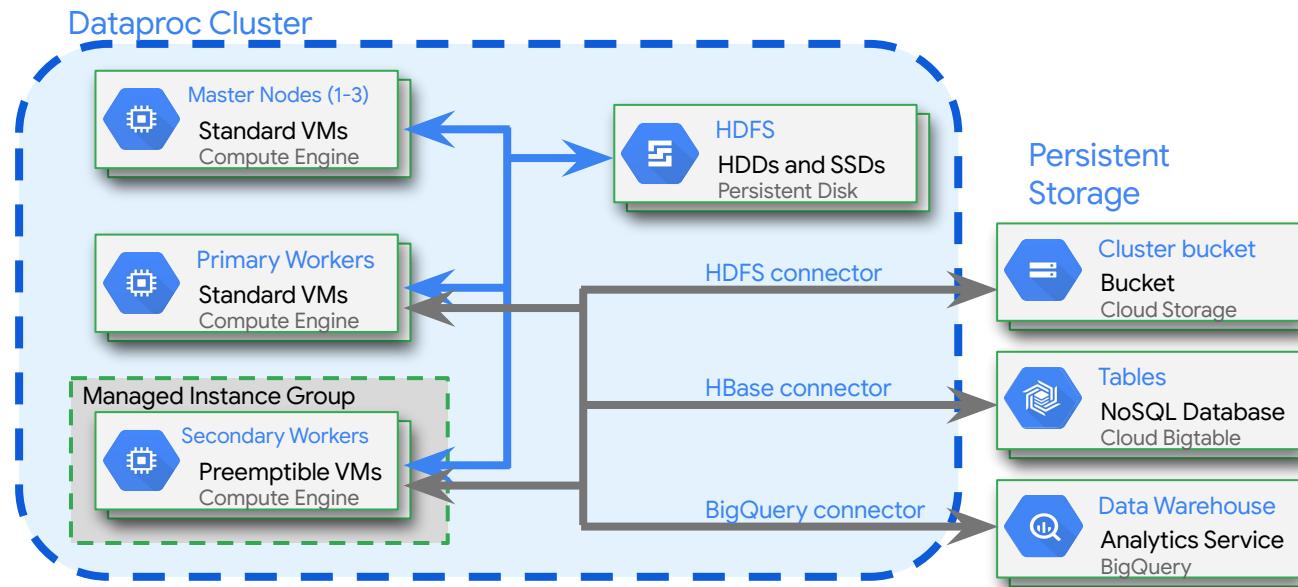
```
gcloud dataproc clusters create <CLUSTER_NAME> \  
    --initialization-actions gs://$MY_BUCKET/hbase/hbase.sh \  
    --num-masters 3 --num-workers 2
```

<https://github.com/GoogleCloudPlatform/dataproc-initialization-actions> (Flink, Jupyter, Oozie, Presto, Tez, HBase, etc.)

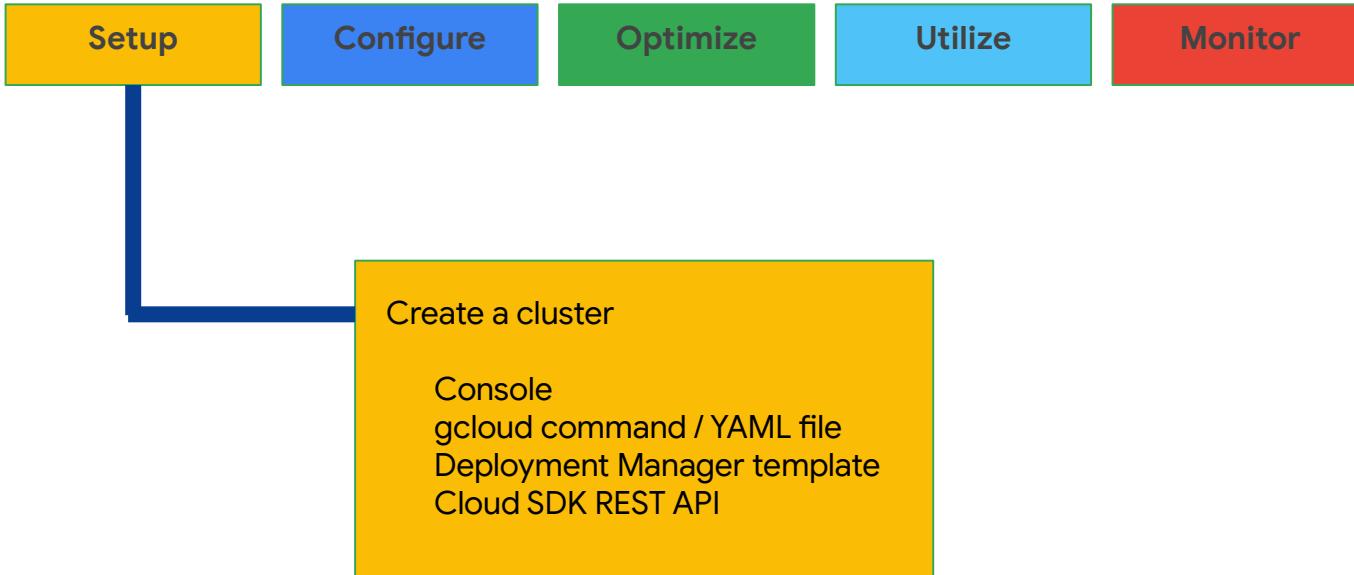
A Dataproc cluster has master nodes, workers, and HDFS



Dataproc cluster can read/write to GCP storage products



Using Cloud Dataproc



Configure

Setup

Configure

Optimize

Utilize

Monitor

Cluster options	Region and Zone Global or Regional endpoint Dataproc version (default is latest)	Single node (1:0) Standard (1:n) High Availability (3:n)
	Optional components	Cluster properties User Labels
Master node options	vCPU cores Primary disk and disk type	Local SSDs
Worker nodes	Minimum number of worker nodes	VM options Initialization actions VM metadata
Preemptible nodes	Maximum number (default is 0)	

