Google Cloud

Executing Spark on Dataproc

Agenda

The Hadoop Ecosystem

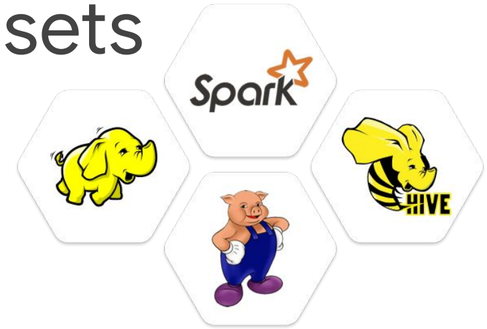
Running Hadoop on Dataproc

Cloud Storage Instead of HDFS

Optimizing Dataproc

Lab: Running Apache Spark jobs on Dataproc

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



Hadoop

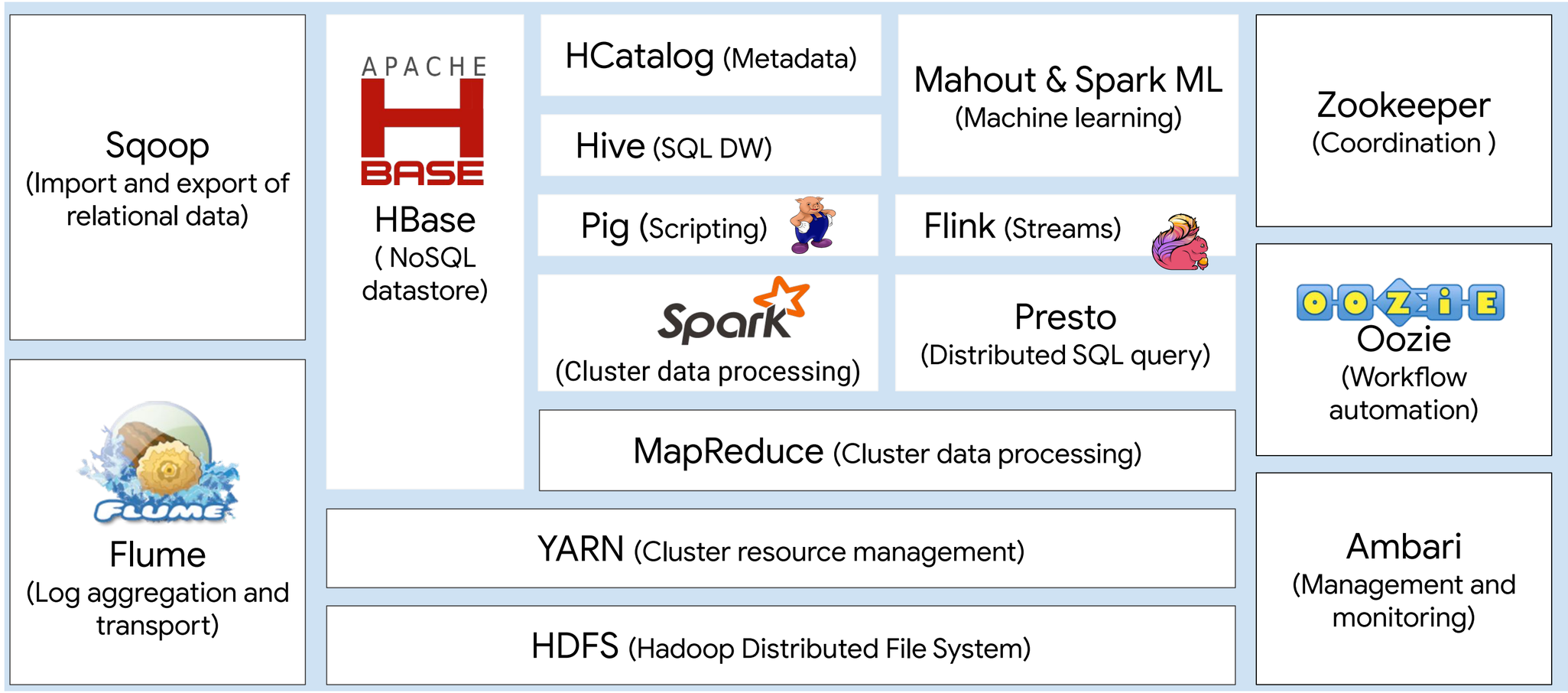
Distribute the processing

Store the data with the processors

Database

Bring the data to the processor

The Hadoop ecosystem is very popular for Big Data workloads



On-premises Hadoop clusters have a number of limitations

- X Not elastic
- X Hard to scale fast
- X Have capacity limits
- X 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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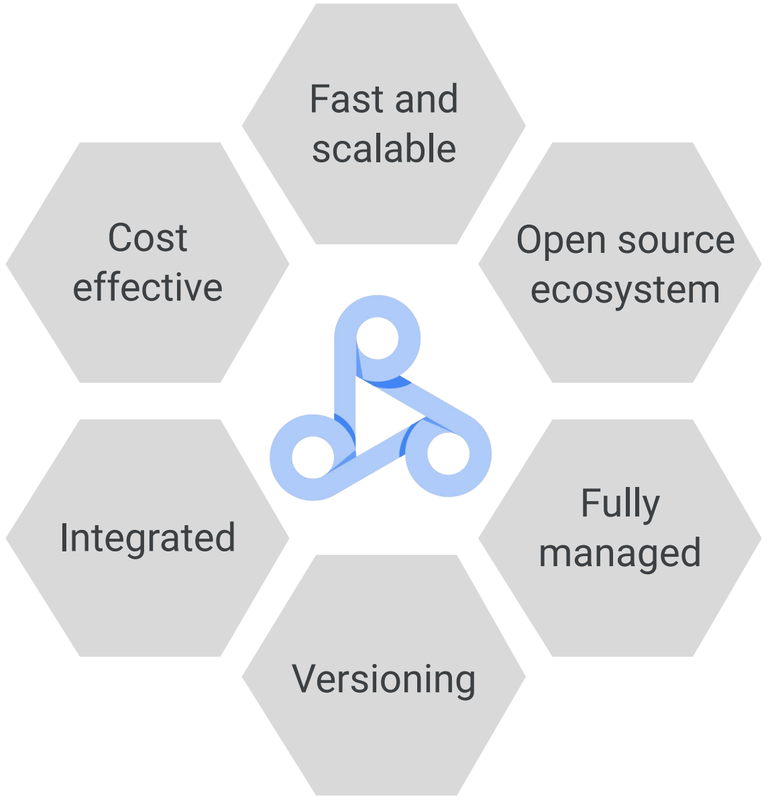
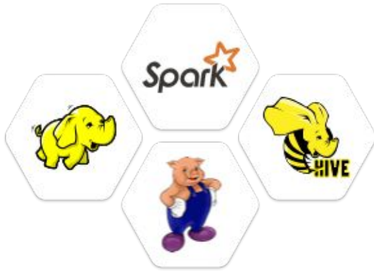
Dataproc is a managed service for running Hadoop and Spark data processing workloads



Google Cloud



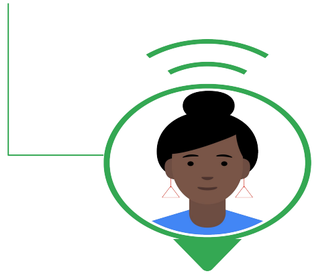
Google Cloud

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

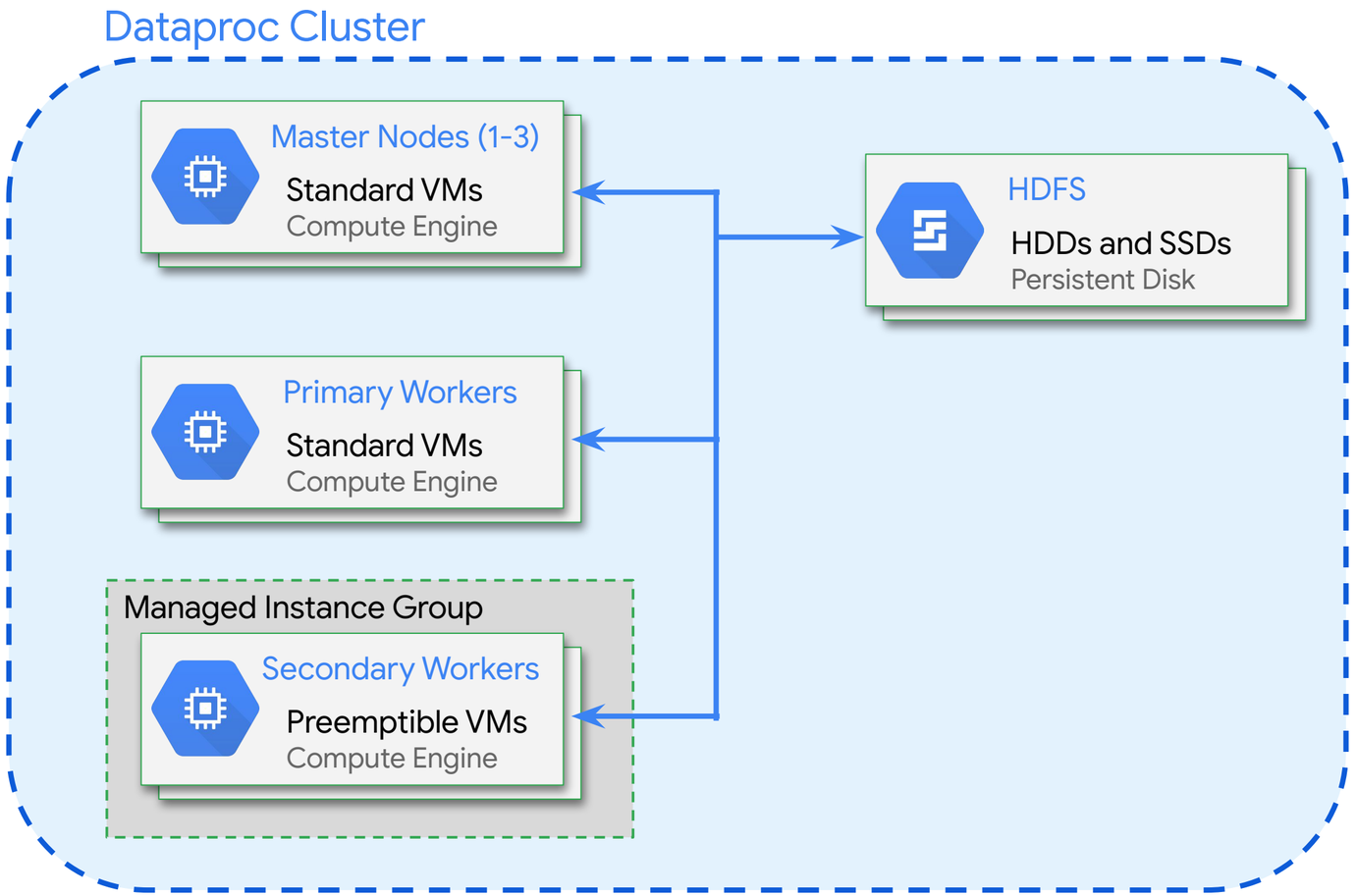
Use initialization actions to install additional components on the cluster.