Optimize

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Configure

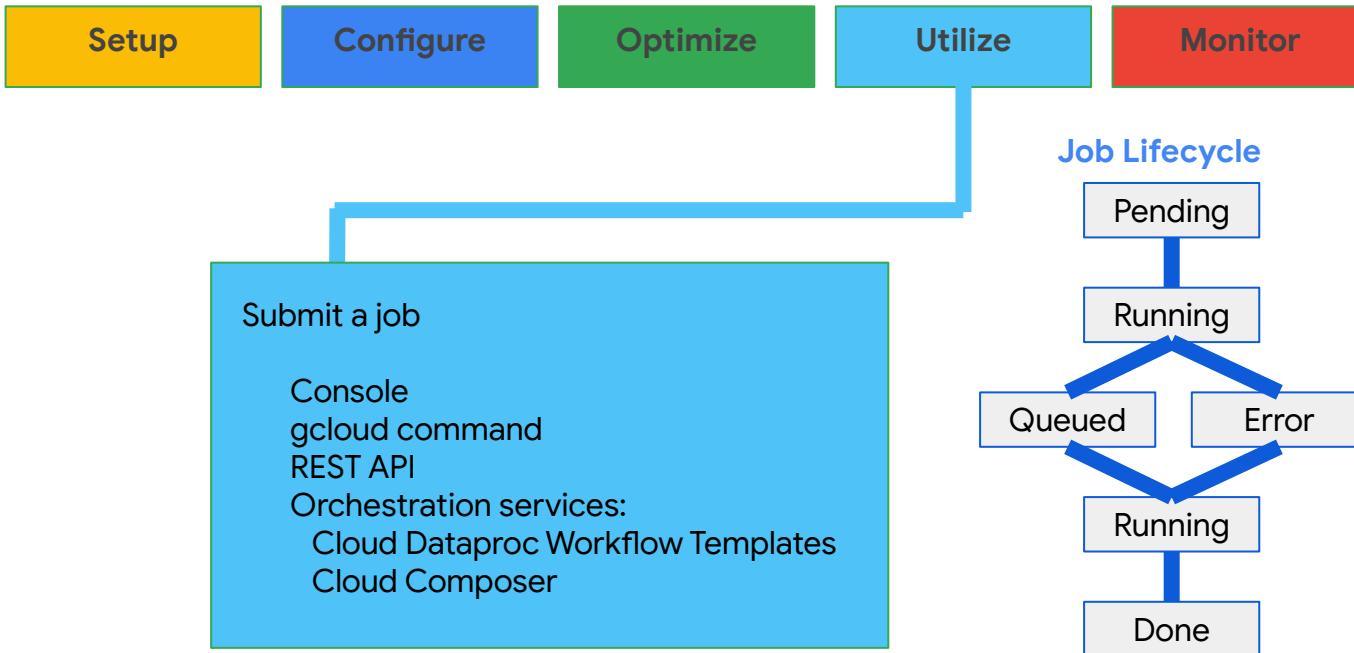
Optimize

Utilize

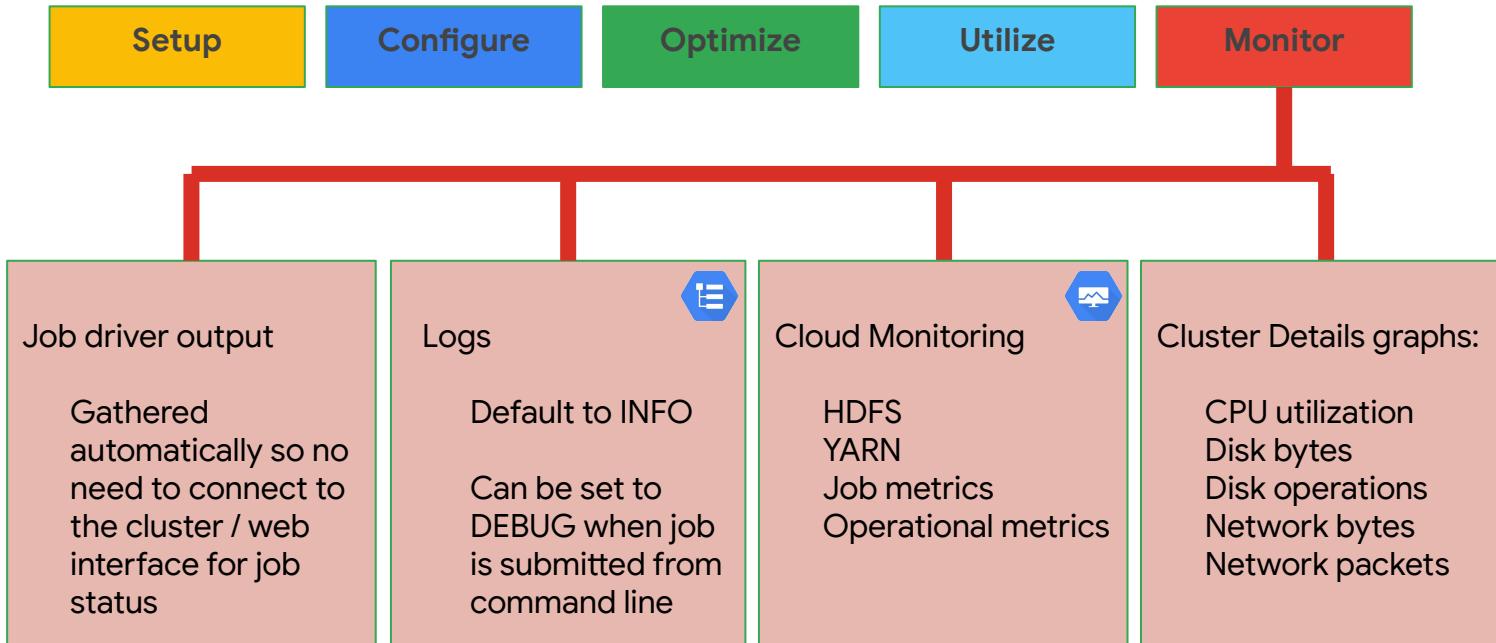
Monitor

Preemptible VMs	Lower cost
Custom Machine Types	Efficient allocation of resources for consistent workloads.
Minimum CPU platform	Consistent distribution of workload -minimum vCPU performance.
Custom Images	Faster time to reach an operational state.
Persistent SSD boot disk	Faster boot time
Attached GPUs	Faster processing for some workloads
Dataproc Version	Specify to prevent changes, or default to the latest

Utilize: Job submission



Monitor through Console and Cloud Monitoring



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The original MapReduce paper was designed for a world where data was local to the compute machine

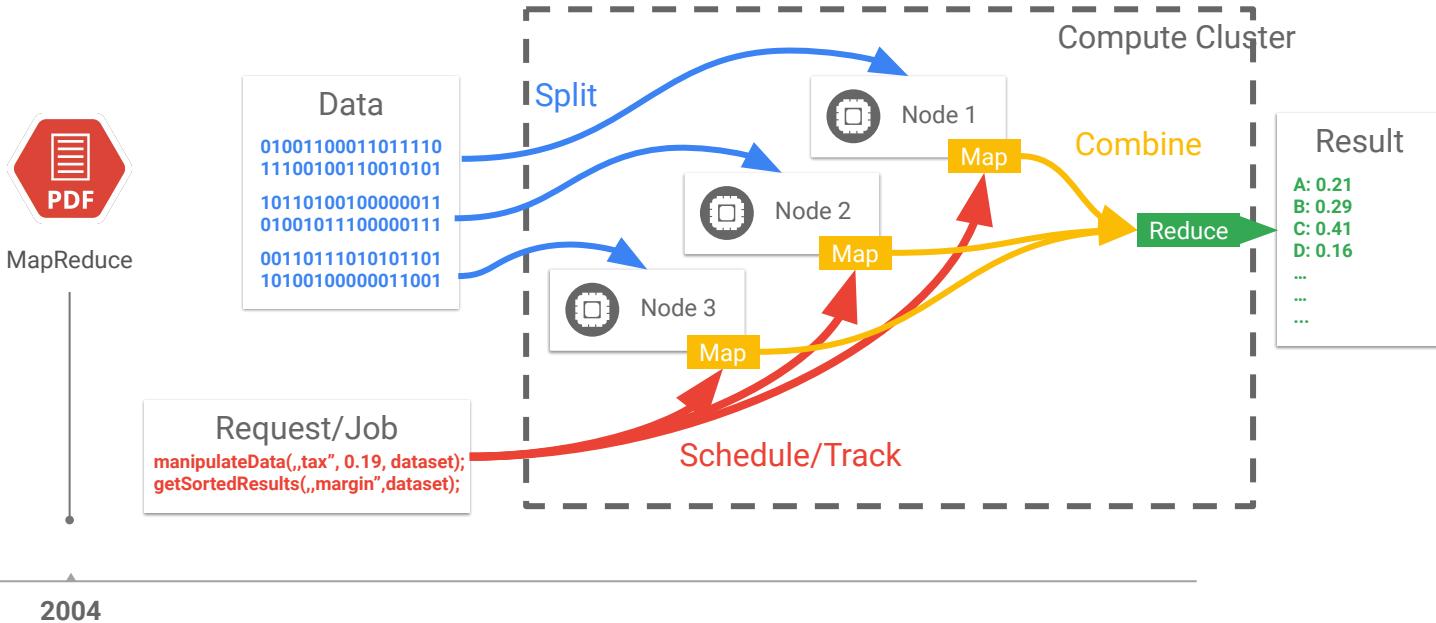


Diagram by Lukas Kästner

HDFS in the Cloud is a sub-par solution

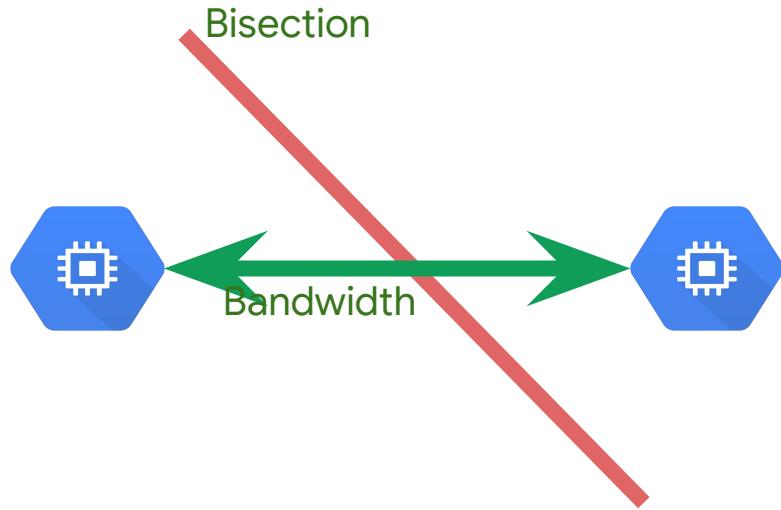
Block size	Locality	Replication
<p>Defaults to 64 MB (often raised to 128 MB)</p> <p>Determines parallelism of execution</p> <p>I/O scales with disk size & VM cores (up to 2 TB and 8 cores)</p> <p>Only accessible from a single node (in RW mode)</p>	<p>HDFS spreads blocks</p> <p>Most execution engines on HDFS are locality aware</p>	<p>Default to 3 copies of each block ($r=3$)</p> <p>Still need $r = 2$ on HDFS, for availability</p> <ul style="list-style-type: none">Cloud Dataproc servers have to transmit $2 \times 3 = 6$ copies of HDFS blocks to Colossus.

Compute and storage are not independent, adding to costs

If you use persistent disks, then data locality no longer holds

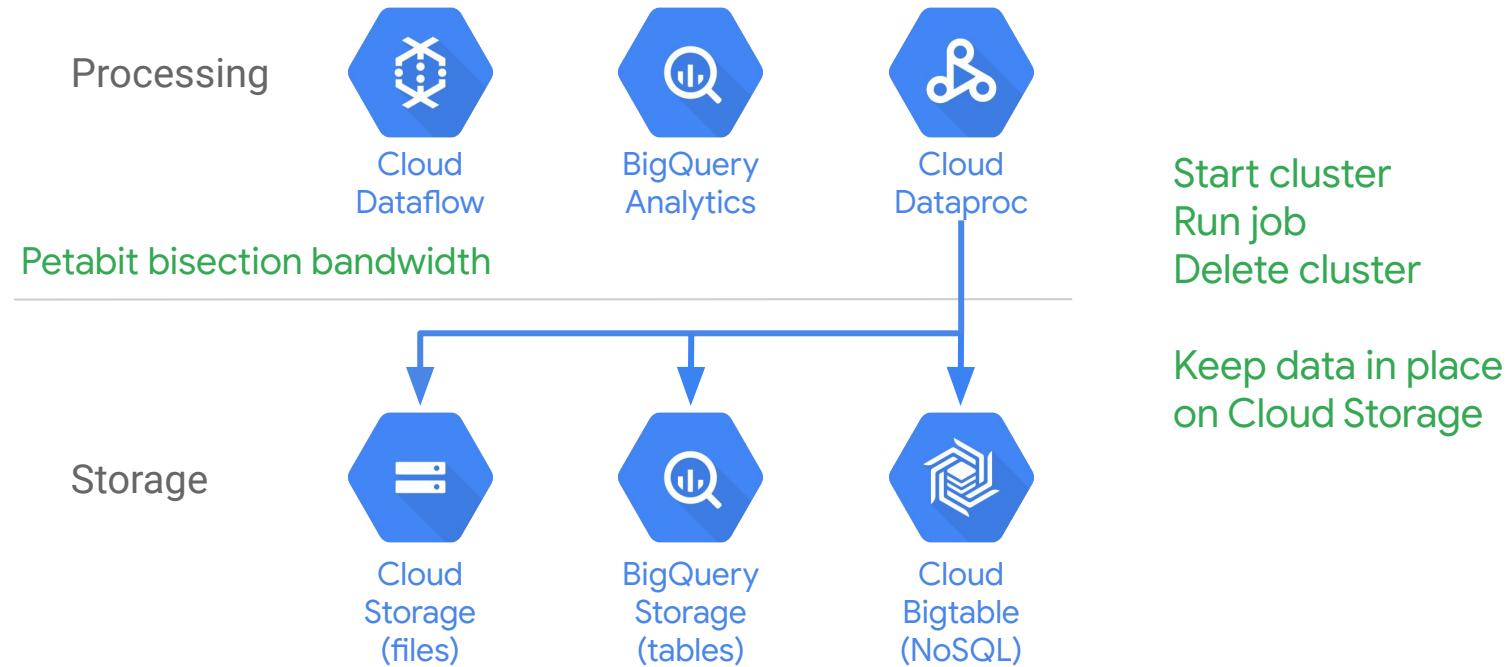
Lots of data replication makes this expensive

Petabit bandwidth is a game-changer for big data

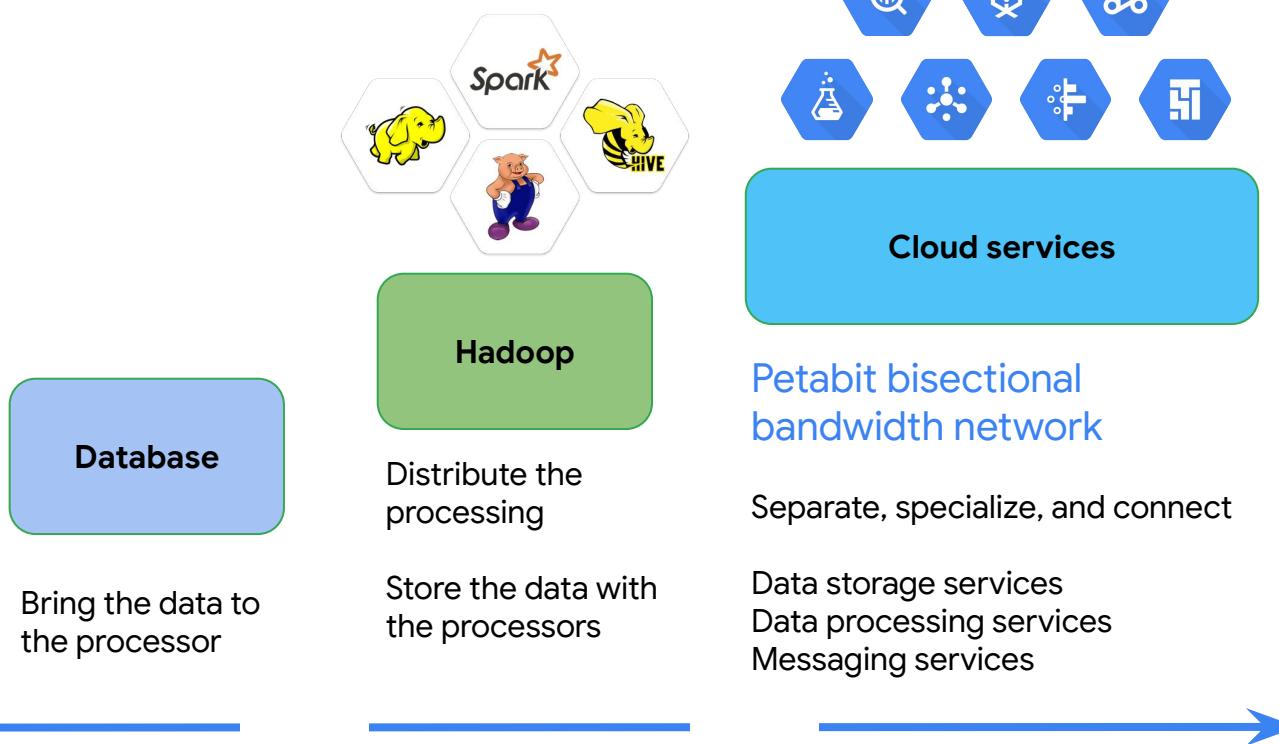


Process the data where it is without copying it

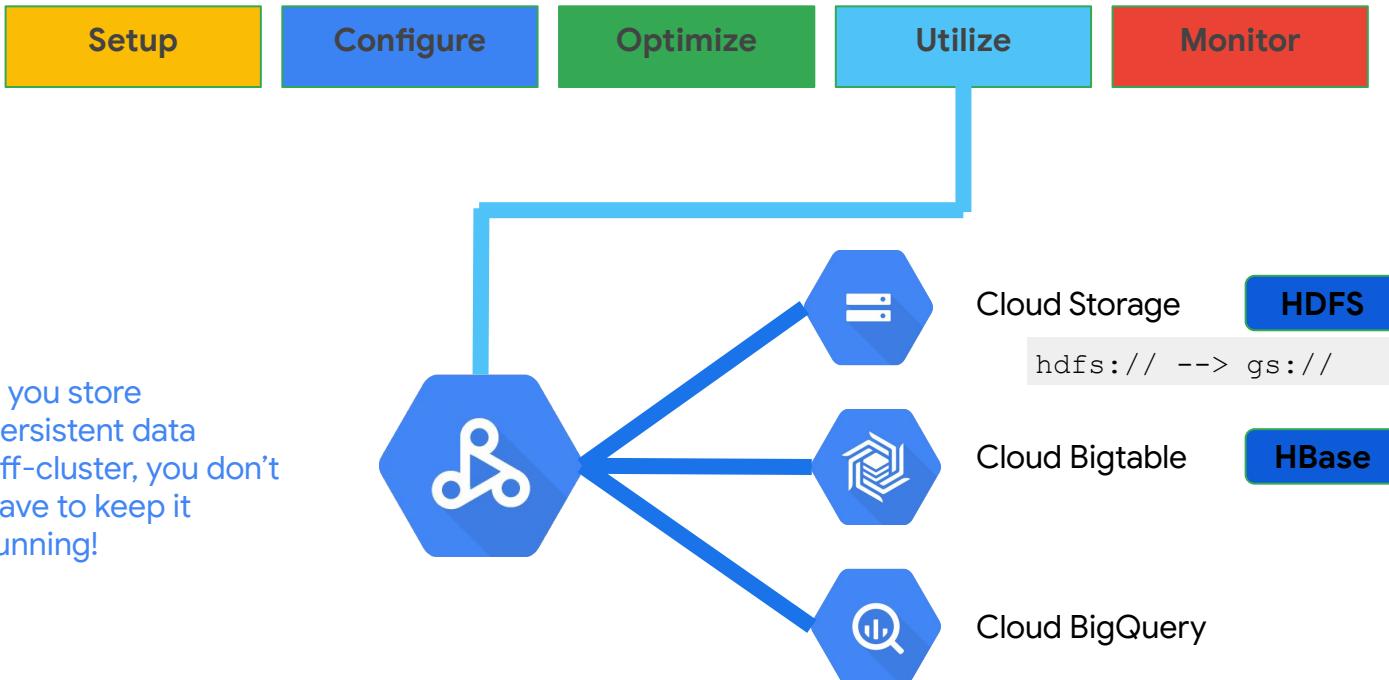
On GCP, Jupiter and Colossus make separation of compute and storage possible