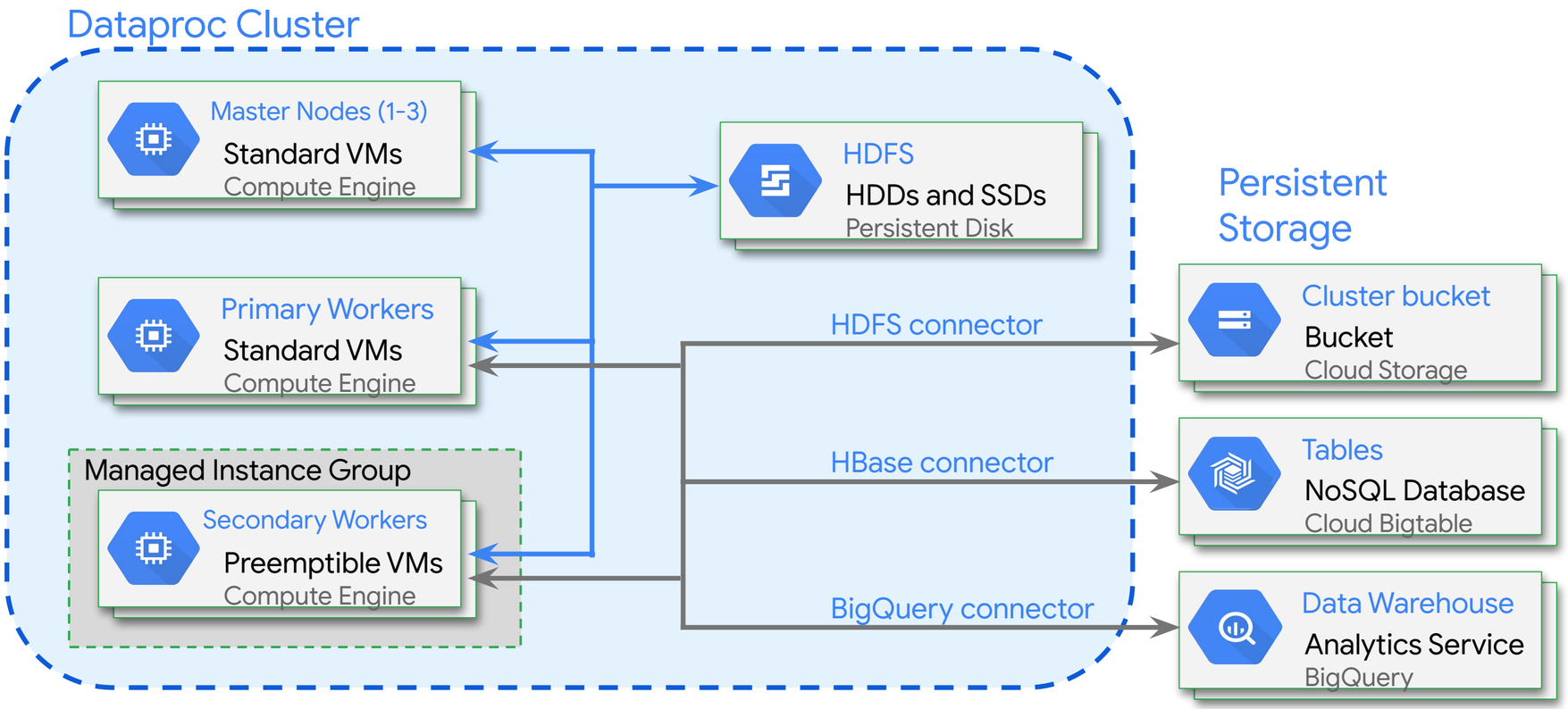
```
gcloud dataproc clusters create <CLUSTER_NAME> \
    --initialization-actions gs://$MY_BUCKET/hbase/hbase.sh \
       --num-masters 3 --num-workers 2
```

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

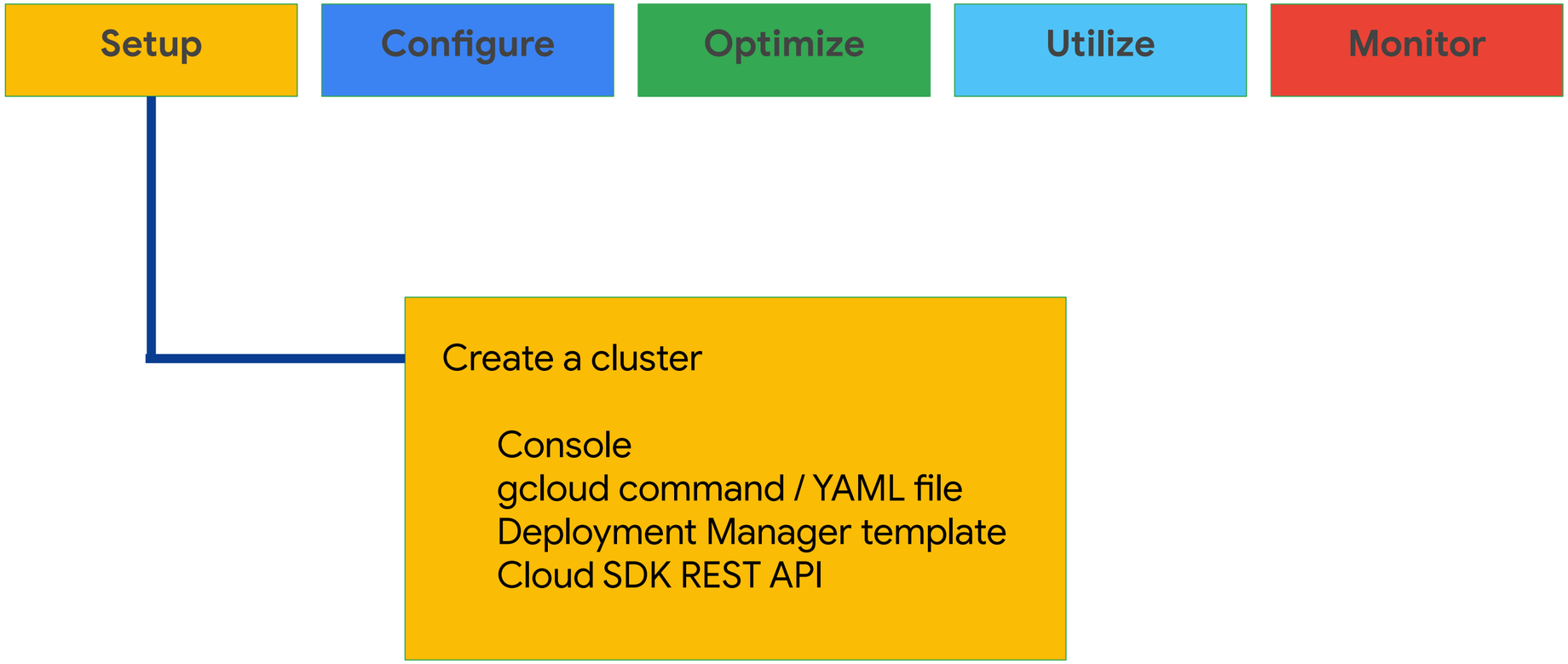
A Dataproc cluster has master nodes, workers, and HDFS



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

Setup | Configure | Optimize | Utilize | Monitor

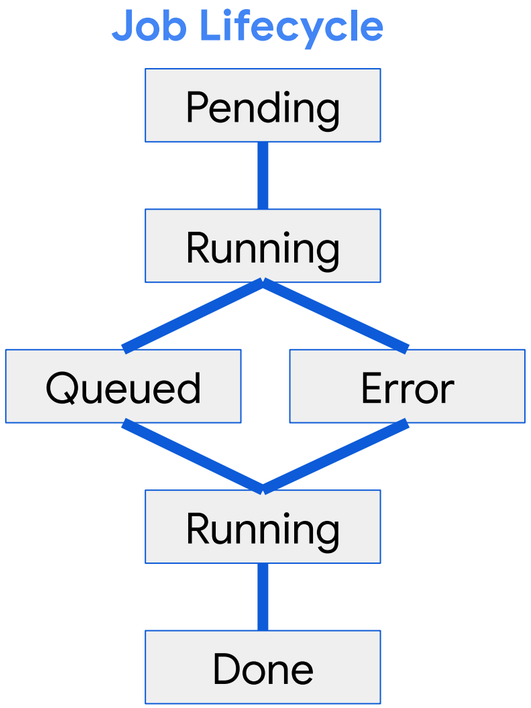
Preemptible VMs	Lower cost
Custom Machine Types	Efficient allocation of resources for consistent workloads.
Minimum CPU platform	Consistent distribution of workload -minimum vCPU performance.
Custom Images	Faster time to reach an operational state.
Persistent SSD boot disk	Faster boot time
Attached GPUs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

Utilize: Job submission

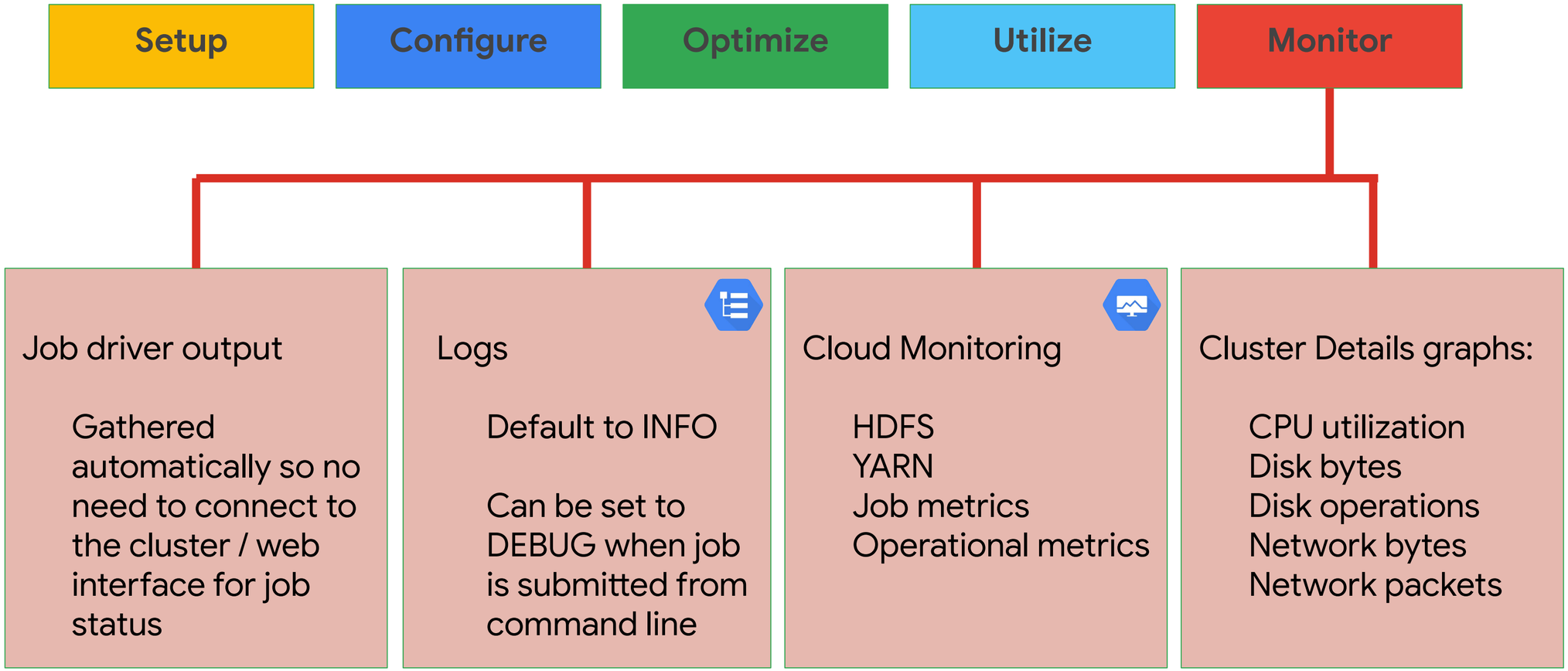
Setup | Configure | Optimize | Utilize | Monitor