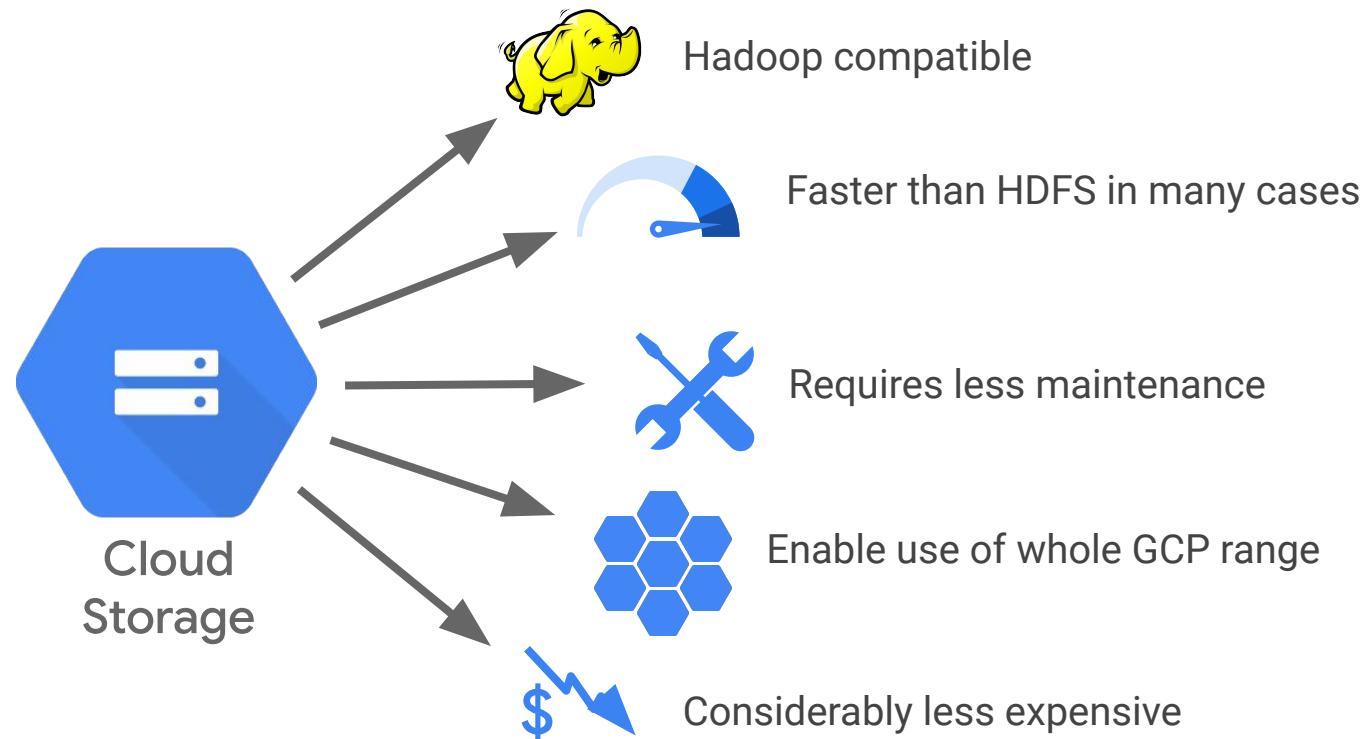
Separation of compute and storage enables better options



Off-cluster storage is the gateway to efficiency



Use Cloud Storage as the persistent data store



Cloud Storage is a drop-in replacement for HDFS



Hadoop FileSystem interfaces - "HCFS" compatible (Hadoop Compatible File System)
File[Input|Output]Format, SparkContext.textFile, etc., just work



Cloud Storage connector can be installed manually on non-Cloud
Dataproc clusters

Performance best practices

Optimize for bulk/parallel operations



Avoid small reads; use large block sizes where possible



Avoid iterating sequentially over many nested directories in a single job



Use Cloud Storage instead of HDFS with Cloud Dataproc

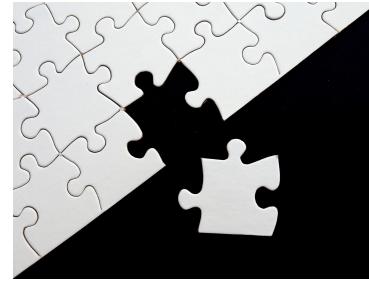
Setup

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Monitor



Cloud Storage is a distributed service

Eliminates traditional bottlenecks and single points of failure

Directories are simulated, so renaming a directory involves renaming all the objects*

Objects do not support "append"

Directory rename in HDFS not the same as in Cloud Storage

Cloud Storage has no concept of directories!

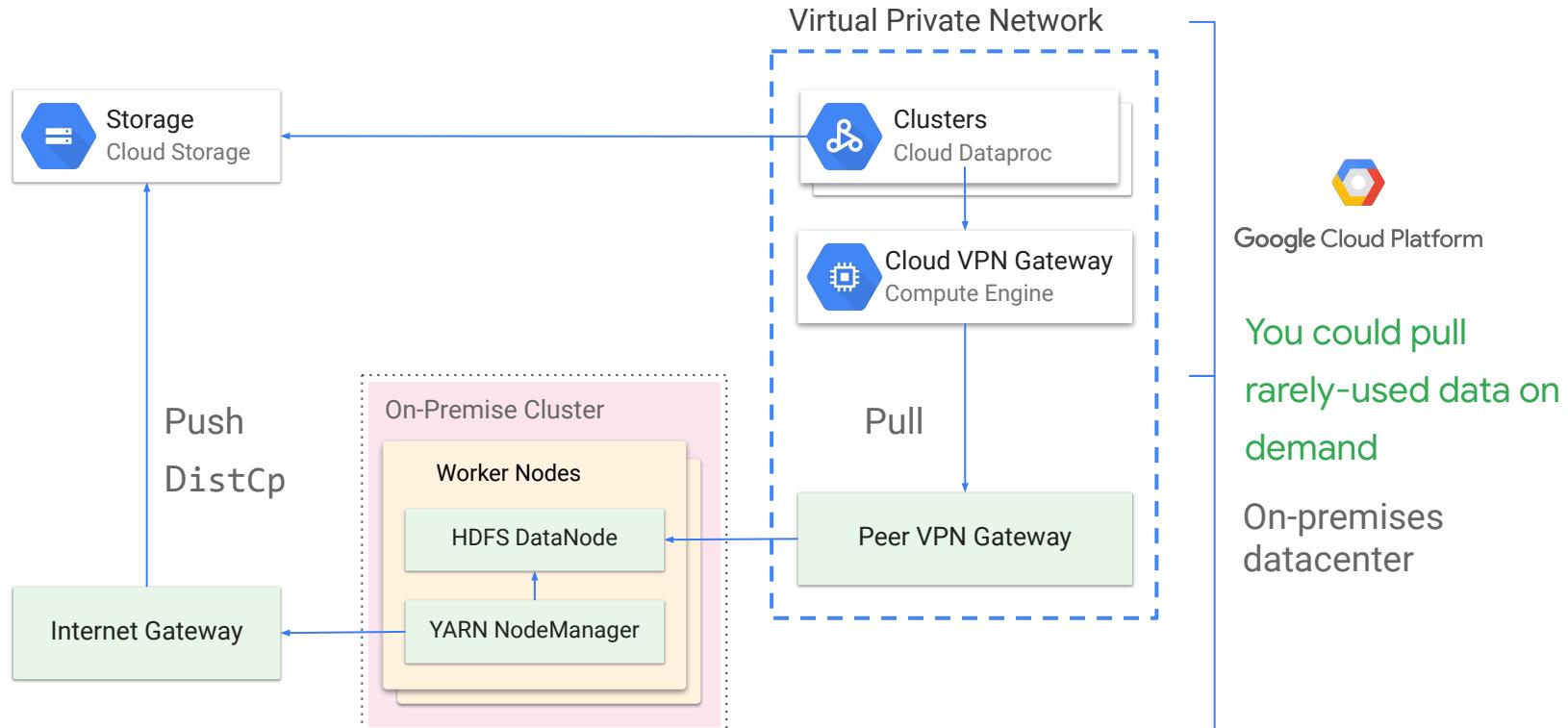
```
mv gs://foo/bar/ gs://foo/bar2
```

- list(gs://foo/bar/)
- copy({gs://foo/bar/baz1, gs://foo/bar/baz2}, {gs://foo/bar2/baz1, gs://foo/bar2/baz2})
- delete({gs://foo/bar/baz1, gs://foo/bar/baz2})

Migrated code should handle list inconsistency during rename!