Submit a job

Console
gcloud command
REST API
Orchestration services:
Cloud Dataproc Workflow Templates
Cloud Composer



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

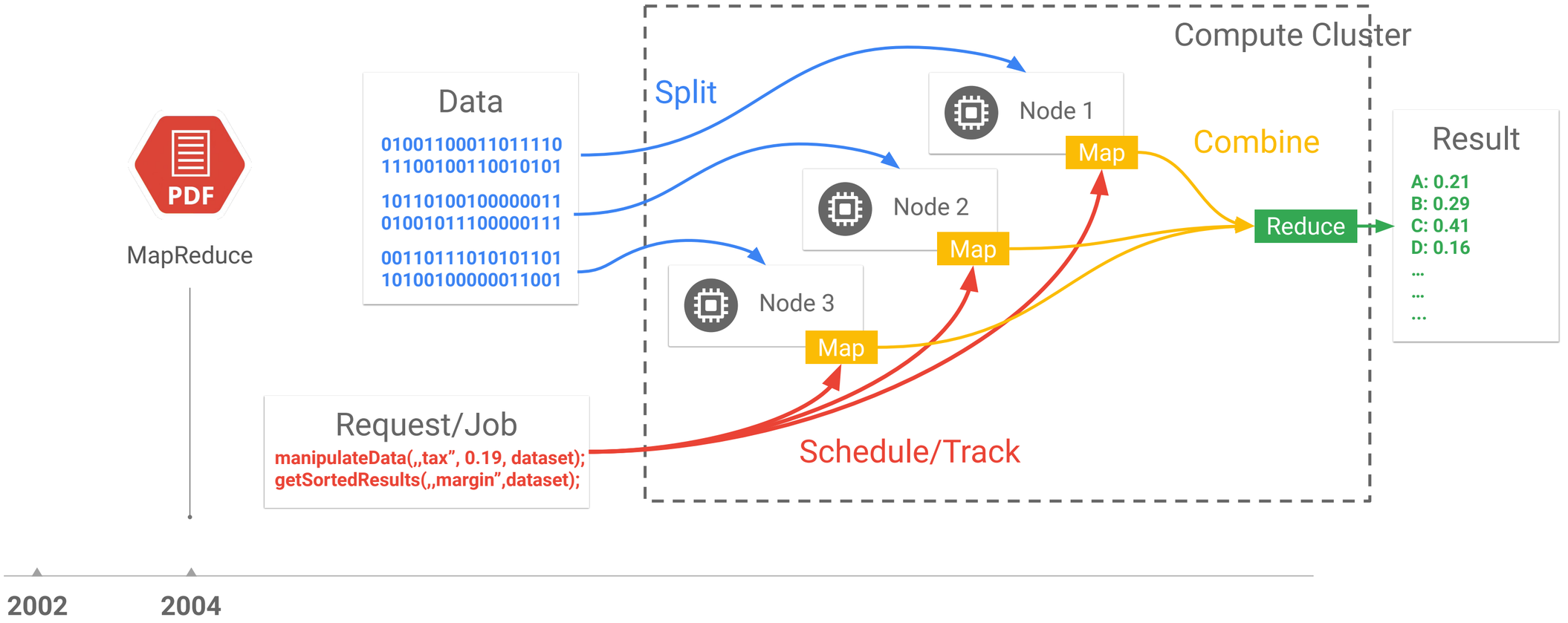


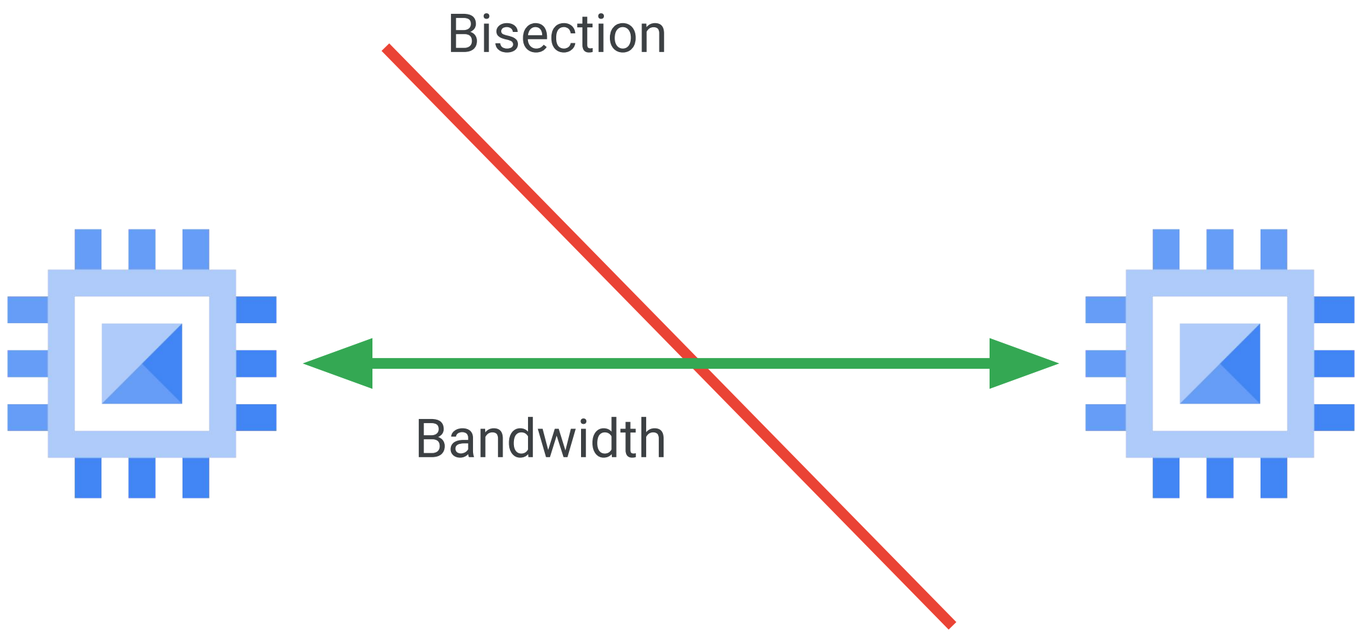
Diagram by Lukas Kästner

Google Cloud

HDFS in the Cloud is a sub-par solution

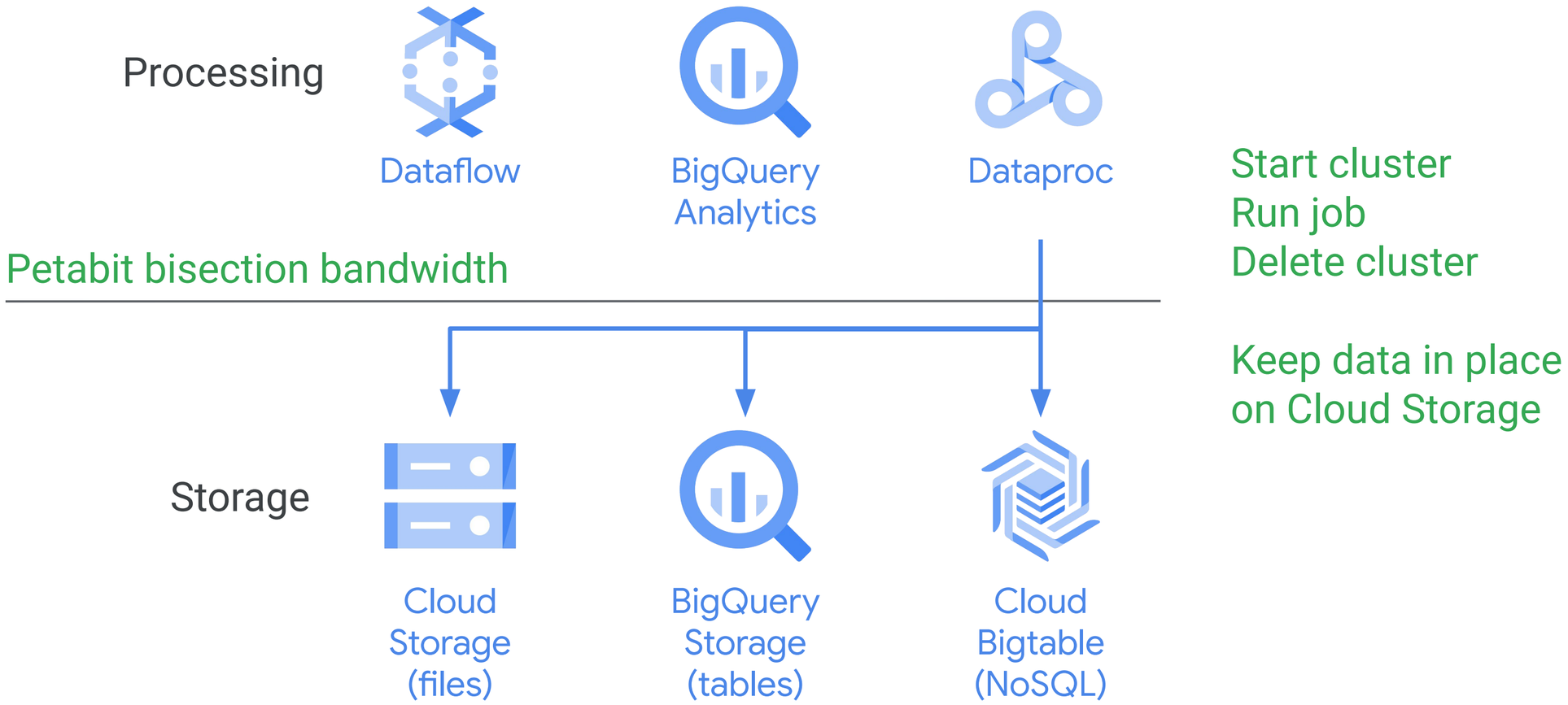
Block size	Locality	Replication
Defaults to 64 MB (often raised to 128 MB) Determines parallelism of execution I/O scales with disk size & VM cores (up to 2 TB and 8 cores) Only accessible from a single node (in RW mode)	HDFS spreads blocks Most execution engines on HDFS are locality aware	Default to 3 copies of each block (r=3) Still need r = 2 on HDFS, for availability • Cloud Dataproc servers have to transmit 2 x 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