- Modern output format committers handle object stores correctly

DistCp on-prem data that you will always need



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Hadoop and Spark performance questions for all cluster architectures, Cloud Dataproc included

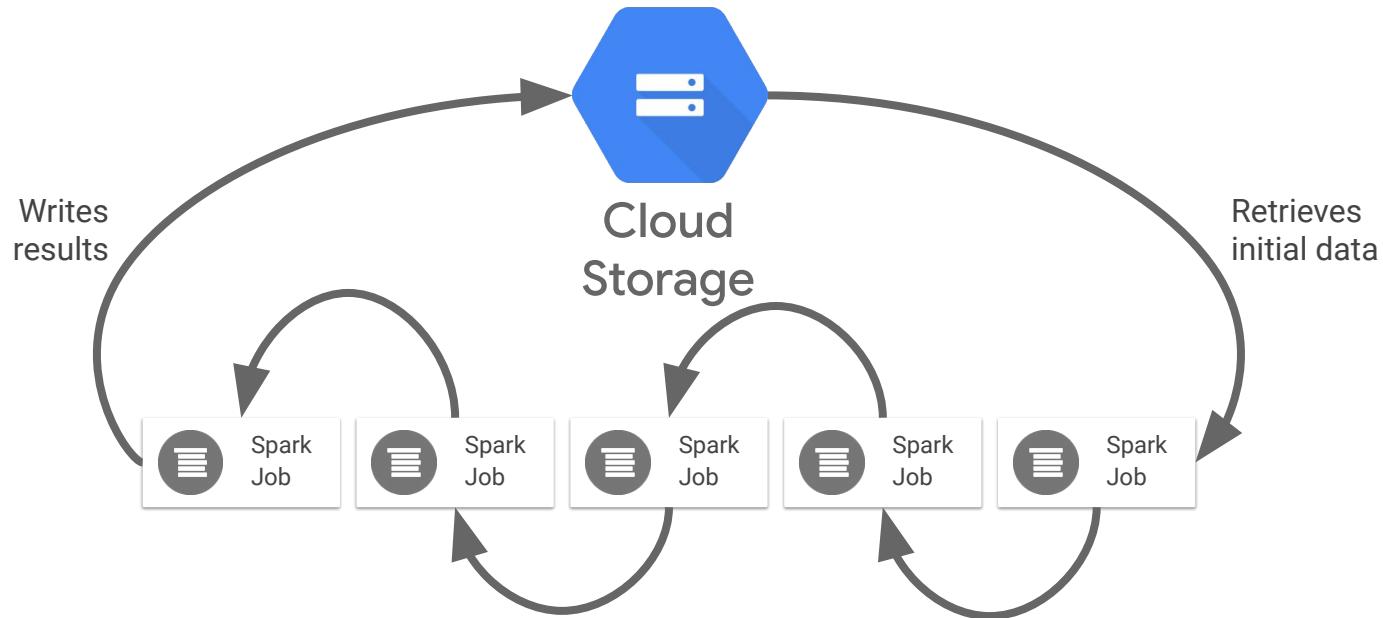
- 1 Where is your data, and where is your cluster?
- 2 Is your network traffic being funneled?
- 3 How many input files and Hadoop partitions are you trying to deal with?
- 4 Is the size of your persistent disk limiting your throughput?
- 5 Did you allocate enough virtual machines (VMs) to your cluster?

Local HDFS is necessary at times

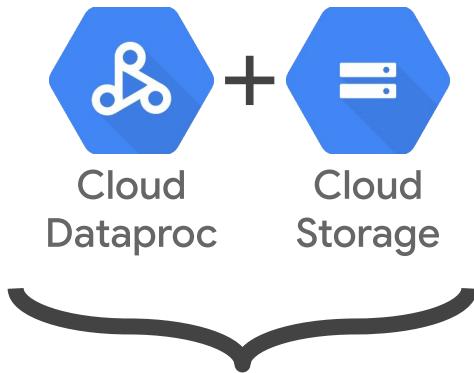
Local HDFS is a good option if:

- Your jobs require a lot of metadata operations
- You modify the HDFS data frequently or you rename directories.
- You heavily use the append operation on HDFS files.
- You have workloads that involve heavy I/O.
- You have I/O workloads that are especially sensitive to latency.

Cloud Storage works well as the initial and final source of data in a big-data pipeline



Using Cloud Dataproc with Cloud Storage allows you to reduce the disk requirements and save costs



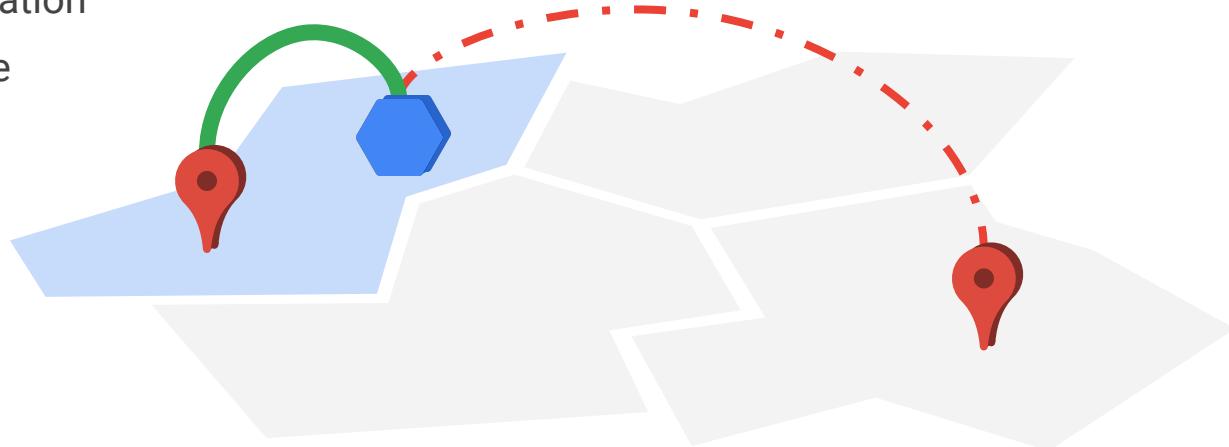
Here are some options to adjust the size of the local HDFS:

- Decrease the total size of the local HDFS by decreasing the size of primary persistent disks for the master and workers.
- Increase the total size of the local HDFS by increasing the size of primary persistent disk for workers.
- Attach up to eight SSDs (375 GB each) to each worker and use these disks for the HDFS.
- Use SSD persistent disks for your master or workers as a primary disk.

Geographical regions can impact the efficiency of your solution

Regions can have repercussions for your jobs, such as:

- Request latency
- Data proliferation
- Performance



GCP provides different storage options for different jobs



Cloud Storage



Cloud Bigtable



BigQuery

- Primary datastore for GCP
 - Unstructured data
- Large amounts of sparse data
 - HBase-compliant
 - Low latency
 - High scalability
- Data warehousing
 - Storage API makes this faster than before
 - Could push down queries to BigQuery, refactoring the job

Replicating your persistent on-premises setup has some drawbacks

Persistent clusters
are expensive



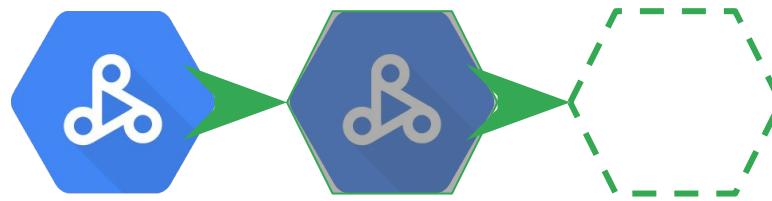
Your open-source-based
tools may be inefficient



Persistent clusters are
difficult to manage



Cluster Scheduled Deletion



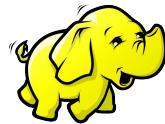
Idle

Timestamp

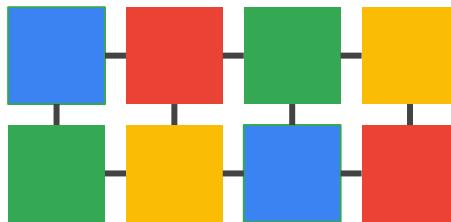
Duration

Minimum 10 minutes
Maximum 14 days
Granularity 1 second

With ephemeral clusters, you only pay for what you use



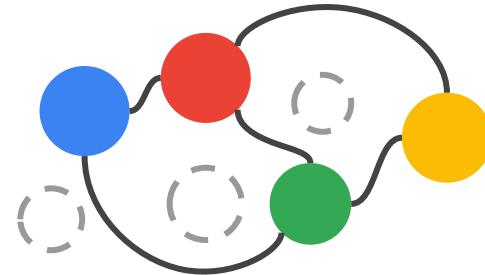
Persistent clusters



Resources are active at all times.
You are constantly paying for all available clusters.