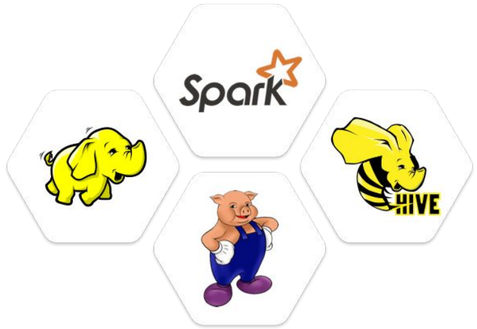


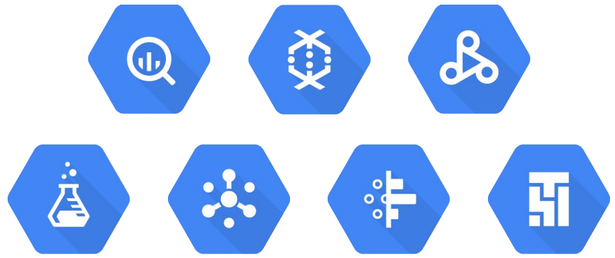
Process the data where it is without copying it

On Google Cloud, Jupiter and Colossus make separation of compute and storage possible



Separation of compute and storage enables better options





Database

Bring the data to the processor

Hadoop

Distribute the processing

Store the data with the processors

Cloud services

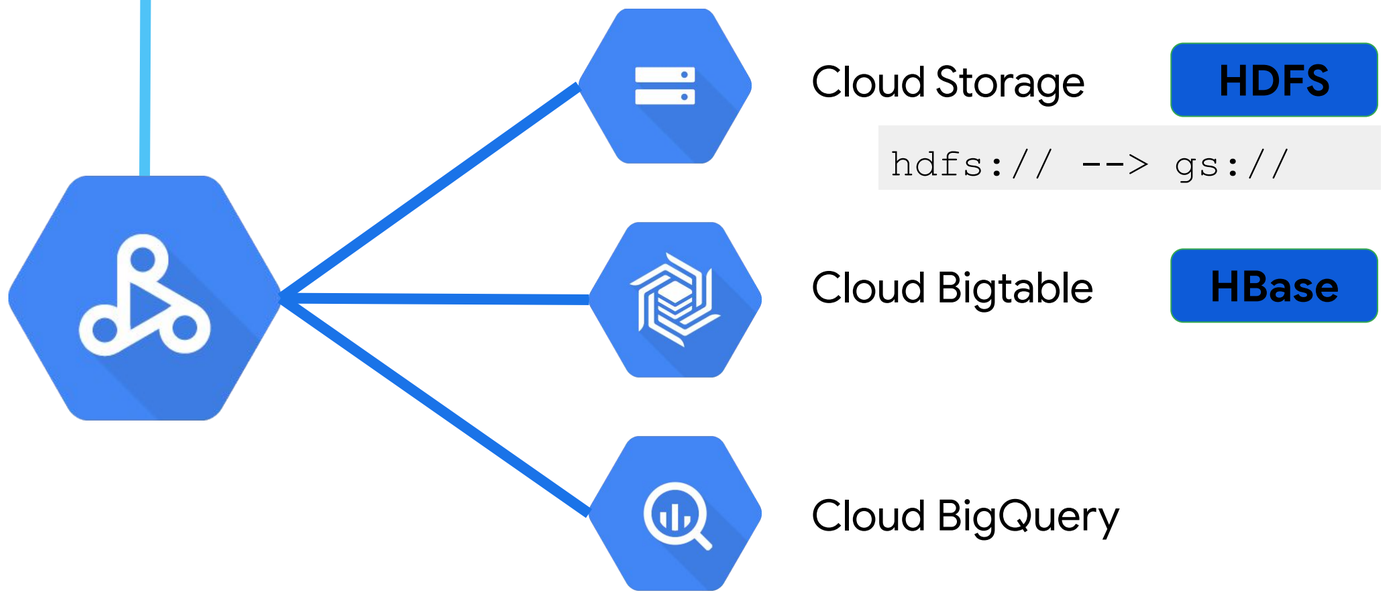
Petabit bisectional bandwidth network

Separate, specialize, and connect

Data storage services
Data processing services
Messaging services

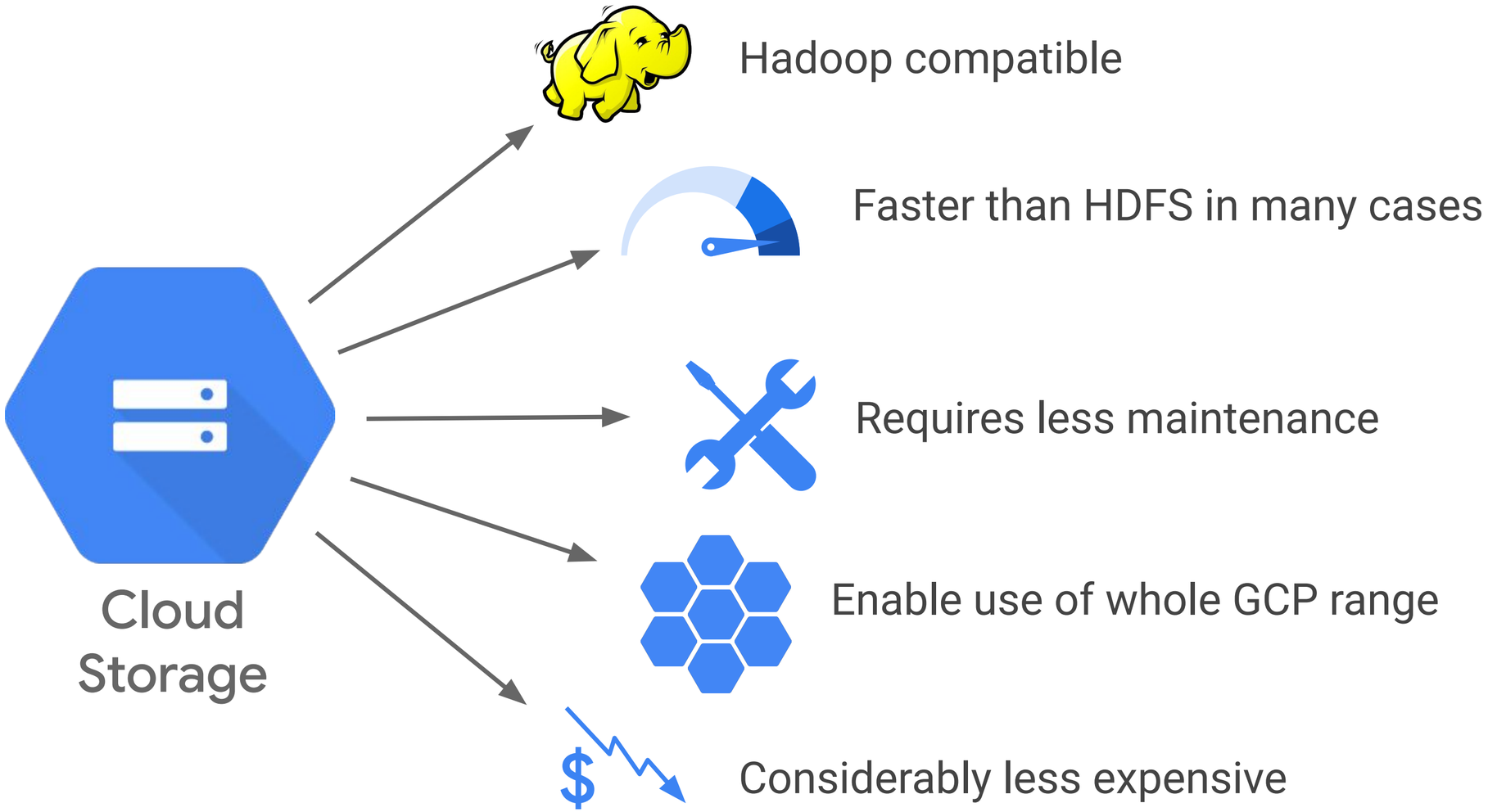
Off-cluster storage is the gateway to efficiency

Setup | Configure | Optimize | Utilize | Monitor



If you store persistent data off-cluster, you don't have to keep it running!

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

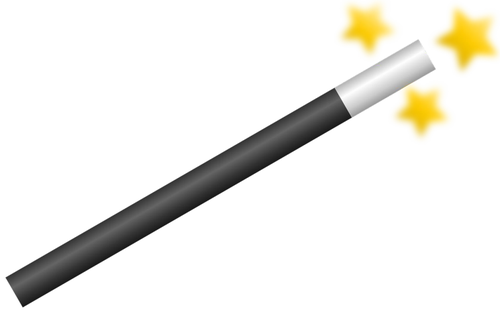
- Avoid small reads; use large block sizes where possible
- Avoid iterating sequentially over many nested directories in a single job

Use Cloud Storage instead of HDFS with Cloud Dataproc

Setup | Configure | Optimize | Utilize | 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!

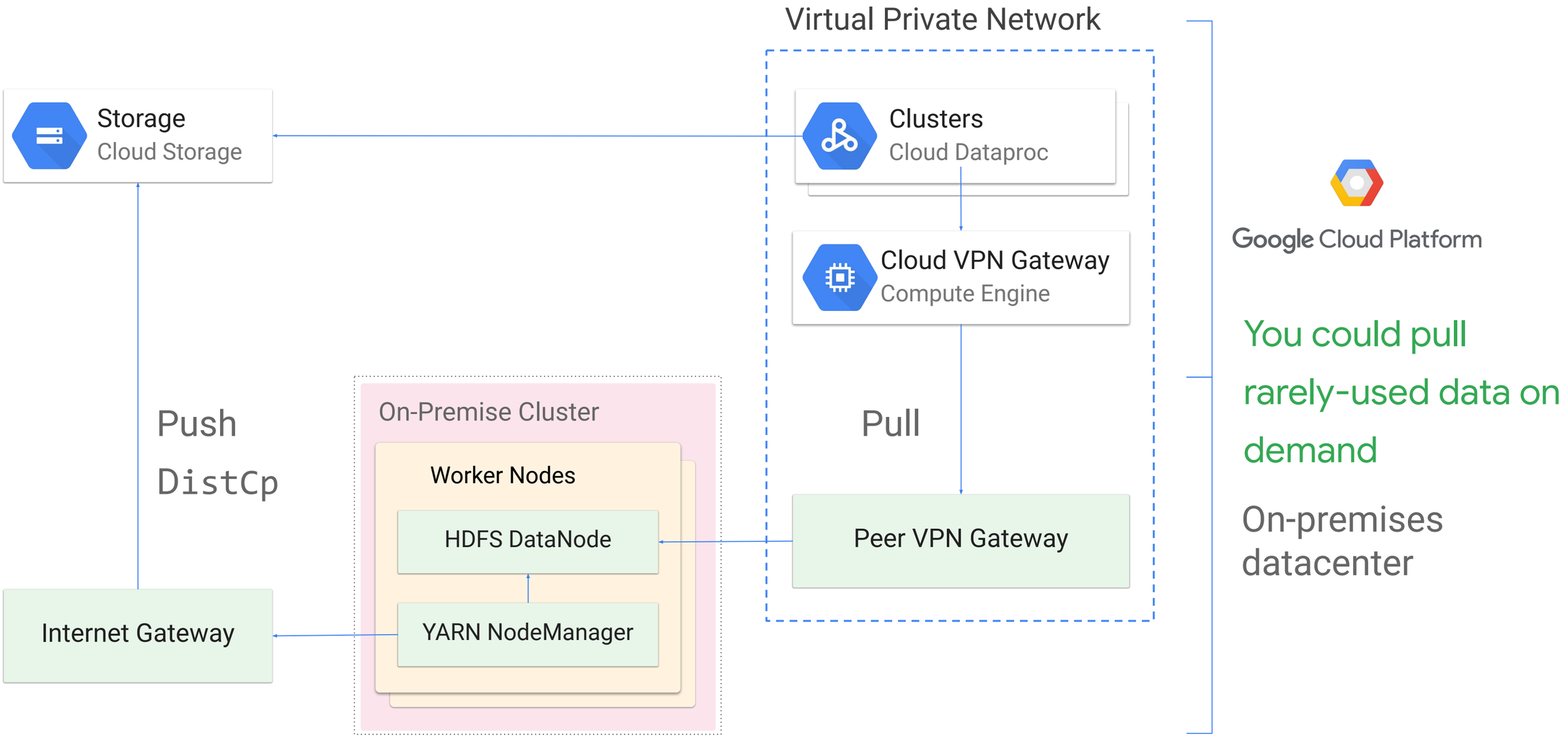
mv gs://foo/bar/ gs://foo/bar2

- 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



Google Cloud

https://hadoop.apache.org/docs/current/hadoop-distcp/DistCp.html

Agenda

The Hadoop ecosystem

Running Hadoop on Cloud Dataproc

GCS instead of HDFS

Optimizing Dataproc

Lab

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

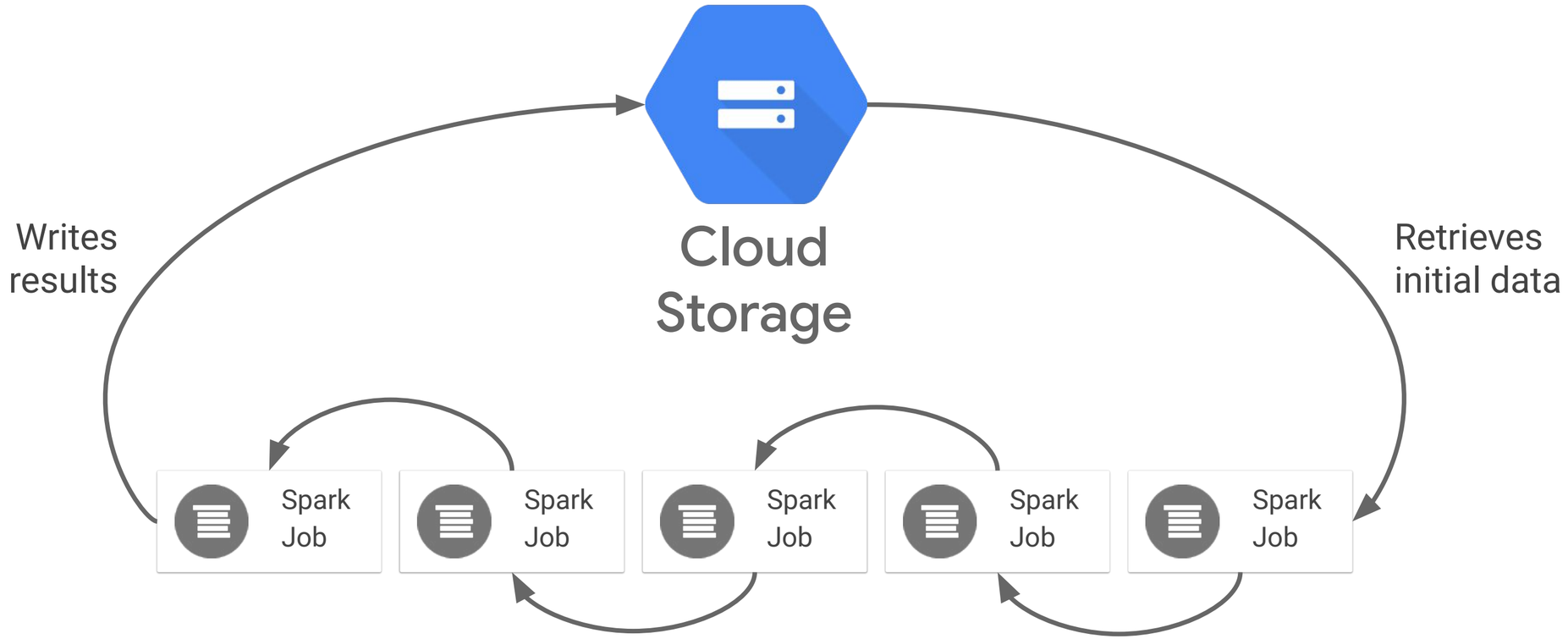
1. Where is your data, and where is your cluster?
2. Is your network traffic being funneled?
3. How many input files and Hadoop partitions are you trying to deal with?
4. Is the size of your persistent disk limiting your throughput?
5. Did you allocate enough virtual machines (VMs) to your cluster?

Local HDFS is necessary at times

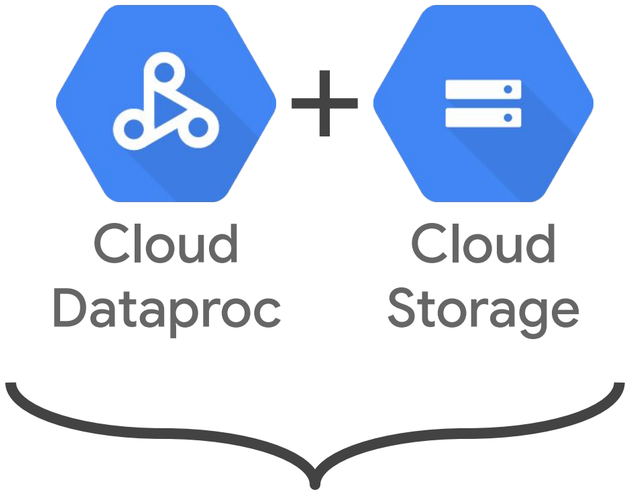
Local HDFS is a good option if:

- 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



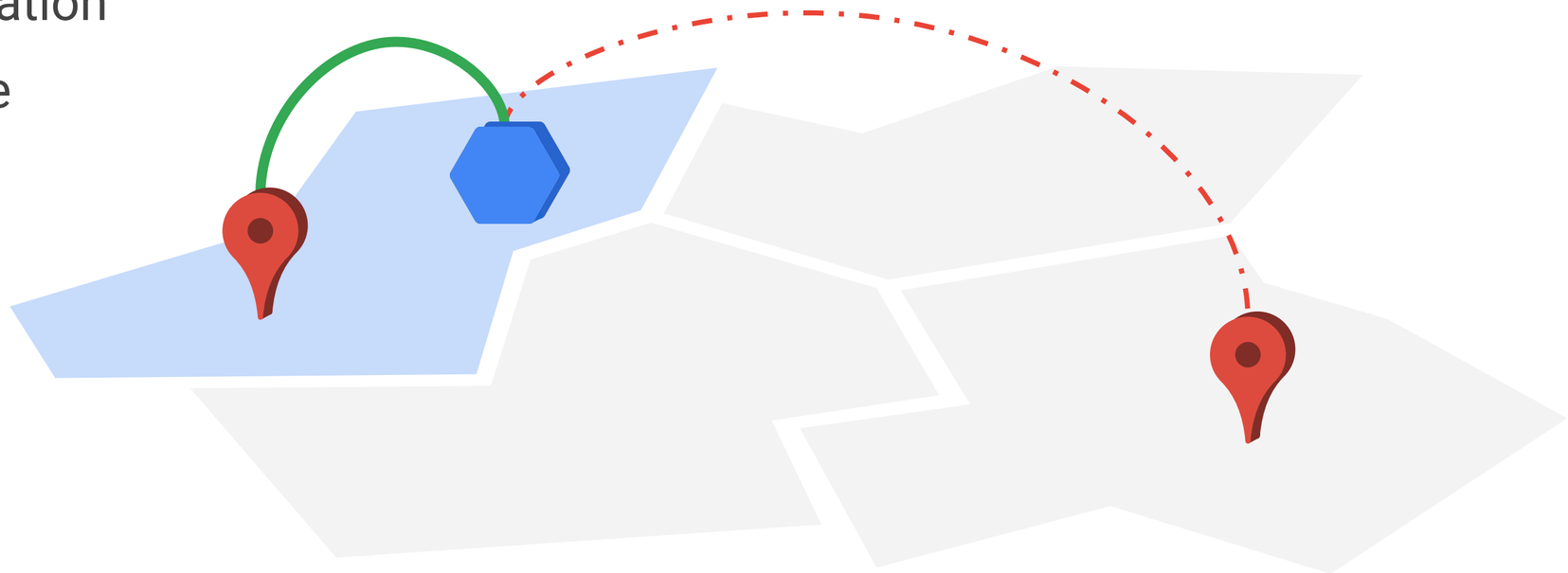
Here are some options to adjust the size of the local HDFS:

- 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

- Primary datastore for GCP
- Unstructured data

Cloud Bigtable

- Large amounts of sparse data
- HBase-compliant
- Low latency
- High scalability

BigQuery

- Data warehousing
- Storage API makes this faster than before
- Could push down queries to BigQuery, refactoring the job