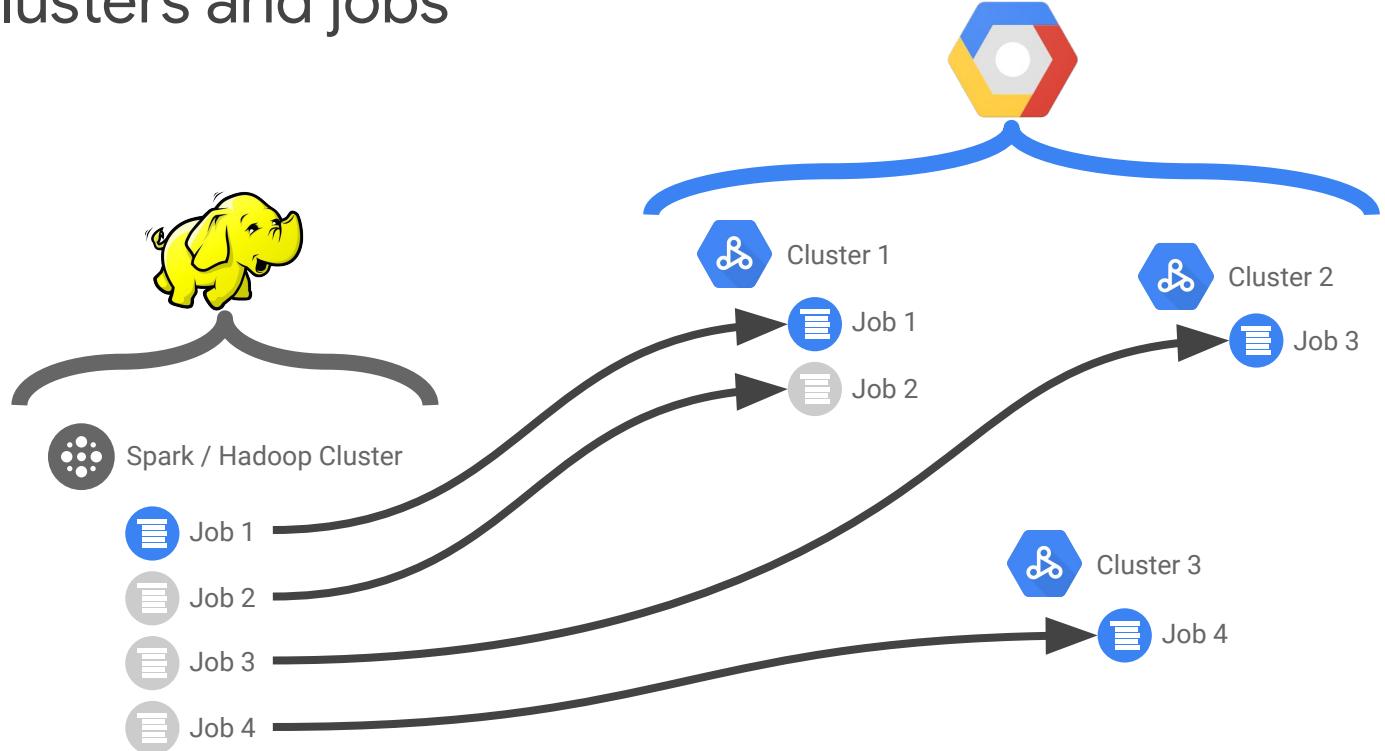


Ephemeral clusters

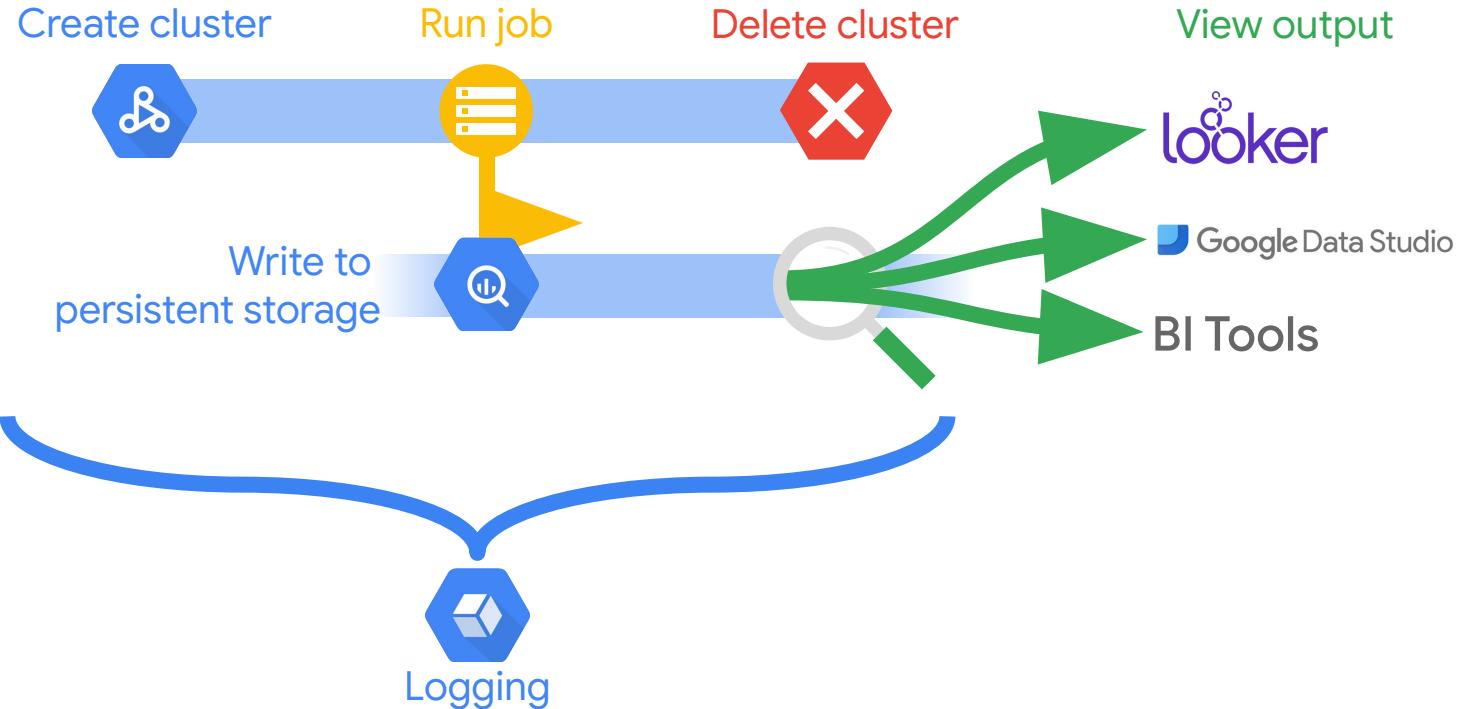


Required resources are active only when being used. You only pay for what you use.

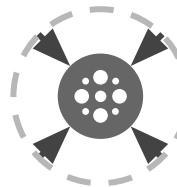
Split clusters and jobs



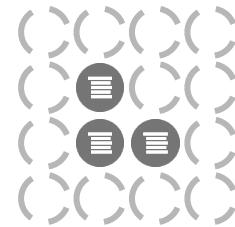
Use ephemeral clusters for one job's lifetime



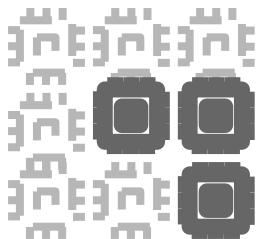
Points to remember if you need a persistent cluster