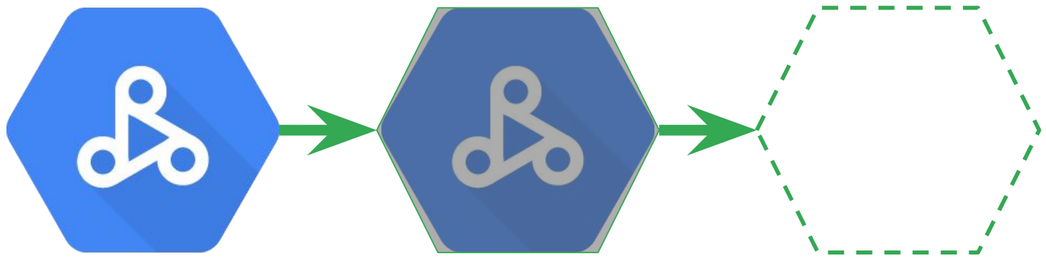
Replicating your persistent on-premises setup has some drawbacks

Persistent clusters are expensive

Your open-source-based tools may be inefficient

Persistent clusters are difficult to manage

Cluster Scheduled Deletion



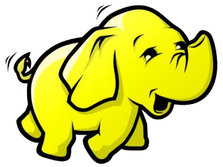
Idle

Timestamp

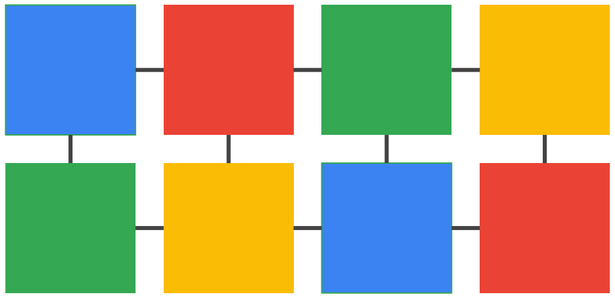
Duration

Minimum 10 minutes
Maximum 14 days
Granularity 1 second

With ephemeral clusters, you only pay for what you use

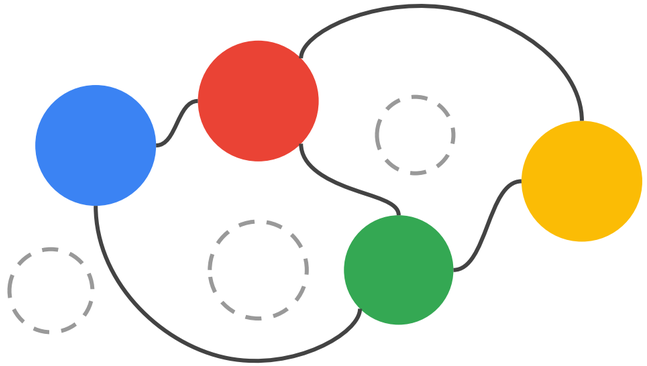


Persistent clusters



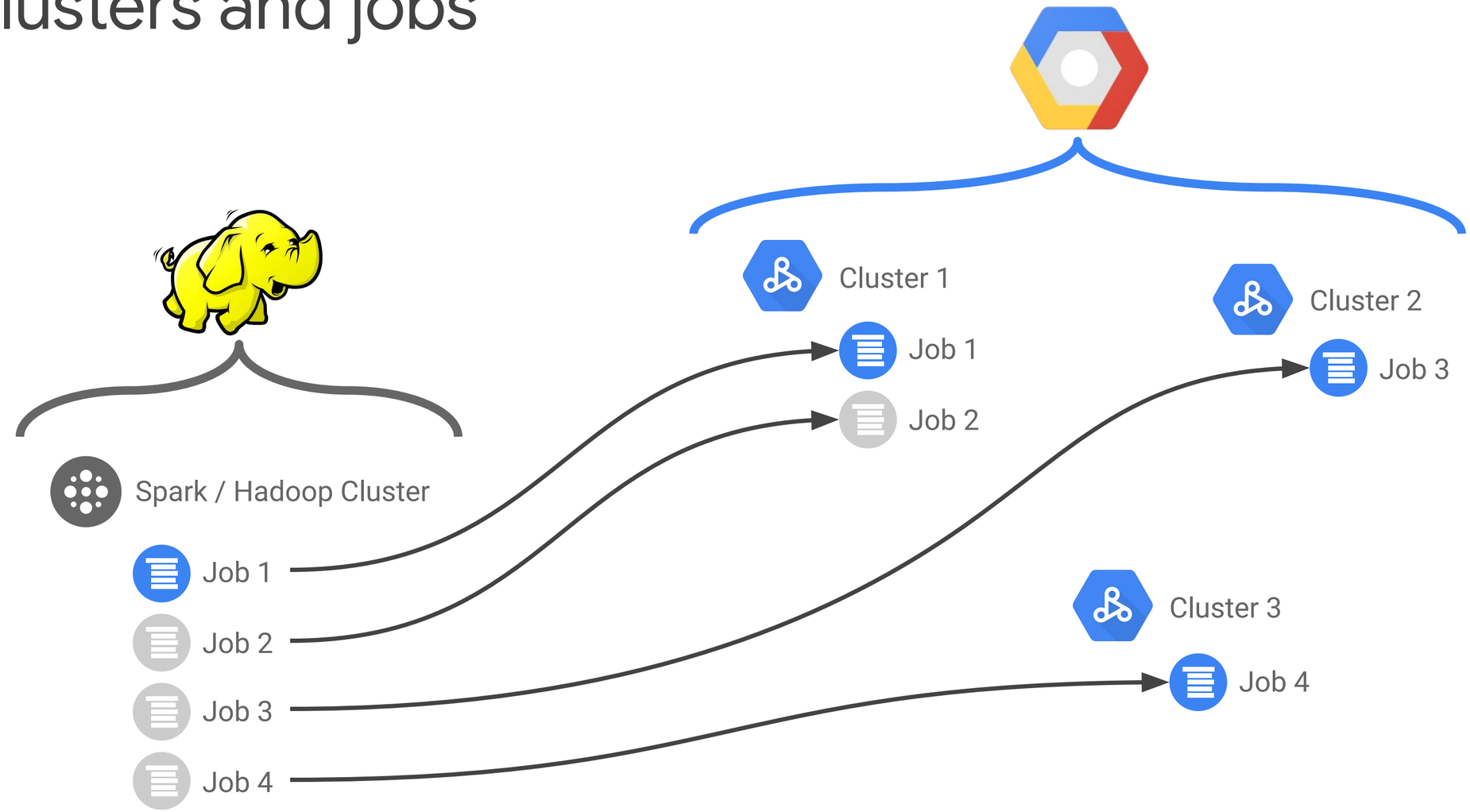
Resources are active at all times. You are constantly paying for all available clusters.

Ephemeral clusters

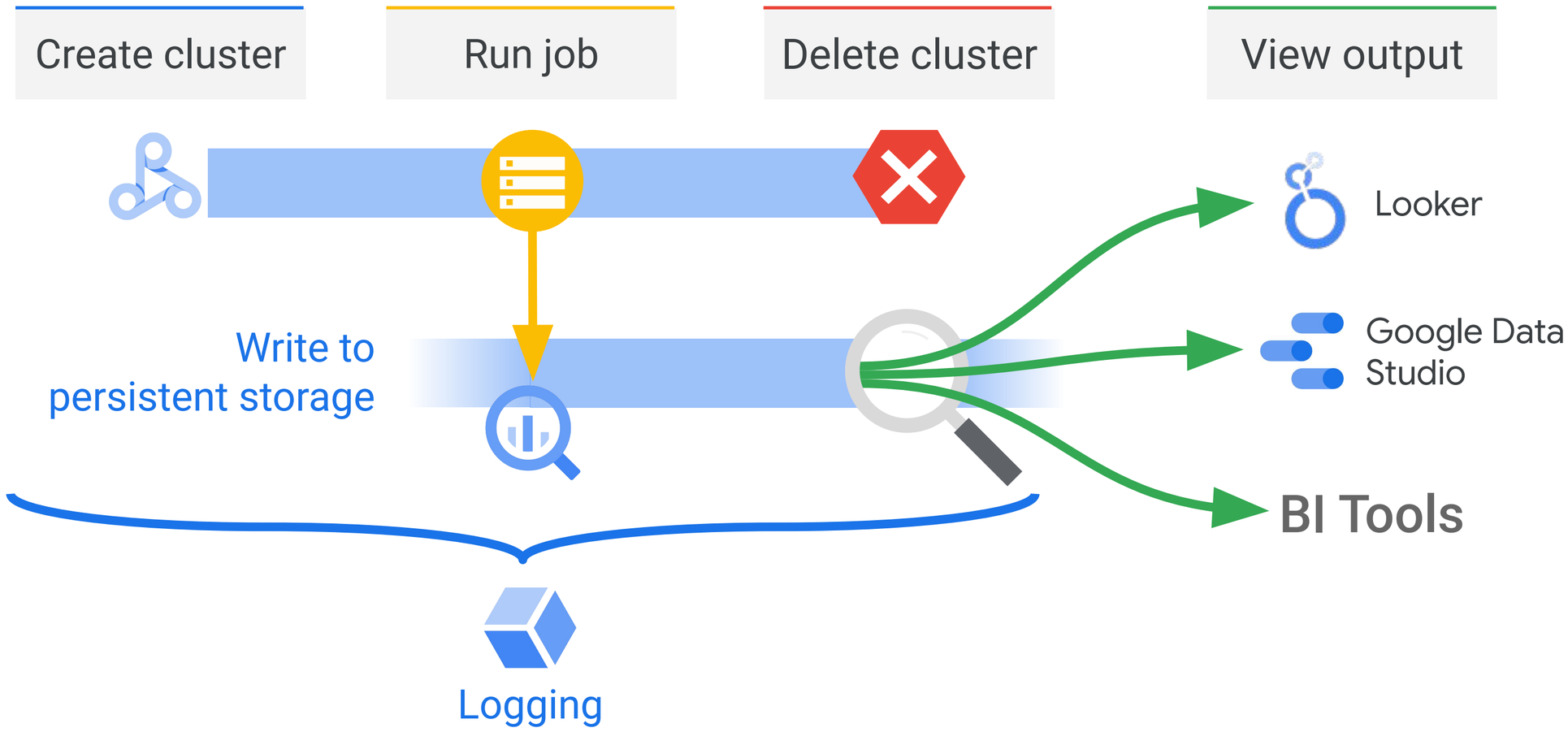


Required resources are active only when being used. You only pay for what you use.

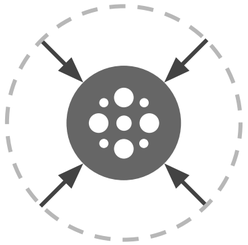
Split clusters and jobs



Use ephemeral clusters for one job's lifetime

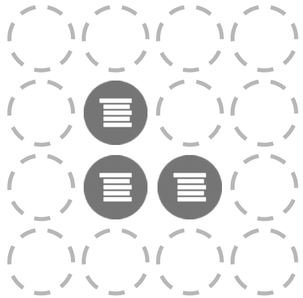


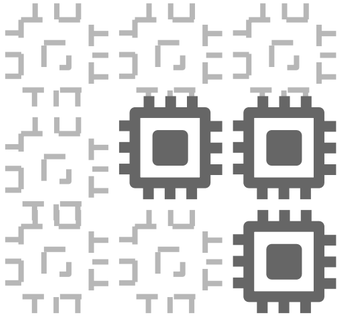
Points to remember if you need a persistent cluster



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

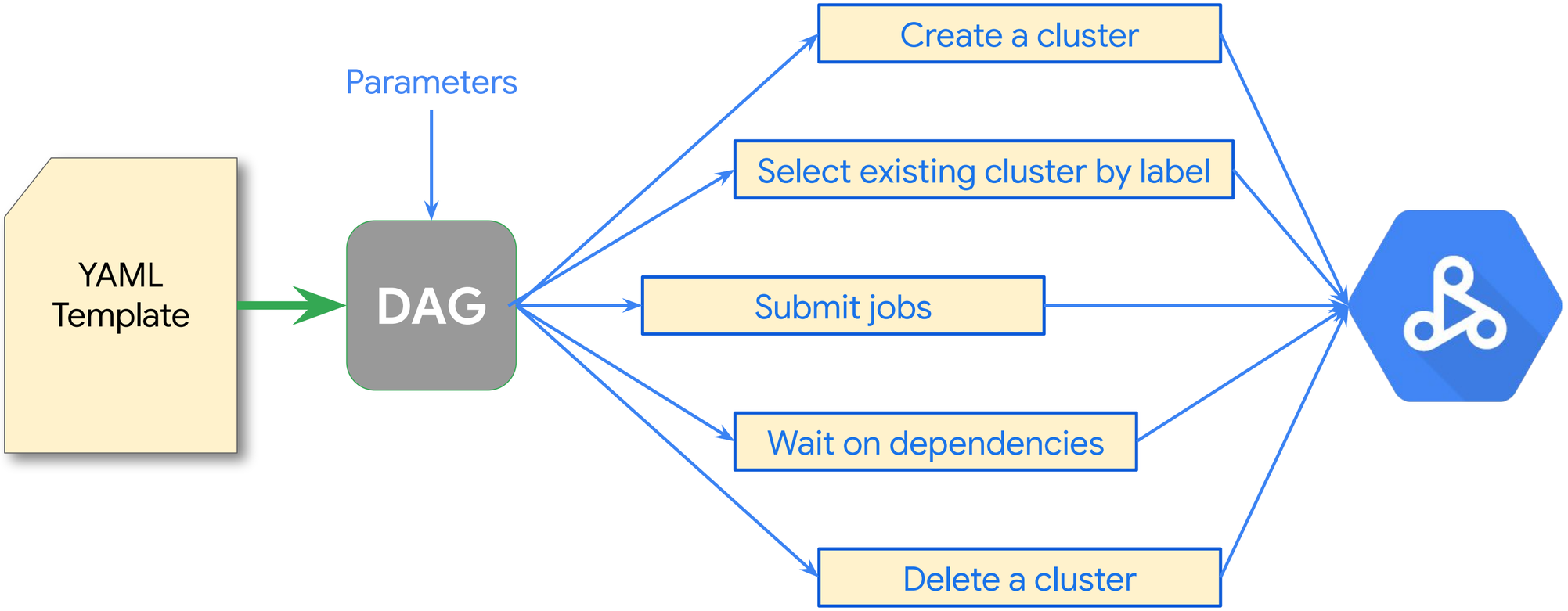
Scope your work on a persistent cluster to the smallest possible number of jobs