Create the smallest cluster you can, using
preemptible VMs based on time budget

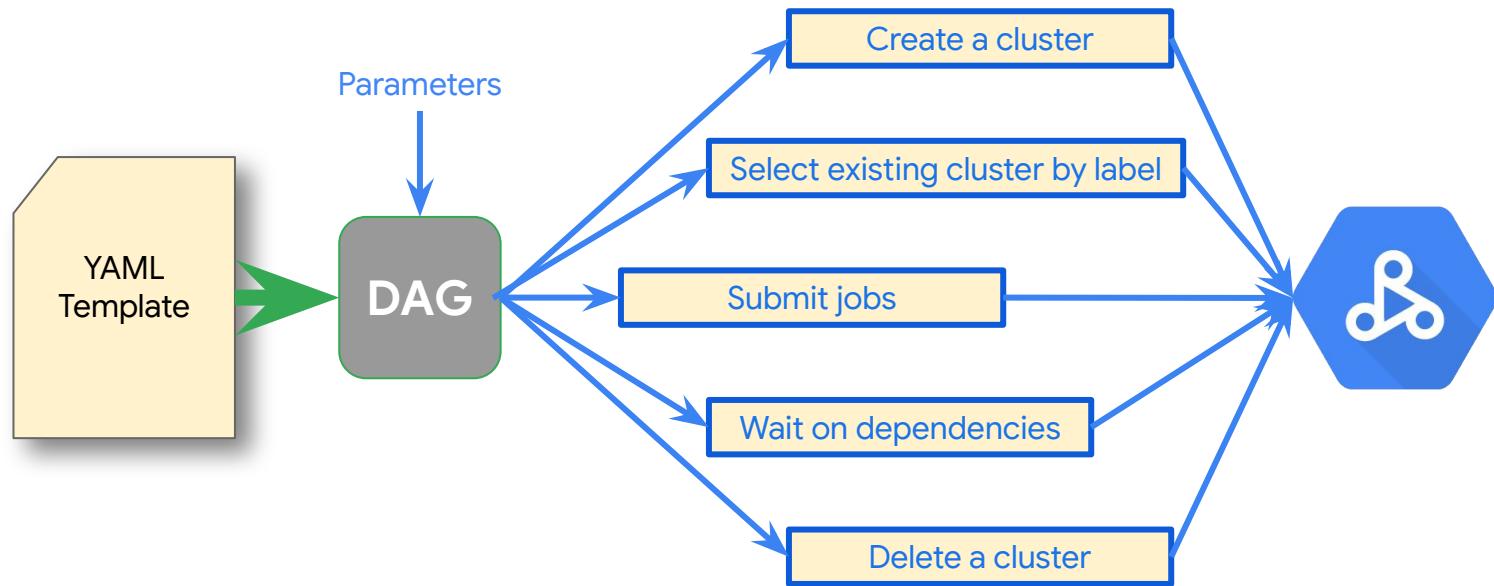


Scope your work on a persistent
cluster to the smallest possible
number of jobs



Scale the cluster to the minimum workable number
of nodes. Add more dynamically on demand
(auto-scaling).

Cloud Dataproc Workflow Template



Cloud Dataproc workflow templates

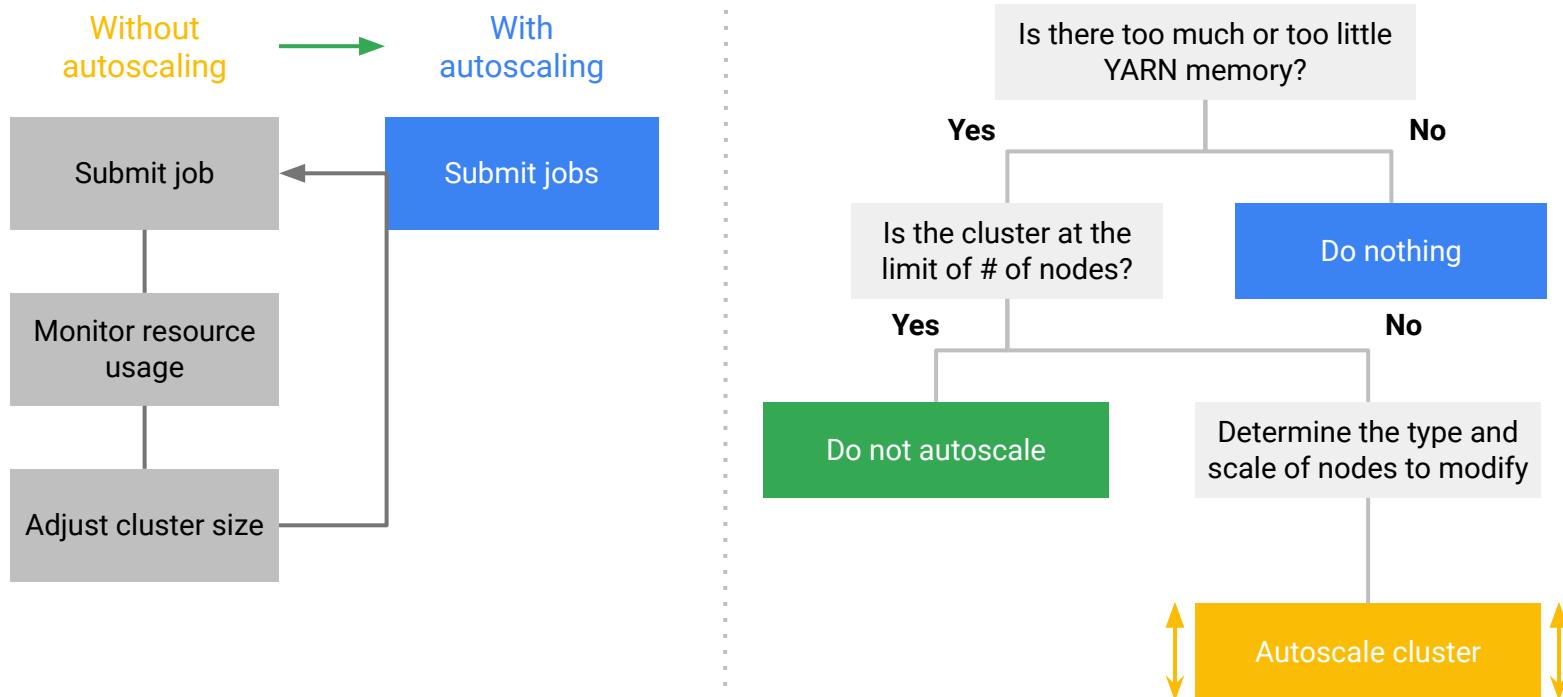
```
# the things we need pip-installed on the cluster
STARTUP_SCRIPT=gs://${BUCKET}/sparktobq/startup_script.sh
echo "pip install --upgrade --quiet google-compute-engine google-cloud-storage matplotlib" >
/tmp/startup_script.sh
gsutil cp /tmp/startup_script.sh $STARTUP_SCRIPT

# create new cluster for job
gcloud dataproc workflow-templates set-managed-cluster $TEMPLATE \
    --master-machine-type $MACHINE_TYPE \
    --worker-machine-type $MACHINE_TYPE \
    --initialization-actions $STARTUP_SCRIPT \
    --num-workers 2 \
    --image-version 1.4 \
    --cluster-name $CLUSTER

# steps in job
gcloud dataproc workflow-templates add-job \
    pyspark gs://${BUCKET}/spark_analysis.py \
    --step-id create-report \
    --workflow-template $TEMPLATE \
    -- --bucket=${BUCKET}

# submit workflow template
gcloud dataproc workflow-templates instantiate $TEMPLATE
```

Cloud Dataproc autoscaling workflow



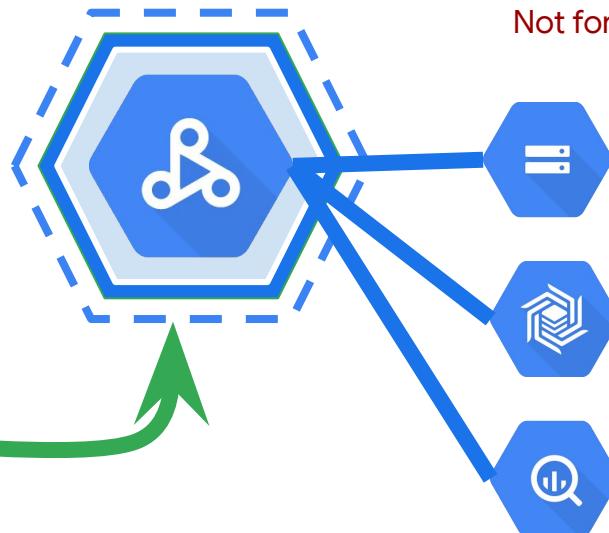
Cloud Dataproc Autoscaling provides flexible capacity