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

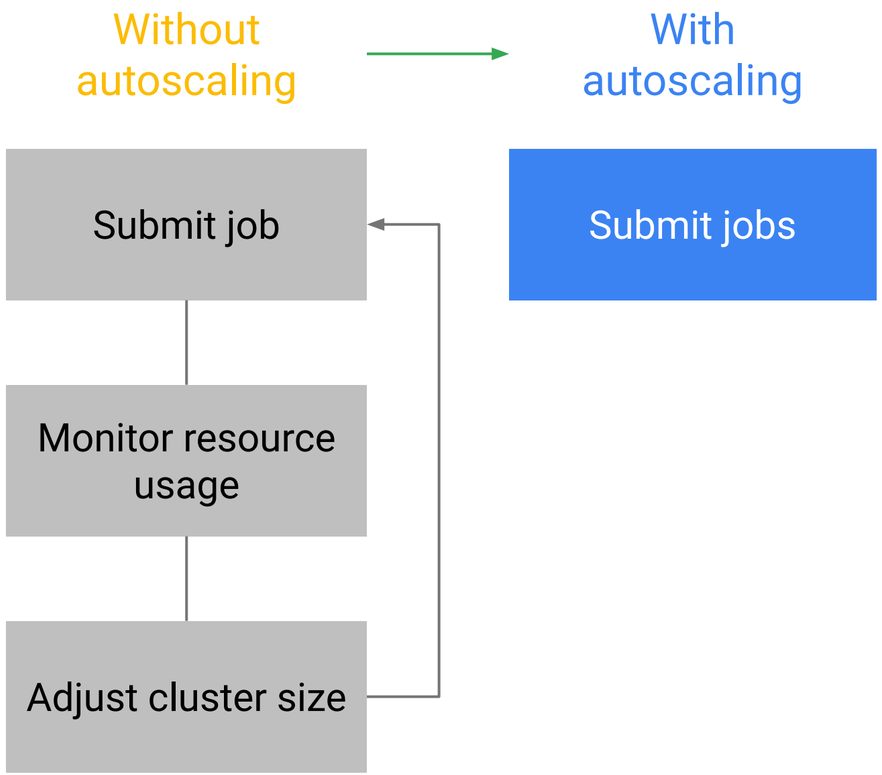
Cloud Dataproc Workflow Template

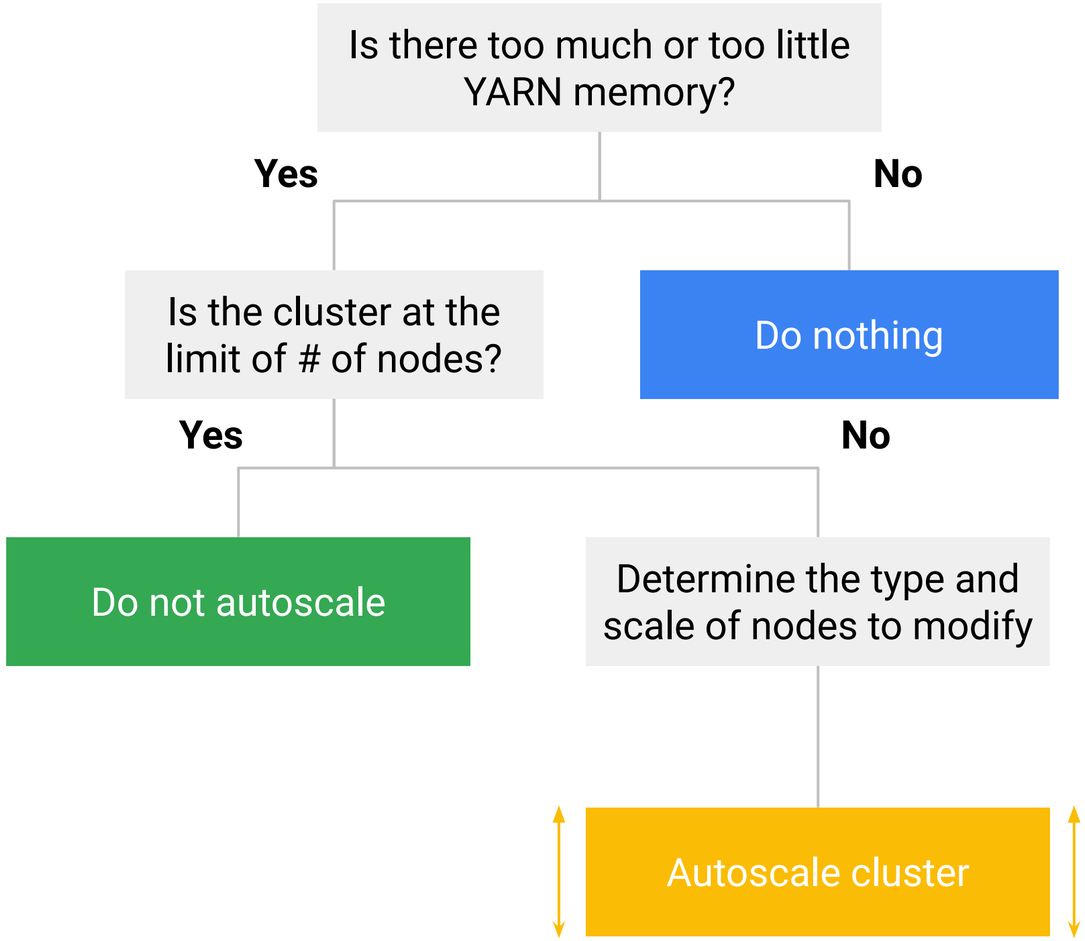


Cloud Dataproc workflow templates

```
# 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



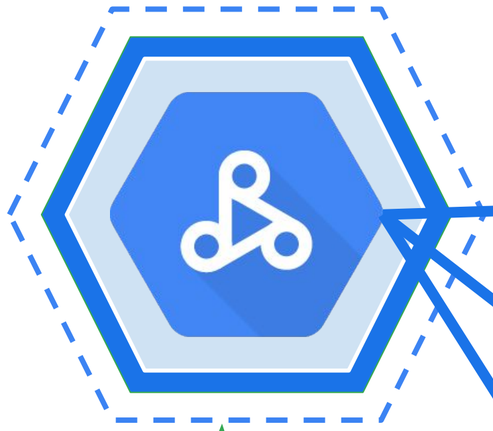


Cloud Dataproc Autoscaling provides flexible capacity

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



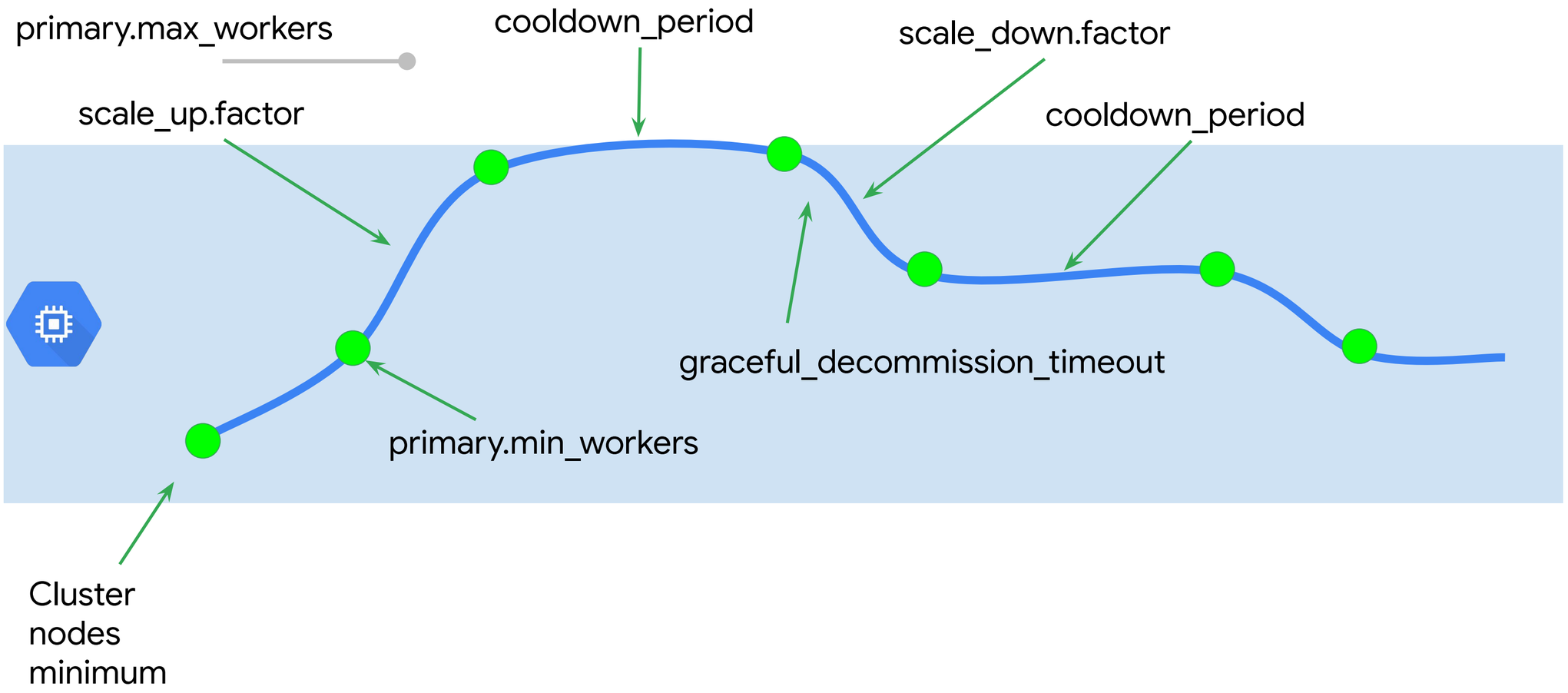
External data
Not for on-cluster HDFS
Not for Spark Structured Streaming

Cloud Storage

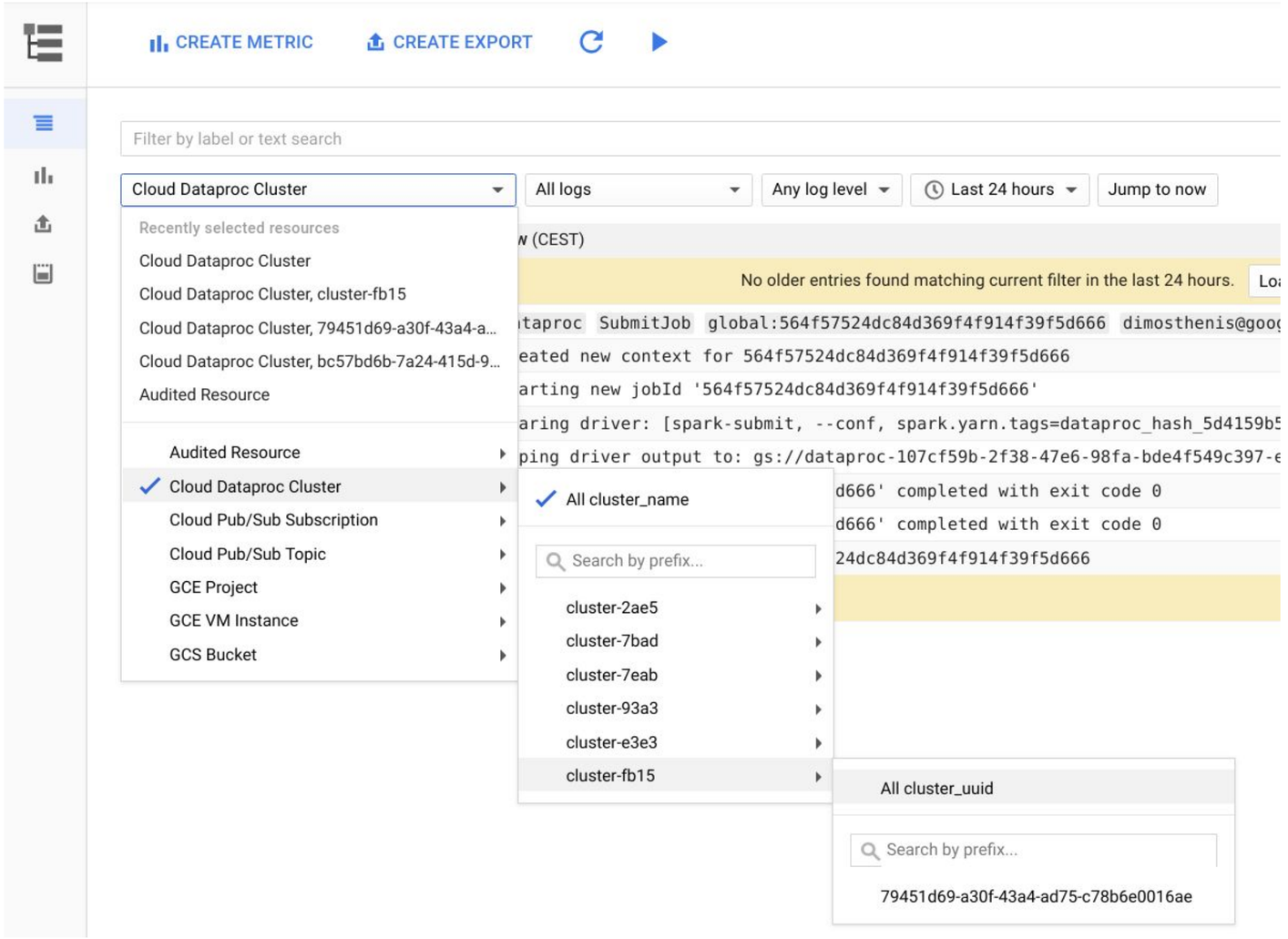
Cloud Bigtable

Cloud BigQuery

How Cloud Dataproc Autoscaling works



Use Cloud Operations logging and performance monitoring



Google Cloud

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: "1e8i240nizp188ay9"
  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
```

Google Cloud

Set the log level

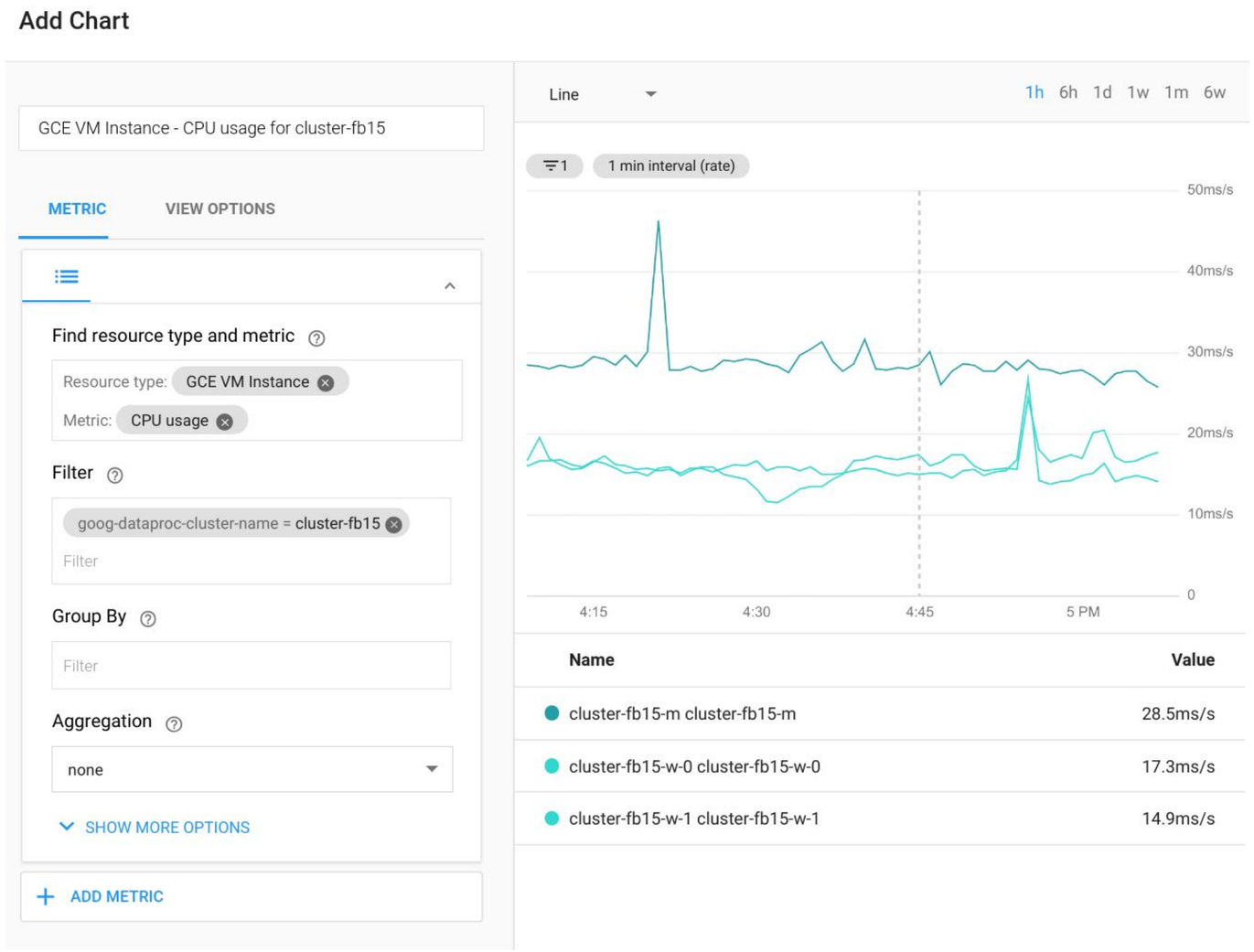
You can set the driver log level using the following gcloud command:

```
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



Google Cloud

Agenda

The Hadoop ecosystem

Running Hadoop on Cloud Dataproc

GCS instead of HDFS

Optimizing Dataproc

Lab

Lab

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

Optimizing Dataproc