Cluster with
lots of jobs or a
single large job

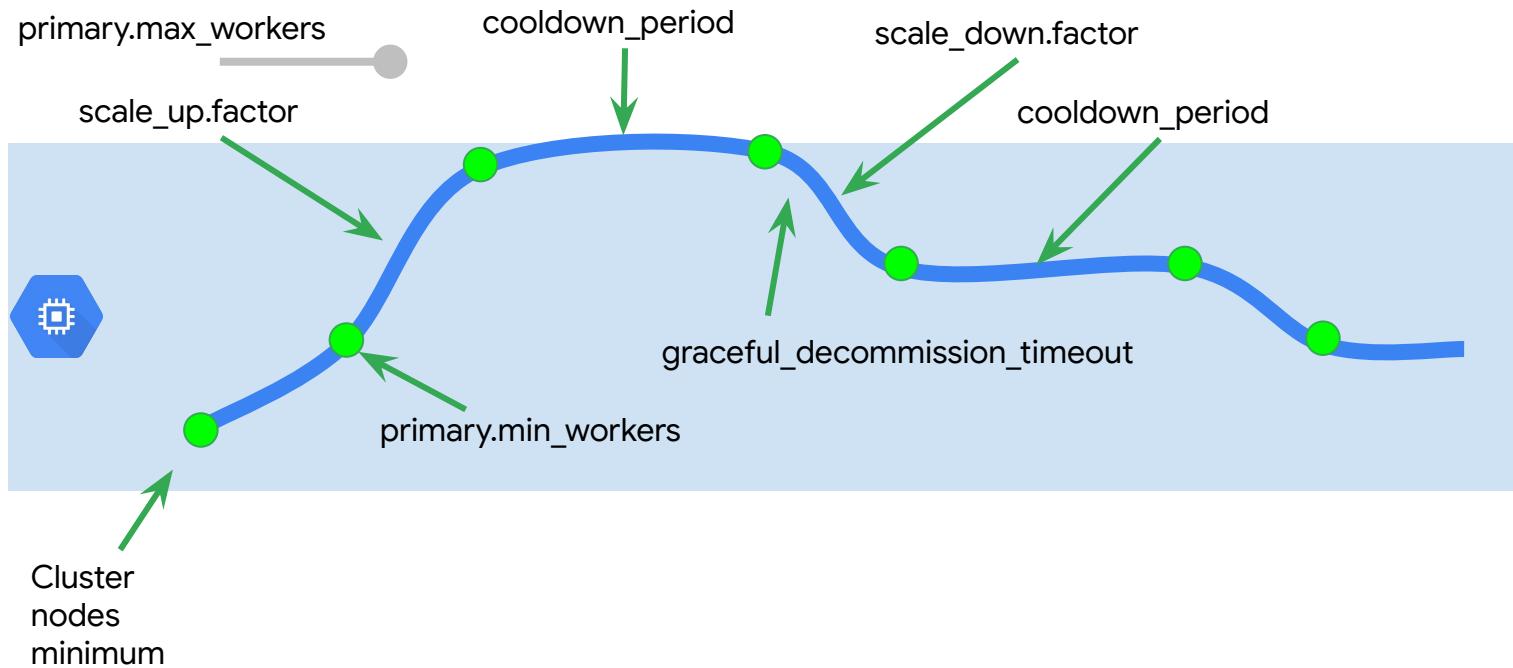
Not for idle
clusters or
scale to zero

Autoscaling is
based on Hadoop
YARN Metrics

External data
Not for on-cluster HDFS
Not for Spark Structured Streaming



How Cloud Dataproc Autoscaling works



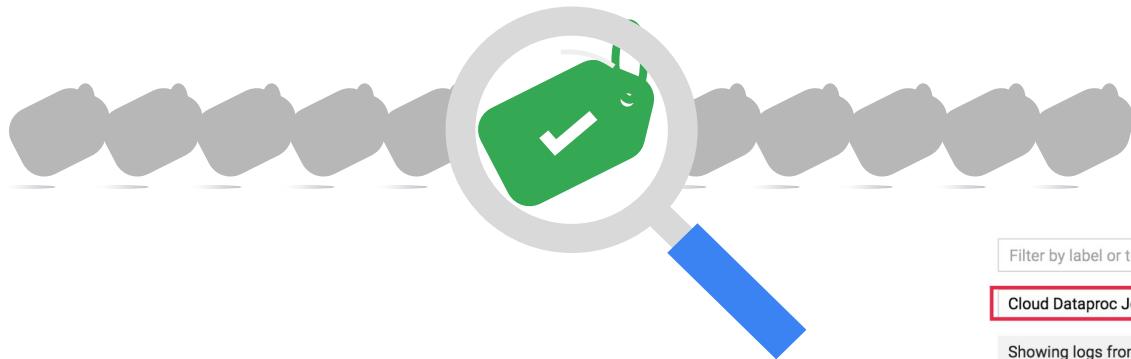
Use Cloud Operations logging and performance monitoring

The screenshot shows the Google Cloud Operations Logging interface. At the top, there are buttons for 'CREATE METRIC' and 'CREATE EXPORT', and navigation icons. Below that is a search bar labeled 'Filter by label or text search'. A dropdown menu shows 'Cloud Dataproc Cluster' as the selected resource. The main area displays log entries for this cluster. The logs are filtered to show 'All logs' at 'Any log level' over the last 24 hours. The results are as follows:

- No older entries found matching current filter in the last 24 hours.
- dataproc SubmitJob global:564f57524dc84d369f4f914f39f5d666 dimosthenis@google.com created new context for 564f57524dc84d369f4f914f39f5d666
- Starting new jobID '564f57524dc84d369f4f914f39f5d666'
- Using driver: [spark-submit, --conf, spark.yarn.tags=dataproc_hash_5d4159b5]
- Pinging driver output to: gs://dataproc-107cf59b-2f38-47e6-98fa-bde4f549c397-e666' completed with exit code 0
- d666' completed with exit code 0
- 24dc84d369f4f914f39f5d666
- cluster-2ae5
- cluster-7bad
- cluster-7eab
- cluster-93a3
- cluster-e3e3
- cluster-fb15

Below the log entries, there are two search boxes: 'Search by prefix...' under 'All cluster_name' and 'All cluster_uuid'.

Create labels on clusters and jobs to find logs faster



Filter by label or text search

Cloud Dataproc Job dataproc.job.driver

Showing logs from all time (PDT)

2019-04-03 09:34:16.478 PDT Pi is roughly 3.1417569

insertId: "le8i240nizp188ay9"
labels: {...}
logName: "projects/google.com:hadoop-cloud-dev/log"
receiveTimestamp: "2019-04-03T16:34:19.778423350Z"
resource: {...}
textPayload: "Pi is roughly 3.1417569514175696"
timestamp: "2019-04-03T16:34:16.478380936Z"

2019-04-03 09:34:16.000 PDT Stopped Spark@19569ebd{...}
2019-04-03 09:33:45.000 PDT Submitted application a...

Set the log level

You can set the driver log level using the following gcloud command:

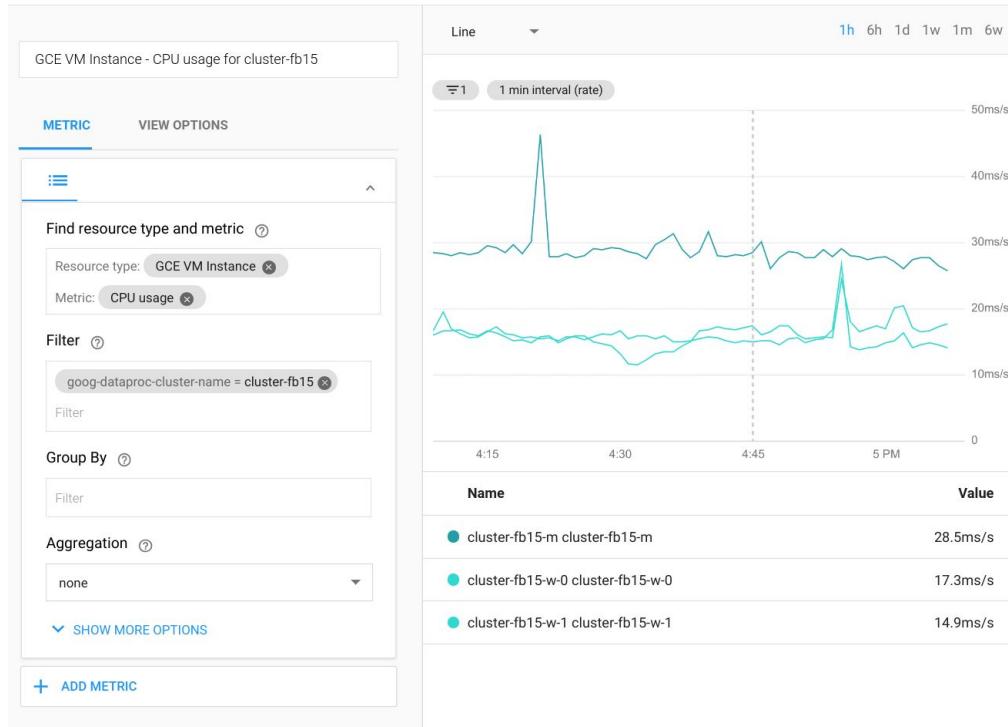
```
gcloud dataproc jobs submit hadoop --driver-log-levels
```

You set the log level for the rest of the application from the Spark context.
For example:

```
spark.sparkContext.setLogLevel("DEBUG")
```

Monitor your jobs

Add Chart



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Running Apache Spark jobs on Cloud Dataproc

Objectives

- Migrate existing Spark jobs to Cloud Dataproc
- Modify Spark jobs to use Cloud Storage instead of HDFS
- Optimize Spark jobs to run on Job specific clusters

Summary

The Hadoop ecosystem

Running Hadoop on Cloud Dataproc

GCS instead of HDFS

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